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Transport Committee

Galileo

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Summary

The Galileo project has the scope to provide real improvements in the world's satellite navigation systems. The United Kingdom's strengths in satellite technology, both in industry and in academia, mean that we are very well placed to participate in this exciting venture. However, we believe that Parliament and the public are not sufficiently aware of Galileo's costs and benefits, which in some cases appear to have been poorly articulated, and insufficiently assessed. Important questions need to be addressed before the European Union Transport, Telecommunications and Energy Council makes final decisions on the programme. They involve the value for money of the project, the date when it is realistic to expect the Galileo system to be operational, the commitment to the Public-Private Partnership proposed for the deployment and operational phases of the programme, and the mechanisms by which the civilian status of the Galileo project is to be secured.

The United Kingdom Government also needs to assess far more clearly what use it will make of Galileo, and which services it will require.

1 Introduction

1. In May this year the European Scrutiny Committee of the House of Commons recommended a number of documents relating to the Galileo satellite programme for debate. It was clear that the Transport, Telecommunications and Energy Council (the "Transport Council") was shortly going to be faced with a number of important decisions on the project, and that further debate in the Commons was likely to be needed before the Council this December. We decided to gather evidence to inform this debate and to issue this short report, which we hope will assist both the House and the Government. We are extremely grateful to our witnesses from academia, from industry and Government, all of whom managed to give us a great deal of information most clearly and succinctly. We are also grateful to Dr Sarah Pearce, our Specialist Adviser, for her help.

2. The Galileo programme is intended to provide the European Union with its own Global Navigation Satellite System (GNSS). Currently, there are two major systems: the United States of America's Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS). Although receivers which use the signals from both GPS and GLONASS have been developed, we were told that the Russian system needs maintenance and upgrading before it can be reliable.

3. The US system is widely used. As the Government memorandum makes clear:

> "GPS was initially designed for US military applications and until 2000 the US government applied "selective availability" – which intentionally degraded the open access signal for civil applications and users – in order to preserve their Armed Forces' advantage and for national defence needs. The US government has since pledged to maintain the full capability, free open service signals (and that it will give six years' notice of any change in this position)."[1]

Nonetheless, its civil uses have been significant, and civil applications for GPS have been found world wide, particularly since the lifting of selective availability. The Government told us that the US was "also planning to improve the GPS service to the civil community but the system's evolution will continue to be governed primarily by US defence requirements."[2]

4. GPS is far from perfect. Like GLONASS, it is a military system, and its signal will be degraded or jammed if the US judges this necessary. Moreover, it has no guarantee of reliability, and can fail.[3] This means it cannot be used for safety of life applications without enhancement.[4] GPS coverage is not uniformly good world wide, and it is particularly limited in areas where there is uneven ground and deep contours – that is, in most modern cities.[5] As it currently functions, GPS alone cannot provide a service which is reliable

1 GG 15

2 GG 15

3 See GG 12, GG 17, Q 76

4 GG 08

5 Q 2, Q 63

enough to allow a full range of safety critical applications, such as navigation aids for civil aviation, to rely on satellite navigation systems.

5. There are two European programmes designed to overcome the deficiencies of GPS. The first is EGNOS – the European GeoStationary Navigation Overlay System. This uses a small number of satellites to correct and verify information from GPS. Our witnesses told us that it would be fully operational "shortly". It is expected to provide a great improvement in the GNSS systems available. Indeed, the Royal Academy of Engineering said: "If the argument were limited to whether Galileo would provide a better or more accurate navigation system alone, then it would be unclear as to why Galileo is required when it has been proven over many years that GPS with EGNOS is available, robust, reliable and accurate."[6]

6. However, EGNOS cannot operate on its own. Since 1999, the European Union and the European Space Agency (ESA) have been working together to develop GALILEO, an independent European positioning system.[7] The Galileo programme has four phases:

- A definition phase which ran from 1999 to 2001, during which the architecture of the system and its services were designed. This cost €80m, funded half from ESA and half from the EC budget.

- A development and validation phase, which started in 2002. ESA has procured two experimental satellites (one from Surrey Satellite Technology Ltd and one from a European consortium), of which the first will be launched by the end of 2005. Following this, a mini-constellation of four satellites will be launched to allow the system to be tested in orbit. This is expected to take place by 2007. This phase is managed by the "Galileo Joint Undertaking", and is funded by €1.1bn split evenly between the EC budget and ESA.

- A deployment phase, involving building and launching all 26 remaining satellites and establishing the entire ground-based component.

- A commercial operating phase, supposedly due to begin in 2008, which will cover the management of the system as well as its maintenance and updating.

7. While the development of the system has until now been funded by public agencies, it is intended that the deployment and operation phases should be carried forward by a partnership with the private sector in which a significant amount of funding would come from the concessionaire appointed to oversee these phases. The cost of the **deployment** phase is estimated at €2.1 billion, with two thirds of the cost (€1.4 billion) to come from industry and the rest (€700m) from the Community budget. PricewaterhouseCoopers (PwC) estimate that **operating** costs for Galileo (not including EGNOS) will be around €140m per year. The Commission has suggested that it will it will be necessary to provide some "exceptional public financing" during the first years of the commercial operating

6 GG 08

7 The European Agency is a separate body from the European Union; The European Space Agency has fifteen Member States; thirteen of which are members of the European Union. (Greece and Luxembourg are the only members of the former EU 15 who are not currently ESA members, although they are in the process of joining). Norway and Switzerland belong to ESA, although they are not EU members.

phase, as the market develops. It has proposed a budget of €500m from the EC to cover the years 2008-2013, but this could be amended as the concession negotiations progress.

8. The Galileo Joint Undertaking, a joint company between the European Union and the European Space Agency, has been established to complete the development and validation phases of the programme. Part of its task has been to

> "Help to mobilise the public- and private-sector funds needed to make proposals to the Council the management structures of the successive phases of the programme on the basis of the following activities:
>
> Draw up a business plan covering all phases of the programme on the basis of data supplied by the Commission on the services that can be offered by Galileo and the revenue they may generate;
>
> Negotiate, via a competitive tendering process with the private sector, an overall agreement for financing the deployment of operational phrases that sets out the responsibilities, roles and risks to be shared between the public and private sectors."[8]

On 9 October 2004 the Chinese National Remote Sensing Center became a member of the Joint Undertaking.[9]

9. Day-to-day control of the Galileo project will shortly pass to the Galileo Supervisory Authority, which is expected to be established early in 2005. A recent Press Release from the European Commission defines the Authority's role:

> "The Authority is a Community agency whose mission is to represent the interests of the public sector vis-à-vis the future concession holder of Galileo, the European satellite radio navigation system.
>
> The Supervisory Authority's tasks are the following:
>
> it will conclude the concession contract with the consortium selected upon completion of Galileo's development phase and, as the licensing authority, will ensure that the consortium meets its obligations under the contract;
>
> it will manage and monitor the use of the public funds allocated to the programme;
>
> it will have full technical competence in relation to security matters;
>
> it will ensure the technical development of the system;
>
> it will enable many third countries associated with the programme to take an active part in the management of this strategic infrastructure;
>
> it will assist the Commission in matters relating to satellite radio navigation."[10]

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8 Galileo: Third European Programme for Global Navigation Services, ESA, March 2003

9 Galileo Joint Undertaking Press Release: Galileo gets a global vision, 09/10/04

10 European Commission Press Release: Galileo: Commission to recruit Executive Director for Supervisory Authority; Reference:IP/04/1148 Date:28/09/2004,

10. In October 2004 the European Commission issued a Communication to the Council announcing that the time had come for member states to make an "irrevocable transition" to the deployment and operational phases of the Galileo programme.[11] Earlier this year it seemed likely that the December Council would be asked to approve a single concessionaire for detailed negotiations. We understand that this decision may be delayed, but Mr David Jamieson MP, the Parliamentary Under-Secretary of State at the Department of Transport, told us:

> "In December, at the Transport Council, we will have the opportunity to consider the European Commission's communication which sets out in detail the final shape of the programme and the services that it will provide. At the same time, we shall be moving towards a decision on who will gain the operating concession under the public-private partnership to build the satellites, launch them into orbit and then provide the services from a fully functioning constellation of 30 satellites."[12]

If the Council is to take sensible decisions it will need as much clarity as possible about the scope of the project, the timing of the operational phases and its funding. Although significant amounts of work have been undertaken on each of these, we believe important questions remain.

2 Considerations for the Transport Council

Benefits and costs

Costs

11. Air Commodore Norman Bonnor, President of the Royal Institute of Navigation, told us the European Union offered to play a part in producing an enhanced GPS, but that this offer was rejected. Mr Jamieson later confirmed that:

> "there were indeed initial discussions between the EU and US authorities on this. I believe they did not progress because there would have been no opportunity for the European side to take part in the decision-making structure for GPS, and, as I indicated in my oral evidence, insufficient prospect of securing a major role for European industry."[13]

The EU therefore had to choose between relying on GPS, augmented with EGNOS, or developing its own satellite system. It chose to develop its own system.

12. The breakdown of costs between the phases of the programme has been summarised above. The figures cannot be taken as entirely definitive. There have already been reports

11 Commission of the European Communities Communication from the Commission to the European Parliament and the Council: Moving to the deployment and operational phases of the European satellite radionavigation programme, Brussels, 06.10.2004 COM (2004) 636 Final

12 Q176

13 GG 15A

that the test programme cannot be completed without extra funding.[14] In a letter to Mr Christopher Chope MP, dated 10 June 2004, Mr Jamieson detailed cost overruns which had already occurred. The precise costs of the deployment phase cannot be accurately estimated until the concession is negotiated, and, as we discuss below, there are many uncertainties about the timing of the programme, and the time required before it becomes self-financing. The total cost of the programme up to the end of the deployment phase (including private-sector contributions) is estimated at between three and a quarter and three and a half billion euros, but there must be significant uncertainties about this sum. Nonetheless, Galileo is expected to be far cheaper that GPS since, as a civilian system, it will not need the resistance built in for military use,[15] but the most recent Explanatory Memorandum from the Government notes "the financial assumptions underlying the Commission's estimate of the costs should in our view be treated with extreme caution and must be reviewed once better estimates emerge from the final evaluation of the bids."[16]

13. The benefits are still more difficult to quantify. Many of our witnesses stressed the importance of a European Satellite Navigation System which would be independent of the United States. GPS cannot be guaranteed to be available for the twenty or thirty years it would take to build a new system.[17] Although GPS is being upgraded, this will take longer than to launch the Galileo system.[18] However, it is clear that the US will be able to jam Galileo signals in areas of conflict at times of its choosing (see paragraph 48 below). Although "until 2000 the US government applied "selective availability" – which intentionally degraded the open access signal for civil applications and users – in order to preserve their Armed Forces' advantage and for national defence needs" it has "since pledged to maintain the full capability, free open service signals (and that it will give six years' notice of any change in this position)."[19]

14. Galileo will provide five services:

- The Open Service (OS), which will be like the current GPS service, free of charge and global, but it will offer no service guarantees and will not provide integrity information to receivers;

- The Safety of Life Service (SoL) will be for transport applications where lives could be endangered, such as trains, aircraft and ships. This service will provide a high level integrity for safety critical applications although the position accuracy will be the same as the Open Service (OS);

- The Search and Rescue (SAR) service is designed for humanitarian search and rescue missions, it will enable distress messages to be received instantly from around the world and the location to be specified within a few metres.

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14 Q 20

15 Q115

16 Explanatory Memorandum On European Community Document, Communication from the Commission to the European Parliament and the Council: Moving to the deployment and commercial operating phases of the European satellite radionavigation programme,COM (2004) 636 final. Submitted by the Department for Transport 1 November 2004, para 13

17 Q6 -7; Q10

18 Q11

19 GG 15

- The Commercial Service (CS) will provide two extra signals to the Open Service. This service will be encrypted and only provided to paying customers;

- The Public Regulated Service (PRS) is designed to be used by public services. The PRS signal is required to be operational at all times, including times where other signals may be jammed. The signal is not only encrypted, but is also separated from other Galileo signals so they can be jammed without affecting PRS, which also has a more robust signal.

15. In spite of this variety of services, in many cases the advantages of Galileo will not come from the system taken alone, but will be produced by combining the signals from Galileo with those from GPS. Professor Paul Cross, Head of the Department of Geomatic Engineering at University College London, told us:

> "I suspect that there are no differences in the services themselves; it is the quality of the service, the reliability and integrity of the service. The key problem with GPS is that although it is a system which has many, many applications, it is not accurate enough for some of them. It does not have integrity built into it, so it is not a guarantee of service and the relatively small number of satellites means that it is not available in many places, especially in the city areas where GPS plus Galileo particularly will lead to something in the region of 60 satellites in the sky and a minimum of something like 14 satellites visible from any point on the earth at any time rather than, at the moment, something like five satellites visible."[20]

The potential applications go far beyond the transport field:

> "It is not just for transport, it is also things like timing for computer networks; even weather forecasting is being based on GPS stations being able to measure things like water vapour and so on. It sounds extreme, but there is a huge number of activities of that kind which are developed and which would suffer if GPS became unavailable for whatever reason."[21]

Our witnesses from the Ordnance Survey told us that highly accurate satellite navigation systems could be used by those in the construction and civil engineering industries, utility companies, surveyors and those involved in precision agriculture.[22]

16. Surprisingly, our witnesses from the General Lighthouse Authorities and from National Air Traffic Services were less enthusiastic. Captain Duncan Glass of Trinity House told us that "from the point of view of the maritime user who has embraced GPS thoroughly since its introduction, there is not much that Galileo can offer that he has not already got".[23] Mr Paul Thomas of NATS said that "the augmentation of the GPS signal through EGNOS provides us with the basic capability that we are looking for from satellite navigation."[24] This was particularly unexpected since in the long term ICAO wishes to use GNSS as the

20 Q2

21 Q 10

22 Qq142-149, Qq157-163; the Royal Institution of Chartered Surveyors also made a submission about the benefits Galileo will bring (GG 09)

23 Q 57

24 Q 55

sole means of navigation for aircraft, and the aviation industry expects this to produce savings in the installation and maintenance of ground based navigation equipment.[25]

17. Both however agreed that there could be real advantages from having a backup system if GPS failed. Dr Witty of NATS told us that "the discussion has had flavour of: is there a choice between GPS and Galileo? For us, if we went to a satellite–only based system we would want both and that would be crucial for us because then we would have diverse, dual channel redundancy …It would be very important to us that if there were a problem on GPS, you would not expect a simultaneous problem on Galileo ..."[26] Air Commodore Bonnor maintained: "GNSS is basic infrastructure: it is the same as the roads and railways." [27]

18. It will not be necessary to wait for the completion of the Galileo project before taking advantage of some of the improvements it will bring; we were told that in some applications, such as surveying, "even if we have got another one or two satellites up there, that will help us in difficult environments, but other types of application will have to wait until the constellation is pretty much complete."[28]

19. Mr Thomas was concerned that the Commission's cost benefit analysis of the Galileo programme included benefits which are properly ascribed to EGNOS, which were already planned and did not depend on Galileo itself.[29] The Minister confirmed that

> "Phase 1 of the 'Galileo Study' by PricewaterhouseCoopers had identified aviation as one of the largest and most robust beneficiaries of the Galileo programme. It forecast benefits of some €5bn pa by 2020 made up of cost savings to airlines and time savings to passengers. This calculation seems to have been based on the assumption that Galileo would be an enabler of RNAV (area navigation) routes in Europe, but the report failed to consider that most commercial aircraft are already able to perform RNAV operations using systems such as GPS/EGNOS. The report appears also to have misunderstood how the benefits of Galileo could be realised through the air navigation charge."[30]

These concerns were raised with the Commission in 2001; the Government's view is that the benefits ascribed to Galileo "would rise towards the PWC level, but over a longer timescale than predicted by PWC, and this would still depend on the removal of other constraints, such as restricted air space in Europe..."[31]

20. It is clear that although there is a market for satellite navigation products, and that market may well develop in unforeseen ways when new services are provided, those who use navigation satellites for navigation itself are not drivers of the new system. Although the aviation community has an aspiration to move to a satellite based navigation system in

25 GG 06

26 Q 82

27 Q 77

28 Q 165

29 Q 103

30 GG 15A

31 GG 15A

the long-term, that will depend on the success of Galileo and the availability of two independent satellite systems.

United Kingdom industry

21. Many witnesses told us that US industry had benefited directly from GPS, and the fact that much information about GPS is restricted for military reasons, so non-US companies were not allowed to compete. European industry could be expected to benefit from a European satellite navigation system.[32] The iNavSat consortium told us that "The UK has perhaps been the most successful country outside of the US to exploit market opportunities that GPS has presented."[33] The Government believes that Galileo could bring considerable benefits to the United Kingdom. Mr Jamieson estimated that the system could create up to 1,000 new jobs in the United Kingdom and in the longer term over 100,000 new jobs across Europe.[34]

22. The United Kingdom is in a strong position because of its highly developed scientific and industrial base. The East Midlands Development Agency drew our attention to the many industries and universities which would benefit in its area alone.[35] The Minister told us:

> "It is important for our industrial interests that the United Kingdom is able to play a full part in the programme. We see it as vital that we are in on the development of the project and the UK has had a leading place in the European space technology programme. Our industry is well placed to benefit from the very significant work that will be on offer and our technical experts have a key part to play in the development of the system and guiding it in the direction that we want it to go. The United Kingdom has a real edge in Europe, in each of these areas: we have companies, both large and small, which are already taking advantage of this and many more waiting for the programme to start operating."[36]

23. The United Kingdom is bidding both to host the Supervisory Authority and one of the Galileo control centres, and one of the two consortia left in negotiations is led by companies based in the United Kingdom. Although most benefits would be gained if Galileo activities were based in Britain, Mr Vos, the former Chairman of Inmarsat, now their Adviser, told us that even if the concessionaire was not based in the United Kingdom software and other value added services were likely to be developed here.[37] The Pinpoint Faraday Partnership told us:

> • "Positioning and related technologies are a vital component of the UK's knowledge economy.

32 GG 11

33 GG 16

34 GG 15, GG 15A

35 GG 05

36 Q 176

37 Q 139

• There is worldwide demand for applications and services derived from positioning information; thus there is a global market for UK-developed knowledge, products and services. The existence of EGNOS and the development of Galileo are helping to increase the store, and value of UK Intellectual Property, and are giving UK organisations a definite selling edge.

• The Galileo programme is already serving as a major stimulant of UK creativity and innovation."[38]

24. **We understand the motives which led to the development of the Galileo programme. We can see the potential advantages, both for the international community, and for the United Kingdom. However, we are approaching the point at which participants are being asked to make an irrevocable commitment to the programme. The costs incurred so far have fallen on the European Union and the European Space Agency rather than individuals and private sector organisations. It is now imperative for the United Kingdom Government and Transport Council to take this opportunity to consider whether the benefits of the Galileo system are commensurate with its likely costs, or whether similar benefits would be attainable with a less ambitious programme. We are not convinced that the costs and benefits have been properly assessed. The Government should not go ahead with the programme until a further, independent, cost benefit analysis has been undertaken.**

Timing

25. A test satellite must be launched in 2005 to ensure that the frequencies reserved with the International Telecommunications Union for the Galileo programme are secured; those frequencies will be lost if signals are not transmitted by June 2006. We were told the deadline would be met and that two satellites are already under construction.[39] After this the task will be to deploy the remainder of the satellites to make up the system.

26. The European Commission has consistently claimed that a Galileo system will be operational "from 2008". Many of our witnesses considered that timetable to be so ambitious as to be virtually unachievable.[40] Professor Sir Martin Sweeting, Director of the Surrey Space Centre, and CEO of Surrey Satellite Technology Ltd, a satellite manufacturer, told us "It is completely impossible to get the complete system operational by 2008"[41], although he thought it would be practicable to have all the satellites launched within 15 years.[42] There was consensus that the Galileo system would be in place before an improved GPS system, but its completion was expected in the next decade, rather than in the next few years, although the operational phase might begin by 2010 -11.[43]

27. **The timetable for the implementation of the Galileo programme must be realistic. It is all too easy to set impossible aspirations, and then to attempt to ensure that**

38 GG 13

39 Q 35

40 Q 91

41 Q 37

42 Q 13

43 Q 99; Q 120

decisions are made to meet those aspirations. Inevitably, there is a danger that decision-makers in this situation will not have access to the information they need, and will not have time to consider the information they do have properly. The December Transport Council must ensure that it is not bounced into making premature decisions for fear that the Galileo project will be delayed. Member States must seek hard information on what timescales are achievable, when real benefits could be expected, and when decisions really need to be taken. They should not hesitate to call for delay in decision-making if they do not have the information they need.

The Public Private Partnership

28. Two consortia remain under consideration for the Galileo concession, which the Government consistently maintains will be a public private partnership (PPP). They are the **iNavSat** consortium, which consists of Inmarsat Ventures plc, the Thales Group, and EADS Astrium Space, SiRF and the **Eurely** consortium consisting of Alcatel, the Italian aerospace and defence group Finmeccanica SpA, Vinci SFR, and consulting, technology and outsourcing company CapGemini. According to the Commission, each has undertaken to provide two thirds of the funding for the deployment period.

29. The cost of the deployment phase is estimated at €2.1 billion, and the public sector funding for this phase is to be €700 million. It is possible that there will be further funding from non-EU countries; agreements have already been signed with China and Israel, and it is likely that other countries, such as Brazil, India Japan, Russia, Mexico, Canada, Ukraine, South Korea and Australia, will be interested.[44] The Commission also makes it clear that some subsidy will be needed in the first few years of deployment, while the commercial applications are being established.

30. The concessionaire would raise the money for its share of the works through equity from their members and borrowing. Each consortium has put forward its own proposals, and they are kept in confidence. However, the broad principles are clear. Money would come from the concessionaire's control of intellectual property rights associated with the project, and from the two subscription services—the Commercial Service and the PRS.

31. The Department's Explanatory Memorandum noted that the allocation of risks was the weakest area of the bids. This surely depends on the ability of the private sector to generate a return on its investment. The individual companies we took evidence from were cagey about their plans. However, the Minister told us:

> "The sort of income streams would be, just as there is on the GPS system, selling the licence for the equipment that would actually be used to receive the signal; that is the same as the GPS, but that of course instead of going to America would come to the concessionaire and to this country. So that would be one source of income. There would be an augmented system, where a slightly better signal could be used for commercial purposes which would be paid for. The PRS, should countries and

public bodies in the countries in Europe find a use for that, would not be paid for by the 25 countries, that would be paid for by those who use the system."[45]

32. Mr Peter Blair, the former Technical Director of the defence systems company, Racal Electronics, said he found difficulty in seeing money coming in from the subscription services when a good service would be available free from GPS and the Galileo open service.[46] Nonetheless, the Ordnance Survey was sure that there would be a market eager for the higher reliability and higher precision provided by Galileo, and estimated 60 –70% of its customers would be prepared to pay for this. There was general confidence that combined Galileo-GPS receivers would come to market early and would not be so expensive that they would deter users.[47] Air Commodore Bonnor was confident that "We have a lot of leisure users who really enjoy any gimmick", and would be eager to buy combined receivers.[48] However, Dr Whitty, the Chief Technology and Programmes Officer of NATS, was concerned that the airlines "would be very nervous about being asked to overpay for what they receive from Galileo."[49] He also made it clear that in spite of the aviation industry's aspirations to use a Global Navigation Satellite System as the primary means of air-traffic control, at present Galileo was not sufficiently important to invest in it as an alternative to well established and tested ground-based systems: "we would not make a major investment in Galileo just on the aviation case alone. If it is there and we are a small player in a big system, then it is advantageous to us."[50]

Bridging subsidy

33. A report by PwC estimates Galileo's yearly running costs at €140 million.[51] In the long term it is to be hoped that these costs would be borne by the concessionaire, but it is clear that there will need to be some subsidy in the first few years of operation. It is entirely unclear how long such subsidy will be required or how much funding will be involved. The Commission has proposed that the European Community should contribute €1 billion in the period from 1 January 2007 to 31 December 2013, of which €500m is earmarked for the funding the first years of the operational phase. It is clear that this figure will be "adjusted according to the outcome of negotiations". It is also possible that the European Space Agency "may, if necessary, contribute to the funding of the programme's deployment and operational phases by means of a contribution to the Supervisory Authority." [52]

34. It is impossible to predict the length of time for which a subsidy would be required. As we have seen, the deployment phase is likely to last for a considerable time beyond the Commission date of 2008. The December 2013 date has been set with reference to the Commission's financial perspectives, and not by reference to any likely timescale for

45 Q 224

46 Q 47

47 Q 68, Q 122

48 Q 65

49 Q 72

50 Q 83

51 Inception study to support the development of a business plan for the GALILEO Programme: Executive summary Phase II, 17 January 2003, page 30

52 Communication from the Commission to the European Parliament and the council 'Moving to the deployment and operational phases of the European satellite radionavigation programme', 6th October 2004 COM(2004)636.

development. Although Mr Richard Vos, the former Chairman of Inmarsat, told us that the business plan projected that "payments for availability of the system will cease in 2012 to 2013"[53] and thereafter money might come back through revenue sharing, he also conceded that "this is the space business: nothing is absolutely guaranteed".[54]

35. We very much hope that the need for a bridging subsidy will cease by 2013. We take some comfort from the fact that the iNavSat consortium proposes to fund the project both through equity from the founder companies and through money put forward by a consortium of banks. We trust that those providing loans and equity will have scrutinised the business plan carefully. However, industry and its backers have made mistakes in the past; the Transport Council must be quite clear that there can be no guarantee that the subsidy will not be required beyond 2013.

Intellectual Property Rights

36. There was some concern about the assignment of Intellectual Property Rights (IPR) to the concessionaire. Although there was general agreement that IPR would be an important source of income for the concessionaire, there were concerns that those rights should be carefully considered. Professor Jonathan Raper, Professor of Geographic Information Science at City University told us:

> "It depends which type of intellectual property you are talking about. There is a lot of intellectual property here. It is a public-private partnership (PPP) and therefore it is right that as they are risking funds they should have some share in that. There is intellectual property in the equipment and all the way down the chain. If the public sector has a right of access to and a right of negotiation on some of the key elements which the users need, for example the nature of the positional message which comes in, then it is acceptable."[55]

37. Mr Blair considered that some companies would consider that they had proprietary rights in intellectual property developed for associated programmes such as EGNOS and warned "You will find that there is quite a bit of IPR which has come in from other programmes in order to do that original work."[56] Mr Carey told us that the detail of the intellectual property rights was a matter for negotiation. We note Mr Blair's comment that the allocation of IPR has always been difficult in projects associated with ESA or the European Union.[57]

38. **The treatment of intellectual property may turn out to be extremely important. We recognise its role as a source of income to the concessionaire. But there should be no permanent transfer of intellectual property rights (IPR) away from publicly funded projects to the private sector. It will be in the concessionaire's interest to ensure that the cost of IPR are not set so high as to stifle the market; nonetheless, companies have been known to misjudge their pricing. There must be arrangements to allow the Supervisory**

53 Q 116

54 Q 117

55 Q 32

56 Q 33

57 Q 34

Authority to intervene if IPR are being controlled in ways which inhibit Galileo's development.

Worst case planning

39. We questioned the Minister about what would happen if the PPP concessionaire went out of business, or if the subsidies required were far larger than those currently envisaged. He replied that in such circumstances the Council would have to consider new funding proposals; the current plans were based on a successful PPP. However, he also told us that "I think it would be inconceivable at that stage that we would pull out altogether, because we would have had so much funding committed."[58] The most recent Government memorandum states that

> "The UK is clear that Council cannot take a final view on the commercial viability of the system or commit taxpayer's money without a clear picture of the value-added by the project and a proper cost-benefit analysis. This will not be possible until the final offer is on the table. It has also made clear that no irrevocable commitments can be made until agreement is reached on the new Financial Perspective for 2007 – 2013."[59]

40. **We entirely support the Government's contention that it will not be possible to take a final view of the Galileo programme until the final offer from the prospective concessionaire is available, and has been properly analysed. While, like the Minister, we have no desire to see the Galileo PPP end as "an orbiting Railtrack", we also believe it would be imprudent for the Transport Council to make an "irrevocable commitment" to the Galileo programme on the assumption that a Public Private Partnership will be entirely successful. We very much hope that the PPP will not fail; if it does, an extremely costly system will need either to be maintained by the public sector, or to be abandoned. The Transport Council should not proceed unless it is confident that, if the PPP failed, it would be content either to fund Galileo directly, or to write off the considerable costs in its development.**

Public Regulated Service

41. One of the decisions for the December and Transport Council will be whether or not to proceed with a Public Regulated Service (PRS). The Public Regulated Service (PRS) is designed to be used by public services, notably the police, coastguard, customs, and many other public sector users. The PRS signal is required to be operational at all times, including times where other signals may be jammed. The signal, as well as being encrypted, is also separated from other Galileo signals so they can be jammed deliberately without affecting PRS, which will also have a more robust signal.[60] There seems to be some confusion between the PRS and the Safety of Life service, since witnesses ascribed benefits to the PRS which might well be achieved through the Safety of Life service.[61] We are

58 Q 190

59 Explanatory Memorandum On European Community Document,Communication from the Commission to the European Parliament and the Council: Moving to the deployment and commercial operating phases of the European satellite radionavigation programme,COM (2004) 636 final. Submitted by the Department for Transport 1 November 2004, para 14

60 Galileo: The European Programme for Global Navigation Services, ESA and European Commission, March 2003

61 See, for example,GG 19

concerned that as currently defined, the Safety of Life signal may be less robust and resistant to jamming and spoofing[62] than the PRS.

42. It is clear that there will be some extra cost in providing such a service. The European Commission suggests that:

> "the costs generated by including the public regulated service in the system represent a very small percentage of the overall infrastructure costs…the service has very little impact on the definition of the main satellite parameters, namely the weight, power and volume of the equipment. The impact on the ground segment is negligible."[63]

On the other hand, Walter Blanchard suggested that the extra expense could arise not so much from the technology itself, but because:

> "If Galileo evidence is to be used in legal matters then there must be hard guarantees that the service can provide the necessary performance at all times. This is an expensive matter, involving back-ups, duplication, constant monitoring and precise record-keeping."[64]

We note that the commercial service will also have guarantees of availability; the Council should be clear whether or not the PRS will entail extra record-keeping.

43. Just as the cost of the PRS is unknown, so too is the extent of its use. The Government memorandum says:

> "The robust, encrypted signal should offer greater security from deliberate attempts to generate a false signal. Potential applications are still under discussion and it is expected that the Galileo concessionaire bidders will make proposals for the use of, and income generation from, the PRS. But the intention is that access to it will be strictly controlled, although the rules are still being discussed. No specific UK need has however been identified at the present time although if other member states specify a need and become paying users of the service, UK companies are amongst the few that have the capability to produce the necessary hardware and software.
>
> By way of example, however, the Commission have suggested that the service could be used:
>
> • by immigration and customs agencies for tracking smugglers of people and goods;
>
> • by peace keeping forces in or close to areas of conflict where NATO military operations require all unencrypted GNSS signals to be blocked; or
>
> • for civilian humanitarian operations in such areas."[65]

62 "Spoofing"; false signals which "pretend" to be from a particular satellite system but in fact are not.

63 Communication from the Commission to the European Parliament and the council 'Moving to the deployment and operational phases of the European satellite radionavigation programme', 6th October 2004 COM(2004)636.

64 GG 01

65 GG 15

In spite of this list, Professor Cross told us "I do not think anybody really knows what these services will provide."[66]

44. The Commission Communication of October 2004 states that "each of the consortiums stresses the importance of the income expected from sales relating to the public regulated service (PRS)".[67] However, Mr Vos told us that PRS was not absolutely central to the iNavSat business plan, although it was part of it.[68]

45. States which wish to use the PRS will need to pay for access to the signal. In our oral evidence, we were told that the PRS was "about five per cent of the cost and 20 per cent of the revenue potential".[69] This contrasts with industry's fears that other Galileo users may be expected to cross-subsidise the PRS.[70] It is easy to imagine that at some point in the future states will wish to resist paying a private sector consortium so much for access to infrastructure which was developed with a substantial amount of public-sector funding. The Department for Transport assured us that

> "the concessionaire will not want to jeopardise the potential income from commercial services by allowing Member States to siphon money away to pay for the PRS. It is expected that the funding of the PRS will essentially be 'user pays'."[71]

Technical difficulties

46. We understand that the Galileo signal has been granted primacy in the band 1260 to 1300 MHz, which is where the PRS signal is located. However, there may need to be restrictions on its use to prevent interference with Air Traffic Control radars.[72] We were told that recent research suggested that the signals could interfere with these radars, and it was possible that restrictions might have to be imposed. Clearly this is a technical issue which we are not competent to judge, but it would be imprudent to decide to back a PRS in this band unless it is clear that it can operate satisfactorily without causing interference to other services.[73]

Military Use and Applications

47. Galileo is intended to be a civilian project, but there have been concerns that the PRS could be put to military use.[74] Mr Jamieson distinguished between using satellite navigation systems for military *uses*, such as tracking groups of men or matériel, and for military *applications*, such as missile guidance systems.[75] There is no bar to using *any* open access

66 Q 44

67 COM (2004)636 final

68 Q 132

69 Q 134

70 GG 10

71 GG15

72 See GG 21, GG O8

73 See GG 21

74 Q 16; QQ 21 -22

75 Q 206, see also Qq 9, 18-19

satellite navigation system for the first use, be it Galileo or GPS.[76] Galileo is not intended for the second use. However, there has been speculation that some states participating in the Galileo project would like to make use of the PRS for military applications, and the Minister confirmed this was a possibility.[77] The iNavSat submission says:

> "Satellite navigation technologies have become mission critical components that will be embedded in every future military platform. Therefore, without the Galileo PRS, the European forces will lose operational capability by being dependant on third parties' technologies. Meanwhile the European industry will be excluded from major defence and security markets in this field."[78]

48. In June 2004 the European Union and the United States reached an agreement

> "that the baseline signals for Galileo, both the Open Service and the PRS, if it is decided to have the PRS, would both be such that the Americans would be able to jam both Galileo signals if they needed to locally in a conflict area while continuing to use the GPS military code. That is the basic operational safeguard for them."[79]

Regardless of any other safeguards, this agreement must provide a disincentive for the military application of Galileo.

49. Mr Jamieson also stressed that there would be safeguards to prevent the PRS being used for military purposes:

> "the purposes for which they can use them will be very clear: it will not be for military applications. The only way that could change, and who knows, there may be a change, but if a change were to take place, that would be by the Council under Pillar 2 and would have to have unanimity of all the 25 countries to make a change to have military applications."[80]

The Government's position, as reported in writing to the European Scrutiny Committee, is not as forthright as the Minister; the Explanatory Memorandum suggests that no agreement has yet been reached in the Council to refer suggestions that the PRS should be used for military purposes to a second pillar forum, which takes decisions by unanimity rather than qualified majority.

> "We will … ensure that sufficiently robust checks and controls on access to the PRS signal, on future decisions over its development, and on requirements in the PPP contract, are written into the Transport Council agreement on the PRS. This should include an explicit requirement that any move towards military applications must be referred to an appropriate, Pillar II, forum. We will be engaging in lobbying partners

76 Q 16; Q 19

77 Q 218-219

78 GG 16

79 Q 210

80 Q 214

to secure these objectives or to join a blocking minority in Council if we fail to secure the restrictions we need."[81]

We were told that there will be a policy on access which sets out how the technology involved would be distributed, but it is clear that there is a great deal of work to be done in defining that policy, and in deciding how it will be policed.[82] Bearing in mind the Minister's remarks about the failure of attempts to involve the European Union in the enhancement of GPS because "there would have been no opportunity for the European side to take part in the decision-making structure for GPS",[83] it is also far from clear to us how the involvement of non-European Union countries in funding the Galileo programme will affect the control of Galileo.

Conclusion

50. The November Explanatory Memorandum indicates that the United Kingdom has agreed to drop its initial opposition to the PRS "since to maintain a hard line against it would be likely to seriously prejudice the viability of the PPP".[84] We are not sure that this is wise. Although private sector funding would be welcome, the case for each of the Galileo services must be made on its own merits. The one clear benefit of the PRS is that it will produce income for the private sector which is out of proportion to the cost of providing the service. The uses described for the PRS are hazy, the United Kingdom Government has said it does not wish to use it and there is a strong suggestion that at least one country wishes to use it for military purposes.

51. **The Transport Council must examine the potential uses of a Public Regulated Service, and the costs of such a service, very carefully. It will be important to avoid saddling the concession with the costs of providing the PRS if it will not be used. There should be clear agreement about the basis on which it will be funded and charged for. Moreover there should be no "mission creep"; if the Council wishes to proceed with the PRS, it should be clear that there is enough demand for the civilian applications of PRS to sustain the service, and that access to the signal is properly controlled. We strongly support the Government's determination to keep Galileo as a civil programme, and urge it to be ready to withhold its consent if any country seeks to allow military applications of the PRS.**

3 United Kingdom use of Galileo services

52. One of the United Kingdom's aims is "to facilitate the development of applications using Galileo in transport", and the Government memorandum gave examples of sectors which might benefit from the improved reliability and accuracy of the signals from the services provided by Galileo:

81 Explanatory Memorandum On European Community Document, Communication from the Commission to the European Parliament and the Council: Moving to the deployment and commercial operating phases of the European satellite radionavigation programme,COM (2004) 636 final. Submitted by the Department for Transport 1 November 2004, para 18

82 Qq 239-241

83 GG 15A

84 Q 18

> "civil aviation navigation,
>
> motorists – initially for navigation but with longer term potential for such uses as pay-as-you-drive road charging and insurance or for intelligent speed adaptation,
>
> railways – including signalling and rolling stock management,
>
> freight logistics operators for fleet monitoring and security,
>
> leisure users for navigation and location-based services."[85]

This list could easily be extended; better satellite navigation services could help in offender tracking and tagging, tracking farm animals, monitoring fishing vessel location, environment monitoring (signals can determine atmospheric profiles), surveillance, monitoring water levels in areas prone to flooding, emergency vehicle fleet management, enhancing the performance of existing search and rescue satellite service and pure scientific research.[86]

53. Given this range of uses, we were surprised that the Minister did not appear to have a very well-developed idea of the use that the public sector might make of its improved navigation signals and that the Government Memorandum stated definitively that "No specific UK need [for the PRS] has … been identified at the present time."[87] We pressed the Minister about whether access to the PRS might be needed for road user charging; in his view: "We are fairly certain that the applications that we want can be carried out with GPS and Galileo working together on the open access system. We are confident that they will carry out what we need. The reason is that we do not need the high level of encyrption, whereas you would on a more secure service."[88]

54. Much of the evidence received earlier in our hearing had explored Galileo's vulnerability to jamming. Although we were told that ground-based receivers were harder to jam, it is clear that it is not particularly difficult to jam open access signals. The Minister told us:

> "if you were operating a jamming system, you could actually jam things like radio signals to people's radios and televisions. Currently, you would be spotted fairly quickly doing it if you were jamming the signal, because you would jamming it for lots of other people as well and the law enforcement agencies would have a role in preventing that."[89]

The CAA noted that "it is conceivable that, in the future, a vehicle driver who has a satellite system fitted to monitor his progress for the payment of road tolls could use a small jamming device to interfere with the signal."[90] We have not taken specific evidence on the ease with which such extremely localised jamming could take place, but if there was an

85 GG 15

86 See for examples GG 09, GG 11, GG 13, GG 17, GG 19, GG20

87 GG 15

88 Q 252

89 Q 257

90 GG 06

incentive to provide it, the market might well oblige. Road user charging systems based on an un-encrypted signal could provide precisely such an incentive.

55. We were also surprised that "The focus around the PRS, certainly from other Member States who are expressing an interest in its use, has been around law enforcement, border protection services and we certainly have established from Home Office colleagues that there is not the need or desire to move in that direction in the UK for those purposes."[91] If Galileo technology is to be used as part of evidence to be given in court it seems to us at least likely that the courts will demand that the most reliable and best documented signal is used.

56. Professor Raper told us that if we were to take advantage of new technology it was important to start thinking about it now, before investment was made in alternative, less satisfactory, systems.[92] **We believe the Government needs to do more to explore the kinds of services it will wish to use the Galileo system for, and to define the signals it will wish to use. We do not believe that central government has addressed these questions as thoroughly as it should have done. Not only does it need to think about its own requirements in more detail, it also needs to help local authorities to consider their potential use of the system.**

Conclusions and recommendations

57. There are important questions to be answered before the Transport Council can commit itself to the Galileo programme. The United Kingdom Government should ensure they are addressed. We need to know:

- What the true cost of the programme is likely to be, and how long it will be before the system is operational;
- Whether Galileo is affordable, and who will really pay for it;
- What benefits Galileo will bring which cannot be achieved by other, cheaper, systems;
- How military use of Galileo will be prevented;
- What role non-European Union countries will have in Galileo's eventual use and
- How the United Kingdom Government and its agencies plan to use the system.

Our detailed conclusions are as follows:

1. We understand the motives which led to the development of the Galileo programme. We can see the potential advantages, both for the international community, and for the United Kingdom. However, we are approaching the point at which participants are being asked to make an irrevocable commitment to the programme. The costs incurred so far have fallen on the European Union and the European Space Agency

91 Q 254

92 Q 40

rather than individuals and private sector organisations. It is now imperative for the United Kingdom Government and Transport Council to take this opportunity to consider whether the benefits of the Galileo system are commensurate with its likely costs, or whether similar benefits would be attainable with a less ambitious programme. We are not convinced that the costs and benefits have been properly assessed. The Government should not go ahead with the programme until a further, independent, cost benefit analysis has been undertaken. (Paragraph 24)

2. The timetable for the implementation of the Galileo programme must be realistic. It is all too easy to set impossible aspirations, and then to attempt to ensure that decisions are made to meet those aspirations. Inevitably, there is a danger that decision-makers in this situation will not have access to the information they need, and will not have time to consider the information they do have properly. The December Transport Council must ensure that it is not bounced into making premature decisions for fear that the Galileo project will be delayed. Member States must seek hard information on what timescales are achievable, when real benefits could be expected, and when decisions really need to be taken. They should not hesitate to call for delay in decision-making if they do not have the information they need. (Paragraph 27)

3. The treatment of intellectual property may turn out to be extremely important. We recognise its role as a source of income to the concessionaire. But there should be no permanent transfer of intellectual property rights (IPR) away from publicly funded projects to the private sector. It will be in the concessionaire's interest to ensure that the cost of IPR are not set so high as to stifle the market; nonetheless, companies have been known to misjudge their pricing. There must be arrangements to allow the Supervisory Authority to intervene if IPR are being controlled in ways which inhibit Galileo's development. (Paragraph 38)

4. We entirely support the Government's contention that it will not be possible to take a final view of the Galileo programme until the final offer from the prospective concessionaire is available, and has been properly analysed. While, like the Minister, we have no desire to see the Galileo PPP end as "an orbiting Railtrack", we also believe it would be imprudent for the Transport Council to make an "irrevocable commitment" to the Galileo programme on the assumption that a Public Private Partnership will be entirely successful. We very much hope that the PPP will not fail; if it does, an extremely costly system will need either to be maintained by the public sector, or to be abandoned. The Transport Council should not proceed unless it is confident that, if the PPP failed, it would be content either to fund Galileo directly, or to write off the considerable costs in its development. (Paragraph 40)

5. The Transport Council must examine the potential uses of a Public Regulated Service, and the costs of such a service, very carefully. It will be important to avoid saddling the concession with the costs of providing the PRS if it will not be used. There should be clear agreement about the basis on which it will be funded and charged for. Moreover there should be no "mission creep"; if the Council wishes to proceed with the PRS, it should be clear that there is enough demand for the civilian applications of PRS to sustain the service, and that access to the signal is properly controlled. We strongly support the Government's determination to keep Galileo as

a civil programme, and urge it to be ready to withhold its consent if any country seeks to allow military applications of the PRS. (Paragraph 51)

6. We believe the Government needs to do more to explore the kinds of services it will wish to use the Galileo system for, and to define the signals it will wish to use. We do not believe that central government has addressed these questions as thoroughly as it should have done. Not only does it need to think about its own requirements in more detail, it also needs to help local authorities to consider their potential use of the system. (Paragraph 56)

Formal Minutes

The following Declarations of Interest were made:

Mrs Gwyneth Dunwoody, Member, Associated Society of Locomotive Engineers and Firemen

Mr Brian H Donohoe, Clive Efford, and Mrs Louise Ellman, Members of Transport and General Workers' Union

Mr Ian Lucas, Member of MSF Amicus

Miss Anne McIntosh, Holder of shares in: BAA plc, BA and BAE SYSTEMS

Mr Graham Stringer, Member of MSF Amicus and a Director of the Centre for Local Economic Strategies

Wednesday 17 November 2004

Members present:
Mrs Gwyneth Dunwoody , in the Chair

Mr Jeffrey M Donaldson	Mr Ian Lucas
Mr Brian H Donohoe	Miss Anne McIntosh
Clive Efford	Mr Graham Stringer
Mrs Louise Ellman	

The Committee deliberated.

Draft Report *(Galileo)*, proposed by the Chairman, brought up and read.

Ordered, That the draft Report be read a second time, paragraph by paragraph.

Paragraphs 1 to 57 read and agreed to.

Resolved, That the Report be the Eighteenth Report of the Committee to the House.

Ordered, That the Chairman do make the Report to the House.

Ordered. That the provisions of Standing Order No. 134 (Select committees (reports)) be applied to the Report.

Ordered, That the Appendices to the Minutes of Evidence taken before the Committee be reported to the House.

[Adjourned till Wednesday 1 December at 2.30pm.

Witnesses

Wednesday 27 October 2004

List of written evidence

Reports from the Transport Committee since 2002

Session 2003–04

First Report	Traffic Management Bill	HC 144
Second Report	The Departmental Annual Report	HC 249
Third Report	The Regulation of Licensed Taxis and Private Hire Vehicle Services in the UK	HC 215-I
Fourth Report	Transport Committee Annual Report 2002-03	HC 317
Fifth Report	The Office of Fair Trading's Response to the Third Report of the Committee: The Regulation of Licensed Taxis and Private Hire Vehicle Services in the UK	HC 418
Sixth Report	Disabled People's Access to Transport	HC 439
Seventh Report	The Future of the Railway	HC 145-I
Eighth Report	School Transport	HC 318-I
Ninth Report	Navigational Hazards and the Energy Bill	HC 555
Tenth Report	The Work of the Vehicle Operating Services Agency and The Vehicle Certification Agency	HC 250
Eleventh Report	National Rail Enquiry Service	HC 580
Twelfth Report	British Transport Police	HC 488
Thirteenth Report	The Rail Regulator's Last Consultations	HC 805
Fourteenth Report	The Work of the Maritime and Coastguard Agency	HC 500
Fifteenth Report	Financial Protection for Air Travellers	HC 806-I
Sixteenth Report	Traffic Law and its Enforcement	HC 105-I
Seventeenth Report	Cars of the Future	HC 319-I

Session 2002–03

First Report	Urban Charging Schemes	HC 390-I
Second Report	Transport Committee: Annual Report 2002	HC 410
Third Report	Jam Tomorrow?: The Multi Modal Study Investment Plans	HC 38-I
Fourth Report	Railways in the North of England	HC 782-I
Fifth Report	Local Roads and Pathways	HC 407-I
Sixth Report	Aviation	HC 454-I
Seventh Report	Overcrowding on Public Transport	HC 201-I
Eighth Report	The Work of the Highways Agency	HC 453
Ninth Report	Ports	HC 783-I
First Special Report	Government and Office of Fair Trading Responses to the Seventeenth Report of the Transport, Local Government and the Regions Committee, The Bus Industry	HC 97
Second Special Report	Government Response to the Committee's Fourth Report, Railways in the North of England	HC 1212

Session 2001-02

First Special Report	The Attendance of a Minister from HM Treasury before the Transport, Local Government and The Regions Committee	HC 771
Second Special Report	Government Response to the to the Fifth Report of the Transport, Local Government and the Regions Committee, Session 2001-02, European Transport White Paper	HC 1285
Third Special Report	Government Response to the Eighteenth Report of the Transport, Local Government and the Regions Committee, Session 2001-02, National Air Traffic Services Finances	HC 1305

Oral evidence

Taken before the Transport Committee

on Wednesday 27 October 2004

Members present:

Mrs Gwyneth Dunwoody, in the Chair

Mr Brian H Donohoe	Ian Lucas
Clive Efford	Mr John Randall
Mrs Louise Ellman	Mr Graham Stringer

Witnesses: **Mr Peter Blair OBE**, on behalf of Royal Academy of Engineering, **Professor Paul Cross**, Professor of Geomatic Engineering, University College London, **Professor Jonathan Raper**, Professor of Geographic Information Science, City University and **Professor Sir Martin Sweeting**, Director, Surrey Space Centre, examined.

Q1 Chairman: Good afternoon, gentlemen. You are most warmly welcome this afternoon. May I begin by saying that we are very grateful to you for coming because we think this is a very important subject? May I ask you to identify yourselves?
Mr Blair: I am Peter Blair; I am a retired professional engineer. I spent the last 15 years of my working life with Racal Electronics. I retired as the technical director of the defence systems company. I spent most of my time in research and development and a lot of that time has involved work on GPS and navigation systems.
Professor Cross: I am Paul Cross; I am the head of the Department of Geomatic Engineering at University College London. I have about 30 years' experience of teaching and research in the field of satellite navigation.
Professor Raper: I am Jonathan Raper, Professor of Geographic Information Science at City University. I am primarily engaged in research on location-based services.
Professor Sir Martin Sweeting: I am Martin Sweeting. I have two jobs: one is as chief executive of a company called Surrey Satellite Technology Ltd (SSTL), which specialises in the manufacture of small satellites and is building the first of the Galileo test satellites; the second is as director of the Surrey Space Centre.

Q2 Chairman: I am very grateful to you; thank you very much. Am I to assume that none of you wants to make a statement before we start and you are all prepared to go straight to questions? Thank you. May I ask all of you what services Galileo is going to provide that will not exist with the Global Positioning System (GPS) augmented by the European Geostationary Navigation Overlay System (EGNOS)? What will we get from Galileo that we will not get from the other mix?
Professor Cross: I suspect that there are no differences in the services themselves; it is the quality of the service, the reliability and integrity of the service. The key problem with GPS is that although it is a system which has many, many applications, it is not accurate enough for some of them. It does not have integrity built into it, so it is not a guarantee of service and the relatively small number of satellites means that it is not available in many places, especially in the city areas where GPS plus Galileo particularly will lead to something in the region of 60 satellites in the sky and a minimum of something like 14 satellites visible from any point on the earth at any time rather than, at the moment, something like five satellites visible.

Q3 Chairman: Are the services mission critical for the organisations and how many of them?
Professor Raper: Probably the most important one is going to be emergency response applications. Those are the key things which are going to be better with Galileo than with just GPS augmented by EGNOS.

Q4 Chairman: Because of this point that they will be more precise?
Professor Raper: Yes. The equation goes like this. Essentially, the greater the number of satellites, the better the satellite position and the better the position the greater the confidence people will have in the system and there will be more investment in it. In evidence submitted by Pinpoint you will see that on a minimum coverage, in other words the worst situation you could be in outside with a receiver, whereas at the moment you only get a fix 32 per cent of the time, with Galileo that will go up to 90 per cent. I have been carrying a GPS and a recording instrument for a year, recording myself everywhere I go and that pretty much accords with my real position.

Q5 Chairman: Was that instigated by your wife?
Professor Raper: Only on one day did I manage to persuade my wife to take it with her, but I learned a number of useful things during that exercise.

Q6 Chairman: We will not go any further. Are the government and the agencies doing enough to ensure that the public services and British industry are aware of the benefits of the new system?

Professor Sir Martin Sweeting: There has been fairly widespread dissemination of the benefits of the utility of the service. Whether it is fully appreciated and whether the importance of the utility is fully appreciated by the general public I am not at all sure. I am not sure the particular message has got through, if you see Galileo as providing a degree of European independence in terms of something which is absolutely essential to European culture, in terms of supporting our current way of life.

Q7 Chairman: Would you say that was an important selling point for the acceptance of the system? Is that not a rather esoteric appreciation, that we need to be independent of an American GPS?
Professor Sir Martin Sweeting: In terms of selling it to the individual members of the public it is not so critical, but in terms of looking at it as a whole, it is an important factor which should be made clear.

Q8 Mr Donohoe: Can Galileo ever really be truly independent of GPS?
Mr Blair: I do not think it can. We have to remember that it has taken something like 10 to 20 years to get GPS to the level of operation and accuracy and reliability that we have. One of the things which has evolved through that time is the space-borne clocks, the clocks borne on the satellite. We have yet to space-prove a clock which does not come from the GPS programme just for a start. There is a whole lot of infrastructure around the world which has to be set up for Galileo to be as effective as GPS and the position of that infrastructure is going to require GPS of the sort the two professors have been working on.

Q9 Chairman: We are talking about 26 extra satellites are we?
Professor Sir Martin Sweeting: Yes.

Q10 Mr Donohoe: Is there a need for 26 extra satellites?
Mr Blair: I think my two friends here would say "The more the better" and I would endorse that. It really is a fact. If you are putting together a navigation solution, the more components you have to it the better the solution is and the more reliable it is the more robust it is.
Professor Cross: It is quite clear that you continue to gain. There is the issue of continued availability of GPS which cannot be guaranteed for the next 20 or 30 years, the kind of period it would need to instigate and build a new navigation system. It is very important to realise the huge amount of infrastructure within Europe and worldwide which is increasingly being developed on GPS. It is not just for transport, it is also things like timing for computer networks; even weather forecasting is being based on GPS stations being able to measure things like water vapour and so on. It sounds extreme, but there is a huge number of activities of that kind which are developed and which would suffer if GPS became unavailable for whatever reason. Who can predict 20 or 30 years' time?

Q11 Mr Donohoe: Could that not adequately be undertaken by the existing system? Could they not upgrade their existing system? This idea of starting afresh with a new system seems ...
Professor Cross: GPS is being upgraded. It will take longer to upgrade GPS than to launch a new Galileo system. If you look at all the projections through to 2015 or thereabouts, we would expect to get an upgraded GPS which is about equivalent to Galileo then, but it is still a system which is controlled by another nation, the military of another nation.
Mr Blair: I should just like to say that GPS comes out of the Timation programme which started in the 1960s. In 1974 it was first released and so on and so on. The Americans are not about to give up on GPS; they are not. They will continue. New versions of it are planned and it will go on. I reckon it will be a good ten years before Galileo is at the level GPS is today.

Q12 Chairman: Ten or 30? If you require 26 to 28 extra satellites, are you really saying you think that is achievable in a period?
Mr Blair: Perhaps you should ask Sir Martin on the satellites.

Q13 Chairman: Yes, Sir Martin, tell us. Can we do that in ten years?
Professor Sir Martin Sweeting: Ten years would be quite demanding but within 15 years it would certainly be practicable.
Mr Blair: Then you have to bed the system down; this is the thing which takes time. It is all the things which were learned in the bedding down of GPS which I am quite sure have to be relearned by the European team. I am quite sure they are capable of doing it.
Professor Sir Martin Sweeting: May I just point out that we should also not just assume because Europe does not have that capability now that it would not actually be a very good capability to acquire in the future.

Q14 Chairman: We take that point.
Professor Raper: It is important to you and your constituents to know that we are stuck in a half-way house. We just do not have enough satellites now to deliver the services which the hype has begun to suggest is going to be available and the full richness of services which are possible. Somebody has to build more satellites and it is important that we contribute to that.
Mr Donohoe: Can I take you to one aspect of this, the defence implications? There are positives but I would argue more negatives in terms of the defence implications. Almost immediately anything was happening in the world, China or wherever, they would just zap these things, would they not, and an awful lot of investment would go up in smoke?

Q15 Chairman: Could they zap 26 satellites rapidly?
Professor Sir Martin Sweeting: It is pretty difficult.

Q16 Mr Randall: Galileo is a civilian project, but how realistic is it to assume that the countries will not be able to use it for defence, for military purposes?
Mr Blair: You certainly could use the open aspects of Galileo in the same way that you can use the open aspects of GPS, for example for tracking the logistics in armed forces and so on. The closer you get to the sharp end, to weapon delivery, the more protection you need around the system. My reading of what is being published about the Public Regulated Service (PRS) is that there are some indications that it could be developed into a military system with certain degrees of jamming protection. You then have the question of how widely you are going to distribute the material which makes that into that sort of system. If the idea is that it is going to be in every police car and fire engine and so on around the land, then you are not going to be able to protect that technology adequately enough. It really depends on what policy is taken to protect the really secret bits of the PRS; that will determine the extent to which somebody could use it for unpleasant purposes.

Q17 Mr Randall: Mr Donohoe's point about them being jammed. Sir Martin, you said you thought it would be difficult to jam them all.
Professor Sir Martin Sweeting: No, I was talking about it being difficult to destroy them all. The word "zap" was used.
Mr Blair: You do not have to jam the satellite. The bad thing about satellite navigation is that the signal originates a long way away and is very weak on the surface of the earth. Therefore you do not need very much power in order to jam it. It is quite difficult to jam land-based users, for example people driving around in tanks and so on because you have to get the jamming energy spread over a wide area. It is relatively easy—relatively easy—to jam airborne applications.

Q18 Mr Randall: So you do not agree with the argument that one of the reasons Europe has to have its own system is that we do not want to be beholden to the States.
Mr Blair: No, not at all. It is public knowledge that we have GPS built into many aspects of our armed forces. We are going to buy the joint strike fighter (JSF) and all of these things will have GPS built into them. I do not think there is any question at the moment—Martin might correct me on this—of a military application for Galileo. I think it is envisaged purely as civilian.
Professor Sir Martin Sweeting: It is certainly envisaged in that way.

Q19 Chairman: But it could be used. This is the point which concerns the Committee: there is nothing which says it could not be developed for such use.
Professor Cross: You could not stop anybody using GPS or Galileo for whatever purpose they wanted to use it, with the services it can deliver, other than by yourself jamming it in that particular area.
Professor Raper: I just want to point out that during the first Gulf War the Americans had to go out and buy civilian receivers because at that time they did not have enough. It is perfectly possible for any nation in the world to go out and buy those and certainly in the initial stages of a conflict, or in the build-up before a conflict, it would be hard to justify regional jamming or selective availability being brought in.

Q20 Mr Randall: How realistic do you think the current cost estimates are?
Professor Cross: They are a small fraction of the cost of GPS, but I cannot answer that question.
Mr Blair: I just saw something in the press about the man running the test programme who says that unless he gets some more money he will not make 2010.
Chairman: That may not necessarily relate to the actual cost, but I am prepared to believe it.

Q21 Clive Efford: Going back to military use, what systems are available to the UK for military use? Does it not stand to reason that they would want to use this system if it were the available state-of-the-art technology?
Professor Cross: GPS is probably so strongly inbuilt into many of the military activities in this country—I am not an expert but I guess it is the case—and within NATO as well, that I think it would take some time to bring in another technology even though there is compatibility with that technology.

Q22 Clive Efford: Technology is changing all the time.
Mr Blair: It is a complicated issue but Professor Cross answered correctly when he said that an enormous amount of technology is already built in. I think that the advantage of having the extra satellites will be mopped up in the GPS receiver. It will not be very difficult to build that in. Basically they will get the advantage without having to make a major change to the system. You also have to think that the control of GPS is in the hands of the US Navy. Whatever view you might take of that, you would reckon that was a bit stronger than a collection of nations. That is an important point.
Professor Sir Martin Sweeting: Notwithstanding the fact that it will take time to introduce a new technology such as this formally to the armed forces, we have seen many instances during a conflict where modern technologies have been introduced very, very rapidly and at short notice when there is a clear advantage.

Q23 Chairman: Not always terribly efficiently, but we accept the point.
Mr Blair: It will be an add-on rather than a supplement.

Q24 Clive Efford: What have been the benefits to UK industry as a result of being involved in the Galileo project?
Professor Sir Martin Sweeting: I can talk from a personal point of view in one sense and that is that the first of the Galileo space-craft is being designed and built in the UK, so that has brought a certain amount of activity into UK industry and from that will spin out a degree of knowledge. I can comment just from that point of view, but my colleagues may have others.
Professor Cross: A substantial amount of money has come through various European framework programmes to fund research in universities and also within industry to fund studies of applications of Galileo and also some of the technical aspects of Galileo as well.
Professor Raper: The civilian applications are going to be location-based services primarily, transport, assistance for the disabled and for other people. We are going to have a head start in that area. We are going to be able to export that know-how. Quite a lot of small start-up companies are active in that area and some of those may grow to a considerable size. The Japanese are a little bit ahead of us in terms of delivering these services, but they are growing absolutely stellar quantities at the moment.
Professor Cross: There are several calls out and being evaluated at the moment for small- and medium-sized enterprises in particular and for large companies for Galileo applications and developments.

Q25 Clive Efford: We are told that UK companies have been very successful in winning contracts, around 30 per cent of the contracts, whilst providing 17 per cent of the funding. What has been the driving force behind that? Is that the quality of our research or is that the strength of our industry?
Professor Cross: We were relatively early adopters in the GPS field in the UK and that has given people a head start I would guess.
Mr Blair: Are you talking specifically about navigation funding or space funding in total in your question?

Q26 Clive Efford: According to the information I have received we have been successful in contracts from the European Space Agency (ESA).
Mr Blair: That would include communications work as well as navigation.

Q27 Clive Efford: I am asking the questions so you can assume my knowledge of this is as detailed as yours.
Mr Blair: I am sorry, it was for clarification. I have been out of industry for four years. Certainly I would say that four years ago I felt the boot was on the other foot. I did not think we were getting the amount. That has probably changed. Martin's contract alone—

Q28 Clive Efford: Let me repeat the question. What would you put it down to? Given your detailed knowledge of the industry, would you say that it is down to our research or the strength of industry or both.
Mr Blair: It is two things. If I might pay a quick compliment to Martin, his company and the work coming out of Surrey University has been very significant. Also the fact that the UK was the first nation to work with the US on GPS and therefore had a lot of satellite navigation technology was a big help as well.
Professor Raper: It is also our excellent infrastructure. If you have a screen like this with a dot in the middle of it moving around in a random manner, that is not very interesting. If it is sitting on top of a map, or other appropriate information you want to look at, that helps. Because we have an excellent infrastructure in terms of maps and other digital information, that is helping us develop a lot of the services and that is being supported in various ways.

Q29 Clive Efford: Could we have got the benefits we have seen in terms of jobs etcetera just by investing in GPS and upgrading GPS rather than going for the Galileo system?
Professor Raper: It is difficult to invest in the GPS system *per se* because clearly it is an American system, paid for by their taxpayer and they only allow American industrial participation in the hardware side of it.

Q30 Clive Efford: Is that not even cheaper?
Professor Raper: No, because there is a strategic consideration. What happens if they change the rules at some point in order to exclude us?

Q31 Chairman: The use of the word "strategic" always flings up the worry that we are not talking necessarily about a civilian application but about a defence application.
Professor Raper: Think of some half-way house, like National Air Traffic Services (NATS) providing air traffic control. What happens if the Americans change the rules on us at a certain point? It would give us enormous difficulty and that is strategic in that sense.
Professor Cross: One of the things which will happen with the so-called modernised GPS over the coming years is an ability of the US to separate a military and a civilian activity. It will be technically possible to deny GPS to civilian users at the same time as allowing access to NATO and friendly nations. That could well be an issue for activities of British industry either within the UK or in other parts of the world in which they operate.

Q32 Ian Lucas: The Galileo concessionaire will have the intellectual property rights arising from the programme. Do you think that is justifiable?

Professor Raper: It depends which type of intellectual property you are talking about. There is a lot of intellectual property here. It is a public-private partnership (PPP) and therefore it is right that as they are risking funds they should have some share in that. There is intellectual property in the equipment and all the way down the chain. If the public sector has a right of access to and a right of negotiation on some of the key elements which the users need, for example the nature of the positional message which comes in, then it is acceptable.
Professor Cross: The important thing is probably the intellectual property on the development applications. As far as I understand, that will rest with those who develop the applications not with the joint undertaking.

Q33 Ian Lucas: Is it reasonable to expect Galileo to be operational by 2008?
Professor Cross: No is probably the answer.
Mr Blair: May I add a quick word on the previous question? Within Racal, and it still exists now in Thales, is a very successful company which supplied differential GPS services. You are probably aware of what they are. The know-how in that was certainly used in doing the initial studies and, for example, working out the algorithms which were used in EGNOS. If EGNOS is part of Galileo and will become part of the concessionaire then there could be some questions as to whether it was reasonable for the concessionaire to collect all the intellectual property rights (IPR). IPR which originated specifically for the Galileo programme, yes there will be a case. You will find that there is quite a bit of IPR which has come in from other programmes in order to do that original work.

Q34 Ian Lucas: Does the fact that this is a public-private partnership make the allocation of ownership of the know-how particularly difficult to work through?
Mr Blair: In my experience it has always been difficult to assign it and reach agreement on this with ESA and the European Union generally.

Q35 Ian Lucas: The scale of this project must make it particularly important.
Mr Blair: Probably.
Professor Raper: A small point to be aware of as far the timetable is concerned: we must take up the slots allocated to us and the satellite must be launched by February 2006 to take up the frequencies allocated to us by ATU.

Q36 Ian Lucas: One satellite?
Professor Raper: One satellite. That means a lot of things have to happen very quickly now. The question mark with the timetable comes after that, when there are fewer major constraints on the timetable.

Q37 Ian Lucas: Professor Cross was very firm in saying that 2008 date is—
Professor Cross: It is simply hard to imagine—I am sure Professor Sweeting has a better take on that as he builds satellites—how one could build that number of satellites and get the system fully operational within what will effectively be a two-and-a-half to three-year period by the time anything starts.
Professor Sir Martin Sweeting: It is completely impossible to get the complete system operational by 2008, that is absolutely clear. It is really a three-phase system. The first phase is next year, a test satellite which utilises the frequencies and reserves the frequency slots essentially. Then there is all the verification phase where a small number of spacecraft will be put into orbit so that a pilot service can be demonstrated. The full service will clearly not be able to occur well before 2010.

Q38 Mrs Ellman: Would you say that the government is doing enough to support research into the downstream applications?
Professor Raper: There are quite a few things they could do and should do. For example, the mapping of the country—and you will hear from the Ordnance Survey later—is not strictly speaking compatible with Global Navigational Satellite Systems (GNSS). It was mostly created in the nineteenth century and is based upon frameworks which require adjustment to GNNS, Galileo or GPS signals, all the systems taken together. Essentially the point is that somebody has to decide whether we are going to live with maps based on another framework and convert in real time or are going to invest. The Republic of Ireland has decided to re-engineer all its maps to the new framework; some countries have decided to do that. Other things are going on at the moment and money is being spent, for example, by transport authorities. You can see the Countdown service on buses and that is based on beacons mounted on lamp posts. That technology could be replaced by expenditure on this. Then there is also a need probably to do things like support public understanding of things like geography, invest in specialist schools and ensure geography does not disappear from the national curriculum too early to make sure we have the skills to operate the system and the applications.
Professor Cross: Another specific example of that with the transport field is on the railways. There are many, many applications of satellite positioning on railways, right down from safety critical applications like signalling and so on. In principle, if you knew where every train was and you had good communications you would not actually need any signals. It would be rather like aircraft and you could control a train in one particular position. In order to do that we need to have very accurate models of the whole railway system, which do not actually exist at the moment. I am sure you do not need me to tell you about it. Most of the information required for that is sitting on shelves in

different parts of different railway companies and nobody is taking the initiative to say "Let's build a proper system".

Q39 Chairman: "Initiative" is not a word very widely associated with the present railway system.
Professor Cross: It needs a top-down initiative to collect together all the information on the railways, every job, all the railway lines and so on.

Q40 Clive Efford: If we are going to introduce this technology into our transport system, when do we start thinking about that? When do we start investing in the beacons on the lamp posts and bus stops?
Professor Raper: That is what we want to get rid of or if they are invested in now they need to be replaced. We need to start thinking about that now because there are lots of other companies with investment decisions yet to make and they can schedule this instead of these beacons.
Mr Blair: You can do it now because you can do that with GPS. You have to remember what was said at the beginning, that it is effectively an improvement on GPS. I know that many of the applications which have been mentioned have been basically researched; basic demonstrations on the railways have already been done with GPS. It is there, it works, it is reliable and has been there for a long, long time. You do not have to wait. You can start with GPS; you can add the signals from the Galileo satellite into it to improve the solution. You could use the same infrastructure with different applications as more satellites are launched.

Q41 Mrs Ellman: What would the market be for Galileo products and why would people use that when they can get services free? Why would they use other than the basic services?
Professor Raper: They are going to be able to get services from Galileo for free. The Open Service (OS) is going to be free as well. Public money is going to recycle through the system and into things like providing emergency services.

Q42 Chairman: I think Mrs Ellman's question is why, if they are going to get certain services free, would they pay for the extra services?
Professor Raper: Because they are not good enough. At the moment GPS is not good enough to deliver all of the priced services; that is the simple reason. We need to double the number of satellites.

Q43 Mrs Ellman: You say that Galileo will deliver more services than are available now.
Professor Raper: Yes, because we will double the number of satellites.
Professor Cross: Are you asking about the Public Regulated Service? Are you asking particularly about the commercial part, those two parts?

Q44 Mrs Ellman: Yes.
Professor Cross: Who will pay and why they should pay is a very good question. I do not think anybody really knows what those services will provide. I imagine discussions are taking place now in terms of assigning the concessions for Galileo and those concessionaires will have made some proposals as to what might be used. I would imagine it is areas where absolute reliability and security of that service needed to be guaranteed. Emergency services might be an example. I suspect that a lot of those examples might also fall within the realms of government rather than necessarily within the realms of the private individual.

Q45 Chairman: Yes, but if I were a government service needing to use for emergency services something which would guarantee that degree of integrity, how would I be guaranteed that? What would be my absolute guarantee that I would pay the extra and get this level of service? Why should I believe that it was that much better than the existing system?
Professor Cross: Because you might well want to be able to be even more sure that you were delivering your ambulance to the right house at the particular time and not on a parallel street, that you were taking an ambulance along a motorway, the M1 and not the A5.

Q46 Chairman: Are you really saying that the extra services could guarantee that level of extra service?
Professor Raper: The other point is that there are integrity checks built into Galileo which are not there in GPS; also in things like the Safety of Life Service (SoL) where you will be able to get feedback from the system.

Q47 Chairman: There might easily be, if GPS were being promoted and improved. Presumably what you are saying is that it is not static.
Mr Blair: That is right, it is not static. I am afraid that I have the same difficulty that Mrs Ellman does in seeing enough money coming in from a Commercial Service (CS) and a PRS when you have a pretty good service available to you free and it is going to be augmented with the Galileo satellite. I personally am not clear why we need the PRS and why we need the Commercial Service.
Professor Cross: I want to say that as well, but I was trying to think of an example.
Chairman: It is all helpful. Do not worry if we ask you awkward questions: that is what we are here for.

Q48 Mr Stringer: How easy is it for non-governmental bodies to block these signals?
Mr Blair: Very easy; yes, very easy. A gentleman I know in the MoD did an experiment to block GPS signals at both Heathrow and Gatwick from the Hog's Back.

Q49 Mr Stringer: That was very helpful of him.
Mr Blair: No, no, it was a highly controlled trial. It is perfectly possible.

Professor Cross: You can buy instruments called GPS-jammers over the web; a very small instrument. How far it will travel will depend a lot on the topography, but certainly many tens of kilometres with a few watts of power.

Q50 Chairman: Do we assume that would be the same if we got our 28 satellites?

Professor Cross: Modernised GPS and Galileo will be more resistant to jamming than the current system because of the nature of the signal.

Q51 Chairman: More resistant.

Professor Cross: Yes. You will need higher power.

Q52 Chairman: You could do it but you might have to spend more on the weapons.

Professor Cross: More or less and you might be found out more quickly because if you jam you have to emit a signal and therefore you are displaying where you are.

Q53 Chairman: We would know what was happening to the gentleman on the Hog's Back.

Professor Cross: Yes, that is right.

Mr Blair: We must remember when we are talking about this that we are talking about the civilian signal. The military signal is far, far more difficult.

Chairman: Gentlemen, you have been extremely interesting and we shall not only consider carefully what you have said but we shall value it as a background. It was very, very helpful. Seldom have I found four so well-informed gentlemen with such control over their verbosity. Thank you so much.

Witnesses: **Dr Rob Witty,** Chief Technology and Programmes Officer and **Mr Paul Thomas**, Group General Manager Development, Technology and Programmes, National Air Traffic Services Ltd (NATS), **Captain Duncan Glass**, Chairman, General Lighthouse Authorities Radio Navigation Committee and **Dr Nick Ward**, Research Director, Research and Development Department, General Lighthouse Authorities of the UK and Ireland (GLA), **Air Commodore Norman Bonnor**, President and **Mr Colin Beatty**, Chairman, Technical Committee, Royal Institute of Navigation, examined.

Q54 Chairman: Good afternoon to you gentlemen. Can we get the identifications and routine bits done first?

Dr Witty: Dr Rob Witty, Chief Technology and Programmes Officer, National Air Traffic Services. I am the senior engineer in NATS. I joined NATS a couple of years ago. My personal expertise is in safety critical software engineering; I am not an expert in satellite navigation.

Mr Thomas: Good afternoon. Paul Thomas. I am the Group General Manager for Development in National Air Traffic Services. In that capacity I both run the development programmes for the replacement services and the asset management of the existing services.

Captain Glass: Good afternoon. I am Duncan Glass, Director of Navigational Requirements for Trinity House Lighthouse Service and I chair the General Lighthouse Authorities' Radio Navigation Committee and the provision of marine aids to navigation of all sorts.

Dr Ward: I am Nick Ward. I am the Research Director for General Lighthouse Authorities involved in the international standardisation of maritime and radio navigation systems.

Air Commodore Bonnor: Norman Bonnor. I am President of the Royal Institute of Navigation from 30 years in the Royal Air Force and over the last ten years instructing a post-graduate course in navigation technology at the University of Nottingham.

Mr Beatty: I am Colin Beatty. I am the Chairman of the Technical Committee of the Royal Institute of Navigation. I have had 30 years in satellite navigation and I run my own company supplying equipment into this area.

Q55 Chairman: We have a good cross-section there one way and another. We cover marine lights and all the rest of it. Did you want to make statements before we go to questions, or are we going to be able to go straight to questions? May I set off with the first question? What are the navigational advantages of Galileo?

Mr Thomas: For us the augmentation of the GPS signal through EGNOS provides us with the basic capability that we are looking for from satellite navigation. What Galileo does is give us a second layer capability. Should, for any reason, the GPS system fail, we have something there which allows us to continue with our plans and our maintain our service delivery.

Q56 Chairman: Are you assuming it would have a greater sensitivity, an augmentation of the existing GPS?

Mr Thomas: No, the performance for us is met by EGNOS plus GPS and Galileo delivers us the same capability for the service that we are required to deliver.

Q57 Chairman: Mr Glass or Dr Ward, on marine navigation.

Captain Glass: From the point of view of the maritime user who has embraced GPS thoroughly since its introduction, there is not much that Galileo can offer that he has not already got. The availability of GPS, the accuracy and to a degree the integrity which we have enjoyed thus far have changed marine navigation substantially from sextants and barium compasses.

Q58 Chairman: We are still teaching people how to use sextants, are we not?
Captain Glass: We are trying, but it is not easy.

Q59 Chairman: You will forgive me, but I am of the age when I think machines do occasionally crash.
Captain Glass: On the technical aspects, I would ask Dr Ward to help me out.
Dr Ward: The main argument is to have a second system because a lot of systems on board ships are totally dependent on GPS, eg, identification systems, electronic charting systems, and if you lose the main input then you lose the whole system. The increasing dependency is the reason for the great concern and the wish to have another system.

Q60 Chairman: Seriously for a moment, is that a matter of training or is it just that people now are automatically taught to be very reliant upon GPS and the old habits have gone?
Captain Glass: Yes, I believe so. From the time I was fortunate enough to drive ships to now it is unrecognisable. The integrated bridge system on a modern ship is something to behold and it GPS usually relied upon, for both positional and timing input.

Q61 Chairman: Could neither of you see an automatic advantage to Galileo which is not found in GPS?
Dr Ward: There is an advantage in the sense that you have more satellites and more redundancy. It is worth making the point that GPS does go wrong. It is a wonderful system, but there are incidents from time to time when one of the satellites goes wrong and misleads the user and there are situations when there are not enough satellites to give a good position. This would be covered by a second system.

Q62 Chairman: That is a question really governed by numbers rather than any material or fundamental advantage.
Dr Ward: Largely, yes; plus some other minor things.
Air Commodore Bonnor: From the point of view of all the users we represent, from people who track animals in the desert to the aviation, marine and land users and increasingly location-based services, fairly soon if it does not have a GPS chip in it every mobile phone will at least have a Galileo chip in and that is an increasing demand on GNSS. My main concern is lack of satellites. The Americans would not accept, as I believe was the first approach by the EU, to have European investment in the system to put another 20-odd satellites in the air. They refused even to discuss it. That is what drove us along the route of having a European system.
Mr Beatty: I should like to add the fact that the majority of the users of this system are going to be on land and a lot of these users will be in the urban environment, in cities, and in areas where they are under trees. The current GPS is very good in some of these areas, but it fails when you get into the high-rise areas like the centre of London and places like that. It does not work very well under trees, whereas the signals we are expecting to get from Galileo are supposed to be much better in those environments. To continue what Mr Bonnor said, the more satellites we have in those sorts of environments the better and if we can augment GPS with Galileo this has to be a great benefit to us.
Chairman: How accurate and reliable do you expect the Open Service to be?
The Committee suspended from 3.31pm to 3.41pm for a division in the House

Q63 Mrs Ellman: What is the expected usage of Galileo among the maritime community?
Captain Glass: Hard to say, as we outlined in our memorandum; we find it quite difficult to see how the mariner will pop out and buy the Galileo receiver when he has already been using the GPS one for some years with great success. They do not get lost as much as they used to and it has taken them into new areas of sailing and power-boating and other activities which they never enjoyed so much. However, we as service providers and regulators will need to encourage, where we can, the adoption of integrated receivers for the very reasons which were made so clear by the academic panel, that with so many satellites up there there is a more robust, accurate and available system than with just GPS. The more the merrier as far as we are concerned. I am not sure how we convince our users that they need to go to buy another piece of kit.

Q64 Mrs Ellman: Will the users have to upgrade their systems to be able to use Galileo?
Captain Glass: Yes, the existing GPS receivers on board ships will not be able to receive the Galileo signal.

Q65 Mrs Ellman: Will there be a big cost to doing that?
Dr Ward: It should be a less serious cost as time moves on because the manufacturers will see an advantage in providing a dual receiver which will operate with both systems. This will be a sales feature. It will increasingly become easy to buy a receiver which will work with both systems and have those advantages.
Air Commodore Bonnor: All the time the price comes down, people tend to rotate their receivers not quite as frequently as mobile phones, but very nearly, particularly in the leisure market and I speak for the leisure market because I assume that the GLA would not speak so strongly for them. We have a lot of leisure users who really enjoy any gimmick. They

will buy Galileo, so as soon as it comes on the market I am sure there will be a big demand for Galileo receivers amongst leisure users.

Q66 Chairman: Surely not a gimmick.
Air Commodore Bonnor: Anything new.

Q67 Chairman: A new facility.
Mr Beatty: The precedent was already set a long time ago for receivers capable of receiving two different types of systems. Since 1994 we have had systems capable of tracking GPS and the Russian Global Navigation Satellite System (GLONASS). The step to go on to add Galileo to that type of receiver, not the existing hardware, but to that sort of design, is not very great.

Q68 Mrs Ellman: So that is not a big problem.
Mr Beatty: It is not a big problem technically; it is obviously a change of the existing hardware. From the technical standpoint, it is not a big task to bring Galileo into a combined receiver, in other words to build a new receiver which would combine those two.

Q69 Chairman: Some of the yachting community are not violently delighted at being forced to use some of the new facilities in GPS now, are they?
Captain Glass: There is a good cross-section of what is available and what they like to use.

Q70 Chairman: That is a very tactful answer, but it is not an answer.
Captain Glass: We are encouraging the regulators and service providers hopefully to arrive at a point in time where all users of all classes do have electronic means of finding their position.

Q71 Chairman: Irrespective of the economics of it.
Captain Glass: From our perspective the economics are driven by the need to continue to provide fixed and floating aids to navigation and radar aids to navigation because we know that not all users are able to fix their position by GPS or any other system.

Q72 Mrs Ellman: What proportion of users is likely to pay for a commercial service?
Captain Glass: I do not know.
Dr Witty: The aviation community would be prepared to pay a reasonable charge. What it would be very nervous about would be, given that it is a highly regulated industry with a European charging mechanism already, about being put into a position where it was asked to pay for and compensate for those areas of users who would not be able to pay or not be able to have charges levied upon them very easily; some of the leisure community, for example. A fair and equitable charge would be reasonable for aviation. If I could speak unofficially on behalf of the airlines, I think they would be very nervous about being asked to overpay for what they receive from Galileo.

Q73 Mrs Ellman: As far as the maritime users are concerned, do you have any assessment?
Captain Glass: It is the same response as I made earlier in that they already have what they want and they enjoy the benefits of having had GPS for a long time. How are we going to charge them for using a similar system alongside, even though it brings the benefits of more satellites and better integrity? For the leisure user particularly, fishermen and commercial shipping that is not a major plus in any way.

Q74 Mr Donohoe: May I turn to NATS in particular? The government has invested something in the order of €95 million or is intent on that and you have backed it up with a further €20 million which works out at something like £14 million. How are you going to get that money back?
Mr Thomas: May I split the investment part? The National Air Traffic Services' investment was in EGNOS. Our investment there was twofold. Firstly, having recognised that GPS provided us with a capability, we also needed to augment it—I am using the technical phrase for augmentation there—to ensure that if we used it for aviation purposes the loss of a satellite would not be a serious detriment to the aircraft's ability to fly the route we had set it upon. Our investment there was to bring that programme forward and to ensure that we got capability through the augmentation system which enabled us to exploit it. Now that process is entering service and we are going through a period of qualification, stability running and operating, the initial period is being funded from the European Commission through ESA. The system has a number of master control centres and remote terminals which monitor the satellites and collect the data to allow us to transmit the correction to the aircraft. That has to be paid for and National Air Traffic Services, by virtue of having invested in the original programme, has been granted a place as an operator of those master control centres and those rims and therefore there is an economic flow back to us, which is never generous, but over the length of time we do expect the recovery of our investment. The government's investment, as I understand it, is through its commitment to the European space programme and that is handled by the department and the principle there is a principle of *juste* return: the government invests a sum of money and the programme places contracts back in the country in approximate proportion—these things are never accurately in proportion. Does that answer the question?

Q75 Mr Donohoe: So the recovery you are going to get from the aviation industry is going to be something in the order of one per cent in terms of the amount you will be able to recover for the constellation of satellites. It does not seem to me like a good return for the money.
Dr Witty: When you talk about one per cent, we have invested in EGNOS to augment the GPS, we have not made an investment in Galileo. The

relatively small amount we have invested in EGNOS we will get that return allowed back by the regulator and that has been agreed.

Q76 Chairman: Have you discussed Galileo from the point of view of an investment?
Dr Witty: We have discussed it, but we are not planning to invest in Galileo at this stage. On the contrary, we are looking to bid to the Galileo operating consortium for business, to use our expertise which we have gained from EGNOS to help with the operations of Galileo. We are hoping to play a role in that if it comes along, but we are not planning to invest in it.
Air Commodore Bonnor: I am sorry, but I think we are missing the whole fundamental reason why EGNOS exists. When President Reagan, after the Korean airliner was shot down in 1983, said he would make GPS available for civilian use, great, but he put no liability or guarantee on it. The only reason we built EGNOS was because we know people wish to use GPS in sovereign airspace across Europe and we need to be able to prove to ourselves as well as to the airline operators that they are getting a service into which we are putting some integrity. Without that we could not allow them to use it, as far as I am concerned: we would have to say no.

Q77 Mr Donohoe: We are talking of a project which in round terms is worth around €3.2 billion. What I am looking for is how that is to be paid for and where the return is for those investing. I do not see exactly how that squares.
Air Commodore Bonnor: I am saying that GNSS is basic infrastructure: it is the same as the roads and the railways. You need EGNOS and Galileo because if people are going to use GNSS, you need to be able to prove that it is working correctly and that people will not have an accident while using it.

Q78 Mr Donohoe: So you are saying that the investment should be made by the public purse, but the savings which come about from that in every respect are going to be made and the benefactors are going to be private industry. Is that what you are saying?
Air Commodore Bonnor: Long term everybody will gain from the use of GNSS.

Q79 Mr Donohoe: No, no, in terms of investment. One takes it on the one hand that from the states of Europe there is going to be something of an investment in the order of €3.2 billion. The aviation industry in particular is going to make savings as a consequence. That is the argument we are being given as an advantage of this scheme: that the aviation industry in particular—it is the only one which has been looked at in any detail—is going to make savings as a consequence. You are telling me that the government and the governments in Europe should invest without any return other than on the basis of the fact that it is infrastructure and should be treated accordingly. It is an awful lot of money to be invested without any return coming back to the public purse.
Dr Ward: May I point out that no cost benefit analysis was carried out for GPS? It was put there with public money and the benefits which have accrued—
Mr Donohoe: It was for defence.

Q80 Chairman: It was for defence purposes.
Dr Ward: But many benefits have accrued to civil industry as a result. I think the same philosophy is behind the thinking on Galileo. We certainly cannot point to concrete savings for the maritime users because they have the services they need already but there are certainly commercial opportunities.
Air Commodore Bonnor: There must be long-term savings in infrastructure which can be removed as a result of proving and having GNSS in place, just in maintenance alone of radar systems across not just Europe but the rest of the world. Africa particularly cannot afford the infrastructure. Galileo will provide that infrastructure and while I can see that people will argue against supporting Third World countries, I think it is an important aspect. We are a rich nation and Europe.
Chairman: We are just trying to get at the arguments.

Q81 Mr Donohoe: Yes, that is fine and it is a brilliant argument if you want to go down that road, but in real terms I am looking at it on the basis of public versus private and it is private industry which is going to gain most from this system and the public purse is the one which is going to pay for it.
Air Commodore Bonnor: And Galileo is going to get huge tax returns from industry as a result of what it develops.
Mr Donohoe: I am not convinced.

Q82 Ian Lucas: Why does the aviation industry wish to have global navigation satellite systems as the sole means of navigation for aircraft?
Dr Witty: At this stage we do not plan to have it as the sole means. As we go into 2005 we would expect to have a GPS navigational service augmented by EGNOS for the integrity reason we discussed earlier. It is a fundamental principle of our safety regime that we never have one of anything; we would always want two or more of something. If the two or more are diverse and different, so there is no common mode failure, that is the kind of thing we like. So navigation for us would be a mixture of satellite-based through GPS and EGNOS, backed up by the ground-based infrastructure we have. They are separate, diverse, different and if one fails the other one is not likely to fail; there is always a diverse backup. That is crucial to us in our safety regime and that is different from road transport where it is not a safety issue if the thing dips out for a few seconds. However, if you do not know where you are and you are 200 feet above the Heathrow runway in fog it really is serious. That is very important to us. Part of the discussion has had the flavour of: is there a choice between GPS and Galileo? For us, if we went

to a satellite-only based system we would want both and that would be crucial for us because then we would have diverse, dual channel redundancy. We would have two different ones. It would be very important to us that if there were a problem on GPS, you would not expect a simultaneous problem on Galileo and you would always have the thing. For us it is not a choice. We would want at least two or more systems which were different.

Q83 Ian Lucas: So Galileo is not sufficiently important to you for you to invest in it as an alternative to the ground-based system.
Dr Witty: Not a key driver at this point. We have the ground-based system, it works very reliably, there are inertial systems inside the aircraft itself and we will move to GPS augmented by EGNOS. That is our current route and that will be in service very shortly. If and when Galileo comes along, then that affords us opportunities and our prediction is that aviation will be a minor user in terms of volume. If it is available to us and we can have it at a commercial rate, then there are some things which we can do, which have been alluded to, which would clean up the systems: we could have high precision navigation in areas which do not have coverage by the ground system; we could get various safety and capacity benefits. We would not make a major investment in Galileo just on the aviation case alone. If it is there and we are a small player in a big system, then it is advantageous to us.

Q84 Ian Lucas: And you would take the business it offered as well. I am not criticising you for that, but you would play a role in that.
Dr Witty: We are looking to expand our business, so if there is a business opportunity to use the expertise—a point the academic panel made earlier—which we have gained by being in the GPS game and we can leverage that to make further business that is important. With the single European sky coming along we have not just to take the UK view. Aviation and air traffic control in particular will change significantly in the coming years in Europe and we need to be a European level player, another reason to go into a European-based system for us. We have enthusiasm for Galileo in that sense. Do not think that we have no enthusiasm: we should like to see it built.

Q85 Chairman: You sounded a little more cautious than that, did you not? In the evidence you gave us you said "... that there remain unresolved issues, particularly development costs, multi-modal applications, charging methods which need to be addressed with urgency". You may be enthusiastic but you are not overly enthusiastic, are you?
Dr Witty: It is not a primary business driver that we have to have it or something bad is going to happen.

Q86 Chairman: Should the Council delay taking a decision on that basis?
Dr Witty: No, I do not think so.

Q87 Chairman: You do not think so.
Dr Witty: No; we should like to see it built. We will have practical advantages if it can be built, but aviation is not the primary driver in that sense.

Q88 Mr Randall: What do you think the United Kingdom would lose if it did not go ahead? What do you think the loss to the country would be?
Captain Glass: The point was well made by the academic panel. That is beyond me, because I only understood half of what they were saying. They did make a very good case that there are so many opportunities from the advanced technology of Galileo over the current GPS and the civil nature of its delivery that it is going to be amazing.

Q89 Mr Randall: So it should not be looked at purely in terms of cost and the immediate advantages, there is a broader thing out there.
Captain Glass: Yes; I am sure. From our point of view and other service providers the more satellites there are the better accuracy and integrity and all that goes with it and the ability to take technology forward in navigation which will reduce risk and hopefully make us safer.

Q90 Mr Randall: Both from the maritime and the aviation point of view, there is a suggestion that Galileo would be a useful backup, in broad terms. If you had the two systems, do you have any view on which one would be used as the first one? Which one would become the backup and which one would be used? Is one better than the other?
Air Commodore Bonnor: You would have to quote the year in which you expect that to happen. I too am sceptical about 2008, but that has partly been caused by the delays in the programme so far which were mainly politically motivated. If Galileo is in by 2010, let us say, or even 2011, it will still be ahead of improvements to GPS. It has a number of major advantages which will spin off into other applications, particularly the extra frequencies. The Americans have already said that the next satellite they want to launch will have one extra frequency on it for civilian use, but it will be 2012 or later before they will have an operational capability with it. Galileo will come up immediately with an operational capability and I would suggest that by the time half the satellites are airborne we would have that level of capability that the Americans will not have until 2012.

Q91 Mr Randall: Do you think the Americans see this as Galileo's competition?
Air Commodore Bonnor: Absolutely; no question.

Q92 Mr Randall: If they had their way we would not have it.
Air Commodore Bonnor: They have a problem. Half of them would like Galileo to be cancelled because they have done extremely well out of GPS, they really have, the whole of their industry, as we have

too. Why are six universities so involved? At the same time the other half in the Federal Aviation Agency desperately want Galileo because their own system, GPS, is not good enough for them. The Americans have a twin personality at the moment.

Q93 Mr Randall: May I address my last question to NATS? You have had some experience of PPP. What experiences do you think you could bring to this particular one?
Dr Witty: That is a very difficult question. I joined NATS after the PPP from industry as part of the plan to bring in industrial expertise, so I have no PPP experience. The post-PPP NATS is an organisation which is taking cost discipline, professional management, driving in many of the best practices which come from industry as a thing which is ongoing inside NATS; that sensitivity to customers, managing costs, making sure we are doing the right things for the customers, being just better at everything we do in that sense because we feel that sense of professionalism and also with one eye on the single European sky. We are now in a competitive era which probably was not true of NATS in the past. There is a sense that there is real competition amongst navigation service providers, which was not there before. For those of us who come from industry—we have a chief executive now who is from industry as well—that is meat and drink, that is our natural flavour, competition is the natural thing we feel. We bring that sense to the organisation.

Q94 Mr Randall: Would I be correct in saying that you want to set up a control centre facility?
Dr Witty: Yes, there will be a Galileo control centre and we should certainly like to bid for that business.

Q95 Mr Randall: Would that cost the UK anything?
Dr Witty: No, we would bid for that.
Mr Thomas: We would bid to provide it.
Dr Witty: We would do that as a commercial business.

Q96 Mr Randall: What would be the benefits of having that?
Mr Thomas: Two benefits: income for us as it builds on our knowledge of operating the EGNOS mission control centre (MCC); secondly, a critical advantage to the UK is that it gets the centre of focus moved a little bit and for us, in the single European skies, that is clearly a very important part.

Q97 Mr Randall: Do you think therefore that there will be lots of other business from other countries to have this control centre, or do they not have the expertise?
Mr Thomas: Yes, we would certainly expect a number of other countries to bid for it.

Q98 Mr Randall: Any idea which particular ones or is that giving away too much?
Mr Thomas: One could expect Spain, Germany and Italy to be particularly interested.

Q99 Chairman: When you talk about competition, are those the countries you are talking about? I am fascinated with this new picture of NATS which is at the sharp end of competitive business. I am filled with admiration; it astonishes me. Who are we talking about? Who are your competitors who are so efficient that they are going to give you a hard time?
Dr Witty: We listed those three countries because there are four EGNOS control centres in Europe: we are one of them and we have listed the other three and they have that expertise which is now in test and soon will be operational expertise. That gives them an edge in the competition. The four of us are people who have operational expertise.

Q100 Clive Efford: I was going to ask about the edge the competition may have. Are they showing more enthusiasm for Galileo at this stage than you are?
Mr Thomas: As air traffic service providers, they are as enthusiastic as we are because they see the same operational advantages in having the second system. Where we differ is that a number of them are not in a public-private arrangement.

Q101 Chairman: So they are efficient.
Mr Thomas: Some of them are government run organisations and in that sense they are in some cases fronting the national position in the European satellite game. For example, ENAV, which is the company in Italy, clearly takes a large proportion of the Italian commitment to being a key player in European satellite business and ENAV is very well positioned to further its claims. We made reference in the written submission to show you how the Italian structure appears to be working.

Q102 Clive Efford: So the answer is yes.
Mr Thomas: Some are, yes. May I return to the point about the competition for just a moment? It is very important that where we are at the moment there are concerns across Europe about sovereignty of air space and, as you know, the single European sky is working towards these things called functional air space blocks as a mechanism to try to break this up. We are not competing today, but what we are doing is very carefully benchmarking our costs. Our customers very clearly look at our individual national costs and the competition manifests itself in a determination to position ourselves at the right place in the league of costs.

Q103 Chairman: Yes and you are also doing cost benefits of the benefits to your customers of these sorts of changes. Aviation is going to walk away from this with a very considerable amount of money, is it not?
Mr Thomas: The challenge to that point is how exactly the previous cost-benefit studies have been done. The cost-benefit study with which I am most familiar took essentially what we are doing today through the precision navigation systems we are able to put in place both through our ground systems and

through EGNOS plus GPS and it attributed those benefits to Galileo when actually those benefits are there today.

Q104 Chairman: So when Price Waterhouse say that more efficient transport would save an aggregate of €3.38 billion and passengers €1.67 billion a year by 2020 ...
Mr Thomas: We have responded on a number of occasions that some of the premise within that study is not true.

Q105 Chairman: In detail.
Mr Thomas: In detail. Changes which are already going through are being put in that cost-benefit case.

Q106 Chairman: Are you ever going to be able to rely 100 per cent on Galileo and GPS?
Mr Thomas: You heard the time frame comments earlier, which you understand, and the answer in the long term is yes, we would hope we can.

Q107 Chairman: So you are going to stop investing in radar in case of jamming? Do you think duplication is a problem?
Dr Witty: The choice for us is satellite versus the ground-based navigational infrastructure of beacons and that kind of thing rather than radar *per se*. To go to a radarless system is something we do not anticipate in the short term.

Q108 Mr Stringer: Previously when you were speaking I understood that in the medium to long term you were considering going to a system based on GPS and Galileo. Did I understand that correctly?
Dr Witty: If Galileo is built and operated successfully, then that gives us that option, yes, to go to a two-satellite system-based navigation and not have so much reliance on ground-based infrastructure.

Q109 Mr Stringer: We heard previously from the academics that it was easy to jam these systems. Would that not make the system very vulnerable to unpleasant people and terrorists?
Dr Witty: That is naturally a concern and that is one reason why we would not go if there were only one satellite base system; we would look for two diverse independent systems.

Q110 Mr Stringer: Presumably if it is easy to jam one system, it is just as easy to jam two systems.
Mr Thomas: May I indulge in a little bit of techno-speak? The evidence I heard from the previous panel was around the fact that to jam something which was on the ground from the ground itself was quite difficult, but to jam it from the air was quite easy. That is true, because from an aircraft flying above a battlefield it is quite easy to hit all of the receivers. Please remember that the civil aviation guys are considerably higher, we are in the process of working through to produce standards for the antennae in civil aircraft which are specifically designed to resist the jamming intent and the other problem of course is that you have a much faster moving target when you are talking about civil aircraft. There is clearly, with a limitless technological capability, the ability to jam. The practical assumption, the practical studies, the practical assessments suggest that it is actually not a substantive threat for our bit of the operation. I do emphasise that you have to take different technical scenarios and work them each way through.

Q111 Chairman: Should the safety of life service incorporate many of the PRS features including greater resistance to jamming?
Mr Thomas: Um.

Q112 Chairman: No, Mr Thomas; um is our reply. You have to think of a more precise answer.
Mr Thomas: The precise answer is yes.
Chairman: Thank you very much. Gentlemen, you have been very helpful and certainly very disciplined and we are very grateful to you. Thank you very much for coming this afternoon.

Witnesses: **Dr Michael Healy**, Director Earth Observation, Navigation & Science (UK), EADS Astrium, **Mr Pat Norris,** Business Development Manager, LogicaCMG, **Mr Richard Vos,** Adviser, Inmarsat Ventures, **Mr Andrew Sage,** Director, Helios Technology Ltd and **Dr Russell Silk,** Manager Satellite Solutions, BT Global Services, examined.

Q113 Chairman: Good afternoon gentlemen. May I ask you to identify yourselves before we go any further?
Mr Silk: Hello, I am Russell Silk. I am representing BT today. I think you know BT, a UK wide communications solutions provider with a global reach in the business market. We are not directly interested in the development and deployment of the Galileo system as such: we are more interested in the products and services and the projects which are likely to flow as a result of Galileo.
Mr Sage: Good afternoon, my name is Andrew Sage. I am Director of Helios Technology Ltd in the UK. Helios is an independent consultancy which has been active in satellite navigation for many years and we have been advising government policymakers and commercial organisations on the commercial viability of Galileo for some time.
Mr Norris: Good afternoon, my name is Pat Norris. I am the Business Development Manager at LogicaCMG in the UK. We are interested in both the initial investment phase of Galileo, but also,

perhaps more importantly, in the long-term applications of Galileo.

Mr Vos: Good afternoon, my name is Richard Vos. I am the former Chairman of Inmarsat, now acting as an adviser on government relations for them. Inmarsat itself is the largest provider of mobile satellite services based in London and also one of the sponsors bidding for the concession for Galileo.

Dr Healy: Good afternoon, my name is Mike Healy. I am the Director of Earth Observation, Navigation and Science, EADS Astrium in the UK. We employ round about 2,500 people in the UK working in space systems and we have been involved in Galileo since its inception in about 1999.

Q114 Chairman: Gentlemen, I understand one or two of you might actually like to say something briefly.

Dr Healy: We have decided that it is better to go straight into the questions.

Q115 Chairman: Thank you. How would you counter the claim that Galileo is only a duplicate GPS, slightly more advanced but very expensive? Who wants to have a go at that?

Dr Healy: As an independent system Galileo is planned to be of a better quality than GPS, but most of the real advantages that the users will see will be in terms of both systems working in a complementary fashion. From the point of view of cost, whilst the cost of the Galileo system would seem to be quite high, it is a small fraction of that required to develop GPS. From that point of view it is a very cost-effective system. If Galileo were a military system with military hardening, etcetera, it would be ten times the cost and I am sure that is the cost of GPS because the US industry have given me some figures which would support that.

Q116 Chairman: Are you quite confident that the contract for Galileo can be structured in such a way as to stop the costs spiralling out of control?

Dr Healy: The European Space Agency are at the moment trying to contract with industry for the in-orbit validation phase of the programme; that is the first four satellites and the associated ground segment. That will be under a fixed price cost arrangement. There is no question of it spiralling out of control as long as the requirements stay the same.

Mr Vos: What we have done is to build a business plan which is based around the remainder of the €3.2 billion which was mentioned earlier on. That business plan effectively assumes that we will meet certain revenue targets and that therefore the costs themselves will end up being limited. Nothing is totally open ended obviously, but the business plan projections that we have are that the system will recover its money, that the payments for availability of the system will cease in 2012 to 2013 and that from that time on effectively we shall be by ourselves.

Q117 Chairman: There is nothing certain about that cut-off point, is there? Is there anything set down at European level to say that will be a cut-off point for the funding?

Mr Vos: As far as availability payments are concerned, that there will be a cut-off point is absolutely correct. Our business model assumes that. It also assumes that from that time onwards we shall be meeting the market projections. If we meet those market projections, then we have also put into our bid a facility where there will effectively be some revenue sharing and on the revenue sharing arrangement that will mean that some of the initial investment, which will have been put up by the European Union, will in fact go back to them. This is the space business: nothing is absolutely guaranteed unfortunately. The one thing I would also add, if I am allowed, is that we have got the funding together—this was a question which was asked earlier. The funding is a mixture of equity from the initial founder companies and also money which has been put forward by a consortium of banks. Those banks clearly require some kind of security and that means that as we start meeting the financial projections, the market projections, they will get more and more comfortable with that. However, we do have the financing in place.

Q118 Mrs Ellman: There are five major Galileo services. Which of those do you see growing faster than others and how do you see the market developing?

Mr Sage: Certainly in my own experience, talking with different users, it seems inevitable to me that the Galileo Open Service, the one which will be free to users at the point of use, comparable to today's GPS service, will be very, very rapidly used by a huge number of users and that within a short space of time, it will be easier to buy a receiver which is a combined GPS/Galileo receiver in virtually every single market sector I can think of. The Safety of Life Service and Search and Rescue Service are both also free to air. The Search and Rescue Service is obviously similar to Safety of Life in that respect, but the Safety of Life Service is obviously dependent upon specific institutional decisions amongst the aviation, rail and maritime users, as you heard in the previous forum. With regard to the encrypted services such as the Public Regulated Service and the Commercial Service, those factors become rather more specific to the concession bidders, which will be difficult to discuss today. Certainly, taking the Public Regulated Service specifically, it is envisaged that will be subject to specific subscription by those Member States that desire it and therefore the business plan being put together by organisations such as Inmarsat and others will have certain assumptions based on their uptake.

Q119 Mrs Ellman: Have any specific assessments been made on how these services will grow? What is needed to make sure that happens? Is a marketing operation required and who should be doing it?

Mr Sage: Many, many market studies have been undertaken funded both by the European Commission and the Galileo Joint Undertaking today. Those are paralleled by all the inevitable analysis you would imagine has been undertaken by the two concession bidders for their business plans to stand up to scrutiny in front both of themselves, in terms of putting forward equity, but also in front of banks putting forward a considerable amount of debt, who would not be doing that without seeing the revenue you would expect.
Mr Norris: Another source of activity to ensure that Galileo is taken up rapidly is a programme that the European Commission is funding through its Framework 6 programme. A whole series of contracts is about to be placed, quite large contracts totalling about €70 million, which are attempting to bring together companies and user organisations across Europe so that standards will be set across Europe and the market will exist on a European scale from day one. Adequate receivers will be manufactured and relationships will be established between companies like my own and British Telecom and our equivalents across Europe, involving road user applications and safety light applications, telecom applications and many others. A whole series of programmes is being part funded through the European Community and part funded by companies like the ones you see here to try to make sure that Galileo is taken up quickly and effectively.

Q120 Mrs Ellman: What is the planned timing in these proposals? It is expected that Galileo will be operational by 2008, is it not? I do not know whether you think that will actually happen. How does that relate to the programme you are talking about?
Mr Vos: The proposal we have put forward is that it will take between four and five years from the time that a contract is actually signed with the Galileo Joint Undertaking. We anticipate signature towards the end of 2005/beginning of 2006. So you are looking at 2010 for the beginning of service.

Q121 Mrs Ellman: So 2010 is the year.
Mr Vos: Yes, that is right.
Dr Healy: It is worth saying that for the first phase of the work, the in-orbit validation which I mentioned earlier, the contracts have not been signed yet for that work and it will take at least four years to put up the first satellites. You are talking about 2008 before the first satellites are available and the first signals are there to begin to test applications and things. There are some experimental satellites which will go up at the end of next year which will also begin to stimulate that market, but the full constellation will be a little later.

Q122 Mrs Ellman: What about the cost of receivers for Galileo compared with GPS? Is there going to be a problem there.
Dr Healy: Galileo has been designed to use very similar frequencies to GPS in a similar though more advanced signal structure. The idea is that from a receiver perspective you will have the same RF antenna, or very similar RF antenna, which is where a lot of the cost is. You might have an upgrade to the software and you will require a bigger processing chip, but by that time that cost will be very similar to the cost of just a GPS chip. For the two together you will see a very small delta cost, particularly with the development in technology that you have in integrated circuits in any case.
Mr Sage: According to my own conversations with today's GPS chip-set manufacturers, some of whom are delivering chip-sets into mobile phones today, the way in which their equipment and chip-sets are developing they anticipate a very, very small, marginal, if any, increase in cost for their equipment based on a software-based implementation of their receivers in the future.

Q123 Ian Lucas: I am having some difficulty establishing where the commercial income from the project is going to come from. Can you tell me who the privately paying customers for the Commercial Service are anticipated to be?
Mr Vos: I am not sure that I am competent to answer that question.
Mr Sage: As has been mentioned previously, there are five Galileo services, three of which have been designed to be free-to-air.

Q124 Ian Lucas: That is the easy bit; everybody will want that.
Mr Sage: In which case it is difficult in many ways to attach direct revenue to those types of services given that they are free-to-air. At the same time, they are there in a critical sense to stimulate the market and learn from the lessons the GPS has learned in the same way. The two remaining services, the PRS and Commercial Service, are encrypted, which allows direct revenues to be attributed back to the Galileo concessionaire. The basic features of the Commercial Service have been defined but there is a degree of freedom still for the concessionaires to define that service how they wish, so that is not something we can discuss today.

Q125 Chairman: Forgive me, I am sure that is right and I am sure Mr Lucas is going to come back at you, but surely someone must have done some assessment. After all, you are not just putting up these jolly little toys to wander round the universe in the hope that everybody is going to use them free and the taxpayers are going to be continually paying for them, are you?
Mr Sage: No, that is correct.

Q126 Chairman: Or am I missing something?
Mr Sage: There have been several studies which suggest that different users would be prepared to pay for features such as a service guarantee.
Chairman: That is what Mr Lucas is asking you.

Q127 Ian Lucas: Who are these people? The only person who seems to be paying at the moment is the taxpayer. It is difficult to see where the private income is coming into this project.

Mr Silk: It is difficult to see at the moment exactly how the commercial market will develop, I shall be quite open about that; it is difficult. However, you have to look at the applications and the services that are on the horizon at the moment to see how it is likely to work. Let us look at an example which members here may or may not like, lorry road user charging, which serves government policy. That is going to be a very large project which is going to be enabled through satellite navigation. The actual value of the satellite signal is very small as part of the overall business proposition which supports this large revenue collecting exercise for the government. It is foreseeable therefore that commercial activity will flow from satellite navigation. What I am saying is that the satellite part is a very, very small part of the overall commercial opportunity which will take place. Whether significant revenue flows back to the original funders of the system I cannot say, although we have had the views of a colleague whose company is in the business of making money from the operation of such satellite services. What I am clear about is that the projects that it enables will generate large commercial opportunities. If you take the project I have just mentioned, the lorry road user charging, that will involve conservatively a £2 billion project to deliver over ten years, and the commercial activity associated with that will involve lots of jobs, lots of high technology IT jobs and BT as a solutions provider would like to be involved with that. A key point I would like to make is that the current service we have in GPS is wonderful service but it is provided on a "grace and favour" basis by the US Department of Defense. We are taking it, we are using it, and that is all very well. Would you put your life at stake on any service that is provided on that basis? Would you offer any business critical service on such a basis? What we are seeing as quite exciting about Galileo and which we need as a commercial service provider, is having performance and security guarantees which are backed up with penalties for non-compliance. Companies like BT are increasingly having to deliver demanding service levels, with guarantees with penalties and you cannot simply rely on GPS for this. That is one of the reasons why I think this is a big step forward. Although I cannot see at present how commercial revenue comes back to the taxpayer the value of the investment is small compared with the industrial activity it will generate.

Q128 Ian Lucas: The reason I am interested in that is that the way our government has chosen to proceed is through a public-private partnership with the private investment that entails. The private investors will want their return, presumably from private sources as well as public sources. To my mind the example you have given me is a public source, a very good example, but it is in the commercial sphere that I am struggling to find examples.

Mr Norris: The telecommunications market is another market that will hopefully be a big user of Galileo. Position information is already a valuable commodity in some countries—Japan in particular is the most advanced and America is the next—where the telephone operators have found that it is commercially attractive for them to make some investment to be able to provide position based information to their subscribers. It is expected that those operators will find it attractive to use GPS and eventually Galileo to provide more accurate position-based information to their subscribers. The market is still embryonic but the projections are that that will be the case and certainly my company is very interested in that. We supply two thirds of the world's messaging software for mobile phones, so anything which can create value, create a service that generates revenue out of mobile telephony, is of considerable interest. That is why we are investing in seeing whether Galileo plus GPS in mobile phones creates services which will be commercially attractive. In fact I am going out to Japan next month as part of a government/industry mission to explore this.

Chairman: This Committee has just returned from Japan and I hope you will not find it as chastening as we did. It is not just that they are light years ahead of us: they are in a different century.

Q129 Clive Efford: Is it true that the European Union/European Space Agency paid for the development of Galileo? So in terms of operating PRS in the future, why should public sector service providers pay again?

Dr Healy: The European Space Agency and European Commission will fund these first four satellites which is something in excess of €1 billion. In order to put the first 30 satellites up and the associated infrastructure, we are talking about €3 billion, so there is still quite a large gap between the two. It is not quite true to say that the funding is already in there and everything is developed, because it is not.

Q130 Clive Efford: My understanding is that the funding of the roll-out is one third/two thirds: one third government and two thirds private sector. It is fair to say that it would not happen without public sector money.

Dr Healy: Yes, it would not happen without public sector money.

Clive Efford: So why should we pay again? Why should public sector users pay again for the PRS?

Q131 Chairman: It is a little difficult for a non-scientific committee. Let me try to put it to you in simple terms. We need to try to evaluate the really basic advantages that this system would offer to members of the general public. Part of it is going to be free anyway. The suggestion is that of course you would want to pay for better services, because they would be that bit more accurate, they would

have that greater degree of integrity. So far what else are we actually talking about? If I already have a system which is working perfectly well and with any luck does not send me down too many cul-de-sacs, why would I want to pay extra for what you are offering me? Where would the advantage lie to the taxpayer?

Dr Healy: The major issue, which was mentioned in the earlier session, is over-reliance on GPS. GPS is becoming so used in everyday life that having one system which you rely on for everything—and it is a very reliable system but it is not perfect—is the fundamental argument. You cannot rely, for something which would be so ubiquitous in ten years' time, on only one system. In the first instance it is a bit of a back-up. Then there are the other arguments which say that it is the integrity service which would be offered, the fact that you have two systems offering an integrity service by the time you have EGNOS with GPS, by the time you have the service guarantees, which are limiting market development. Russell was saying that BT does not rely on GPS, because they cannot fully rely on it, so they are not using satellite navigation to its full potential. When Galileo is there they will use it a lot more. So there is a limitation on the commercial market development today by having this system which is controlled for military purposes.

Q132 Clive Efford: How essential to Galileo being attractive to the private sector is the potential to charge for the PRS system? Is it central to your business plan?

Mr Vos: It is not absolutely central to the business plan, but it certainly forms a part of it; probably somewhere up to about one fifth of the potential revenues could come from that area. It has been built into the business plan. If it does not happen, and we have always recognised that this is a market which will be decided more by politics perhaps than by the usual commercial reasons, we have always recognised that there will be gaps within Europe, there will be some countries which do not wish to opt in to PRS, we have had to make some assumptions on that as to where we will actually get some revenues from that.

Q133 Clive Efford: In terms of the overall proportion of Galileo, what proportion does the PRS system pick up? My understanding is that a very small proportion of the system is required to serve PRS.

Dr Healy: Yes, the additional cost of the PRS in terms of the infrastructure which is needed for it is a relatively small proportion of the €3 billion. It is something like €150 million. It is not a small number but it is relatively small compared with the full infrastructure cost.

Q134 Clive Efford: That sounds disproportionate to what was just said in terms of it making up about one fifth of the revenue potential.

Dr Healy: Yes. It is about five per cent of the cost and 20 per cent of the revenue potential.

Q135 Clive Efford: That sounds like good business to me if I am using taxpayers' money. Looking at it from the point of view of the taxpayer, that is very fair.

Dr Healy: The reason why PRS is relatively inexpensive is because it is an additional service over and above what you have with the Safety of Life Service.

Q136 Chairman: Would some European nations not be anxious to turn this system into a defence system?

Mr Norris: Every European country will have the opportunity, through the Galileo Security Board to influence the ways in which Galileo is used. I have no idea what they may choose to do; that is the business of the governments through this international body which has been created and the UK has played a leading role in creating its terms of reference and rules. It is for the governments, through the institutional arrangement in Europe.

Q137 Clive Efford: For the individual in the street, my constituents, what is so critical about Galileo? What do we get for this investment of taxpayers' money that we could not have got by some other route or through existing systems? What is the real driving force behind it?

Dr Healy: In a very simplistic sense, there are jobs in the upstream space infrastructure area. There are probably round about 500 jobs today, or will be in the very near future, in Galileo just in the upstream. There will be a multiplicity of jobs that will come from this investment in the downstream, because we have that much more visibility over what is happening, over the definition of the system and that means that the industry can react very quickly to this.

Q138 Clive Efford: So this is Keynesianism: burying pound notes and paying people to dig them up.

Dr Healy: There are industrial benefits and there are more than industrial benefits to this programme. Just to give you one example, the market studies which have been done say that if GPS were non-operational for one day in 2015 it would cost Europe €500 million in commercial problems. That is how much the European economy will be dependent on Galileo and that is probably a conservative estimate. That is just if it goes down for one day. You cannot guarantee that a system will work completely perfectly for the rest of time.

Q139 Clive Efford: If we were not to win the contract then how would that case, in terms of it being a sound investment, be undermined? How crucial to the economic benefits you have just described is going on to the next stage and being successful as a bidder?

Mr Vos: In answer to that one, quite a lot of the upstream work would be lost because the alternative consortium is based on continental suppliers. Some work may come back in because Britain has a lot of know-how; some work will stay,

in that we believe also that the major benefit for industry will actually come from the downstream side. In other words, we shall still be able to get development of value added services, development of software which goes with the Galileo system, but we should lose the upstream.

Q140 Mr Donohoe: If you were sitting in front of us in the United States as equivalent businesses in the United States inside that tent of GPS, would you be arguing on the same basis as you are in front of us today?
Mr Sage: From a user perspective, I would entirely. From an industry point of view, there is clearly an edge of competition between GPS and Galileo. From a market perspective, it does not matter whether you are in the US or Europe, you have the same downstream benefit from having a second constellation.
Chairman: Gentlemen, you have been extremely helpful. Thank you all very much.

Witnesses: **Mr Neil Ackroyd,** Director of Data Collection and Management, **Mr Duncan Shiell**, Director of Strategy and **Dr Paul Cruddace,** Geodetic Adviser, Ordnance Survey, examined.

Q141 Chairman: Gentlemen, good afternoon to you. May I ask you to identify yourselves first?
Mr Shiell: Good afternoon, I am Duncan Shiell; I am the Director of Strategy at Ordnance Survey, Britain's national mapping agency.
Mr Ackroyd: I am Neil Ackroyd; I am the Director of Data Collection at the Ordnance Survey.
Dr Cruddace: My name is Paul Cruddace; I am the positioning team manager of Ordnance Survey, which means the application of GPS technology to our business.

Q142 Chairman: I hope you will thank your director, who was kind enough to write to me and explain that she was sending three of her very bright gentlemen to keep us in order and we are very grateful to you. You have done a market analysis of the usefulness of Galileo. Are you confident its services will be sufficiently useful to ensure the private sector will be able to contribute two thirds of the cost?
Mr Ackroyd: The analysis focused very much on the applications at the high end of the positioning market, at the centimetre level and metre level, so for surveying and mapping applications. We still have confidence in that study. In many cases, since we did that study, the applications have evolved even further.

Q143 Chairman: In what way
Mr Ackroyd: The adoption of these technologies in areas such as construction has accelerated more quickly than we had anticipated. Again I say the use of higher accuracy services than people have been talking about up to this point have been adopted now in earth moving equipment.

Q144 Chairman: Is that only in large construction projects? Is that housing or is that large factories? What part of the industry has picked this up?
Mr Ackroyd: At the moment it has picked it up for the large infrastructure projects such as the CTRL project, which uses the technology, the North Birmingham relief road project. One of the reasons why the technology has not migrated to smaller projects is back to the original point about availability of satellites. When you get into the urban areas or you get into smaller scale projects such as a housing development you are obviously surrounded by obstructions to the signal.

Q145 Chairman: Is it therefore not so accurate, because after all CTRL is not being built through open fields, is it?
Mr Ackroyd: A lot of the CTRL project to date, before it came into London was built in the open.

Q146 Chairman: I see; you are not talking about the final stages.
Mr Ackroyd: No. It is true to say that the accuracy is high level accuracy, at a centimetre level, and for that you really do need to have the best signal availability, even more so than we have been talking about earlier today for general navigation applications.

Q147 Mr Stringer: We heard previously from the academics that it is obviously better to have spots on maps rather than on blank screens. We also heard that for some part of the country, railway lines in particular, those maps do not exist. Why do they not exist? What are the technical difficulties in getting those maps onto screens?
Mr Ackroyd: The mapping does exist. The comment that was made was that it was not coincident with GPS or Galileo, that the mapping did not overlay the positioning very precisely. We are actually only 18 months away from completing a five-year programme to ensure that in all areas of the country the mapping is coincident with GPS and Galileo.

The Committee suspended from 4.47pm to 4.57pm for a division in the House

Q148 Mr Stringer: Can we assume that in the near future both systems will be able to be used for tracking trains essentially?
Mr Ackroyd: Yes, we can assume that the positioning which is delivered by GPS or Galileo will be coincident with the national mapping infrastructure which the Ordnance Survey supports.

Q149 Mr Stringer: What benefits will Galileo bring to you and your organisation that you cannot achieve using GPS?

Mr Ackroyd: One of our primary drivers is to capture all real world change in Great Britain within a very aggressive time frame, within six months of a property being built. Much of that driver is because our mapping underlies the land registration process and we work very closely with the Land Registry. The use of satellite positioning has massively increased our efficiency. With GPS alone we have improved our production activities by 40 per cent, so we are 40 per cent more effective; within a year of adopting the technology we increased our capacity for surveying substantially. That has allowed us to capture new forms of data, to better meet our customers' needs. So we have invested a lot of that efficiency in capturing enhanced transport infrastructure information such as the road network infrastructure to develop better applications for our users and our partners to develop those. So there is an addition in terms of the better quality data, faster data which we can capture. Also a general efficiency in cost of capture; it does reduce our cost of operation.

Q150 Mr Stringer: Will you be using any of the commercial services and in particular will you be using PRS?
Mr Ackroyd: Specifically PRS, in terms of our day-to-day surveying applications, will probably not be used directly by the Ordnance Survey, but we do allow infrastructure to allow other users to use the satellite positioning systems to enhance their accuracy.

Q151 Mr Stringer: You will have to explain what that means.
Mr Ackroyd: Today we have been talking about positioning at a few metres level, two to three metres, but there is a large user base of this technology which wants more accuracy than that, wants sub-metre and centimetre. It is with our infrastructure that we are able to support that higher precision position requirement. In that sense, we would be looking to support the PRS service to allow people to get even higher levels of accuracy out of that service if they so desired.

Q152 Mr Stringer: Any other commercial services?
Mr Ackroyd: In terms of forecasting data, we do see that we offer services in terms of GPS today and we would offer services associated with Galileo in the future as well.

Q153 Mr Stringer: You say it is important to do research into anti-jamming technology. Why is that?
Mr Ackroyd: From the concerns which have been raised today, I think there is a lot of concern about the potential for jamming satellite-based signals. There are, however, actually many techniques and technologies available to compensate for that concern. We heard earlier today about antennae design. There are many architectures today which were developed in the high precision end of the GPS market which could be translated to the consumer end of the market and which would improve the resilience to jamming. The receiver design technologies which allowed surveyors to get centimetres from the GPS signal, if applied to the Galileo signal or GPS signal in future, would improve the resistance to jamming. Those are areas where we would anticipate some benefit and further research.

Q154 Clive Efford: Could you tell us whether you have done any analysis into the costs involved in switching over to Galileo? What is the cost for your organisation?
Dr Cruddace: As Neil Ackroyd has just mentioned, we are at the moment putting out a new GPS infrastructure which will enable both business and outside commercial and government organisations to improve the positioning of GPS. We see that that probably has a limited life until Galileo comes along. Once Galileo is with us, we will replace that infrastructure with a combined GPS and Galileo infrastructure, so that will mean that anybody with a GPS/Galileo receiver can get centimetre positioning anywhere in the country. To do that, we will have to wait until the receiver manufacturers come out with those receivers. We have no idea of the cost of those receivers at the moment, but we assume that there will be some added cost to the GPS and Galileo receiver in the future.

Q155 Clive Efford: So it is a bit of a leap of faith then. If you cannot do a detailed cost-benefit analysis of what the benefits are that come from Galileo, but what the costs are in using the service, it is very difficult to judge the benefits.
Mr Ackroyd: We have to make some assumptions on the anticipated cost of receivers in the future. We can look at the market trends in GPS and one of the areas that we have obviously looked at is how this technology has reduced in price substantially. If we make assumptions about the future receivers being at a similar price point to current receivers, the cost-benefit analysis does work through very quickly for us and the return on investment, for us as a user of GPS, was very fast; it was somewhere in order of about 18 months.

Q156 Clive Efford: Do you anticipate that the difference between the existing GPS system and Galileo will be that significant that it will justify that? It is unlikely to bring you another 40% increase, is it not?
Mr Ackroyd: Absolutely, you are quite right, but most equipment is depreciated over about a five-year period and in any business, as long as you buy into the cycle of investment at that sort of level, then you can quite happily accommodate. From a technology point of view, the additional costs within the receiver are not high; the architecture of the receiver is very similar.

Q157 Clive Efford: You are very enthusiastic about Galileo. What do you think are the wider benefits to other government departments for instance?

Mr Ackroyd: From our perspective, we see a very close correlation between, as a previous witness mentioned, this application of a position and the detailed mapping which underlies that position; you cannot divorce the two. A position in isolation is of interest only if you know where other things are. When you look at how our high altitude digital data is used, you can see many areas where the benefit will be delivered very quickly. A good example is the utility market place, where—

Q158 Chairman: You are not going to tell me that they have maps.
Mr Ackroyd: They are beginning to increase the utilisation of digital data.
Chairman: I am delighted to hear that.

Q159 Clive Efford: So they know where the holes in the road are.
Mr Ackroyd: Absolutely, and in fact driving this is something like the New Street Works Act where you fuse the high accuracy positioning and high accuracy digital data that the Ordnance Survey are capturing and suddenly you do know where you are digging your holes and you suddenly do know where your underground assets are because you can position them as you bury them. There is a big potential benefit there and that does require higher accuracy; that requires accuracies of the order of 30 to 40 centimetres which the infrastructure the Ordnance Survey investing in will support.

Q160 Mrs Ellman: What would you say the most serious consequence would be if Galileo were delayed or did not take place at all?
Mr Ackroyd: In the sort of broader sense for Ordnance Survey it would reduce the application or take-up of some of our high-scale, large-scale digital data sets. Having accurate positioning is very much a motivating influence to using accurate data. For example, utilities, the example of the construction organisations would continue to use conventional techniques which are substantially less efficient than the new techniques. A good example is in the construction industry where, if people are using this sort of technology on an earth moving machine like a bulldozer or grader, they are increasing the efficiency of that machine by round about 30 per cent. That is a major efficiency to take into any production process if you enter—

Q161 Chairman: I am sorry to interrupt, but is that actually a selling point which is used by anyone selling to the construction industry? I am just fascinated to hear that it makes that much difference and I wonder whether they are aware of that.
Mr Ackroyd: They are and most of the large contractors are now using it on the large profile projects, such as the large road building projects, and migration down to the smaller projects, where the same efficiency was delivered, would be augmented very much by Galileo, because then you would be able to work in a housing development, or in a factory, or site development within an urban area much more reliably. Today they tend to use conventional technologies which are time-consuming and inefficient to use.

Q162 Chairman: And would that be the open signal?
Mr Ackroyd: That could be the open signal. Again, it comes down to what level they would value additional reliability. If the PRS service gave them additional reliability in very difficult areas such as under trees or very close to buildings, then they would clearly have the business benefit to take the PRS service as well.

Q163 Mrs Ellman: And you could not do these things by any other means?
Mr Ackroyd: You could, as we do today, go out with a complete kitbag of equipment, GPS, lasers, conventional total station, tapes, which is how we do it today. In the future, that does constrain it being broadened out or wider user-based because you do require a little bit more specialism in using all the different equipment. With an enhanced constellation from GPS and Galileo, you would have a set of equipment which was much more usable by an operator than having to go out with lots of different ways of doing the same thing.

Q164 Chairman: I am interested in your view about timescales, because, after all, your own department, and I say this with admiration, has improved and changed and advanced at enormous speed and you are doing things now which I think routinely would have been thought of as being quite advanced say five or ten years ago. How long do you think it would be in the timescale before not only were these services available, but before they penetrated the various commercial users in the way that you are talking about? Or can we not guess that?
Dr Cruddace: That very much depends on how Galileo is implemented. A lot of the services will be able to come on the stream as soon as there are maybe even one or two Galileo satellites up there.

Q165 Chairman: So we will not to wait for the twenty-eighth satellites.
Dr Cruddace: No, indeed. In our type of application, even if we have got another one or two satellites up there, that will help us in difficult environments, but other types of application will have to wait until the constellation is pretty much complete.

Q166 Chairman: Yes, I understand that. But then what do you envisage as being the timescale for use of dual systems so that you are not dependent on one, but you have two available?
Mr Ackroyd: From our investment strategy, we would anticipate, as we heard the previous witnesses saying, 2007 to 2008, that would be the time that we would be investing. Once we know there is a stability about the receiver design and the signal infrastructure, we would get incremental

benefit straight away. That would be the same for any user of high accuracy digital data: they would see the benefit almost immediately.

Q167 Chairman: Very quickly.
Mr Ackroyd: Yes, very quickly.

Q168 Chairman: I know this seems like a sort of idiot question, but that is my function. What kind of estimate have you made of the percentage, say of your customers, who would demand that very much finer degree of accuracy? If it is judgment in meters, in spite of what my planning department think, I think you are quite capable of working that out really.
Mr Ackroyd: In terms of users—it is easier for us to characterise it by users—the markets that drive sub-metre level positioning today are really the construction civil engineering market places, the utility market place, some of the new application areas, such as precision agriculture, where they want to apply pesticides.

Q169 Chairman: But make a sort of guess for me. What percentage of the business? We understand that these are estimates, but what kind of figures are we talking about of your overall business?
Mr Ackroyd: Of the Ordnance Survey's business?

Q170 Chairman: Yes.
Mr Ackroyd: I would say that about 60 to 70 per cent of our business would be leveraged off higher accuracy positioning.

Q171 Chairman: As much as that?
Mr Ackroyd: Primarily because a large number of users of our data are in that sort of utility space, are in what I call, construction space.

Q172 Chairman: Because the commercial advantage to them would be way beyond the cost of you providing those kinds of supply.
Mr Ackroyd: Yes. There is also a recognition here that when GPS was first launched nobody considered that we would be positioning in real time, in centimetres or in millimetres and these technologies which are coming and the additional frequencies with Galileo will give us so much more robustness, that we could actually find new applications which would benefit from centimetre levels.

Q173 Chairman: So as much as anything, it is not just the exactitude of this system, it is the width of application and it is the guaranteed application. Is that really what you are saying? It is the guarantee of the system operating properly?
Mr Ackroyd: Yes. Improved accuracy actually is an important part of improved integrity, because then if there is an error, you can detect it more quickly.
Chairman: I think that is extremely helpful. Do we have anything else? Gentlemen, you really have been very useful, thank you very much indeed. We are very impressed.

Witnesses: **Mr David Jamieson**, a Member of the House, Parliamentary Under-Secretary of State and **Mr Phil Carey,** Head of Ports Division, Department for Transport and **Mr Paul Johnston,** Head of Security Policy, Foreign and Commonwealth Office, examined.

Q174 Chairman: Greetings Minister. As you know, you are always most warmly welcome at this Committee.
Mr Jamieson: Good afternoon Mrs Dunwoody. I am David Jamieson the Parliamentary Under-Secretary of State at the Department for Transport.

Q175 Chairman: And you have brought with you?
Mr Johnston: Paul Johnston; I am the Head of the Security Policy Group within the Foreign Office, which is the Group which deals with European Security and Defence Policy and NATO issues.
Mr Carey: And I am Phil Carey, Head of Ports Division in the Department for Transport and I have responsibility for co-ordinating the government's work on the Galileo programme.

Q176 Chairman: Did you have something you wanted to say to us Mr Jamieson, or are you prepared to go straight to questions?
Mr Jamieson: With your permission, Mrs Dunwoody, may I just make a short statement? Firstly, I want to thank the Committee for initiating this inquiry and inviting us here today with your usual courtesy. It is important to ensure that we approach the European global navigation satellite system, Galileo and EGNOS, with a full understanding of its benefits as well as its potential pitfalls. Key decisions are to be taken this year and next. In December, at the Transport Council, we will have the opportunity to consider the European Commission's communication which sets out in detail the final shape of the programme and the services that it will provide. At the same time, we shall be moving towards a decision on who will gain the operating concession under the public-private partnership to build the satellites, launch them into orbit and then provide the services from a fully functioning constellation of 30 satellites. I am convinced that participation in the Galileo programme is good for the United Kingdom and I know that this view is already shared by industrial interests in this country. Galileo is a major European transport infrastructure project with potential for enormous benefits for users over the next 20 years and beyond. Transport remains the primary focus, but in practice, there will be many other applications for the technology and they will give great new opportunities for United Kingdom companies. The United Kingdom agreed to become a full participant in the Galileo programme because we believe that this technology will be vital in the

next few years as a multitude of applications are developed, both for government use and also in the private sector. It is important for our industrial interests that the United Kingdom is able to play a full part in the programme. We see it as vital that we are in on the development of the project and the UK has had a leading place in the European space technology programme. Our industry is well placed to benefit from the very significant work that will be on offer and our technical experts have a key part to play in the development of the system and guiding it in the direction that we want it to go. The United Kingdom has a real edge in Europe, in each of these areas: we have companies, both large and small, which are already taking advantage of this and many more waiting for the programme to start operating. It is also important that we have achieved and agreed a durable basis for the relationship between Galileo and the US GPS system. The EU/US agreement on the interoperability between Galileo and GPS was a good outcome for all involved, including NATO, as well the European Union Member States and the United States. On the latest official estimate, the cost of the development and validation phase of Galileo, before the public-private partnership takes over, is expected to be in the order of £1 billion, but that cost must be seen in context. Half the money comes from the European Union Trans-European Network's budget and the other half is financed through the European Space Agency. Of the latter, the United Kingdom is currently committed to pay in the region of £65 million. That investment could create up to 1,000 new jobs in the United Kingdom and in the longer term, when the system is fully operational, Galileo could have created over 100,000 new jobs across Europe and a market for equipment and services approaching £700 million a year. We can benefit from that and will do so most effectively as a full participant in the programme. Finally, Mrs Dunwoody, there is little doubt that Galileo will become a reality and our experience, so far, has shown that the United Kingdom has a lot to offer and a lot to gain from the programme. Whilst we will achieve that best from position of full commitment, I accept that we must be able to do so on terms that we find acceptable. That is our aim, and I will do all that is reasonably possible to achieve that. I am looking forward to the Committee's report on this issue and I hope it will be in time to help inform the discussions that we have at the Transport Council in December.

Q177 Chairman: One would hope so Minister. That all sounds astonishingly optimistic. So am I to take it that the difficulties which did exist have been resolved ahead of the Council meeting in December?
Mr Jamieson: With a project of this size, one would expect there to be a lot of difficulties especially with the number of countries involved and the sort of competing interests. Not least, we have to resolve the issues with the United States on the interoperability which were terribly important. A lot of those issues are now resolved. We are in a better place than we were six months ago and a much better place than we were 12 months ago, but there are some issues to be revolved. There are still things to be sorted on the issues to do with the concessionaires who will operate the system and the PPP; that will take time. I do think we must actually commit ourselves to making a success of that.

Q178 Chairman: So do you assume that in December, a decision will be taken about one of the two consortia?
Mr Jamieson: I think in December, we will be in a position to give further confirmation of the EU's commitment to Galileo. I think a decision will be made on the PRS part of the system, which we now support. I think that the decision on a final concessionaire is probably more likely to be made in February or at the next Council meeting in the spring. Then I would imagine the final confirmation of who that concessionaire would be and getting them underway with the contract would be late in 2005.

Q179 Chairman: Are those decisions going to be taken by qualified majority voting?
Mr Jamieson: Those decisions will be; yes.

Q180 Chairman: Are there any sceptics amongst any of the other European nations?
Mr Jamieson: About what?

Q181 Chairman: About moving towards the next stage of Galileo which will be, even by its own cost estimates, fairly considerable in terms of investment.
Mr Jamieson: We are not aware of any scepticism. There are many questions to be asked and we, the French, the Italians and the Germans particularly have been asking a lot of questions. I think the newer accession states, because they have had less involvement up to now, have understandably had fewer questions. We are the countries that have the major space industry and have the most to gain from it and there have certainly been questions and discussions, but I am not aware of what I would call scepticism or certainly no cynicism.

Q182 Chairman: Are you confident about the Commission's cost estimates?
Mr Carey: I think we certainly share the scepticism of several other member states about the value for money of the programme, the importance of ensuring that there is a clear value for money case. You may have seen the communication from the Commission a week or so ago which provides the basis for discussions leading up to the December Transport Council. That proposes a funding line for the next six-year period, 2007 to 2013 of €1 billion for Galileo and seeks an irrevocable commitment from the Transport Council. We and several other Member States are clear that that is certainly not a commitment that can be made at this stage of the process before the concession

negotiations have concluded and before the overall negotiations on the European Community's financial perspective are concluded next year.

Q183 Chairman: Are those reservations shared with other members of the Transport Council? Or is it just the British that have this nasty feeling that they should have value for money?
Mr Carey: We are most definitely not alone on that, and other Member States are equally concerned about the overall Community budget and recognise that we need to firm up on the value for money proposition in Galileo.

Q184 Chairman: Are you satisfied that there is not indication that the Commission would expect to go on putting in the same subsidies after 2013?
Mr Carey: I think that the need is identified for a subsidy in the run-up to 2013.

Q185 Chairman: Yes, I think we are aware of that, but I am asking you something else. The attitude towards this ought to be governed, not just by value for money at the moment, but what we are committing ourselves to in the long term. What degree of exactitude is there in the Commission's statement about the subsidy that will be needed continuously because the tax payer has a boring habit of wanting to know what is happening to their money?
Mr Carey: In seeing the final details of the successful bidder's proposal, we will need to see what the funding requirement is beyond 2013. The reason that the Commission is focused on the public funding provision up to 2013 is because it is recognised that it is in the early years of the concession that there may be the biggest shortfall between the revenues obtainable from the system and the costs incurred.

Q186 Chairman: And you would expect those figures to be available to you once the contracts are ready for signing in effect.
Mr Carey: We would certainly want to see greater detail on this over the next six months or so.

Q187 Chairman: Forgive me, but in government circles, "wanting to see" and "being confident that the figures will be available" are not exactly the same thing.
Mr Jamieson: I think that other countries will also want to see those figures and to know what the ongoing commitment will be. Once we have got to the point where we have chosen a preferred concessionaire and then to the point where we finally confirm that concessionaire, later in 2005, I think we will want a very, very clear idea of what the ongoing commitment of the public sector will be at that stage. There are still some negotiations to take place. It is not set in stone yet. I am sure that there will be other countries who will want to know what their commitment is going to be.

Q188 Mr Stringer: As I understand the basic structure of the finance of the project two thirds of the money is expected to come from a concessionaire, private services.
Mr Jamieson: Yes.
Mr Carey: Yes

Q189 Mr Stringer: What happens if that money does not materialise?
Mr Jamieson: Well, this will become clear during the coming year. Firstly, why we need to make a commitment of the European countries is so that we are making this commitment on the basis of the knowledge that we have now so that the concessionaires can then get the money from the bankers and the financial support that they need. If we did not do that, of course, then they would not get any support. That is the first thing. The concessionaires will obviously have to do a good job, doing their own homework, of establishing whether or not they can do what they say they are going to do within the cost. We are obviously going to have to monitor that. If, for any reason, that money was not forthcoming in the end, let us say that at the end of next year, then we would really be right back, not to square one, but we would be a lot of squares back in the game, where we would then have to reconsider the whole programme and how we are going to fund it.

Q190 Mr Stringer: I think you are missing the point. Take us three years into the future, four years into future, contracts are signed, the banks, the government, the European Union, the Commission, everybody else has looked at the figures and everybody is happy, but when it comes down to it, that income does not arise. Who takes the risk? Does the government pay for the loss of revenue?
Mr Jamieson: At that stage, if that happened, and remember that one of the benefits of this is that you transfer that risk into the private sector, rather than into the public sector, because if it were wholly in the public sector then it would fall on the governments that were involved, but if, *in extremis*, the concessionaire was collapsing for some reason and it could not go on, then there would have to be a discussion at the Council as to what was going to be the future and how we were going to fund it. I think it would be inconceivable at that stage that we would pull out altogether, because we would have had so much funding committed. However, we would then have to make a separate decision later on. I hope we will not get to that stage and that is why we need to do a very thorough job of making sure the concessionaire's figures are good and robust.

Q191 Mr Stringer: Well that sounds to me like a pretty strong public sector guarantee of taking 100 per cent of the risk.
Mr Jamieson: No, the risk at the moment will be taken by the concessionaire and if losses were incurred, those would be by the concessionaire. What I am saying is, if, in the very unlikely event

they collapse completely, then we would have to make a decision as to what we were going to do, whether we were going to fund it or let it collapse altogether.

Q192 Mr Stringer: Clearly if the concessionaire were liquid, they would take losses if they went bankrupt. I think I heard you say that the European Union would carry on with the project and the taxpayer would pick up the tab.
Mr Jamieson: What I said was that we would have to make a decision as to how we were going to fund it in the future and it may be, that at that stage there may be other concessionaires who would want to come forward and take the project on.

Q193 Mr Stringer: But potentially, and I think you are being admirably open and honest, you are saying the whole of the cost could go back to the European Union and the taxpayer.
Mr Jamieson: In a set of circumstances where a number of things happen, which I think are unlikely, that is a possibility. What is very important in negotiations and discussion we have, particularly in the next few months leading up to the final decision about the concessionaire, is that we make sure that all the figures are robust and that that event does not happen.

Q194 Mr Stringer: How is that unhappy scenario fitted into the cost-benefit analysis which is being done for you?
Mr Carey: The cost-benefit analysis goes back to three years or so ago and we expect to see more detailed cost-benefit work to support the decision to proceed with the actual contract itself next year. That would obviously need to take account of whatever allocation of risk emerged from the negotiations underway over the next few months. As witnesses from the industry side may have told you earlier on, the particular focus of the additional bidding period about to begin is on risk allocation to try and achieve the best balance between public and private sector risk and that would have to feed into the assessment of overall cost benefit before we make the final decision.

Q195 Mr Stringer: I take that to mean that the scenario where the concessionaire falls flat on its face, goes bankrupt, is not part of the cost-benefit analysis. Is that right?
Mr Carey: If it ends up coming back into the public sector in time, yes that would be a completely different version of the Galileo programme and that is almost back to square one in assessing the risk.
Mr Jamieson: It would not be the version that we have in front of us now; it would be a new scenario, a new version and we would have to make new decisions.

Q196 Mr Stringer: I thought the purpose of cost-benefit analysis was to look at both the costs and the benefits. So that cost is not taken into account. We heard earlier from some experts that the original cost-benefit analysis double-counted the benefits, because in actual fact some of the services which had been credited to the Galileo system already existed from GPS. So there is really only marginal benefit but you are counting it as 100 per cent benefit. Would you care to comment on that?
Mr Carey: I certainly was not aware of that.
Mr Jamieson: We were not aware of that. We will look at that evidence and we will do you a note on that. I should like to see precisely what they said and give you a considered response to that.
Mr Stringer: That would be very helpful.

Q197 Chairman: You do realise that we do not really relish the idea of an orbiting Railtrack the Second.
Mr Jamieson: You may not relish the idea of that, Mrs Dunwoody, and I can assure you that we concur with that view tenfold and so would many other countries involved in this process.

Q198 Mr Donohoe: What is the USA's attitude towards Galileo?
Mr Jamieson: The United States has entered into an agreement with the European Union on the interoperability of GPS, so they will be complementary systems.

Q199 Chairman: Are you sure of that? Has that been agreed recently?
Mr Jamieson: Yes, that was agreed last June. It was just before we had the Scrutiny Committee last June. I think I announced at that meeting that we had just concluded that agreement. So, yes, there is a great interest, because it will complement the work of the GPS.

Q200 Mr Donohoe: Why the need for both, if they are going to complement each other? Why do we not, instead of having all this resource set up as though we are reinventing the wheel, go and help the Americans improve their system?

The Committee suspended from 5.30pm to 5.40pm for a division in the House

Mr Jamieson: Why have the two systems? Essentially, Galileo is a civil system for civil uses, GPS has civil uses but was essentially a military system and it was designed and is used for that and will continue to be used for that by NATO and ourselves as part of NATO and of course the Americans as well. The Galileo system is complementary to GPS and part of the reason why the Americans welcome it is because it is actually complementary and will give them better access to some of the open access services and actually improve them. It gives accuracy: instead of about ten metres on the open access system, we have accuracy down to about one metre which, for certain purposes, is going to give a much better system to use. The other thing is that we will benefit in the United Kingdom, and to the wider extent in the European Union, from getting some of the technology and the industry working on this space project and the massive amount of other industry

that comes from it, the software that is going to be developed, that we are particularly good at in the UK. Those systems, instead of being located, as they are currently, in America and to a much lesser extent in Russia, they are going to be here in the European Union. So it is good for our country, it complements the system. The other thing it has is greater integrity: because of the larger number of satellites, we will have a much greater integrity on the open access system.

Q201 Mr Donohoe: But you did say it was compatible and it seems to me that it is almost as though you are having duplication for no real purpose. If, for instance, you were to have a partnership with the United States to look at how you would advance the present system, so that it would operate perhaps even more efficiently than what you explained, then, it does seem rather a waste of public money for us to be investing €3.2 billion in this system when there is already one there.
Mr Jamieson: We have the best of both worlds here: we have an interoperable system, so we can use GPS in conjunction with Galileo, but what we also have is a system that is more sophisticated for our use. The really important thing is that if we, let us say, worked with the Americans in improving the GPS to bring that up to standard, we would have to do similar things and there would be similar costs. I presume, if we went into a partnership with them, we would have to find some of those costs, but we would not get the benefits then for our own industry.

Q202 Chairman: Who pushed to make this a PPP in the first place, Minister?
Mr Carey: I think it was advisers to the Commission led by some UK players; certainly the UK government was keen to pursue the PPP route, but several other Member States were interested in getting best value from this.

Q203 Mr Donohoe: May I ask why the US changed its position? I have talked to generals in the American Pentagon who are totally opposed to the concept. They believe that it will be, at some point in the future, used militarily and as a consequence of that, they are already working on proposals to overcome this, by using lasers to knock them out of the air or whatever. What has changed the American's attitude to this?
Mr Jamieson: Firstly, you can see why the Americans might take an approach, not of hostility, but you could understand why they would have an approach where they would have some doubts about it, because in fact, it is going to supersede some of the work that GPS is currently doing and, of course, the system is not entirely free to the United States, they sell the licence for the equipment which actually receives the GPS signal and of course their industries benefit from that. I think their reservations would be that they would see some of the industry developing in other parts of the world. I think that is a huge benefit to us in the United Kingdom. I think what has changed their view is that they are seeing the enormous determination that there is in the European Union to make this a success. On the basis of that what they have done is to work with us in making sure that they are interoperable, because they are going to get some benefits from that. I think the other thing is, now that the assurances which have been given about military use—and I am talking about military applications, not use by the military, which I would define as separate—now they have got some reassurance that it will not be able to be used by hostile third countries against the United States is probably why they have changed their mind.

Q204 Mr Donohoe: Who gave them these assurances?
Mr Jamieson: This was in the negotiations that have taken place.

Q205 Mr Donohoe: Was this in Ireland?
Mr Carey: Yes, it was signed in Ireland.
Mr Jamieson: Yes, it was signed in Ireland.

Q206 Chairman: So this is the European Union offering them this guarantee that it cannot be used against the United States by a hostile country. Is this signed in blood? Where did this assurance come from?
Mr Jamieson: Let us be clear what it could be used for. The current GPS system which Americans have ownership of could be used by a hostile nation for determining where the tanks were or troop movements; they can use GPS. The Americans, in a war situation, would then have to block that signal to the hostile country. What they have from us and a total determination, I have to say, from most of the countries in the European Union, is the desire not to use this for military applications. The sort of military application I am talking about is not determining where troops are or where a tank might be, but actually guiding a missile to a pinpoint location.

Q207 Mr Donohoe: The fact is that the Americans at this stage do not have the technology to be able to do just exactly what you have said. That is the understanding that we have. They do not have current technology and infrastructure to jam systems at this point.
Mr Jamieson: My understanding was that they had.
Mr Carey: The technology is advancing. The essence of the agreement between the EU and the US, in which the UK played a—
Mr Donohoe: They may have in the future, but they do not have the current technology to be able to do that.

Q208 Chairman: We have just been told, however, that it is very easy to jam these signals. Is that so, or not?
Mr Jamieson: The open access system, just like the GPS, would be open access anyway and for use of movement of troops, not for applications but for general military use, then if they wanted to that in

a war theatre, I think they call it, had to do it, they have to jam the signal, they have to jam their own signal.

Q209 Mr Donohoe: We are told that they could jam the Galileo signal, but maintain their own system.
Mr Jamieson: Yes.

Q210 Mr Donohoe: Is that your understanding?
Mr Jamieson: But they cannot jam the whole signal round the world, they can only jam it in narrowly geographically focused situations. It is not cutting the whole system off. Paul Johnston may be able to enlighten us here.
Mr Johnston: I think the crucial feature, or one of the crucial features of the EU/US agreement that was reached in June, was that the baseline signals for Galileo, both the Open Service and the PRS, if it is decided to have the PRS, would both be such that the Americans would be able to jam both Galileo signals if they needed to locally in a conflict area while continuing to use the GPS military code. That is the basic operational safeguard for them.

Q211 Chairman: And that was actually the undertaking.
Mr Johnston: That is correct and that is precisely why we are—

Q212 Chairman: So it a very specially focused technical undertaking that can be delivered from their point of view because they still have a degree of control.
Mr Johnston: Yes, and that is why we insisted with our European Union partners that those signals had to be separate in order that the Americans would have the certainty that they could jam in a specific area.

Q213 Chairman: Fine; and that has been agreed.
Mr Johnston: That has been agreed by both sides.

Q214 Chairman: And that will be part of the specified conditions for whoever is the undertaker here.
Mr Jamieson: Absolutely and even further than that: that will be clearly written into the purpose that Galileo will have in the PRS systems. It will be used by governments, but the purposes for which they can use them will be very clear: it will not be for military applications. The only way that could change, and who knows, there may be a change, but if a change were to take place, that would be by the Council under Pillar 2 and would have to have unanimity of all the 25 countries to make a change to have military applications.

Q215 Chairman: So unlike the other decisions which have been taken by qualified majority voting, you are saying this one would need unanimity.
Mr Jamieson: Indeed, absolutely.

Q216 Mr Stringer: Which countries do want to use Galileo for military purposes? You distinctly said a majority of countries do not.
Mr Jamieson: Are you defining the difference between military purposes and military applications?

Q217 Mr Stringer: I am trying to understand what you said.
Mr Jamieson: Well, for military purposes, you could have the movement of troops and tanks; just as for any civil use like movement of buses it could be very useful in military circumstances.

Q218 Mr Stringer: What I want to find out, when you said a majority of countries in the EU do not want to use this for military purposes, is which countries are in the minority that do want to use it for military purposes.
Mr Jamieson: One of the military applications could be guiding a missile to its target and it could be very attractive to someone who was going to sell guided weaponry to which they could fit this and sell it to third countries. There has been talk that the French had some interest in this.

Q219 Mr Stringer: So the French. Are they in a minority of one or do any other countries want to?
Mr Jamieson: I am personally not aware of any other country which has an ambition.
Mr Johnston: The EU as a whole has agreed in successive Transport Council decisions that this is a civil programme. As the Minister explained, it would require all EU Member States to change it into anything other than a civil programme. I am not aware of other countries which see a requirement for that; 19 of the 25 EU Member States are members of NATO, therefore all of them use GPS as the *de facto* NATO standard. There are permanent agreements between the European Union and NATO which allow the EU to have access to NATO planning and NATO assets for EU-led operations which will be the case, for example, with the EU-led operation that the United Kingdom will be leading in Bosnia where we take over from NATO in December. That will be an EU operation supported by NATO assets, with the NATO commander working for the European Union. So I think there is a strong, if you like, "Atlanticist" majority in the European Union, particularly the new Member States, but others as well, who see a very clear distinction between the EU role and the NATO role. Indeed the new EU treaty, which everyone has signed up to, includes, as a British initiative, for the first time in an EU treaty, language which says that NATO is the basis of the collective defence of its members. So in fact the debate in the EU in those terms is moving towards greater clarity, that NATO does collective defence and the EU does crisis management.

Q220 Ian Lucas: We have heard about the different timescale and that there has been some discrepancy about the progress. Given that the decisions of the Council take place in the sort of timescale that you have indicated, when do you expect that Galileo will be operational?

Mr Jamieson: May I ask Mr Carey who has been dealing with this to run through the timetable as we see it?
Mr Carey: The stated position from the Commission and from the joint undertaking is that the Galileo programme should become fully operational by 2008.

Q221 Chairman: Fully operational? All the satellites.
Mr Carey: That is the stated position. I think all involved recognise that with the complexity of negotiations around the PPP there may have to be some slippage in this. The Commission themselves intend to return to this once more progress is made with the PPP negotiations through the course of next year. I think therefore, it would be sensible to talk about a sort of 2008 to 2010 timescale in practice for full operation.

Q222 Ian Lucas: The evidence that we have heard today was emphatic that that was a completely unrealistic date; not just because of the financial arrangements, but because of the technical situation.
Mr Carey: Yes, there is a combination of factors which are slowing the programme down and it is the Commission and the joint undertaking at present which are in the lead in terms of formally defining where this is going and we wait for them to catch up with these realities and set out a new programme as soon as they feel able to.

Q223 Ian Lucas: How does that affect the costings? How does that affect the projected income as far as Galileo is concerned?
Mr Carey: In most cases, it would just be a shift forward in the timescale. There will obviously be some additional costs to the bidders through the next round of negotiations, but that in itself is not necessarily a factor which is leading to any increase in the cost of the programme.

Q224 Ian Lucas: What are the projected sources of income from the private sector for the public-private partnership?
Mr Jamieson: The sort of income streams would be, just as there is on the GPS system, selling the licence for the equipment that would actually used to receive the signal; that is the same as the GPS, but that of course instead of going to America would come to the concessionaire and to this country. So that would be one source of income. There would be an augmented system, where a slightly better signal could be used for commercial purposes which would be paid for. The PRS, should countries and public bodies in the countries in Europe find a use for that, would not be paid for by the 25 countries, that would be paid for by those who use the system.

Q225 Ian Lucas: By the public sector?
Mr Jamieson: It would be by whoever was making use of it in those countries. So, if a country were using it, let us say, for surveillance purposes and using it in conjunction with their police, they would want a highly encrypted code that could not be accessed easily by others; whichever body it was, they would have to make a decision as to whether it was worthwhile to buy that service in from Galileo.

Q226 Ian Lucas: Do you think it is right that the public sector makes the initial investment and then has to pay for the services when they are supplied at a later stage?
Mr Jamieson: I think we have to make the initial investment. What is happening then is that the private sector is making a huge investment into this: we are seeing all sorts of benefits in terms of our industry. Some of the benefits will be from what is the "free service", but I put that in inverted commas, the open access service which will be just freely open. Those are the sorts of services, quite honestly, that we will want to use. The majority of the uses would actually come from that Open Service. So, for example, if in the future we were looking at in-car services, better navigation systems, even some sort of pricing system for roads—which may come, we have opened a consultation on that, it may happen in the future—that would be happening in that sector, so we would be benefiting from the money that we had invested.

Q227 Mrs Ellman: Minister, you spoke about Galileo bringing, I think you said, 1,000 new jobs to the UK. Could you identify those jobs a little more and say where they would come from?
Mr Carey: I would need to check on the detail of where that comes forward, but we certainly have been drawing on consultants' reports, ESYS, going back to 2002 which assessed the extent to which the UK might benefit from the work in the development in the deployment phases of Galileo and, as I am sure industry colleagues have been telling you already, the UK has in fact been doing extremely well so far in winning work from this phase of the programme. When you start to count up the associated companies which will be supporting the direct contractors on Galileo, I think you will probably find you are already in that area of 1,000 jobs.
Mr Jamieson: What we do know is that of the value of the work which has been done so far in the first stage, the UK has picked up 30 per cent of that work out of all the countries involved. I am not sure we are going to be able to carry on with that proportion of benefit, but at the moment we have picked up a very substantial benefit and what we will do, if it would be helpful, is drill down to get a bit more detail for you on which companies might have benefited.

Q228 Chairman: Investigate please.
Mr Jamieson: Yes. It is the space industry which has benefited, the people who are building the satellites. There is a company in Surrey which built the first satellites. Yes, this is benefiting us in a big way. The other thing that really attracts me to it is that these are not low quality jobs; these are right

at the cutting edge of science jobs, the things we in the UK are really good at and the sort of jobs that we are trying to encourage in this country in the future.

Q229 Mrs Ellman: What is the government doing to maximise the research into business benefits?
Mr Jamieson: We are doing a number of things. We want to make sure that local authorities and regional authorities are working together and companies are getting the very best use of what technologies there could be there in terms of, firstly, the use of them and, secondly, the benefit in creating jobs and getting in on the contracts. We have had one Galileo Day which was sponsored by my department where we invited in a lot of the interested parties and that had a lot of interest. I know that a number of the regional assemblies now are very proactively working with the companies in their area and looking to see how they could benefit from bidding for some of the contractual work.
Mr Carey: The British National Space Centre is leading on this work. They support the Pinpoint Faraday Partnership to develop downstream applications; they are working with the regional development agencies, with the Institute of Electrical Engineers as well, to promote awareness of the opportunities for wider UK industries from the programme. As far as the 1,000 jobs figure is concerned, we certainly know that already something like 500 people are employed in Galileo industrial work in the UK at present and we would expect the further jobs to come from upstream UK suppliers to those direct contractors. We can firm up on the detail of that, as the Minister indicated.

Q230 Mrs Ellman: What has been done to promote how Galileo can benefit public services? Has there been any promotion, information, going, say, to local authorities to see how this could be used?
Mr Jamieson: I do not think we are perhaps in that phase yet. I think once the system becomes established and once we have some more certainty with the concessionaire and perhaps at the end of next year when we are in a position of more certainty, that will be a time very much when the users of the system will be looking to see how they can make really good use of it. I think a lot of them will have it in mind already, bus companies I am sure for accurate pinpointing of where their buses are. There are some quite interesting applications: pinpointing where your children are by having a sort of satellite system which might be quite useful for young children.

Q231 Chairman: I think Mr Orwell thought of that first.
Mr Jamieson: The really exciting thing about this is that, just as six or seven years ago we did not think we were going to have a mobile phone that would take a picture you could transmit half way across the world, this opens up a lot of wonderful new opportunities and what we want industry and the public and private sector to do is to look firstly at how we can make use of it and secondly how we can build in some of the technologies. I can imagine attracting this type of job into an Objective 1 area would be extremely valuable.

Q232 Mrs Ellman: The UK is bidding at the moment to host both a Galileo control centre and the supervisory authority. Is that something that you are supporting and that you feel would be beneficial?
Mr Jamieson: Absolutely. This will entail, not a huge number of jobs, but it will be jobs. We have two areas, in Wales and the East Midlands, which are actively putting their bids together to get that in their area. But, as you know, these things are done by negotiation between the countries. The really important thing is where the concessionaire then has their headquarters; it may not be in one place, it will probably be in several countries, but I think that is going to be really important. That is really where the jobs are going to be and, of course, we in the United Kingdom are looking attractive for that, but it will not be for us to decide, that is for the concessionaire to decide. We are looking attractive because already a lot of the industry base, a lot of the intelligence is in this country but the warning is, of course, that the French are competing very strongly, so are the Germans and Italians.

Q233 Mrs Ellman: Could you just clarify who would actually be deciding where these things are and what sort of things would the concessionaire be deciding?
Mr Jamieson: The Supervisory Authority would be a matter for the Council to decide. That does not involve huge numbers of jobs, but it will be significant and important for whichever country gets it. The concessionaire will decide, obviously, where they are going to have their own base. It will be for that company to make that decision, just as it is for any companies now. It will be important, again because it will be significant, but I think what will be even more important beyond these two centres, what will be really important, is where the goods and services are bought from and we in this country are really good at some of the downstream services in terms of software. Those are the things that are going to be really valuable in creating employment opportunities.

Q234 Mrs Ellman: What progress is being made on setting up the supervisory authority and on deciding its structure?
Mr Carey: The core structure and principles of its operation are in place following agreement to the regulation on management structures at the June Council this year. That has determined that the supervisory authority will be set up to follow on from the current joint undertaking. The supervisory authority will be contracting with the successful concessionaire to oversee the operation of Galileo. The supervisory authority will be steered on questions of strategy and policy by the Transport Council, but it will have its own administrative board to carry out day-to-day

business and that administrative board will make decisions on a majority voting basis. There are separate arrangements to be put in place in the event of crisis, that is, in the event of a threat to the security of the European Union or of individual Member States and that then gears the Pillar 2 unanimity approach to action and in the event of a crisis, any Member State could seek a decision of the General Affairs and External Relations council, acting by unanimity, to instruct the supervisory authority to take whatever action is necessary.

Q235 Chairman: Is there any likelihood, if the commercial services do not take off, that the public services, which would be fairly plainly in the public sector, mainly, because the ones you quoted are nearly all public applications—
Mr Jamieson: The PRS system, yes.

Q236 Chairman: Is it therefore possible that we shall have a continuing subsidy from the state for these services?
Mr Jamieson: If that did happen, and I think it is highly unlikely because there would be a lot of exciting commercial uses, in fact I think there are going to be far more than we are anticipating at the moment, but in the unlikely event of that, the point I was making to Ian a moment ago, those who use the PRS system will pay for it. If a country is making a lot of use of it or the public services in that country, it seems to me only right that not all the countries pay, but those which make use of it pay.

Q237 Chairman: Yes, I understand that. Let me ask you something else. How would you in fact control some country that decided to use the system for military ends, particularly if it was a country that was quite good at ignoring the rules? I make no particular allegation.
Mr Jamieson: I am sure the Foreign Office have contemplated this.

Q238 Chairman: No country immediately springs to mind.
Mr Johnston: The first thing to say is that we are safeguarded by the provision in the treaty which says that the common foreign security policy, which embraces all aspects of security within the union, requires decisions to be taken by unanimity.

Q239 Chairman: Yes, Mr Johnston. Let us start this conversation again on a new basis of realism. I am not really very interested in what it says on the paper. I am saying to you: how do you monitor what individual countries do with this system?
Mr Johnston: There is going to be what is called a policy on access, which will set out how the Council, on which all the Member States are represented and the subsidiary bodies, distributes the technology involved; in the case of the PRS system that would be to public authorities. We will be arguing, as this policy on access is developed, for there to be a high degree of transparency and very robust measures.

Q240 Chairman: So it is quite possible it will not be transparent and you will not have any kind of robust controls.
Mr Johnston: We will have to make the case for that and I am sure we will have plenty of allies in doing so.

Q241 Chairman: And that will have to be decided by unanimity, including those who might have a tendency not to do things by general agreement.
Mr Johnston: If there are security or defence implications, the treaty says that decisions are by unanimity.

Q242 Mr Donohoe: May I just ask a question about what the Minister said in terms of it only being paid for by those countries who are using it?

Mr Jamieson: The PRS?

Q243 Mr Donohoe: Yes. Did you mean that?
Mr Jamieson: Most of that work has probably been done in the development stage and of course we all contributed to the development stage. The extra cost of getting it fully operational is probably now really quite small, a small proportion of the total cost. What I was saying was that if the PRS system is used by a country, usually a public body in that country, then they would pay for the access to that, yes. The concessionaire would have to consider the costs and prices and so on, but that will all be built into it. So it is the user who pays and at the moment we cannot see any applications for ourselves.

Q244 Chairman: You did say that, so that means that a less robust service is going to give you the technology base you need for things like air traffic control.
Mr Carey: I am sorry; I did not follow the question

Q245 Chairman: The Minister has just repeated what you already said in your evidence, that you do not see a specific UK need for a PRS. Does that really mean that you are quite satisfied that less robust services will give you the technology base you need for air traffic control, or for something like road pricing, or for tagging offenders, one of Mr Blunkett's bonanzas?
Mr Jamieson: I think the simple answer to that is if that the air traffic controllers come to us and they say, well we are going to need—

Q246 Chairman: No, no; forgive me, Minister. You are the Ministry for Transport and we have had a little involvement with national air traffic services over the last two or three years. Are you genuinely saying to me that the department sees—that is what you said, you said it again today—no specific UK need for PRS? Is that really your view?
Mr Jamieson: Yes, that is currently our view.

Q247 Chairman: Ordnance Survey have said to us that it is essential to the emergency services. Is that wrong?

Mr Jamieson: Sorry; who has said that?

Q248 Chairman: Ordnance survey, those boring people that do all the mapping.
Mr Jamieson: If they have expressed that as a view and if they can sustain that view and put that point to us, then I am happy to change my mind.

Q249 Chairman: But you are not aware of that. You are not aware that it might be essential for critical operations.
Mr Jamieson: No, because that has not been bought to my attention. What I am saying is that we are in favour of the PRS existing and we are going to be voting in favour of it at the Transport Council. What I am saying is that we have not identified currently any need that we have. That does not mean to say that we are not open to persuasion that there might be uses that could be made of it by us.

Q250 Chairman: So, under what circumstances could you imagine the Galileo Safety of Life and the commercial signals being withdrawn but the PRS signal remaining?
Mr Carey: I do not think we have envisaged those circumstances. Certainly the services such as the Safety of Life one would provide the added accuracy and protection that a lot of emergency service uses would need. We have not yet seen a clear requirement to move into the PRS from these agencies, but ultimately that would depend on their own operational requirements which we will need to keep track of.

Q251 Clive Efford: Could you explain whether the government sees road charging and the national lorry charging scheme being under PRS or another part of the system?
Mr Jamieson: We are clearly open to persuasion otherwise, but as we understand what will be required of the lorry user charging and any future charging for road pricing is that the open access system would be more than adequate to carry that out. That is our current understanding. These things are in their infancy and we are a long way from road user charging; probably ten years away at least. We are a few years away still from lorry user charging.

Q252 Clive Efford: Is that one of the areas that caused you to have doubts and that you have now had negotiations about and overcome, which has led you to the conclusion that you would now support PRS being part of the system?
Mr Jamieson: No, I do not think so. We are fairly certain that the applications that we want can be carried out with GPS and Galileo working together on the open access system. We are confident that they will carry out what we need. The reason is that we do not need the high level of encyrption, whereas you would on a more secure service.

Q253 Clive Efford: I will have to go back and check the detail in the evidence, but my recollection is, from what we have heard this afternoon, that it contradicts that and that the expectation is that those sorts of services would be part of the PRS system. Would that surprise you?
Mr Jamieson: This is the value of these hearings. If people are saying that to us, then we are very happy to look at that. But I have to say, in all the discussions and negotiations we have had up to this point, that has not been, to my knowledge, drawn to our attention before and you would have thought after several years, if people really believed that and knew what our position was, they would have drawn that to our attention.

Q254 Clive Efford: I was just about to express the astonishment that you were expressing, in the sense that if government have been involved in discussions about Galileo, I am actually surprised that whether it is part of the open access system or whether it is part of the encrypted system is not something which has been copper-bottomed.
Mr Carey: The focus around the PRS, certainly from other Member States who are expressing an interest in its use, has been around law enforcement, border protection services and we certainly have established from Home Office colleagues that there is not the need or desire to move in that direction in the UK for those purposes. A broader survey may well bring other evidence.

Q255 Clive Efford: Is an encrypted service more secure?
Mr Carey: Yes.

Q256 Clive Efford: We heard earlier on that you can buy these jamming devices quite cheaply, so if I were a lorry operator and I popped down and bought a load of jamming devices, could I avoid paying the lorry charge?
Mr Jamieson: I think that is going to be highly unlikely, because, just as the GPS military system is very difficult to jam, this encrypted system, being a much more powerful signal, will be very, very much more difficult to jam.

Q257 Clive Efford: No, you have just said that we are not going to be using the encrypted system. We just heard from some very pointy-headed people who are very knowledgeable that you could actually, on top of a very high hill around the South of England, jam quite a wide area and at very good cost by the sounds of it. Have we given consideration to the fact that the lorry scheme will be open to abuse even before it is introduced?
Mr Jamieson: Just as if someone were operating a signalling system, which, as I understand it, is not a cheap and simple system, if you were operating a jamming system, you could actually jam things like radio signals to people's radios and televisions. Currently, you would be spotted fairly quickly doing it if you were jamming the signal, because

you would jamming it for lots of other people as well and the law enforcement agencies would have a role in preventing that.

Q258 Clive Efford: But the technology is there and if it could be localised in order to mask the movements of a lorry, you could save quite a considerable amount of money. I would not suggest that anyone would go to those lengths, but I am just using it as an example of where we may have a flaw in the system if we have not given it full consideration.
Mr Jamieson: In theory it could be done. You could equally argue that people could steal the diesel for their lorries and they could get free travel that way; there are all sorts of ways you could cheat. This is going to be much more obvious: if somebody is actually jamming the signal, that is going to be traceable and very obvious.

Q259 Clive Efford: If we had to go to the encrypted system, if the methods that we need in order to introduce these charging systems required it, would you feel aggrieved if the taxpayers were forced to pay again for the PRS system, having paid a third of the development cost?
Mr Jamieson: I do not think I would be aggrieved. At the moment this is a bit of a hypothetical question, because at the moment we are told that that is not going to be required. I think we should be very disappointed if we found the open access system were not giving us a lot of the things that we anticipated the current uses for. We should be very disappointed.

Q260 Clive Efford: I think we all would, given that you have made the assumption, but do not seem, if you will forgive me, to be able to guarantee that we will be able to do what we want to do on the open system. For instance, we were told earlier on that the PRS makes up 20 per cent of the business case from the private sector for Galileo
Mr Jamieson: Or thereabouts.

Q261 Clive Efford: But it is actually only 5 per cent of the costs. Given that taxpayers across the European Union have paid a considerable amount towards the development of Galileo already, does it seem fair that they should pay again, if they need to use the encrypted system?
Mr Jamieson: Yes, but the investment that is being made from the public sector is providing all this open access that is free of charge, except for the cost of getting the receiving equipment. That is free of charge and that is what we have paid for. What we are saying is that if people need very specialised encrypted services, then there will be an extra cost and the cost should not fall upon those countries which are not actually using it.

Q262 Clive Efford: What intellectual property rights will be required by the concessionaire?
Mr Carey: The IPR, in principle, rests with the supervisory authority and it is still one of the factors for negotiation, how far the concessionaire—

Q263 Chairman: There is a lot of question marks really, is there not? Forgive me, we are at an early stage, but we are not at that early a stage, because we are talking about committing many millions of euros. May I just ask you a political question Minister? Supposing (a) you do not get the contract and (b) you soon discover—
Mr Jamieson: Sorry; who does not get the contract?

Q264 Chairman: I am sorry if I am not precise. Supposing a British company does not get this concession and is not part of this spearhead for new technology and new services and new public services, what is your attitude to the continued commitment of large amounts of money to this service going to be?
Mr Jamieson: It would be preferable that the concessionaire which has the UK interest in it would win the bid. There is no question about that: that is preferable. If it is the other bid, which I think is French, Spanish, Italian based, then there will be still, firstly, be lots of opportunities for UK companies to be bidding for the work and to be providing the industrial side of it. The other thing is that we will still have all the uses of the system.
Chairman: I see. So you are quite satisfied.

Q265 Clive Efford: May I go back to the costs? In an earlier answer you seemed fairly confident about 2008, but you accepted that there might be some delay because of the negotiations around PPP, which, if the Underground is anything to go by could take us into the next century. I wanted to ask about costs in relation to timescale. If we are now talking about 2011 to 2012 for implementation, has that made you revise your costs? Is there an additional cost to the public purse?
Mr Carey: No. First of all we await this confirmation from the Commission of a changed timescale. Their most recent communication still bases the forward public expenditure profile on the basis of a 2008 operational date. That question mark over the starting point is one of the factors we will question in the discussions in Council in the next month or two.

Q266 Clive Efford: If the concessionaire is chosen in that intervening period, which seems likely, would they be able to come back then and say "Well, time has moved on, costs have moved on, we need more money if we are going to put all these satellites up"?
Mr Jamieson: Well, I hope there would be a preferred concessionaire by the spring of next year, but then there will be some further negotiation before the final contract is signed and at that stage we would have to be determined that all their figures stacked up and that we fully understood

their figures and that the case was robust before we gave the contract. What we would not want is that after the final contract had been signed and they had finally got the job, then they were coming back to us.

Q267 Chairman: Minister, I can see we are going to have endless fun on this for many years to come. I am very grateful to you and your colleagues for coming this afternoon. We shall continue to take a warm and careful interest in what happens. We shall also hope to get a report out soon enough to make some comments.

Mr Jamieson: I hope our contribution to your deliberations has been helpful.

Chairman: You always, Minister, are not only enlightening, but charming, helpful and talented and indeed I am astonished altogether that you are only a minister in the Department for Transport. Thank you very much for coming.

Written evidence

Memorandum by Walter F Blanchard Esq (GG 01)

GALILEO

Q1. *What benefits will Galileo Phase II bring that EGNOS (European Geostationary Navigation Overlay System) will not?*

EGNOS is not a navigation system. It is a limited-purpose monitoring system designed only to perform checks on the correct performance of GPS independently of the US's own GPS monitoring service. It is incapable of independent fixing and would be useless for navigation on its own. It was considered advisable to build a system to check GPS independently because the United States does not provide any guarantees of GPS performance to civilian users and disclaims responsibility for poor GPS performance over foreign countries. Galileo is intended to be a complete navigation aid capable of independently providing navigational fixes and operating without the aid of GPS.

Q2. *How important is it for the EU to be independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?*

Both are military systems without any foreign civil input or control. They respond primarily to military requirements although in the United States' the needs of its own civil community are taken into account albeit without accepting any legal responsibility. Although the United States has a joint military/civil control organisation for GPS, the military side has over-ruling powers. Foreign users have absolutely no say in how either system is operated and both the United States and Russia have consistently refused to discuss any such possibility. In these circumstances foreign users, such as the UK, are unable to certify GPS receivers or other equipment because there is no guarantee of the basic system. For this reason, the use of GPS for tracking vehicles for road-tolling schemes in the UK (for example) will be impossible until the UK can obtain legally enforceable guarantees that the system will always be working to the necessary specification for the purpose. This the United States refuses to provide. This problem is repeated in many other applications and unless the USA changes its stance the only alternative is for the EU to build its own system with a proper civilian control system having legal traceability.
Apart from that, the engineering techniques used in both GPS and Glonass are now almost 30 years old and newer techniques have become available that can be used to design a system superior to either system in such respects as, for instance, interference and jamming. Also, GPS often fails for such purposes as car tracking in urban "canyon" areas because of high-rise buildings blocking the direct path to the satellites. This is a function of the number of satellites in orbit; only a small percentage are at sufficiently high elevations to be seen in "canyons" at any one time. The answer is more satellites in orbit and it has been calculated that to provide reasonable certainty of having enough satellites at high elevations for accurate fixing about 55 satellites are required. GPS has only 30 and there is no proposal to increase this number. Galileo, providing another 30, would remove this problem provided both systems were interoperable.

Q3. *What are the potential benefits of the Public Regulated Service (PRS) system? Is it realistic to expect that Member States will not want to cross-subsidise PRS from commercial services?*

The PRS is designed to supply highly controlled and protected services for those services requiring them. Examples are Government safety services, police, customs and Armed Forces. These users need a fully guaranteed service protected from attack by criminals, terrorists, and interference of all kinds including malicious jamming. If Galileo evidence is to be used in legal matters then there must be hard guarantees that the service can provide the necessary performance at all times. This is an expensive matter, involving back-ups, duplication, constant monitoring and precise record-keeping. The other services provided by Galileo, not being intended for this kind of user, will not be so heavily documented and controlled and their use might then be open to challenge in the courts. A parallel situation exists today where there have been groundings and collisions between ships although GPS has been in use at the time. The fact that the GPS appeared to be indicating correctly and the Master accepted it as accurate is not basically admissible evidence because there is no guarantee, and non is available, that the system itself was performing correctly at the time. It is a lengthy and expensive business proving otherwise using only unofficial records.

The PRS will be available only to authorised Government-sponsored users who can be trusted with its special encryption codes and receivers. For those users who would not be able to get such authorisation but would want a similar accuracy there will no doubt spring up an after-market of commercial service providers offering improved facilities while using only the Open or Commercial services. A similar thing happened some years ago when for a time the US Government allowed civil users only a degraded signal providing an accuracy of 100m instead of the full 5m. A rash of providers appeared offering enhancement services known as Differential GPS (DGPS) which restored accuracy to 5m for which they charged commercial rates.

Should this happen with Galileo it is very doubtful whether such providers would look kindly on also having to subsidise the PRS which many of them would see as a competitor. However, this is very much a matter for political decision and one for the countries concerned to solve at a higher level than the user.

Q4. *Are the arrangements to prevent military use of Galileo sufficiently robust?*

Not being either a politician or a military man this is not a question I am qualified to answer.

Q5. *Are arrangements to oversee the security aspects of Galileo appropriate?*

(Same reply).

Q6. *What are the potential benefits of the programme to UK industry, and to UK users of Galileo, such as NATS?*

In the implementational stages no doubt the benefit to UK industry will be in the ratio to which the UK commits itself to funding, as is the case now. As regards later navigational applications, it will depend on the commercial acumen of British companies and in this respect it is regrettable that there are now no British companies left engaged in fundamental research and development of navigational systems, an area in which the UK once led the world. However, the major applications of Galileo are foreseen to be outside the area of traditional navigation and no doubt once a highly accurate satnav system is in place, with full performance guarantees not presently available for GPS, entrepreneurs will find new market areas. There should of course be considerable benefits to British companies working in the field of satellites in general, and equipment used in launch vehicles. One such company, Surrey Satellite Technology, a spin-off from the University of Surrey, has already obtained a valuable contract for an experimental satellite. An indirect benefit to industry is that the type of engineering needed to design, build, launch and control navigation satellites is very advanced and new to this country and should trigger off increased activity in Universities and research institutes. The Universities of Nottingham and Surrey have been prominent in the past in promoting GPS technology and the introduction of a "home" system, to which they would presumably have much greater access than they have had with GPS, would be a considerable boost to them and the others who would follow. The UK is lagging behind in advanced electronics and some other areas, including very precise timing, and Galileo would provide a new sector badly needed.

Benefits to NATS would come only in the longer term, when, in agreement with Eurocontrol and ICAO the system might be used for the more accurate control of aircraft movements over the UK. If this came about, and it was proved that it was sufficiently reliable and accurate enough to replace the current short-range navaids such as VOR and DME there could be a considerable monetary saving in the installation, calibration and maintenance of those aids. Further, because it would be available everywhere, at all altitudes, at a predictable high accuracy, it would lend itself to a rationalisation of airways and possibly eventually to their abandonment in favour of area control. This would mean better airspace utilisation and the reduction of air traffic delays.

About the Author

President of the Royal Institute of Navigation from 1993 to 1996.

Founder and Chairman of the UK Satellite Navigation Users' Group 1988–1993.

Founder of the European Group of Institutes of Navigation (EUGIN) 1994.

Awarded the US Institute of Navigation's Thurlow Award for 1995.

Awarded the Royal Institute of Navigation's Gold Medal 1995.

(Both for "The most significant contribution to Navigation of the Year"; the world's first geostationary satellite-based differential GPS system.)

Author of numerous studies for the EC and others on satellite navigation systems.

Visiting Lecturer to Nottingham and Surrey Universities MSc navigation courses.

Expert Witness in the London Marine Courts on the use of satellite navigation.

BOOKS:

"The Pilots' Guide to Satellite Navigation" Airlife, 1997.

"Navigation from Balloons to Concorde" Woodfield 2004.

IN PREPARATION:

"History of the Decca Navigator Company".

Walter F Blanchard, FRIN

19 July 2004

Memorandum by the General Lighthouse Authorities of the United Kingdom and Ireland (GG 02)

"GALILEO"

THE EUROPEAN CIVIL GLOBAL NAVIGATION SATELLITE SYSTEM

1. INTRODUCTION

The functions of the General Lighthouse Authorities

1.1 The Corporation of Trinity House, the Commissioners of Northern Lighthouses and the Commissioners of Irish Lights are the General Lighthouse Authorities (GLAs) for England, Wales and the Channel Islands, Scotland and the Isle of Man and the whole of Ireland respectively, as defined in Part VIII of the Merchant Shipping Act 1995 (MSA 1995). They have a duty as GLAs to discharge a public undertaking to deliver an aids to navigation service for the safety of the mariner.

1.2 Their functions as GLAs are financed wholly from private revenue derived from the commercial ship owner with no burden on Treasury or taxpayer. The UK Secretary of State for Transport (DfT) acts as quasi-trustee of the General Lighthouse Fund (GLF) under the MSA 1995 to ensure the fair and sufficient distribution of funds for the efficient and effective operation of the GLAs, for the benefit of the mariner. The aim has been to ensure accountability to Parliament by providing the best value for money service by the most appropriate means, commercial or otherwise, without compromising the safety of the mariner and to enhance compliance with the Governments obligations in the SOLAS Regulation V/13.1 ". . .to provide. . .such aids to navigation as the volume of traffic. . .and. . .degree of risk requires".

2. BACKGROUND

The GLAs have been providing Radio Navigation services for maritime users for more than 60 years, vis: Radio Beacons, Radar Beacons, Decca Navigator Service, VHF Radio Lighthouse trials, Differential GPS (DGPS) and are currently carrying out Automatic Identification System trials as well as having just signed a contract to provide a trial LORAN—C signal from a UK transmitter.

2.2 The GLAs have represented the UK on the EU GNSS Advisory Forum from 1998 to 2001, which evolved into the European Maritime Radionavigation Forum, now sponsored and based at Trinity House in London and responsible for producing for the European Commission (EC) such documents as the maritime User Requirement for future GNSS and Galileo—subsequently adopted by the UN Maritime Organisation as Resolution A.915(22).

2.3 The GLAs Research and Development facility has a dedicated Radio Navigation (RNAV) Team devoted to undertaking project studies for the EC and others principally in respect of the development of Galileo and associated systems. The maritime aspect of the European Radio Navigation Plan (ERNP) currently being produced, was written by the GLA RNAV Team as consultants to the EC Contractor.

2.4 The General Lighthouse Authorities are the leading authority for the provision of maritime Radio Aids to Navigation in UK waters. Having regard to their expertise and experience in this area, the GLAs welcome the opportunity of assisting the Committee with its Inquiry.

3. CALL FOR EVIDENCE

The Transport Committee has called for evidence on the Galileo programme. This programme, led by the European Union, is intended to establish a new global satellite navigation constellation with appropriate ground infrastructure. A decision on Phase II of the Galileo programme is expected to be taken at the meeting of the EU Transport Council in December 2004.

We respond to the Committee's questions as follows:

3.1 *What benefits will Galileo Phase II bring that EGNOS (European Geostationary Navigation Overlay System) will not?*

Galileo Phase II is the Operational Phase which will see the introduction of a complete, independent civil-controlled Global Navigation Satellite System (GNSS). This will provide an alternative to the existing U.S. Global Positioning System (GPS).

EGNOS is an augmentation system, not yet fully operational, regional in coverage and reliant on GPS. An augmentation system is one which receives the signals from a GNSS, applies corrections to it, and monitors the integrity of the satellite derived position(s) and transmits this information to the user receiver. It is planned to integrate EGNOS into the Galileo structure—this could be as a fully integrated component of the system or continuing as a regional augmentation system.

Since shipping is an international and global activity, a regional system such as EGNOS cannot meet the requirements of the maritime user on its own. Whereas Galileo provides a global service.

3.2 *How important is it for the EU to be independent of the U.S. Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?*

This question raises three distinct issues: Political, Strategic and Operational.

Whilst the GLAs do not consider the Political issues within their remit, it is clear that Galileo has strengthened the position of the EU in international discussions on navigation.

At the Strategic level the European aerospace industry is dependent on continued involvement in major projects such as Galileo.

From an Operational perspective, Galileo brings greatly improved performance in terms of accuracy and availability as a position fixing system, when compared to the current GPS alone.

Galileo itself is inherently superior to current GPS due to improved technology and contributes significantly to a more robust GNSS by more than doubling the number of satellites deployed, using signals broadcast on several frequencies and providing independent control.

Galileo will, therefore, reduce the well-known vulnerability of GNSS to interference and jamming, although it cannot eliminate this problem.

GLONASS, at this time, has only 10 satellites operational and therefore cannot be considered as a usable component of GNSS in this condition.

3.3 *What are the potential benefits of the Public Regulated Service (PRS) system? Is it realistic to expect that Member States will not want to cross-subsidise the PRS from commercial services?*

The Public Regulated Service adds greatly to the complexity, and hence cost of the Galileo System. If this expense is borne by the European manufacturers and service providers it will place them at a disadvantage when compared with their non-EU competitors.

It is difficult to see what the PRS can offer when compared to the benefits to the user of GPS and Galileo combined. The PRS will reduce vulnerability to some forms of attack, but still will not resist certain types of jamming.

3.4 *Are the arrangements to prevent military use of Galileo sufficiently robust?*

It is not possible to prevent military use of Galileo, or any other radio navigation system. However, the principle of Galileo is to provide the World with a civil controlled and operated GNSS. This is in contrast with the U.S. owned GPS which is, de facto, controlled by the US Department of Defense.

3.5 *Are arrangements to oversee the security aspects of Galileo appropriate?*

Understandably, the security aspects of Galileo are not in the public domain, therefore we are unable to comment on them, although we note that they are being addressed by a suitably qualified, pan-European team of experts.

3.6 *What are the potential benefits of the programme to UK industry, and to UK users of Galileo, such as NATS?*

Numerous studies have quantified the potential benefits of the Galileo programme. There are reservations about some of the assumptions made in those studies, in respect of maritime use and applications. However, there are undoubtedly opportunities for the UK maritime industry.

Benefits to the users are as outlined in our response to the question in 3.2 above, ie availability of an enhanced GNSS Service, which has the potential, in time, to lead to reductions in other forms of aids to navigation.

4. Additional Information

The following information is provided for consideration by the Committee and is derived from the GLAs involvement in the European Maritime Radionavigation Forum, the International Association of Marine Aids to Navigation and Lighthouse Authorities and project studies and research into radio navigation applications and systems, primarily for the benefit of the European Commission in the development of Galileo.

4.1 *Sole Means*

Whilst GPS has brought readily available and accurate position fixing to millions and has changed the manner in which the mariner conducts a voyage, there is concern in the maritime sector over such high reliance on GPS for positioning fixing and timing. Due to the known vulnerability of the system to interference and jamming.

The bridges of most modern commercial ships are fitted with a number of key navigational aids which rely on inputs from GPS for position and timing.

Given that 95% of UK trade is carried by sea and our waters are some of the busiest in the world, the potential for disruption, environmental damage and even loss of life resulting from interruption to the GPS signal is of great concern. For example an integrated bridge has GPS inputs to radar, electronic chart, autopilot, Automatic Identification System (AIS), Global Maritime Distress and Safety System (GMDSS), Emergency Position Indicating Rescue Beacon (EPIRB) and more.

The advent of Galileo will only ameliorate this concern to a limited degree. The similarities of GPS and Galileo mean that they suffer from the same weaknesses. It is essential to retain a mix of complementary systems as the fundamental principle of marine navigation is *never to rely on a single source of navigation information when alternative sources are available*.

Currenntly, as described in the GLAs' recently endorsed "Marine Aids to Navigation Strategy to 2020" or "2020 The Vision", we undertake to provide a mix of visual, radar and radio aids to navigation, noting that the user is relying heavily on GPS, and will rely on Galileo in the future. The GLAs continue to warn the mariner against reliance on a sole means of position fixing and encourage verification by alternative means whenever possible. The back-up to GNSS is a mix of aids as described above.

Further mitigation of the risks attached to 'sole' reliance on GNSS is the future provision of a terrestrial radio navigation system. The GLAs are actively pursuing the coverage of UK waters by LORAN-C through their investment in trials commencing later this year.

4.2 *Cost recovery*

It is planned that Galileo should be operated, on a self-sustaining basis through a concession to the private sector. This implies that the concessionaire will generate revenue from services provided. The pricing structure for these services has yet to be defined. It is important that the burden of costs is reasonable, is fairly distributed across the user communities and is transparent.

Charging users for services may be a great disincentive to the use of Galileo, in the light of a free service from a competitor (GPS) that already enjoys massive receiver sales and system use World wide.

Whereas aviation and maritime users are regulated and could be charged for use of Galileo through existing mechanisms, their numbers are vastly outweighed by the potential mass market users eg land vehicles, who may prove more difficult to charge.

It is difficult to see how the maritime users will be persuaded to purchase, install and operate a Galileo receiver and pay for the service, when they already use GPS free of charge. Especially when GPS has provided them with a service significantly better than any previously known. Consequently, without regulation or incentives, the take-up of Galileo in the maritime sector is expected to be slow.

Duncan Glass
Chairman GLA Radio Navigation Committee
Trinity House Lighthouse Service

August 2004

Memorandum by Professor David Last, University of Wales (GG 03)

THE GALILEO INQUIRY

1. I hold a personal chair in the University of Wales and am Head of the Radionavigation Research Group at Bangor. I hold the degrees of BSc(Eng), PhD, and DSc. I am a former Vice-President of the Royal Institute of Navigation, a Fellow of the Institution of Electrical Engineers, and a Chartered Engineer. I have 36 years experience as a researcher in the radio navigation field and have published some 250 papers on electronic navigation systems. I have proposed, and helped develop commercially, tracking systems employed at sea and for high-security vehicles on land. I have helped influence the current mix of radionavigation systems in Europe and the US as a contributor to the draft baseline European Radionavigation Plan and as an author of many papers on navigation policy. I have acted as a Consultant on radio-navigation and communications to numerous companies and to governmental and international organisations. I am an instrument-rated aircraft pilot and user of terrestrial and satellite navigation systems.

2. I wish to respond to the question raised by the Committee: *How important is it for the EU to be independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?*

3. I believe the view that Galileo is independent of GPS to be fallacious and that it is neither possible, nor necessary, for Galileo to be independent. I argue this case in the Appendix attached. Galileo and GPS together, using common receivers, will offer approximately twice the number of satellites of GPS alone. This increase in the number of satellites will be of great value to the many industries for which satellite navigation is now an essential tool. The Russian GLONASS system is no longer of significant value, having very few satellites and almost no users.

4. The Appendix is a paper I delivered as an invited keynote presentation to the European Navigation Conference held in Rotterdam in May 2004. The conference was organised by the European Union Group of Institutes of Navigation (EUGIN). It is hoped that the Committee will also find the paper valuable as background material.

August 2004

APPENDIX

GPS AMD GALILEO: WHERE ARE WE HEADED?

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Abstract

Many in Europe see a combination of GPS and Galileo as the basis of a viable future Global Navigation Satellite System (GNSS). This paper argues that, although Galileo and GPS may well complement one another, they are so dissimilar in important aspects as to make combining them in this way exceptionally difficult. The attempt to do so has already led to tensions between the US and Europe.

Although GPS serves both civil and military functions, it was originally a military system and is still operated by the armed forces of a single nation. It plays a vital role in the security of the US and of European NATO members, in addition to the commercial benefits it brings to both regions. Galileo, in contrast, will be a civil system, operated by the many nations of the European Community, with others possibly contributing, too. Although both systems offer open, free-to-air access, Galileo promises additional commercial services, on a user-pays basis, with real-time integrity and legally-enforceable service guarantees.

The two systems will be obliged by technical and commercial pressures to share common frequency bands and to employ compatible codes, timing sources, and geodetic frameworks; users' receivers will need to accept both sets of signals. Galileo thus requires US cooperation for its commercial success, while at the same time apparently threatening US national security and industrial advantage! Not surprisingly, the process of combining these two disparate systems into a single entity has been fraught with difficulties.

A *modus operandi* now appears to have been reached by the US and Europe. This paper examines the compromises on which it is based. It notes the significant challenges that Galileo still has to overcome, and it questions the degree to which Europe's ambition to be independent of the US in GNSS has survived the realities of combining the two systems. The paper argues, however, that what has been achieved bring us much closer to the objective of a truly global satellite navigation system, a goal of great value.

Introduction

GPS and Galileo are both Global Navigation Satellite Systems. Most people regard them as very similar to one another, using the same principles and frequencies, virtually the same thing. We see them as complementary. Well, complementary they may be; those who will use combined GPS-Galileo receivers will neither know, nor care, that there are two separate systems. But similar they are not; and if we ignore the profound differences between them, we put both at risk.

Think of their origins. GPS started life as a military system. It now serves both military and civil functions, but when push comes to shove, as in the recent US-EU tensions, the military requirement prevails. Galileo, in contrast, started life as a civil system. Only gradually have questions of its possible military role emerged.

GPS is the sole property of a single nation; others may use it on terms that suit that nation's interests. That is clear. It is entirely reasonable. But, an inevitable consequence is that GPS looks inwards, to the US. Galileo belongs to the many nations of the European Community. It is outward-looking; those countries have welcomed, and sought, the active participation of other nations, including China, India, and Canada[1].

But these are just a few of the profound differences between the two systems. There are also differences of radio frequencies, codes, modulations, of time standards and geodetic frameworks. One system is free of charge, the other operate under the user-pays principle. One is run by the military, the other will involve a public-private partnership. Then, GPS is now a mature system; it has been a stunning success. Galileo is essentially a proposal and has still not disturbed the heavens or the ether. Glen Gibbons said recently: "It would be hard to imagine a more different approach to participation in defining, deploying, and operating a system than that between GPS and Galileo"[2]. So, we should not be surprised if, in combining these two disparate systems into a single whole, tensions arise. Whether we succeed or fail in resolving those tensions will determine the success of the resulting GNSS.

How We Got To Where We Are Today

How did GPS and Galileo get to where they are today? Although the public have only recently discovered GPS and see it as a brilliant new technology, the first satellite was actually launched in 1978[3]. Most of the GPS pioneers are retired. If the first Galileo satellite does fly on time, it will be a full 27 years behind GPS!

GPS was developed as a US Air Force "weapons aiming system and force enhancer", created to give the US, quite literally, more bang for its buck[4]. It was a military system; no one had any vision of what it has become today. There were certainly no cost-benefit analyses for civil use!

When in the early 1980s, the military discovered to their considerable surprise that, "there are civilians using this stuff", they were at first hostile[5]. The researchers were obliged to register as arms manufacturers[6]. But civil users multiplied, and the US then foresaw their enemies using GPS-guided unmanned aircraft. Their response was to turn on Selective Availability (SA), which degraded the position and velocity accuracies available from GPS.

But for most purposes, the remaining accuracy was quite sufficient. Civil use flourished. And, for higher-precision applications, differential techniques were developed. DGPS was indeed the way ahead, in the air and on land. It was the foundation of this very series of conferences. At sea, the US Coast Guard drove it forward[7]. So, by the mid-1990s we had a bizarre situation: the US government had spent nearly $20 billion creating GPS, this highly accurate navigation system. Then, they spent a further large sum on selective availability to deny that accuracy to most users. Now, the US was spending yet more money on deploying differential systems that not only defeated SA, but actually gave the civil community higher accuracy than that of the *military* GPS, that SA was there to defend!

This could not go on. Under growing pressure from civil users and equipment manufacturers, the US government decided in 1996 to switch off SA as soon as "new military security technologies" were "in place"[8]. In 2000, SA was replaced by a "capability to prevent hostile use of GPS and its augmentations while retaining a military advantage in a theater of operations without disrupting or degrading civilian uses outside the theater"[9]. This policy remains fundamental to the relationship between GPS and Galileo.

[1] "Galileo progress: new alliances, ITTs", Galileo's World, November 2003, http://www.galileosworld.com/galileosworld/article/articleDetail.jsp?id=75613).

[2] Gibbons, G, "Interoperability: Not so simple", GPS World, 14, 12, p6, December 2003.

[3] Easton, R L, "The navigation technology program", Navigation, 25, 2, p107, Summer 1978.

[4] US Department of the Air Force, "Program Management Directive for NAVSTAR Global Positioning System (IWSM)", PMD 4075(31)/PE35164F/35165F, Nov 1992.

[5] Brown, A, "A perspective on land navigation—the evolution from man-packs to modules", Proc. GNSS2000, Edinburgh, Scotland, May 2000.

[6] Misra, P & Enge, P "Global Positioning system—signals, measurements, and performance", p31, Ganga-Jamuna Press, Lincoln, MA, USA, 2001.

[7] US Coast Guard, "Broadcast standard for the USCG DGPS navigation service", COMDTINST M16577.1, April 1993.

[8] Office of Science and Technology Policy, National Security Council, "US Global positioning system policy" 29 March 1996.

[9] "US Policy Statement Regarding GPS Availability, March 21, 2003", www.navcen.uscg.gov/gps/default.htm.

In announcing the intention to end SA operation, Vice-President Gore gave other reasons for the move[10]. It solidified "US industries' lead in this important technology". It "could add 100,000 jobs to the US economy". The new US policy would be to encourage the acceptance and integration of GPS worldwide, and to advocate GPS and US Government augmentations as international standards. Clearly, the US had made a huge investment in GPS and intended to maximise the payback. The drivers of US GPS policy would be: preventing its use by enemies, and maximizing commercial returns. They would have been Europe's policies too, I believe, if Europe had developed GPS.

Europe's Response: Galileo

But Europe hadn't. And Europe read clear messages in those US statements. When Mr Gore said that GPS was "an integral component of the Global Information Infrastructure, with applications from mapping and surveying to air traffic management", Europe saw that it too needed all those things. When he said that GPS had "generated a US commercial . . . equipment and service industry that leads the world", Europe wanted to share in that industry.

And, since US policy was to "limit availability of their radionavigation systems in the event of a real or potential threat of war or impairment to national security"[11], Europe saw that its access to this vital new utility depended on the decisions of a single nation, with which it might well disagree on matters of national security. Recent event have given examples of just such disagreements. Europe's response was Galileo.

Now, this conference will provide a very detailed picture of Galileo. So here I will simply give a summary, stressing what it offers that is new and different. Galileo, like civil GPS, has an open, free-to-air service. But it also has a Commercial Service: you pay for additional signals that give higher accuracy, a higher data rate, or extra messages. Then, there is a Safety-of-Life service and a search-and-rescue facility. And finally: the contentious PRS, the Public Regulated Service, encrypted and reserved for government agencies and law enforcement[12].

What is new and different? First, Galileo will warn users of satellite failures immediately (real-time integrity), where unaugmented GPS can take an hour to do so. Galileo will offer service guarantees to commercial and safety-of-life users; GPS provides no legal guarantees. Galileo is controlled by many nations, operating through the European Commission and the European Space Agency, with a commercial service provider working under a concession, like MacDonald's! And, there is no military Galileo service: the concept is that European NATO nations already have full access to military GPS. Thus, Galileo can remain a civil system[13].
The Galileo project is now 10 years old. It has proceeded in strict accordance with the finest European traditions of glorious war and vicious in-fighting, followed by compromise decisions! That, at least, is the impression you get of Galileo from the press. But you will learn in this conference that Galileo is indeed being funded, and that prototype satellites should be launched next year, in time for the June 2006 deadline for retaining ITU frequency assignments. Also, the concessionaire is currently being selected[14].

The hope of Europe was that Galileo would give it independence of the US in satellite navigation, and also a profitable new industry: perhaps, another Airbus or GSM. But, for that industry to be profitable, there has to be a viable Galileo business. The market analysts predicted a huge global satellite business, with mobile phones and car navigation the major market sectors[15]. But what was much less clear, and in my view still is, was: what proportion of that market Galileo will capture; just who is exerting the market pull for Galileo; who will pay for its services? There is no doubt that the world wants GNSS, but will it pay for Galileo?

What has emerged strongly is that the attraction is not Galileo alone, but GPS-plus-Galileo, 60 satellites instead of 30, with completely-integrated receivers. But such a combined system, of course, requires the co-operation of the US.

[10] "President opens door to commercial GPS markets; move could add 100,000 new jobs to economy by year 2000", White House, Office of the Press Secretary, 29 March 1996.

[11] US Departments of Defense & Transportation, "Federal Radionavigation plan 1999", Section 1-5(1), DOT-VNTSC-RSPA-98-1, DOD-4650.5, December 1999.

[12] http://europa.eu.int/comm/dgs/energy—transport/galileo/programme/needs—en.htm.

[13] "NATO armaments directors sign a memorandum of understanding for the operational use of the worldwide US navigation system, the Navstar GPS", NATO press Release (93)65, Brussels, 29 October 1993.

[14] http://europa.eu.int/comm/dgs/energy—transport/galileo/programme/needs—en.htm.

[15] Technomar GmbH, "Structural Analysis of the Satellite Navigation Applications Segment", Report for European Commission, Nov 2000 (OREGIN Workshop, 27 Feb 2001)
http://www.fdc.fr/oregin/workshop/Pilot—Projects—Introduction—P—FLAMENT.pdf.

The US Response to Galileo

Now, many in the US, once they had fathomed out what Galileo was (and separated it from the NASA Jupiter probe also called Galileo) welcomed it with open arms; after all, 60 navigation satellites is 60 for the US as well! The increased number offers better penetration of urban canyons and reduced scintillation effects at low latitudes. Maybe, too, Galileo-plus-GPS will give us civil dual-frequency operation 4 years ahead of GPS? And since Galileo and GPS will have separate control segments, vulnerability will be reduced. Everybody wins!

But to others in the US, Galileo was like the arrival of the Mongol hordes from the East! They saw it as driving a coach-and-horses through their GPS policy. Firstly, it directly challenged their ambition to lead the world GNSS industry. Well, that's business! But, what about US national security? Why withdraw GPS from a theatre of operations if the bad guys in the black hats simply keep on coming at you, using Galileo? So, the US had to be able to remove all GNSS. That meant that either Europe would agree to withdrawing Galileo if the US demanded it, or that the US would jam Galileo.

The Frequency Question

And that led to the frequency question. GNSS frequencies are very limited, so Galileo is obliged to use the same frequency bands as GPS. That is essential, too, if we are to have low-cost combined receivers. But then, how do you stop Galileo and GPS from interfering with one another?

This question resulted in some truly spectacular engineering, with Galileo's signals wrapped intimately around those of GPS, yet never touching; safe sex in the frequency domain[16]!

But now it appeared that the Galileo L1 PRS signal, the government service, might be overlaid onto the GPS M-code, the future encrypted US military signal. Would PRS interfere with M-Code? Probably not! But if the US then jammed Galileo PRS, not only would Europe be up in arms, but the US would be jamming its own M-code signal too!

So now we had a major dispute between the US and Europe. NATO piled in on the US side, arguing its need "to deny a potential adversary's access to . . . any . . . satellite navigation services"[17]. This row came at an unhappy time of heightened tension between the US and Europe, and among European nations, over Iraq. Was this US hegemony? Was Europe to become, as President Chirac claimed, "a vassal" of the United States?[18],[19]? Or was it simply common sense in a continent whose security depends on NATO and GPS?

Whatever your views, these matter simply had to be resolved if Galileo was to have a commercial future, sharing frequencies and receivers with GPS. And in the present world climate, both sides desperately needed to achieve a security and non-interference agreement.

Peace Breaks Out!

They appear to have done so, and peace seems to have broken out[20, 21]. After three rounds of negotiation, Europe has agreed to move the PRS signal away from the M-Code, and outside the declared GPS band. So now, either the open services, or the PRS, or the M-Code could be jammed with a degree of isolation. Much more positively, Europe and the US have agreed to implement common signal structures. In addition, they will make their separate timing and geodetic standards inter-operable, so opening the door to a combined system. And they have also agreed on open trade: neither side is to mandate the use of its own system alone. As Julie Karner says[20], they now have a common goal: the best possible GNSS for users around the world. All this is to be embodied in intergovernmental agreements to be signed next month at the US-EU summit in Dublin.

Challenges to Galileo

Without this agreement, I doubt that a combined Galileo-GPS system could have been achieved? Yet, for Galileo, great challenges remain. Listen out for these topics in the Conference sessions:

- If Galileo is funded to completion (and will it be?) how will it recover that investment? Will the signals perhaps be lightly encrypted, with manufacturers paying a levy on each receiver?
- Who will take that legal liability for Galileo? How extensive will it be, and what will that cost?

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[16] Godet et al, "Galileo spectrum and interoperability issues" GNSS2003, Graz, Austria, April 2003.

[17] Bell, R G, "GPS and Galileo—Capabilities and compatibility", European satellites for security conference, Brussels, Belgium, 19 June 2002.

[18] James, B, "US out of line on global positioning, EU Says", International Herald Tribune, 19 December 2001.

[19] "Les dossiers d'une rivalité sous-tendue par la mésentente entre Paris et Washington" Le Monde, 24 December 2003, (http://www.lemonde.fr/web/article/0,1-0@2-3222,36-346999,0.html).

[20] Karner, J, "Status of GPS-Galileo cooperation—A US perspective", Munich Satellite Navigation Summit 2004, http://www.munich-satellite-navigation-summit.org/Beitraege/4Ses1-Karner.pdf.

[21] Hilbrecht, H, "Galileo institutional and international issues", Munich Satellite Navigation Summit 2004, http://www.munich-satellite-navigation-summit.org/Beitraege/2Open-Hilbrecht.

— How will the Galileo frequencies and codes be secured? They are currently filed in the name of a single nation, and under challenge.

— How much control will be ceded to nations outside Europe, as part of the various proposed agreements?

— How much access will Galileo have to the latest GPS technology, which is ahead of Europe's?

And how much now remains of Europe's dream of independence in satellite navigation[22]? As we have seen, combined receivers and national security have required cooperation, not competition. There is to be a level commercial playing field with the US. Frequencies and codes are to be shared, so when civil GPS is lost to interference, Galileo will also be lost. And is there still any realistic scenario in which GPS would be withdrawn and Galileo would continue, independently?

Where to Now?

And yet, what has been achieved is so much more than those early dreams. We may have here nothing less than the future of GNSS. Together with new satellites from Japan, and financial and technical collaboration worldwide, the impact of this Galileo-GPS combination will dramatically exceed the sum of its parts. This truly-global Satellite Navigation System, a goal of immense value, is almost within our grasp. Let's go for it! We must not let it slip now!

Memorandum by The Royal Institute of Navigation (GG 04)

GALILEO

I write on behalf of the Council and members of the Royal Institute of Navigation in response to Press Notice: 37/2003-04 dated 16 July 2004 calling for evidence on Galileo and asking the following six questions.

Question 1.—What benefits will Galileo Phase II bring that EGNOS (European Geostationary Navigation Overlay Service) will not?

There is a widespread misconception about what the European Geostationary Navigation Overlay Service (EGNOS) is and why it was necessary to develop such a system for Europe. EGNOS is not a complete navigation system in itself; the primary aim of its design is to monitor the minute-by-minute operation of GPS and GLONASS satellites in view from Europe and so provide confidence in their use, mainly but not exclusively by commercial aircraft. EGNOS also improves accuracy and provides one or two more navigation satellites in view.

GPS and GLONASS were both developed to meet military needs but, while they have become widely used for civilian purposes, they do not meet the safety requirements of commercial air or marine transport where safety of life and the environment are paramount. Furthermore, while the USA and Russian Federation have encouraged the civilian use of these systems, which are provided free of charge to users, neither country is prepared to guarantee performance or continuity of operation.

Under international law (United Nations Charter), a nation has a legal obligation to ensure the correct functioning of navigation systems that it provides, or permits to be used, within its sovereign airspace and territorial waters; thus, it must also provide timely warnings of any failure or maintenance activity. To date, the correct functioning of lighthouses, radio beacons and other "Aids to Navigation" in the UK navigation infrastructure has been assured by national agencies such as the National Air Traffic Service and the General Lighthouse Authorities who provide, operate and maintain such aids. When GPS and GLONASS became operational, individual nations needed some means of assuring the correct operation of the satellites available to users throughout their area of responsibility.

In the marine case, this has been partly achieved in UK territorial waters by installing a number of coastal stations that monitor GPS satellites and transmit integrity data to users; this service has been standardised under the auspices of the International Association of Lighthouse Authorities (IALA). In civil aviation, the speed of modern airliners means that a very reactive monitoring system operating over a much larger area than just UK sovereign airspace is essential. The European Civil Aviation Conference (ECAC) States recognised the need to collaborate across national boundaries and hence EGNOS was developed. For similar reasons, other countries are developing EGNOS type services; specifically, WAAS over North America, MSAS over Japan and GAGAN over India.

By contrast, while Galileo will be a Global Navigation Satellite System (GNSS) with a similar infrastructure to GPS, it has been designed for civilian use from the outset. It will therefore meet the safety requirements of civilian users including the performance and integrity monitoring capabilities needed for safety of life operations of air and marine transport. The design aim of the Commercial Service of Galileo

[22] "Europa gibt auf—Galileo wird abh—ngig von den USA", tagesschau.de, 29 November 2003.

is to guarantee this level of performance and accept liability for any failure to meet these stringent requirements. There are some technical doubts about how this guarantee will actually work, especially for a combined Galileo/GPS receiver using statistical filtering techniques.

The Galileo Joint Undertaking (JU) is the management agency responsible for the implementation of the development phase, preparation for constellation deployment and the related ground infrastructure as well as preparing for the exploitation phase. The Galileo JU has also been tasked with incorporating the EGNOS infrastructure and capabilities into the Galileo system anticipating that civilian operators will use the combined capabilities of both Galileo and GPS, and possibly all three GNSS. Thus monitoring of GPS and GLONASS satellite functioning will be required both as an interim measure before Galileo is declared operational and into the future.

In summary, EGNOS provides merely an augmentation of GPS and GLONASS, while Galileo is a standalone, independent GNSS solution designed to meet a wide range of civilian user needs with improved availability.

Question 2.—How Important is it for the EU to be Independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?

As mentioned earlier, both GPS and GLONASS were designed as military systems to meet military requirements. Because GPS had become such a vital part of the US transportation, communications and timing infrastructure, the Interagency GPS Executive Board was set up in 1996. It includes representatives from the Departments of Defense, Transportation, State and Commerce who provide advice on programme management. While consultation with US civilian authorities exists, and the needs of civil users are considered, GPS is controlled and operated by the US military authorities in the "US national" interest, with no direct involvement from other nations. The situation with GLONASS in the Russian Federation is similar although less clearly defined. Neither country has shown any willingness to share control of GPS or GLONASS as part of an international consortium, although they are apparently content to continue providing worldwide civilian access to these systems free of charge, but without any liability for performance or continuity of service.

Concerns over control, management and ownership of GPS and GLONASS, together with many of the issues discussed under Question 1, support the requirement for an independent GNSS under the control and management of a much wider consortium of nations to meet the current and future needs of civilian users. Dependence on GPS for positioning, navigation and timing is already widespread amongst the civilian community, and the level of dependence is continuing to grow; in some fields, it could be regarded as total. Galileo offers the vital opportunity to reduce this dependence and provide better capability.

Question 3.—What are the Potential Benefits of the Public Regulated Service (PRS) System? Is it Realistic to Expect that Member States will not want to Cross-subsidise PRS from Commercial Services?

The Public Regulated Service (PRS) is designed to be a more highly controlled and protected service than the Commercial Service. It aims to meet the needs of Government agencies such as safety services, police, customs and excise and, to some extent, the Armed Forces of the nations where fishery protection or pollution are involved. However, MOD has stated that they will continue to rely mainly on GPS for military warfare purposes for the foreseeable future. The Government agencies need a fully guaranteed service with the highest possible protection from attack by criminals, terrorists, and interference of all kinds including malicious jamming. If Galileo evidence is to be used in legal proceedings then there must be strong guarantees that the service can provide the necessary performance at all times. This is an expensive matter, involving back-ups, duplication, constant monitoring and precise record-keeping. The other services provided by Galileo will not be so heavily documented and controlled and, as a result, their use might be open to challenge in the courts as has occurred with incidents involving GPS.

The PRS will only be available to authorised Government-sponsored users who can be trusted with its special encryption codes and receivers. For those users who would not be able to get such authorisation but would want a similar accuracy there will no doubt spring up an after-market of commercial service providers offering improved facilities while using only the Open or Commercial services. Should this happen with Galileo, it is very doubtful whether such providers would look kindly on also having to subsidise the PRS, which many of them would see as a competitor. This is very much a matter for political decision and one for the countries concerned to solve at a higher level than the user.

QUESTION 4.—ARE THE ARRANGEMENTS TO PREVENT MILITARY USE OF GALILEO SUFFICIENTLY ROBUST?

As was shown by the development of differential techniques to overcome GPS "Selective Availability" (the means by which the US attempted to deny civilian access to very accurate positioning), there are no truly effective methods of preventing military use of an open GNSS service, either by friendly or hostile users. However, the encryption techniques used by the US to restrict use of the GPS Precise Positioning Service (PPS) have been effective. Similar or more recent techniques should enable access to the Commercial and Public Regulated Services of Galileo to be robustly controlled.

These, of course, are the technical and infrastructure controls on use. Institutional control through treaties and agreements would be needed to deter or prevent participating nations from using encrypted services for warfare purposes; such arrangements, and any political sanctions they might involve for non-compliance, may not be sufficiently robust.

QUESTION 5.—ARE ARRANGEMENTS TO OVERSEE THE SECURITY ASPECTS OF GALILEO APPROPRIATE?

Clearly with the recent growth of terrorist activity, the design and implementation of the security aspects of Galileo have been taken very seriously. Attacks on the satellite constellation itself are thought to be extremely unlikely; however, the ground control sites that pass data to the satellites and monitor their operation and efficiency are vulnerable. Duplication of ground control stations, something of an afterthought for GPS, has been built into the early Galileo planning and, while costs inevitably limit the extent of such security measures, the designers have learnt from the US experience. Galileo user receivers will also be vulnerable to interference and jamming as are GPS receivers; monitoring such activity, and effective policing to stop it, is the responsibility of the Office of Communications (Ofcom).

Galileo will be a unique project in Europe, involving a wide range of political, economic, regulatory, security and commercial interests. It needs an organisational structure that reflects this unique character. The management structure must be open to development as the project progresses, but its design has already taken account of a number of fundamental needs, including safety and security of the system.

QUESTION 6.—WHAT ARE THE POTENTIAL BENEFITS OF THE PROGRAMME TO UK INDUSTRY, AND TO UK USERS OF GALILEO, SUCH AS NATS?

With the rapid development and expansion of civil applications, the potential commercial and industrial benefits of developing and operating a GNSS are enormous. The European Community rightly fears that these benefits will be lost to European industry if we continue to depend on GPS and/or GLONASS. Without a major change of policy by USA or the Russian Federation to enable shared international control of their systems, Europe can make no direct contribution to how GPS and GLONASS may develop and be modernized in future years. This inhibits European research and development activity and effectively precludes, or at least hampers, future industrial involvement in either system; hence the need and resolve to develop and implement the European Galileo system.

GPS is now suffering from its own success, mainly created by the much longer life of the early production satellites. As a result, the system is still primarily based on technology that is 30 years old. While plans are in hand to update the constellation, the US authorities are reluctant to commit major increases in funding while the legacy systems are still operating successfully. Galileo has been designed to meet the current and future needs of a much wider range of users. As a result, users in UK and throughout the World will gain from the additional capabilities it should provide.

One extremely important capability for both industry and commerce will that of "timing and synchronisation"; the financial, tele-communications and power distribution sectors of the British economy have come to rely more and more on GPS for this service. Galileo will improve the robustness of this critical input by providing better continuity and capability; however, since Galileo shares frequency bands with GPS, it will be vulnerable to many of the same sources of interference and jamming as GPS.

While the potential benefits to UK industry and commerce are extremely important, there will also be many major scientific applications that will benefit UK citizens. Scientific applications of GPS have ranged from improved weather prediction to monitoring of the Earth's crustal movement and sea level rise. Universities and research institutes in the UK have seen an exponential growth in research activity associated with GPS applications, which will expand even faster with the additional capabilities of Galileo.

Because of growing congestion in UK and European airspace, plans have already been made by NATS and Eurocontrol, and some implemented, to introduce area navigation (R-NAV) to replace the current system of fixed air routes throughout Europe that are based on ground beacons. This is in line with International Civil Aviation Organisation's (ICAO) concept and palns for future civil air navigation. Current short-range navigation aids such as VOR and DME, on which the fixed routes are based, can only meet this requirement in a limited manner. GNSS is seen as the primary means of achieving the more efficient use of airspace that can result from R-NAV because of its worldwide availability, at all altitudes, and at a predictable high accuracy. GPS and GLONASS (with EGNOS) give a partial solution, but Galileo has been specifically designed to meet needs of this type. In the longer term, there could be a considerable monetary saving on installation, calibration and maintenance by removing redundant NATS infrastructure.

In representing the needs and aspirations of users, The Royal Institute of Navigation is concerned that justification of the Galileo project is too often related merely to commercial benefit. There is undoubted industrial and commercial benefit from Galileo to UK and the rest of Europe, but justification of the project should also be made very strongly on the need to provide a safe and efficient infrastructure for navigation, positioning and timing. The Royal Institute of Navigation believes that provision of such infrastructure is as important for the future prosperity of the United Kingdom as the provision of motorways and rail tracks.

Air Commodore Norman Bonnor FRIN FRAeS
President

September 2004

Memorandum by the East Midlands Development Agency (GG 05)

THE GALILEO PROGRAMME

INTRODUCTION

East Midlands Development Agency (emda) is one of nine Regional Development Agencies in England. The RDA's were set up by Government in April 1999 to bring a regional focus to economic development. emda's business-led Board leads the agency in directing a wide ranging strategy and business programme, focusing on the following 3 Key Drivers:

— Enterprise and Innovation;
— Climate For Investment;
— Employment, Learning and Skills.

It is within the context of enterprise and innovation driver that emda carried out studies on the potential applications of space technology and the benefits to regional industries, particularly in downstream service applications.

The emda study[23] identified that satellite navigation was a key enabling technology which will open-up new opportunities for the region. The specific areas to benefit from such a system were identified as being general transport, congestion control, road charging, logistics services, tracking systems, aviation, surveying, insurance and land management.

It is appropriate for the agency to respond to the Transport Select Committee's enquiry, as the region has built-up world-class expertise and know-how in satellite navigation within its regional academic and industrial infrastructure.

1.0 WHAT BENEFITS WILL GALILEO PHASE II BRING THAT EGNOS (EUROPEAN GEOSTATIONARY NAVIGATION OVERLAY SYSTEM) WILL NOT?

1.1 *EGNOS*

1.1.1 EGNOS transitional system is Europe's first venture into Satellite Navigation; the system is designed to augment the two satellite navigation systems, GPS and GLONASS, currently operating.

1.1.2 EGNOS will enhance the positional accuracy provided by these navigation systems and will include the system integrity function, which is vital in providing Safety of Life services. This feature is particularly important in a number of Aviation and Maritime applications.

1.1.3 It is forecast that, once implemented and proven in service with GPS and GLONASS, EGNOS function is planned to be integrated into the future Galileo system.

1.2 *Galileo*

1.2.1 Today's two principal satellite radio navigation systems, Global Positioning System (GPS) and GLONASS are both under military control, the former controlled by the US and the latter by Russia.

1.2.2 Both systems are open to civil applications in Europe and elsewhere, but do not offer a guarantee of precision and/or continuous service. Moreover, the military authorities in both countries are capable of denying or downgrading the signal at any time for reasons of national security.

1.2.3 We understand the advantages of Galileo to include the following:

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[23] Source: Exploiting the Midlands Space Industry Potential Oct 2003.

The Galileo system will be under civilian control and will be available to organisations wishing to set up a wide range of reliable commercial navigation, tracking and positioning services.

Galileo is being designed to accommodate a range of civilian/commercially-based services from the outset and therefore has the potential to be optimised, in areas such as precision and availability.

1.2.4 Assuming compatibility with GPS the addition of the Galileo satellite constellation will increase the number of navigation satellites available for use. This will provide the potential for improved precision and possible alternatives for the implementation of the integrity function.

1.2.5 The orbits chosen for the Galileo constellation are such as to make Galileo satellites more available in urban areas, where shadowing from buildings is a potential problem.

1.2.6 From the East Midlands Regional perspective the Galileo Phase II will provide an independent commercial service on which "safety critical applications" business can depend and thus allow regional UK businesses to use their market application expertise and develop business services and products in these areas.

2.0 How Important is it for the EU to be Independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite system (GLONASS)?

2.1 As stated in response to the previous question GPS and GLONASS, are both under military control and offer no guarantee of precision or continuous service. The controlling military authorities are capable of denying or downgrading the signal at any time for reasons of national security.

2.2 Currently Europe is in the process of developing an integrated transport system, and an essential component is a "robust safety critical" positioning and navigational system which is both precise and reliable

2.3 The market for transport and precision location requirements are projected to develop, with a potential market estimated at 9 billion euros a year and estimated job creation of 100,000 European jobs.[24]

It is therefore very important that EU develop a robust commercial navigation/positioning system that can access the growing commercial market for safety critical applications.

3.0 What are the Potential Benefits of the Public Regulated Service (PRS) System? Is it Realistic to Expect that Member States will not want to Cross-subsidise PRS from Commercial Services?

3.1 The benefits of providing PRS can be considered at different levels including industrial/economic (development of a European PRS receiver manufacturing industry and of a PRS export market) and political and socio-economic (European capacity to provide continuity of service, especially for applications on which member states rely during crises).

3.2 The potential PRS market covers EU security-related applications such as civilian security, police forces, or customs as well as armed forces of EU and ESA member states and friendly nations involved in peacekeeping operations.

3.3 We understand that access to PRS and the associated receivers will be strictly controlled leading to the potential for increased security in times of crisis.

3.4 emda understands that the Galileo operation phase will be operated via a PPP, and has assumed that the Concessionaire will, within their operational business plans, feature and account for the PRS service whilst providing robust value offers to the customer for the commercial services.

4.0 Are the Arrangements to Prevent Military Use of Galileo Sufficiently Robust?

4.1 We at the agency do not have detailed information on these arrangements. However, it has been stated that Galileo "will be capable of being used in a military role", which could potentially be peacekeeping or other, using PRS. We understand access to PRS and associated equipment will be only available under strictly controlled access conditions.

4.2 The design and configuration for the PRS channel appears to be the subject of continuing discussion and negotiation and, as far as we know, has yet to be finalised.

4.3 There would appear to be nothing to prevent the use of other channels eg the Open Service (OS) and Commercial Service (CS) or others, for subversive and/or military purposes.

4.4 If these cases arise then consideration may have to be given to methods of denying or degrading the use of these services on security grounds. This is currently the case with GPS. The implementations of such procedures appear to conflict with the strategy of providing the highest possible availability to commercial users but, in such circumstances, can hardly be avoided.

[24] Inception Study to support the development of a business plan for Galileo, PricewaterhouseCoopers Sept. 2001.

5.0 Are arrangements to Oversee the Security Aspects of Galileo Appropriate?

5.1 We have no detailed knowledge of the security activities associated with Galileo. It is clearly important that Galileo services are highly secure and resistant to disruption by unintentional or intentional means.

5.2 Galileo security is necessarily concerned with physical, documentary and operational issues and must be seen as an overarching activity from the outset of the project.

5.3 Detailed attention must be paid to security aspects associated with the ground segment, the space segment and any associated augmentation system. Use should be made of experience from other space based satellite systems.

5.4 GPS receivers are extremely sensitive and commercially available equipment is relatively easily disrupted by interfering signals. Similar characteristics are expected for receivers used with Galileo. Operating frequencies should be carefully chosen and coordinated to minimise potential problems in this area. For a potentially global system this presents a challenging requirement.

5.5 PRS and Safety of Life services and equipment may be able to implement additional techniques to increase the robustness of these services.

5.6 We are aware that a Galileo Security Board has been set up and has defined the following tasks,

— Defining the technical characteristics of the system with regard to security (encryption etc).

— Assisting the commission in its negotiations with third countries, particularly on the issue of sharing frequencies with the US.

— Helping to draw up the proposal for the future security structure for Galileo activities.

5.7 It is not possible for us to comment further on the specific arrangements made to oversee security. However it is essential that, for Galileo system operations to be successful, all security issues are addressed rigorously throughout the design, implementation and operational phases.

6.0 What are the Potential Benefits of the Programme to UK Industry, and to UK users of Galileo, such as NATS?

6.1 A Galileo navigation system meeting the objectives of high precision, secure and continuous availability will enable the development of a wide range of associated systems.

6.2 The applications envisaged include mass market, commercial revenue earning systems and the more demanding and critical Safety of Life applications.

6.3 The deployments of highly available and cost effective navigation and positional systems have the potential to impact favourably on the environment, productivity and safety through the more efficient use of transport and energy resources.

6.4 In a regional study on the applications of space industry technology on downstream applications emda identified that satellite navigation is a key enabling technology, which opens up new opportunities in many sectors. Specific areas to benefit from such a system include general transport, congestion control, road charging, logistics services, tracking systems, aviation, surveying, insurance and land management.

6.5 The East Midlands hosts a number of major industrial clusters which will potentially gain benefit form the Galileo; these are Rail, Logistics and Aerospace.

The Rail Industry engineering cluster of over 200 companies (probably the highest density of Rail engineering expertise in Europe) will, given the projected accuracy and service integrity, apply these to "safety of life" requirements within the rail sector, Specific identified exploitation areas for satellite technology involve applications within the European Rail Traffic Management System's (ERTMS), European Train Control system (ETCS) and European Traffic management Layer (EMTL).

The Logistics Industry has a strong core developing in the East Midlands, being situated as it is ideally for transport network hubs. The desire in the Industry is to become more efficient in the use of resources whilst increasing the number of loads shifted, and at the same time attempting to protect the environment. Satellite technology will become increasingly important in the field of traffic management and control, efficient vehicle loading advice, and procurement. Load Tracking and efficiency will become a key concern to logistics companies to maximise vehicle utilisation and reduce costs of transaction. Wireless transactions and traffic network management to ensure full loads will be enhanced by better satellite information flows.

The Aerospace sector in the East Midlands will clearly benefit from better management of logistics, but the sector itself contains high tech manufacturers who will be beneficiaries from the Galileo build program. The Aerospace sector depends heavily on reliable navigation and tracking systems for safe and efficient transportation of people and cargo, both in the air and on the ground. Most of the existing technology in use is currently in the hands of the military where the technological developments have been incubated. The transfer of this kind of technology into the private sector will be immensely beneficial to both the UK Civil and military Aerospace sectors.

6.6 A number of space research and teaching centres already exist within the East Midlands.

Loughborough and Nottingham universities are undertaking engineering research and teaching activities in communications, signal processing, electronics and computing systems which are areas that could provide important inputs into space related projects.

The University of Nottingham IESSG (Institute of Engineering Surveying and Space Geodesy) is very strong in techniques applicable to surveying, monitoring and navigation using space-based assets such as GPS. The IESSG has also established a strong position with respect to the current European Galileo project and has initiated a number of complementary postgraduate courses. Many of the projects undertaken by the department are directed at studying application areas which could benefit from using space-based sensors to improve and or complement established techniques. The projects are generally practically oriented and the IESSG has strong connections to commercial and inter-governmental organisations.

The University of Leicester is very strong in techniques applicable to Space Science. The Space Research Centre and Department of Physics and Astronomy have also established a strong position with respect to a diverse range of space related scientific missions. The Leicester Space Science groups have strong connections to international academic and international space science research organisations.

The space related work undertaken by the De Montfort University Geomatics group is smaller in scale than that carried out by the Universities of Nottingham and Leicester. The Geomatics group has focussed on the specialised area of radar altimetry. The techniques developed have been applied to previously recorded satellite radar altimetry data (ERS 1). This has resulted in improved mapping details for several areas of the world.

From an East Midlands Regional perspective Galileo phase II will derive genuine benefit from linkages with universities engaged in space research within the region. It will also provide valuable infrastructure to strengthen and build on current research at research centres and academic institutions within the region.

David Wallace
Director (International)

September 2004

Memorandum by the Civil Aviation Authority (GG 06)

THE GALILEO PROGRAMME

Introduction

The Committee called for evidence on the Galileo programme, which is intended to establish a European owned global navigation satellite system (GNSS). Galileo is intended to provide a GNSS under civilian control, which will provide acceptable levels of safety, address concerns over liability and meet all reasonable user requirements. Galileo will comprise a satellite constellation and appropriate ground infrastructure, complementing the US Global Positioning System (GPS) and Russian Global Navigation Satellite System (GLONASS). The existing GPS and GLONASS systems were originally designed from a military perspective and remain under the control of the military authorities of those single states. Generically GPS and GLONASS are referred to as GNSS I. Galileo will contribute to GNSS II, a second-generation satellite system which will provide significant improvements. Galileo will, however, be globally available and will be under international civil control and management, meeting the requirements of all categories of users for position, velocity and time determination. A decision on Phase 2 of the Galileo programme is anticipated at a meeting of the EU Transport Council in December 2004. Prior to that meeting the Transport Select Committee wishes to explore a number of questions and this memorandum provides evidence on each of those questions.

Question 1—What Benefits will Galileo Phase II bring that EGNOS (European Geostationary Overlay System) will not?

Phase 2 of the Galileo programme, known as the Development and Validation Phase, involves the first stage of the implementation of the Galileo infrastructure. This phase will include consolidation of mission requirements, development of satellites and ground-based components, and the "in-orbit" validation of the system. The aim is to validate the technical options and create the conditions for subsequent rapid deployment of the infrastructure. Consequently Phase II will provide no benefits to the end user but is an essential step towards the full deployment phase and eventually a fully operational system.

The phrasing of the question implies a misconception of the capability delivered by EGNOS as it is not directly comparable with Galileo. Galileo will provide a standalone Global Navigation Satellite System with a similar infrastructure and capability to GPS, designed to function alongside both GPS and GLONASS (the latter albeit subject to sufficient funding being made available to complete its infrastructure). EGNOS is an augmentation system to GPS or GLONASS, and is dependent on these systems.

The main difference between Galileo and GPS is that the former has been designed from the outset for civilian use and is thus planned to meet the safety requirements of civilian users. This addresses the performance and integrity monitoring capabilities required for Safety of Life operations, which includes Air Transport. EGNOS is a Space Based Augmentation System (SBAS) and has been designed to improve the accuracy and integrity of the navigation information obtained from GPS or GLONASS. It is not a complete navigation system in itself. EGNOS essentially monitors the operation of GPS or GLONASS and provides correction signals to overcome any inaccuracies. Within Europe the use of GPS has been generally limited to en-route and terminal area operations as a supplementary navigation aid and the carriage of "conventional" land-based navigation systems is still required. These functions enable certification of aircraft to use GPS/GLONASS with EGNOS in the final stages of flight to Category 1 approach equivalence, ie final approach. The validation process for EGNOS has yet to be completed but it is not designed to meet the requirements for use as a final approach aid to replace Instrument Landing Systems (ILS) beyond Category I approach conditions. It would not, therefore, provide a Category 2 or 3-instrument approach capability, which is available at major airports such as London Heathrow or Gatwick, but would provide an instrument approach capability to runways at smaller airfields where an instrument landing system did not exist. It is not presently considered there will be a significant demand within the UK for EGNOS but it is understood the French have plans to use EGNOS to provide an instrument approach facility at many of their regional airports where such a capability does not currently exist. EGNOS is designed to operate over a finite geographical area predicated on the footprint of the geostationary satellites used. This includes most of Europe and a large part of the African continent, where there is potential to exploit EGNOS in areas which are poorly served by ground based navigation aids. China, the US, Japan and India are developing similar SBAS systems.

Many European airlines are very sceptical and do not favour EGNOS since they believe that current navigation equipments provide the navigation solutions to meet their operational requirements. Much of this scepticism relates to concerns over cost, both to fit new equipment and a fear that they will have to pay the majority costs of a system for which they have limited requirements.

EGNOS was under development before Galileo and it is considered its inclusion in the Galileo Programme was due to a mix of both political and technical factors. EGNOS should be operational by 2006 and if it had not been included in the Galileo Programme there was a real risk that the EGNOS Programme would have been abandoned due to lack of funding. This would have led to a loss of significant investment by the EGNOS developers. The EGNOS Programme has mustered significant technical expertise, which will be of use to the Galileo Programme; it is understood there was concern that this would be lost/dispersed had the EGNOS Programme been stopped. In the longer term following Galileo introduction it is not clear what role, if any, EGNOS will have. It is more likely that once Galileo is operational the needs of the aviation community will be met by the much more accurate information and integrity that Galileo should provide. Nonetheless, it is understood there are plans to integrate EGNOS with Galileo to maintain the augmentation capability in the event of a system failure.

Question 2—How Important is it for the EU to be Independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?

GPS and GLONASS are military systems. GLONASS is currently not fully operational with less than half of the satellite constellation actually functioning and its future is dependent on sufficient funding being made available and the continued access to the launch site in Kazakhstan. In the US, arrangements between the Department of Defence and civilian authorities are in place to ensure that the needs of the civilian users are considered in relation to GPS. However, GPS is still controlled and operated by the US military authorities who are not willing to share control of GPS. The same is true of the Russian authorities where GLONASS is concerned. Both are willing to continue to provide worldwide civilian access to their systems free of charge but they will accept no liability for performance or continuity of service. European concern over the control and management of GPS and GLONASS is one of the stated drivers of the Galileo Project, which will include liability arrangements. To maximise the benefits of Galileo it must be interoperable with the existing systems and this is planned. Moreover, the introduction of an independent system will increase redundancy and improve worldwide coverage. The Galileo system should meet the majority if not all current and future needs of civil aviation users.

Question 3—What are the Potential Benefits of the Public Regulated Service? Is it Realistic to Expect that Member States will not want to Cross-subsidise PRS from Commercial Services

The Public Regulated Service (PRS) is proposed to provide an encrypted signal to meet the needs of certain Government agencies such as police, safety services and customs and excise. From a civil aviation perspective this could be used for example by police helicopters. Here the CAA would need to be satisfied that the PRS specification met the necessary aviation standards, although from what has been stated this is likely to be the case. It is difficult to see how all costs could be attributed specifically to a particular service, as there will undoubtedly be some common functionality. In the UK the cost of the aviation infrastructure is recovered from users. Aviation users currently receive free GPS signals and have stated they have no desire to pay for Galileo services at all, let alone cross-subsidise elements of it!

QUESTION 4—ARE THE ARRANGEMENTS TO PREVENT MILITARY USE OF GALILEO SUFFICIENTLY ROBUST?

As has been demonstrated by the development of differential GPS techniques to overcome "Selective Availability" (the means by which the US attempted to deny very accurate navigation signals to civilian users, now withdrawn) there is no truly effective method to prevent military use of an open GNSS service. However, encryption techniques should enable access to the Galileo Commercial and PRS services to be controlled. From a CAA perspective, we would not have a difficulty with military use of Galileo to permit military aircraft to meet required civil aviation navigation standards. The MOD should be asked to comment on military use of Galileo for other military purposes.

QUESTION 5—ARE ARRANGEMENTS TO OVERSEE THE SECURITY ASPECTS OF GALILEO APPROPRIATE?

With increasing reliance being placed on the use of satellite navigation, concerns have been raised about the possible vulnerabilities of the system. These vulnerabilities fall into the categories of intentional and unintentional interference. Unintentional interference includes atmospheric effects, radio frequency interference and human factors. GPS modernisation and the addition of Galileo as an extra satellite navigation system will do much to reduce the possible effects of unintentional interference. The more satellites that are available, assuming that the operator has a receiver capable of receiving signals from the different systems, the greater is the redundancy built into the overall system.

Potentially, intentional interference is a far greater problem. This can take the form of jamming or, in these days of international terrorism, sabotage. Jamming is a potential problem because of the low power of the satellite system signal thus making it possible for someone with a comparatively simple piece of equipment to interfere with the system. For example, it is conceivable that, in the future, a vehicle driver who has a satellite system fitted to monitor his progress for the payment of road tolls could use a small jamming device to interfere with the signal. However, the modernisation of GPS and the introduction of Galileo with new frequencies should reduce the threat of such intentional interference although it can never be completely eradicated. The question of sabotage is, perhaps, more pertinent. In to-day's environment the effect of a terrorist attack on a navigation aid, or even a group of aids, would be comparatively local and the effect limited because of the availability of alternatives. An attack on a satellite navigation system could have a more far-reaching affect because of the global nature of the system. Attacks on the satellite constellations themselves are considered extremely unlikely but the ground infrastructure, which passes data to the satellites and monitors their operation and efficiency is far more vulnerable. The planning of Galileo has included the duplication of ground control sites and they are spread across the globe. This was something of an afterthought with GPS although, again, the GPS ground infrastructure is spread wide, thus making an effective act of sabotage more difficult. Although cost will be a limitation, the design of the Galileo infrastructure will reduce the risks of sabotage and, in the event of any attack, the affects of such an attack. Furthermore the use of encryption for certain more accurate services (Commercial and Public Regulated) should reduce the risks of unfriendly elements using the system for hostile purposes. The design of Galileo has already taken into account a number of security requirements. Notwithstanding this, the CAA considers there will be a need to retain some form of reversionary ground-based navigation system to provide redundancy. The extent and make-up of this has yet to be determined.

QUESTION 6—WHAT ARE THE POTENTIAL BENEFITS OF THE PROGRAMME TO UK INDUSTRY AND TO UK USERS OF GALILEO SUCH AS NATS?

With the rapid expansion of civil applications of satellite technology for navigation, the potential commercial and industrial benefits of operating a GNSS are significant. If we continue to rely on GPS and/or GLONASS these benefits may well be lost to Europe. Currently the US and Russia will not entertain the prospect of shared control of their systems and this position is unlikely to change. Consequently, Europe would not be able to make any contribution to the modernisation and development of these systems, thus hampering European research and precluding industrial involvement in either system. The advent of Galileo will provide European industry with the opportunity to contribute to the development of satellite and receiver technology as well as a wide range of other areas connected with the control and development of a GNSS. The EU also foresees major benefits to European industries stemming from the Galileo Project in a range of applications that satellite navigation will either introduce or support.

As far as UK aviation users of Galileo, and indeed GPS, are concerned the potential benefits are widespread. The European Civil Aviation Conference Navigation Strategy, developed through EUROCONTROL, includes the development of Area Navigation (RNAV) where onboard systems allow aircraft to navigate without direct reference to ground radio navigation beacons. Increasingly the primary input to these onboard systems will be from satellite navigation. Because of its worldwide availability and increased accuracy compared to GPS and GLONASS, the advent of Galileo will add to the benefits achieved from RNAV leading to a more efficient use of increasingly busy airspace. Furthermore, as satellite navigation develops with augmentation systems and additional constellations such as Galileo, the need for ground-based aids will decrease. The ECAC Navigation Strategy sees the eventual withdrawal of Very High Frequency Omni-directional Radio Range (VOR) beacons, which will present the Air Navigation Service Providers (ANSPs) such as NATS, with reduced infrastructure costs. Most large airliners already carry an

avionics fit that includes GPS, Inertial Navigation Systems (INS) and a Flight Management System (FMS). The combination of highly accurate satellite navigation information and INS information will greatly increase the accuracy of the navigation solution for all phases of flight, thus meeting the ICAO aim to rely on GNSS as a sole means of navigation. This remains some way off because, amongst other things, users with slightly less comprehensive avionics will still rely on a mix of conventional and satellite sensors; for example small regional airlines, business jets and General Aviation who are more constrained by cost. The use of a common, highly accurate time reference, which GNSS gives, will also have benefits. Currently in areas such as the North Atlantic, aircraft separation includes an element to cater for inaccuracies in timing references. If a common accurate source was in use, this separation could be reduced, thereby increasing the capacity of the airspace. Increased capacity would also result from the increased accuracy of the navigation solution mentioned above. In the face of increasing demands for air travel this capacity enhancement is vitally important.

Other potential benefits of the increase in GNSS capability that Galileo will bring include:

a. A worldwide seamless system consisting of several interoperable satellite systems and regional augmentations that will make advanced navigation infrastructure available to all nations. This will bring capacity and safety benefits.

b. The potential offered by GNSS to provide one avionics system for all phases of flight, thus reducing the amount of equipment carried. Whilst the weight and cost savings derived from this advantage may be relatively small for individual aircraft, the cumulative effect of the benefit over entire fleets for their full life-cycle will be substantial.

c. Safety benefits including more accurate prediction of flight trajectories, potential reduction of Controlled Flight Into Terrain (CFIT), more airports with precision approaches, ground movement guidance and enhanced navigation performance in oceanic and remote areas.

d. The rationalisation of ground infrastructure with the eventual goal of having "sole means" GNSS thereby producing savings in installation and maintenance costs over time. This may also free-up portions of the radio spectrum for other purposes in the longer term.

September 2004

Memorandum by LogicaCMG (GG 07)

GALILEO

1. LogicaCMG is pleased to have the opportunity to provide evidence to the Transport Committee on the importance of Galileo and EGNOS. We have participated actively in the preparation of the evidence being submitted to the Committee by the UK Industrial Space Committee (UKISC), and we have made some contributions to the evidence from the Pinpoint Faraday partnership. In this letter, therefore, we try not to repeat information in either the UKISC or Pinpoint submissions, and concentrate instead on additional points primarily related to Question 6: the benefits of Galileo to UK industry and users.

Galileo & EGNOS serving the economy and society

2. We note the already substantial encroachment of GPS into commerce and society, and the plans for major public sector initiatives that depend on GPS for example in:

— road user charging
— prisoner tagging
— air traffic control.

3. UK and other European air traffic control authorities have made substantial commitments to EGNOS as a technology that will save money in the long run, and LogicaCMG is proud to have been selected in Europe-wide competition to provide the most critical element of EGNOS, namely the Check Set, that provides the integrity information enabling aviation and other safety-critical users to depend on the GPS/EGNOS information.

4. Looking to the future, we are a partner in one of Europe's pilot projects that is exploring the use of satellite navigation for road tolling—the ARMAS project[25]. As part of a European consortium led by Skysoft of Portugal, we are assessing the feasibility of introducing EGNOS and Galileo in road applications and services. The current phase of the work is analysing the critical issues related to the successful introduction of virtual tolling based on EGNOS and Galileo, such as prevention of fraud. A demonstrator version of a road tolling system has already been created in Lisbon and is being used to explore practical

[25] See http://armasii.skysoft.pt/

issues in using satellite navigation. Trials in London and other cities across Europe have been held or are planned. We would be pleased to arrange for the Committee to visit the demonstrator in Lisbon to see at first hand the benefits of EGNOS in a road tolling environment, and to discuss the results of the London trials.

5. LogicaCMG is the world leader in mobile telephony applications—more than half of the world's text messages use our software, currently > 500 million subscribers. Satellite navigation is a strategic technology for our future products in the mobile telephony sector—under the general heading of location based services. Through the European Commission's Sixth Framework programme we are committed to investing to develop standards and products that will exploit Galileo's special features (in conjunction with GPS) for this marketplace.

6. We are also using the Sixth Framework programme as a mechanism for channelling some of our investments in the road user charging area, and in other more specialist applications of Galileo, such as ultra-precise positioning.

7. The UK Government's Pinpoint Faraday programme (of which we were a founder member) is another useful channel for investment funds, since it brings together academic and industry resources to address specific technological targets. We have two Galileo-related activities underway via this route.

UK helps to shape Galileo

8. LogicaCMG's marketplace is those information technology systems of major organisations that are business critical. These customers in turn address mass markets in the telecommunications, transport, defence, retail, manufacturing, energy, finance, health care, criminal justice, and many other sectors. Our technology is the intellectual engine at the heart of applications such as electronic banking or e-commerce. Although the contract value of our contribution to a programme may be relatively modest, it allows the resulting services to be scaled for the mass market. Therefore, through the indirect channel of our customers, the investments we make in technologies such as satellite navigation play a part in delivering new mass market services and products across the board—in both public and private sectors.

9. Our central role in EGNOS (see §3 above) has given the UK a sound technical understanding of the technology, while ensuring that this critical part of EGNOS is designed to state of the art industry standards.

10. Turning to Galileo, early this year we were selected in open competition by the European Space Agency (ESA) to design the ground facilities of Galileo. This role has allowed us to ensure that the design incorporates the latest concepts and technologies from across the information technology sector. We are the largest IT security assessment organisation in the UK, and this expertise plus our commercial background has given ESA a design that will enable the Galileo operator to implement the policy laid down for security and Public Regulated Service (PRS) with confidence.

11. We have also helped to shape the institutional arrangements proposed for Galileo. Unlike our counterparts around Europe we have had the opportunity here in the UK to define the detailed arrangements for the £2 billion military Skynet-5 satellite system currently being procured by the Ministry of Defence under a Private Finance Initiative (PFI) regime[26]. In 2000-2001, the European Commission used our Skynet-5 PFI experience to help define the PPP arrangements of Galileo. For the past year we have been participating in the PPP process from the industry side as a member of one of the three bidding consortia short-listed last December. We see the Galileo PPP concession contract as a major opportunity for industry to create added value across the economy.

Government support for industry

12. UK Government support has been a crucial factor in the ability of UK industry to gain central roles in Galileo and EGNOS to date. An article in the forthcoming (October) issue of the house journal of the Royal Institute of Navigation, Navigation News, explains how UK industry has been winning far more Galileo contracts than in proportion to our funding—in brief, UK industry had won almost 30% of the recent ESA contracts in comparison with UK's 17% share of the ESA funding. This success is due of course to UK industry's inherent expertise, but also to sound Government policy in supporting industry initiatives in advance of the European procurement decisions.

13. LogicaCMG can point to several instances where UK Government support via the British National Space Centre (BNSC) has positioned us for key Galileo roles, eg

(a) a small study funded by BNSC allowed us, assisted by Surrey Satellite Technology, to develop a low cost concept for a Galileo-type satellite system, thus helping to persuade ESA of our ability to design the complete Galileo ground segment

(b) BNSC lobbied ESA for our role as supplier of the EGNOS Check Set, confirming to ESA that our role was considered a UK priority; the success of our Check Set project confirmed to many in ESA our capability to design the complex Galileo ground segment

[26] We now have a £100 million contract within that programme to supply and maintain the main Skynet-5 ground IT systems

(c) a small project, jointly funded by LogicaCMG and BNSC (via ESA), enabled us to create a demonstrator of the technology that can assure many of the most complex aspects of Galileo security; again this helped to reassure ESA of our competence to design the complete Galileo ground segment, including its sensitive security components.

We hope that these remarks are helpful to the Committee's work and we would be pleased to provide clarification or further information on request.

Patrick Norris
Business Development Manager—Space

September 2004

Memorandum by the Royal Academy of Engineering (GG 08)

GALILEO

EXECUTIVE SUMMARY

The Royal Academy of Engineering is pleased to submit evidence to the House of Commons Transport Committee's Inquiry into the Galileo satellite system. The Academy has a number of Fellows with direct experience of the Galileo project and many with broader experience of the space industry. This response draws upon their knowledge in answering the Committee's questions; however, the Fellows have felt unable to comment on the area of security raised in two of the Committee's questions. Questions on such security issues could probably be adequately addressed only by representatives from the MoD or DSTL.

The Galileo satellite navigation system currently under development has similarities with other satellite navigation systems such as GPS (Global Positioning System) and GLONASS (Global Navigation Satellite System) but also has a number of important differences, particularly in that it is a civilian owned and operated system, and in the types of services that will be offered.

The standard GPS signal is not offered with any full-time performance guarantee and therefore is not considered suitable for fail-safe "safety of life" applications. However, there are currently two systems available in Europe which provide a degree of enhancement to the GPS system. Differential GPS (dGPS) monitors the error in the GPS signal from ground stations at known positions and then broadcasts an error correction signal to nearby receivers. A free dGPS service is operated by the General Lighthouse Authorities for navigation around UK waters. EGNOS (European Geostationary Navigation Overlay System), a collaboration between the European Commission (EC), the European Space Agency (ESA) and Eurocontrol, the air navigation safety organisation, provides an enhancement of the GPS system using three geostationary satellites and a network of ground stations to provide a wide area differential GPS service and integrity monitoring service.

The Academy sees merit in a European owned and controlled non-military satellite navigation system that offers users a guaranteed level of service. It also seems likely that additional services offered by the Galileo system will be of great benefit to European industries especially in the transport sector with a number of UK companies standing to benefit from developing those applications. Galileo's interoperability with the existing GPS system is a major advantage.

(a) *What benefits will Galileo Phase II bring that EGNOS (European Geostationary Navigation Overlay System) will not?*

GPS is an independent global satellite positioning system, with many military and civilian applications. However, it exhibits several drawbacks, especially when used for civilian applications. These include low availability/coverage in environments with an obstructed view of the open skies, such as high rise urban canyons (a problem that Galileo will alleviate), no system integrity (ie inability to inform users when the system is not reliable) and, of course, the joint military-civil ownership of the system, which does not allow it to offer guarantees of service performance. These are essential not only for safety-critical transport, but also for many government and commercial applications.

EGNOS, one of several regional augmentation systems to GPS, does mitigate some of the drawbacks of GPS. Through the continuous monitoring of the GPS satellite signals, it can generate and broadcast corrections, which improve navigation accuracies, and information about the current system integrity of GPS. It also improves availability/coverage marginally, acting as "extra" (two or three) satellites in the visible sky.

EGNOS demonstrators showed that it was possible to use very effectively, and with high accuracy, the existing and proven GPS system with a group of European based integrity and quality monitoring stations. If the argument were limited to whether Galileo would provide a better or more accurate navigation system alone, then it would be unclear as to why Galileo is required when it has been proven over many years that GPS with EGNOS is available, robust, reliable and accurate.

However, EGNOS cannot operate on its own as a global satellite navigation and positioning system. This is not the case of Galileo which, like GPS, has been designed from the beginning as an independent global satellite navigation and positioning system, but for civilian use and controlled by the EU. As a result, it does not suffer from some of the drawbacks of GPS. Moreover, it is proposed that Galileo will offer several types of service. These include the free Open Service (OS) similar to that offered by GPS at present, the Safety of Life (SoL) service, the enhanced Commercial Service (CS), the Public Regulated Service (PRS), and Search and Rescue (SAR) service. Last, but not least, Galileo has been designed to be compatible and interoperable with GPS. The resulting combined Global Navigation Satellite System (GNSS) will overcome several of the drawbacks of GPS, offering a significantly better availability/coverage in environments with an obstructed view of the open skies, a significantly higher level of system integrity, and considerably improved navigation and positioning services, than those offered by GPS augmented with EGNOS and the other regional augmentation systems. The new GNSS will also generate many more new applications, including several so far unforeseen ones.

The Academy believes that Galileo will therefore not only bring many commercial and industrial benefits to EU businesses and governments, but also help countries in other regions of the World (some of which are already participating in the Galileo Project). Ordinary citizens will also reap benefits through the development of many applications of significant benefit to society.

(b) *How important is it for the EU to be independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?*

Both GPS and GLONASS were originally designed, operated and controlled as military systems. GPS has since evolved to become a dual military-civilian facility, with hundreds of scientific, commercial and industrial applications. GLONASS, on the other hand, has declined over the years due to lack of funding, leaving GPS as the only fully operational global satellite navigation system. The arrival of Galileo will bring two distinct advantages to GNSS users, both in the EU and elsewhere.

Firstly, GPS and Galileo, as two compatible but independent systems, will reduce the economic risks of relying on a single global satellite navigation system. Even a short outage of GPS, due to malfunction, or deliberately for test purposes, or even as a result of a premeditated attack on its infrastructure, could cause significant disruption. This would affect many commercial, government and private system users relying on GPS for navigation and positioning, with inevitable safety-of-life and financial consequences. This is important not only for EU member states, but also for the US and the rest of the world. The recently signed agreement between the US and the EU, on the interoperability of GPS and Galileo, implicitly recognises that these two systems can act as back ups for one another, in case of major system failures.

Secondly, GPS and Galileo operating together, and thus offering a much larger number of satellite signals, will lead to a more accurate and dependable global satellite navigation and positioning system for many current and new applications. Furthermore, the civilian design, operation and control of Galileo, together with the public-private-partnership approach, will create additional incentives for new market driven applications, products and services. The potential of two independently operated, yet compatible and interoperable satellite navigation systems has been recognised not just by industry and commerce in the EU, but also in the US and several other countries. These include India, Israel, China, Brazil and Mexico, who have expressed the wish to become involved in the Galileo Programme.

(c) *What are the potential benefits of the Public Regulated Service (PRS) system? Is it realistic to expect that Member States will not want to cross-subsidise PRS from commercial services?*

Not much information exists in the public domain on the Public Regulated Service (PRS), other than what is available on the Galileo websites. This is partly due to the need to protect the evolving PRS system from potential future threats, but also because its precise mode of operation and target user communities have not been clearly defined yet. Nevertheless, although not specifically publicised, the recent classified US-EU agreement on the interoperability of GPS and Galileo[27] would have included an understanding allowing the projected PRS signal of Galileo to co-exist with the military precise signal of GPS.

Unlike the Open Service (OS) signal of Galileo, which will be freely available, the encrypted PRS signal will have features which will make it more resistant to jamming and interference and will remain available when the OS is deliberately denied locally or regionally. This is both to protect the PRS from threats, disruption and other subversive activities by hostile agencies or individuals, directed against national security, law enforcement, economic activity and emergency situations.

[27] "Done Deal" GPS World 20th July 2004

The precise method of funding the PRS service will not be decided until after the Concessionaire, who will be operating Galileo, has been decided upon at the next EU Transport Council meeting in December 2004. Possible funding methods could include, for example, each EU member state being given the option of contributing to the funding of PRS, should they plan to use it. Another option would be for the user agencies to pay the Concessionaire directly, not unlike satellite TV. A third option would be for the EC to pay the Concessionaire an availability fee for each Galileo service being made available. The final choice, which will have to be approved by the Transport Council, could well include elements of all these three options.

There are, however, numerous possibilities for cross funding which probably cannot be ruled out. The use of Galileo as a means for Member States to collect road tax or tolls could see the compulsory fit of devices to all road vehicles.

(d) *What are the potential benefits of the programme to UK industry, and to UK users of Galileo, such as NATS?*

Satellite navigation and positioning has a wide range of industrial, scientific and commercial applications, some of which are already visible in everyday life, most notably in car navigation. The arrival of Galileo and its interoperable usage with GPS will lead to a substantial increase in applications in all sectors, because of the resulting significant improvement in system integrity, accuracy and coverage.

UK industry is well placed to benefit from both the core Galileo development activities (including the space-based hardware), which will ultimately lead to the Galileo navigation signals, and the future industrial activities which will exploit these signals by providing commercial services and applications. Indeed, UK industrial companies are already leading the production of the first experimental satellite and its ground control, and are contributing substantially to the second prototype Galileo satellite. UK industrial companies are also expected to make major contributions to both the space and ground infrastructures of the main Galileo system. This is also the view of UKISC, the United Kingdom Industrial Space Committee.

Some negative impacts of Galileo have also been noted although these may be overcome in the fullness of time. In particular, Galileo is less efficient in terms of radio spectrum usage than the current GPS system requiring 122MHz compared to GPS's 71MHz[28] leading to potential interference with other systems including air traffic control radars.

UK companies will also lead in the exploitation activities which will accelerate when Galileo becomes operational. This is because of the expertise and experience traditionally associated with UK industry and business to generate revenue from new technical developments, as was the case with GPS and satellite communications. Indeed, UK companies are already key players in the two consortia short listed for the concession to operate Galileo. UK companies also have key roles in several of the EU Framework Programme's R&D activities directed towards the exploitation of Galileo over a wide range of professional and mass market applications, ranging from agriculture and surveying, to location-based services.

The UK also has a long-standing tradition of university based research leading to the development of new scientific and commercial applications, as was clearly demonstrated with GPS, when it started life as a military utility. Moreover, in many cases, university research has also led to the formation of Small-to-Medium Enterprises (SMEs). This has happened over a wide range of technologies, including satellite navigation. This will repeat itself when Galileo comes on stream and provides existing and future SMEs with added incentives to develop new GNSS applications and business opportunities.

While the benefits in terms of jobs and work of investing in Galileo systems can clearly be seen, some of these benefits could be accrued from continued investment in the development of current GPS systems.

Richard Ploszek
Assistant Manager, Engineering Policy

September 2004

Memorandum by the Royal Institution of Chartered Surveyors (GG 09)

GALILEO

I am writing on behalf of the Royal Institution of Chartered Surveyors (RICS) in response to your call for evidence on Galileo, dated 16th July 2004. RICS is the world's leading professional body on all aspects of property, construction and associated environmental issues. It represents, regulates and promotes the work of property professionals across the world and has over 110,000 members in 120 countries. It is an independent, not-for-profit organisation committed to providing impartial, authoritative advice on major issues affecting business and society. Under the terms of its Royal Charter RICS is required to act in the public interest.

[28] "Galileo Frequency and Signal Design", J-L Issler, G W Hein, J Godet, *et al*, GPS World, 1st June 2003

A Response to the Transport Committee from RICS

Although RICS feels that it cannot comment with authority on all of the questions asked within your press notice dated 16th July 2004, we believe that HM Government should fully support the Galileo satellite navigation initiative.

What benefits will Galileo Phase II bring that EGNOS (European Geostationary Navigation Overlay System) will not?

The benefits are primarily technical but with a multitude of possible applications. Others will delve into the minutia of the technical aspects of EGNOS/Galileo compatibility but essentially EGNOS is a EU centred GPS augmentation system that seeks to "piggyback" on already existing Global Navigation Satellite Systems (GNSS) such as GPS and Glonass and is therefore dependent on the operational integrity of said systems. Galileo will not only provide another signal platform for EGNOS to operate on but will also provide redundant positional information that is essential, in say, the emergency services and aviation environments. EGNOS has also been designed to perfectly augment and improve the accuracy of Galileo signals (through differential corrections). It should also be remembered that EGNOS is EU wide whilst Galileo gives a global remit to possible commercial services.

How important is it for the EU to be independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?

Others will be better able to comment on this issue. Suffice to say, that in 2000 President Clinton turned off "selective availability s/a" and at a stroke improved GPS accuracy (for public users) by a factor of ten to +/− 10 metres. The US can easily turn it on again. The Russian system is in a varying state due to economic difficulties. Galileo is needed to supersede and augment these already existing systems, in particular, for aviation purposes.

What are the potential benefits of the Public Regulated Service (PRS) system? Is it realistic to expect that Member States will not want to cross-subsidise PRS from commercial services?

Others will be better able to comment on this issue, however we believe that the question is unclear.

Are the arrangements to prevent military use of Galileo sufficiently robust?

Others will be better able to comment on this issue.

Are arrangements to oversee the security aspects of Galileo appropriate?

Others will be better able to comment on this issue.

What are the potential benefits of the programme to UK industry, and to UK users of Galileo, such as NATS?

RICS believes that the possible future benefits of high accuracy Galileo positional information are myriad and very far-reaching. Many high quality and very in depth documents already exist on this subject and other organisations will probably go into more technical details. From high precision farming to the tracking of animals (witness the confusion during the recent Foot and Mouth epidemic here in the UK) to the registration of GM crops, Galileo will serve to aid the rural economy to reach a more efficient model. Within the realms of transport; road charging, congestion charging, vehicle/fleet management and tracking, toll charges, bus/tram/rail safety and tracking will be improved.

Safety within aviation is defined by accurate navigation. The availability of high precision Galileo signals will further augment existing navigation services.

Environmental programmes, flooding alert systems, supra national geographic information initiatives such as Inspire will all benefit.

Highly accurate clock (timing is one of the "hidden" successes of GNSS) transmissions will allow more efficient and faster data transactions, improving internet and intranet capabilities.

As an island, the UK is highly dependent on marine navigation, particularly in high density/use areas such as the English Channel, Galileo will further aid navigation systems employed by mariners, natural resource (oil/gas) companies and commercial operations.

As already mentioned the Galileo has a great multitude of potential benefits, we would like to again state that RICS fully supports this EU initiative.

James Kavanagh BSc(Hons) C.Geog MInstCES
Geomatics Faculty
Assistant Director, Faculties and Forums

September 2004

Memorandum by National Air Traffic Services Ltd (GG 10)

GALILEO SATELLITE NAVIGATION PROGRAMME

INTRODUCTION

1. NATS welcomes the Committee's decision to conduct an inquiry prior to the possible decisions to be taken by the Transport Council in December 2004, and its invitation to submit evidence.

2. Satellite navigation was identified by the International Civil Aviation Organisation (ICAO) as an important element in providing a global Air Navigation Service. The first system offered to the international community was the USA's Global Positioning System (GPS), followed by the USSR's (now Russia) GLObal NAvigation Satellite System (GLONASS).

3. The civil aviation industry noted that neither system met its requirements for integrity (how well the system can be trusted), availability and continuity (the risk of sudden unplanned loss of service).

4. The international aviation community designed a specification, subsequently adopted by ICAO, to provide additional satellite-based services which would overcome the shortcomings of GPS and GLONASS. The Satellite Based Augmentation System (SBAS) is implemented in Europe by the European Geostationary Navigation Overlay System (EGNOS).

5. In 1997 NATS invested in EGNOS through the British National Space Centre (and with permission from the UK government), along with other Air Traffic Service Providers (Spain, Germany, France, Italy, Switzerland and Portugal), the French Centre for Space Studies and the Norwegian Mapping Agency. The total Air Navigation Service Provider (ANSP) investment represents 1/3rd of the total costs or 1/2 the investment costs (since European Commission funding is through Grants, not Investments).

6. By 1999 the EC had convinced Member States to produce and operate their own Satellite Navigation System, Galileo, aiming to overcome the technical and political weaknesses of GPS, and provide institutional and technical coverage if one or other system was withdrawn for any reason (technical or political).

7. It is planned (as recommended by European Transport Ministers) that EGNOS will be integrated into Galileo to provide a combined GPS/Galileo Safety-of-Life Service.

8. NATS' response to the Committee's questions is as follows:

Q1: WHAT BENEFITS WILL GALILEO PHASE II BRING THAT EGNOS (EUROPEAN GEOSTATIONARY NAVIGATION OVERLAY SYSTEM) WILL NOT?

Reach & Functionality

9. Galileo is similar to GPS, and brings an additional 27 operational satellites to complement the US system. Galileo aims to be a global system, like GPS, with agreements already signed with China and Israel and further agreements being negotiated with Brazil, India, Japan, Russia, Ukraine, Mexico, Canada, South Korea and Australia.

10. EGNOS supports and enhances GPS allowing it to be used in many safety critical applications that were not part of its original design remit, providing users with integrity information on the GPS satellites, correction of errors in the GPS navigation data, and greater availability of GPS service.

11. EGNOS is one of several SBAS standardised by ICAO. Other SBAS are being brought into operation to provide augmented GPS coverage in other parts of the world, most notably WAAS in the USA, GAGAN in India, SNAS in China and MSAS in Japan. These systems combined will provide a global SBAS service. Galileo coverage will be global by design.

12. Unlike GPS, Galileo is planned to provide its own integrity signal so should not require an SBAS overlay. It will also provide a guaranteed performance of service. Galileo will not provide integrity corrections for GPS, which will use the ICAO-standardised SBAS for this service.

13. There is no suggestion that GPS will be withdrawn since the US economy (and others) are so dependent on the wide system use across many areas and applications, and the SBAS have been developed to provide the required signal integrity. However, there is a question-mark over whether GPS will remain free of charge given that Galileo is expected to recover its costs.

Application & Marketability

14. SBAS are designed to be compatible and interoperable; they have also been designed to meet the requirements of aviation as the most demanding user and thus also likely to satisfy the needs of all other potential users. As it happens, EGNOS is currently being used mainly for agricultural purposes eg high precision seed drilling, and was used most recently at the Athens Olympics to help the security operation.

15. Used together in Europe, Galileo and GPS/EGNOS will provide a back-up service for each other in case of single system failure whilst the combined accuracy, availability and integrity of Galileo and GPS/EGNOS will open the door to many more applications.

16. The signal structure of Galileo should enable mass-market receivers to become more easily available due to a price and weight reduction in the receiver—critical in markets such as mobile phones etc. Because of its complex signal structure GPS needs large amounts of processing power, requiring a more robust power supply (battery). Galileo, by using a secondary pilot signal, requires less power and therefore cheaper, lighter user equipment.

Robustness

17. The main difference between the potential of the two systems is that Galileo is standalone whilst EGNOS is dependent on GPS. If GPS were to fail completely so that it broadcast no navigation signal, EGNOS would not be able to fill in the gap by itself. GPS/EGNOS and Galileo together will provide a very robust service.

18. It is recognised that EGNOS must be evolved and integrated into Galileo to ensure continuity, integrity and reinforcement of its capability. This includes the technology and infrastructure. This is particularly important for the transition from EGNOS to Galileo. The EGNOS Operators and Infrastructure Group (EOIG) has made a proposal to the EC which would maximise the utilisation of EGNOS infrastructure and provide a seamless transition for users migrating from EGNOS to Galileo. NATS is a member of the EOIG.

Timing and other Dependencies

19. As well as navigation services, both Galileo and GPS also provide an accurate timing signal that can be used in many applications requiring a time input, eg time stamping of data transfer which is finding applications in the financial markets. GPS needs EGNOS to provide an additional level of confidence that timing information is correct; Galileo is planned to provide its own integrity signal to give assurance that timing information is correct.

Q2: How important is it for the EU to be independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?

20. Future funding of GLONASS is uncertain, so it cannot be relied upon for the foreseeable future.

21. GPS was initially designed for US military applications. However, the US government has offered a civil service on an open access signal to the international community free of direct user charges. Whilst the US government has pledged to maintain this free service (with the caveat that it will give six years notice of withdrawing it), it must be remembered that provision is always dependent on military requirements. (It should be noted that in the 15 years since this offer was made the USA has both maintained and improved the free civil service and it has not been interrupted, even through both Gulf wars.)

22. Despite the USA offer, most industrial benefits have accrued to the US since its industry has the edge on competitors in the provision of user equipment. Therefore a GNSS under civil European control is vital if European industry is also to develop applications and services that can exploit the potential market.

23. A European system will also mean independence from any change of policy under a future US administration. It is worth noting that improvements in the GPS system, along with more substantial guarantees for provision of service, have in large part happened because of Europe's demonstration that it has the capability to develop and deploy an alternative system. Thus it could be said that GPS users have already reaped a reward from Galileo!

24. The ideal, however, is a symbiotic use of both GPS and Galileo, and this seems to have been recognised by the EC and US who have now negotiated an agreement on the technical, operational and political use of both systems.

25. It should be noted that China has entered a co-operative agreement with the EC to mutually exploit the benefits of Galileo. If Europe fails in providing a Galileo service, China has second call on the signal frequencies and plans its own global system in that case.

26. As mentioned in paragraph 19, there is an interest for the financial markets. The UK has the biggest financial market in Europe and it is important to its interests that both systems are available to ensure uninterrupted service. To that end, it would also be helpful to site the Galileo Control Centre in the UK as this in itself provides additional assurance to UK interests.

Q3: What are the potential benefits of the Public Regulated Service (PRS) system? Is it realistic to expect that Member States will not want to cross-subsidise PRS from commercial services?

27. There can be no fundamental objection to the "sponsorship" of the PRS by commercial agencies, but this must be equitable and balanced against the usage by local or governmental authorities for other purposes.

28. Civil aviation users should not be expected to cross-support a public service. Any such attempt would be counter-productive in a commercial sense since it would result in European airlines funding a global service, putting them at a commercial disadvantage. If the decision is taken to cross-subsidise from the civil aviation sector, any funds transfer must not impact on NATS' finances (eg by funds being channelled from en-route charges).

29. The EC anticipates major investment from a Public Private Partnership (PPP). If such investment is forthcoming, a private shareholder would have a major influence on the development and implementation of Galileo to the extent of determining the role of other Galileo participants. The EOIG has organised a European Economic Interest Group (the European Satellite Service Provider) to operate EGNOS cost effectively, and it may create a platform where this role can be enlarged to manage Galileo elements as a subcontractor to the Galileo Operator. NATS will host EGNOS infrastructure and operate, in co-operation with other states, the EGNOS SBAS from its control centre at Swanwick. NATS considers it an incremental step to enlarge this responsibility to include operation and management of Galileo ground/space infrastructure and provide a safety management service.

Q4: Are the arrangements to prevent military use of Galileo sufficiently robust?

30. NATS is unable to comment in detail on this. However, to meet NATS' operational Safety Case, such arrangements must be shown to be robust.

31. NATS is ideally placed to be involved in this aspect as its core business is running a civil/military operation for the provision of an air traffic service where the system is recognised and certified. For this reason NATS has joined one of the consortia bidding for the Galileo operating contract, to provide safety management skills and with the eventual aims of operating the Galileo Control Centre and operating the system under commercial terms.

32. In addition, in order to operate in the UK, NATS is required to provide assurance to the Safety Regulation Group (SRG) that sufficient protection is inherent.

Q5: Are arrangements to oversee the security aspects of Galileo appropriate?

33. NATS is unable to comment on this aspect but notes that any arrangement should not impact adversely on the Safety-of-Life service. Safety case/certification requirements must be considered in formulating policy in this area. NATS will require evidence that the designs incorporate effective protection against malevolent intent (ie hackers).

Q6: What are the potential benefits of the programme to UK industry, and to UK users of Galileo, such as NATS?

34. It is generally accepted by UK industry that there will be commercial and political advantages in hosting a Galileo Control Centre facility. The Galileo Control Centre would use technology and procedures derived from the existing EGNOS Mission Control Centres, reducing operating and development costs. The existence of a UK EGNOS MCC at Swanwick is therefore an advantage which the Government could use to strengthen the UK's position within Galileo. NATS has supported initiatives for the UK to host new European GNSS institutions to be set up to act as the responsible agency to the European Commission.

35. Rationalisation of the ATS industry across Europe under the Single European Sky (SES) is expected to lead to fewer air traffic control centres. NATS is leading the way in reducing its current four centres to two of the most modern in Europe, and since one already hosts an EGNOS MCC it is a logical development for NATS to seek to host a Galileo Control Centre.

36. Progress towards the SES is designed to end fragmentation of the ATS industry, lead consolidation towards common and interoperable systems and regional networks, all of which require a commitment by Air Navigation Service Providers to working together to achieve SES goals. The development of Galileo on a pan-European basis can help reinforce the importance of building these international relationships and regional networks.

37. Quite apart from the political and technological statement this would make by putting the UK at the forefront in Europe, a comprehensive facility in the UK would generate support for other service industries to the benefit of both national and local economies. Other European States also, of course, have a similar ambition to host these centres and therefore strong UK representation is essential not only by NATS at a technical level but also by the UK Government in European debate.

38. It is interesting to compare the UK position with that of Italy, which is reported to be planning a €310m investment in Galileo. This includes €130m from ASI (Italian Space Agency), €113m from a government development fund and €67m from ENAV. A further €204m is expected from Italian industry. This provides ENAV with a significant platform to influence Galileo and they are already participating on Galileo activities at the highest level to insure and enhance their position. It also supports Italy's ambition to host the proposed GNSS agency, identified above. By contrast, the current UK position is that any investment should be from the commercial sector; the financial constraint on NATS is such that any investment at the level reported for Italy would result in a proposed rise in the en route charges which would not be approved by our economic regulator or, if approved, would fall disproportionately on UK airlines.

39. A potential role for NATS is to represent the UK in a similar role to ENAV for Italy on the Galileo initiative, under direction from the DfT and BNSC.

40. In purely technical terms, Galileo will not provide a user advantage that could not in theory be achieved using GPS/SBAS (EGNOS). However Galileo, as a certified and regulated system, does offer advantages that could allow NATS to reduce its ground-based navigation infrastructure whilst increasing the potential for adding capacity in line with anticipated demand. It should also be noted that unaugmented GPS is used only as a back-up system in air navigation in the UK; NATS' regulator will not certify its use as a sole service navigation source as it does not provide the required integrity.

41. The need to maintain a ground-based air navigation system (and the high capital and maintenance costs associated with it) is removed by the reciprocal back-up provided by Galileo and GPS/EGNOS, which together will create sufficient confidence in continuity of service. The aviation industry has set out this position fully in the GNSS Common Aviation Position Paper (developed in 2001 by IATA, Eurocontrol and European ATSPs, and attached at Appendix 1).

42. The wider aviation industry is concerned that it may be required to pay for a major part of the Galileo programme through user charges—currently the only Europe-wide charging mechanism that could be used for recovering costs. The underlying reason for this caution is that it has not yet been shown how other users will pay their fair share for the service. NATS shares this concern, firstly because the cost/benefit ratios in aviation are currently very finely balanced and secondly, it would result in NATS becoming an unpaid revenue collector which has the potential to heavily distort the PPP business model.

43. It is also important to recognise that the largest users of Galileo's navigation services are most likely to be the road transport sector. There is potential for a very wide range of users, and whilst the importance of meeting the needs of the civil aviation sector should not be underestimated, equally its financial contribution should not be inequitable or excessive.

44. NATS believes that the future provision of efficient air traffic services will be highly dependent on satellite navigation technology. It could, for instance, provide the navigational input for an Automatic Dependent Surveillance (ADS) system in the North Atlantic enabling more effective use of airspace in one of the world's busiest air corridors. Furthermore, the increased positional accuracy offered by satellite navigation is fundamental in enabling the design of enhanced route structures and separation techniques as RNAV developments progress. The business benefit to NATS and its customers is in the resulting increases to airspace capacity.

Conclusion

45. NATS supports the development and operation of Galileo but recognises that there remain unresolved issues, particularly on development costs, multi-modal application and charging methods which need to be addressed with urgency.

46. The UK is well placed to take a leading role in the operation and management of Galileo as a certified and regulated system, but this will require strong UK Government leadership in Europe.

47. It is generally accepted within the aviation industry that a global satellite navigation system will create greater efficiency at lower ongoing maintenance cost than a ground-based navigation infrastructure. The high navigational accuracy of satellite navigation could also enable more capacity to be added within regulated airspace.

48. The effective deployment of satellite navigation technology relies not on Galileo "instead of" GPS/EGNOS, but "as well as". There is no suggestion that GPS would be withdrawn.

49. It is prudent to ensure that there is more than one global service provider, and that the providers can work together to ensure uninterrupted service at both technical and political levels. As a major world economic driver, Europe should be at the heart of such development. The reciprocal support that GPS/EGNOS and Galileo can provide will ensure a robust service and introduce an element of competition to help drive technology development.

50. Progress towards the Single European Sky relies on international partnerships which can be further cemented through providing a European satellite navigation system.

51. A robust means of ensuring fair distribution of costs is essential, as is a charging mechanism which recognises the benefits, and the cost of providing service, for various users from mobile phone companies to the financial markets to the agricultural community.

52. It remains an absolute criterion that any navigation service provided for aviation use must be compliant with ICAO SARPs (Standards and Recommended Practices).

Corporate Communications

September 2004

Appendix 1—GNSS Aviation Needs, A Common Aviation Community Position (2001)

INTRODUCTION

A3.1 The European Commission has published a communication on a multi-modal European satellite navigation system called Galileo proposing that Europe develops, funds and operates, as from 2008, a constellation of navigation satellites, independent from, but fully interoperable with GPS. The United States has indicated that the GPS service will be improved by the addition of a second civil frequency (L5) and the first GPS Block IIF satellites should be launched from 2005 onwards. In this document, the term GNSS applies to any system or component of systems of navigation by satellite, be it Galileo, GPS and their various augmentations like EGNOS, WAAS, or any GBAS system.

A3.2 The operations of many airspace users are, by their nature, global. The aviation community requires worldwide systems that provide safe and efficient services, are compatible and interoperable and do not require different avionics. All States should join their efforts to achieve this. The aviation community will only accept "benefit driven" solutions and will strongly resist all those that are "technology driven", not supported by a clear business case. However, it is recognised that the transition to GNSS requires a long-term strategic decision. A key element in stimulating investment in new systems is the early demonstration of benefits offered to the aircraft operators.

A3.3 Therefore, in order to attract the attention of the aviation community and maximise the chance of obtaining the commitment for equipage, utilisation and payment for a GNSS based navigation infrastructure and service, candidate GNSS suppliers should consider their plans in the context of the views of the aviation community as expressed in this document.

THE CONTEXT

ICAO

A3.4 The general objective of the global ICAO CNS/ATM Concept and System is to give to the aircraft operators the freedom to dynamically follow preferred flight profiles with a minimum of constraints, while also maintaining or increasing the actual level of safety. Such a system, if successfully completed and implemented, will give a new perspective to the airborne and ground components of the CNS/ATM systems. Although the achievement of such flexible ATM operations is largely an ATM issue, a GNSS, providing a robust global area navigation capability, will be an important enabler of the global ICAO CNS/ATM Concept. This concept will be derived in ICAO regional transition plans. ICAO has up to now approved SARPS for some GNSS elements such as GBAS, SBAS, GPS and Glonass.

EUROCONTROL

A3.5 The EUROCONTROL Air Traffic Management Strategy for 2000+ identifies CNS as a global business, based on cohesive benefit-driven technical choices backed by realistic investment plans and political commitment. The EUROCONTROL Navigation Strategy for the ECAC area provides for a harmonised, cost-effective and customer oriented evolution of the Air Navigation System until 2015 and supports a judicious deployment of GNSS and a rationalisation of the ground infrastructure. In addition the EUROCONTROL Satellite Navigation Strategy states that GNSS should:

(a) be global for aviation, through co-operation with ICAO and the FAA,

(b) enable early benefits to be realised from existing systems,

(c) be multi-modal for Europe, through co-operation with the EU and ESA,

(d) provide ultimately sole means navigation for all phases of flight.

GNSS Aviation Community Views

A3.6 The aviation views expressed in this paper reflect the global nature of aircraft operations. The concept of Required Navigation Performance (RNP) developed by ICAO is supported. This concept, which is applied today on a world-wide basis, defines the capabilities required for an aircraft to navigate in a particular airspace segment and allows the aircraft operator the choice of a specific equipment to achieve that capability. The required capability could be provided by either GNSS, the current ground based navigation infrastructure, airborne systems or a combination of those. The choice of the technology will be, in all cases, benefit driven. It is recognised that, at least for the foreseeable future, a rationalised terrestrial infrastructure must be retained until sufficient experience and confidence has been gained to validate GNSS operations.

Final Goal

A3.7 If world-wide GNSS is the most cost beneficial solution, and is supported by a successful safety analysis, it should become the "sole service" navigation system, for provision of positioning and timing data, for all phases of flight.

A3.8 The term "sole service" is used here to mean the only radio-navigation service provided external to the aircraft. It avoids certain confusions associated with the term "sole-means".

A3.9 In order to achieve this goal, there is a clear need for a worldwide Navigation Strategy, not only a European Navigation Strategy. All Strategies should be developed under the auspices of ICAO and be supported by all the key partners. Such a world-wide Strategy should address:

(a) Sole service concept feasibility regarding safety requirements;

(b) Technical, Operational and Safety requirements, calling for the development of a world-wide Navigation Satellite System that can be used, as the sole-service for provision of positioning and timing data, for all phases of flight down to CAT II/III operations, calling for due consideration of regional and sub-regional specific requirements; and calling for global interoperability and complementarity;

(c) Institutional Requirements calling for world-wide resolution of institutional issues and guarantees from the GNSS Service Providers;

(d) Cost allocation and Charging Requirements, calling for fair and equitable charging and cost-allocation between civil aviation and other user categories, between States and between phases of flight (en-route vs. approach/aerodrome);

(e) Transition Planning, calling for commitment for decommissioning of ground-based navigation aids, giving due consideration to Global Equipage Implications and calling for Commitment from Users to equipage with appropriate GNSS avionics and calling for the establishment of an Implementation Plan.

A3.10 Those items are developed in the following paragraphs.

Technical Operational and Safety Requirements

Demonstration of the sole service concept feasibility regarding safety requirements

A3.11 The objective presented in section 2.1 could be achieved only if the demonstration of the feasibility of the sole service concept is acceptable from a safety point of view. This is a prerequisite that conditions the economical interest of the GNSS strategy. Studies must be undertaken in order to progress on this essential matter. It is clear that the economical interest of a GNSS solution is tightly linked to the feasibility of the concept. It must be noted that a sole service concept implies that the GPS and Galileo system are considered as complementary and not as alternative. On the basis of this feasibility demonstration, a Safety Case should be developed with a world-wide application as recommended in Annex 11 of the Chicago Convention. The Safety Case will be the basis of the GNSS certification process

Level of Service

A3.12 GNSS and its augmentations must be part of a worldwide system serving all users categories and all phases of flight down to CAT II/III operations, where required. The deployment strategy for GNSS must clearly demonstrate that it can evolve to support CAT II/III operations and that the GNSS service provider(s) are bound to such evolution.

Aviation users

A3.13 The interest of all aviation user categories shall be considered appropriately while developing the Technical, Operational and Safety Requirements and preparing the Transition Plan and the Implementation.

Geographical Differences for the Level of Service

A3.14 While GNSS must provide a common worldwide level of service, its architecture must recognise regional operational needs. Certain areas will require CAT II/III capabilities, while others may require only CAT I or NPA/APV capabilities or less. The system architecture and the deployment of the infrastructure must consider these issues from the very beginning in order to avoid over or under specification. The system must be kept open for further improvement as requirements may progressively change in the future.

Interoperable and complementary GNSS

A3.15 The aviation community requires cohesive satellite navigation infrastructure planning that will lead to the creation of a world-wide seamless system. They require a world-wide navigation satellite system rather than regional systems developed in an uncoordinated manner. As Galileo and GPS Block IIF are currently planned, their development should be done in a co-ordinated manner and aviation must be reassured that there will be total interoperability between the two systems permitting seamless equipment and certification.

A3.16 In order to achieve the final goal, that is, the utilisation of GNSS as the sole service navigation system for provision of positioning and timing data, for all phases of flight, aviation must be reassured that sufficient redundancy exists between Galileo and GPS IIF, providing the required level of system reliability and avoiding common failure modes.

A3.17 In addition, the system must be sufficiently robust to external interference to avoid the need for ground based navaids to be retained as a back-up.

INSTITUTIONAL REQUIREMENTS

Global Institutional Issues

A3.18 There is an urgent need to solve, on a worldwide basis, GNSS institutional issues. This will require a strong action at ICAO level and will imply, in addition to the requirements detailed in paragraph 2.2.1 above:

(a) Development, validation and approval of global Standards and Recommended Practices (SARPs);

(b) Development and agreement on a clear liability chain that involves States, Authorities, the owners of the GNSS infrastructure, the GNSS service providers, the ATS providers, the avionics manufacturers, the aircraft manufacturers, the airspace users, etc;

(c) A world-wide Transition Plan must be developed to ensure both the phasing out of unnecessary conventional ground based aids and aircraft equipment including a time schedule.

Guarantees from the GNSS Service Providers

A3.18 The GNSS service provider(s) must offer sufficient guarantees to third-party service providers, eg ANS providers, and airspace users that his obligations are being fulfilled. The acceptable formulation of these guarantees is also a prerequisite for the resolution of the safety issues presented in paragraph A3.11. These obligations cover, amongst other things:

(a) Level and quality of service;

(b) Maintaining the service provision;

(c) Maintaining the agreed operating costs and pricing.

COST ALLOCATION AND CHARGING REQUIREMENTS

Cost Allocation

A3.19 The EUROCONTROL Enlarged Committee of Management developed for Route Charges a methodology for determining the appropriate proportion of costs that should be borne by aviation in a multi-modal GNSS, based on an index for each navigation requirement. It was expected that a figure of around 1 % should be recovered from aviation users for a constellation of satellites offering a CAT I landing capability. This in recognition that aviation is only one potential user of GNSS based products and should be treated in a fair and non-discriminatory manner in the provision of a multi-modal service. The 30

EUROCONTROL Member States have endorsed this conclusion and methodology. This methodology is proposed to be accepted world-wide, resulting in the development of a legal structure that recognises the multi-modal nature of GNSS.

Charges

A3.20 Aviation charges for GNSS should be based on actual level of service, should not discriminate against airspace users, should be competitive and set in a transparent manner. Airspace users should be protected in the case where GNSS service providers are not capable of collecting the expected level of user charges from non-aviation users.

TRANSITION PLANNING

A3.21 During a transition period, that would start only after the demonstration of the sole service concept feasibility and the confirmation of its cost beneficial aspect, conventional ground-based aids will be used alongside the space-based aids. During this transition period and after, the aviation community will only pay its fair share of costs for GNSS (as it applies to any system or component of systems of navigation by satellite, be it Galileo, GPS and their various augmentations like EGNOS, WAAS, or any GBAS system) provided that GNSS will have been demonstrated to be cost-beneficial.

A3.22 The transition to GNSS will only be successful if all stakeholders have formalised a firm transition plan detailed by phases of flight with binding commitment, at all appropriate levels, for implementing the relevant avionics on board of all airspace users' aircraft and, at the same time, for the decommissioning of the non necessary ground based navaids.

A3.23 To take into account the regional dimension of the planning, the transition plan mentioned above must be regional. In order to achieve the world-wide objective it is necessary that these regional transition plan (as it is the case today with the ICAO CNS/ATM regional transition plans) are tightly co-ordinated in order to validate the economical aspects used as the justification of these plans. In this context and subject always to the requirements of paragraph A3.22, it is acknowledged that in addition to operational benefits, EGNOS will assist the European industry in acquiring experience in the monitoring of a constellation of satellites which may in itself result in a reduction of the transition to sole service.

Memorandum by AMICUS the Union (GG 11)

THE GALILEO ENQUIRY

AMICUS VIEW ON THE CONTINUED UK GOVERNMENT SUPPORT FOR GALILEO

Employment: The creation of high value, high skill employment opportunities will be a key outcome of full UK participation in Galileo. Numerous estimates have been made concerning the creation of direct employment for the development, deployment and operation of the Galileo constellation and these provide reasonably consistent estimates. Other estimates of the indirect employment opportunities that Galileo will generate are more varied due to the uncertainty in the downstream market development. The common factor however is that downstream opportunities are far in excess of the direct employment Galileo will generate.

Considering direct employment opportunities, KPMG research in 1999 found that Galileo would support 4,000 jobs during the development phase. For the deployment phase this figure would rise substantially during the period 2006 to 2009 and in the long term, for the operational activities, Galileo would create some 2,200 jobs each year. These estimates have been consistent in later studies, for the reasonably well-defined infrastructure activities for Galileo. If anything, the assumptions made by KPMG tend to lead to a pessimistic calculation and therefore these numbers can be considered as a worst case.

Estimates of the indirect, or downstream employments opportunities have varied more widely. Today in the United States, the downstream applications and products markets for GPS alone is estimated to be of the order of €2bn–€3bn, supporting up to 100,000 jobs[29]. The average estimates for the future growth of the GNSS (GPS & Galileo) downstream markets indicate a market size in 2010 of €12bn with 25% attributable to the addition of Galileo and by 2020 rising to €28bn with over 30% attributable to the addition of Galileo. Further estimates which include the high value added services are believed to be around €250bn. These figures indicate employment opportunities created directly as a result of the addition of Galileo to GNSS of in excess of 100,000 between 2010 and 2020.

Given that the United States has a leading position today in GNSS applications solutions markets and Japan and the Far East generally have a leading position in the chip and low cost electronics markets, it would be unreasonable to expect all of these employment opportunities to be realised in Europe. However,

[29] Frost & Sullivan Report

with the planned support for application and receiver development already featured in the Galileo programme plans, it would be reasonable to expect some 40% of these opportunities to be within Europe. This still implies some 40,000 rising to 100,000 jobs across Europe, representing some 8,000 to 24,000 in the U.K. alone.

The importance of these figures lies not only in the number of jobs the UK could secure. As important is the fact that these would be highly skilled engineering jobs that would support and build upon the excellence that the UK has already established in the high-tech engineering/space technology sector and in applications development markets.

Economic Efficiency: The economic impact of GPS in the US has already been substantial and is well documented. Whilst the US economy has experienced efficiency gains, it is becoming increasingly reliant on a single satellite navigation system, which was not engineered for failsafe dependability for civil applications. As GPS applications develop in Europe, it is reasonable to expect that a similar degree of reliance will occur. Two independent systems (Galileo working with GPS) will clearly provide the level of dependability that cannot be obtained by any single system, thus, the consequences of the failure of either system would be greatly reduced—the economic damage would be minimised.

Enhancing the applications resulting from GPS by factoring in the proposed Galileo constellation should mean that future economic growth prospects are even more attractive. Two independent systems (Galileo working with GPS) should provide greater accuracy and reliability that will inevitably generate new applications and opportunities for commercial exploitation (particularly in dense urban environments).

Industrial Benefits:

European GNSS product, applications and value added service provider companies currently command only a very small share of the global GNSS market.

The scope for growth of European companies in the GNSS market and consequently the reduction in European dependence on US technology and US industry, depends on two main factors:

— Increasing market share in the existing navigation market

— Maintaining existing market share in a larger global market for navigation products, applications and services

The planned development of Galileo will contribute substantially to the achievement of each of these two opportunities for growth in European industry.

Galileo studies have indicated that the global market for GNSS products and services based on GPS alone will reach €9bn annually by 2010, rising to €17bn annually by 2020. The introduction of Galileo will increase this overall GNSS market size to €12bn annually in 2010, rising to €28bn annually in 2020. This growth in market size represents an opportunity for growth in the European product, application and value added service provider industries.

When considering the market share achievable by European industry, one must consider what has already happened in the United States in the development of the GPS based GNSS market. The US controlled GPS system, coupled with the injection of development funding by the US government, has meant that US industry enjoys a dominant role in the GPS based GNSS market place. This has resulted in a very low market share for European companies. The introduction of a European controlled infrastructure, coupled with a similar stimulus to European application and receiver development, will mirror the historical evolution in the US.

The overall effect of introducing Galileo as planned will therefore significantly increase the market addressable by European product, applications and service provider companies, as well as dramatically increase the achievable market share of this larger market.

In addition, Europe must maintain the industrial capability and capacity to build, launch and operate satellites for navigation and timing purposes and also for telecommunications, meteorological and scientific exploration uses. From this perspective, Galileo will pose a number of challenges in design, manufacturing and certification that will help Europe to further develop its industrial capability in the future. The development of Galileo will ensure that Europe's capabilities in the fields of space qualified atomic clocks and volume parts procurement for multi-satellite constellations will be enhanced and dependence on US suppliers and technology reduced.

Full UK participation is likely to enable work on key elements of the satellite payload aspects of the programme. Cutting edge developments have been taken forward on ground control technologies, which could be deployed on this project. Securing the work on these high-quality elements of the Galileo system would be invaluable for the UK sector as a whole. It would ensure that the UK is able to maintain its role as a leader in innovative aspects of Galileo and support its efforts to refine the technology itself, and its manufacture, for exploitation in other areas.

Developing space technologies and applications is a complex and long-term process. In the same way that the commercial applications of satellite communications took some time to mature so the technologies supporting Galileo will also need support before their potential will be fully realised.

Services of National Interest: Some European countries consider that Galileo will address some areas of national security. In the UK however, the view is that since all NATO members benefit from and have access to the US GPS signal, it is not clear how Galileo would bring any significant military or national security benefits. However, when considering services of national interest in U.K, we can consider services that the government has the responsibility to deliver and fund. Primary examples are Police, Fire and Ambulance services.

Whilst there may not be a need for a public regulated service or "secure" service for use by these emergency and law and order services, these activities will benefit from Galileo in much the same way as other commercial users. The greater dependability and accuracy from both Galileo and GPS working together will enable the evolution of new and improved methods of working and resource planning (knowing where police officers are in relation to a crime scene, etc). Improvements in efficiency and effectiveness, resulting in lower cost and higher quality service delivery will result, amongst other things, from:

— Better fleet management across all services

— Improved location of victim or scenes of an emergency

— Improved safety and deployment of pedestrian police

Public Good:

Transport: The provision of a completely independent satellite navigation system has clear benefits in the area of transport and this is well documented:

— Civil Aviation—The increased dependence that can be placed on satellite navigation, resulting in the gradual removal of some ground navigation aids for civil aviation.

— Transport Congestion Charging—The prospect of being able to monitor traffic actively through satellite navigation now gives the opportunity to dynamically charge in those areas where traffic is congested. Congestion is a well-documented cost in all industrial economies—The British Chambers of Commerce have estimated that congestion on UK roads costs the economy £20 billion a year. Additionally, moves to discourage congestion through fiscal incentives would clearly have benefits for urban pollution.

— Rail—In the long term, a dependable satellite navigation system should enable railways to migrate from the current block signalling approach to a more dynamic, flexible system, which would enable more trains to share the same track resource.

— Maritime—The provision of navigation service for shipping is a governmental responsibility, as for air traffic management services for civil aviation. The maritime sector already benefits from GPS, but requires augmentation systems to provide an adequate service. The cost of this augmentation, whilst not the dominant factor in overall maritime services costs, is nevertheless significant. Galileo can reduce this cost and at the same time improve the level of service to the maritime community.

The U.K. and Europe:

The Galileo programme offers an excellent opportunity for the UK to demonstrate its intention to play a central role in European affairs. The UK has much to offer the Galileo programme and this is not limited to the technical capabilities of UK industry. By being at the heart of the Galileo programme, the UK will have the opportunity to positively influence the way in which Europe's institutions procure public services. The UK has a leading position in the development of PPP solutions and has demonstrated typical savings of around 17% compared to traditional procurement methodologies. The export of the PPP concept by the UK can help to improve the efficiency and effectiveness of European infrastructure provision and service procurement activities. This would ensure the UK achieves a good balance between an active role at the heart of Europe and obtaining better value for money for the UK's financial contribution to European budgets.

Europe and the International Community:- It can be argued that one of the key objectives of closer European integration is to create a partnership of equals with the US through closer partnership of European member states. Galileo demonstrates

1. That Europe has the technical capability to develop such a complex system without recourse to US technology, on time and to cost.

2. The system will be of equal benefit to the US as it will be to Europeans.

Galileo is an excellent opportunity to demonstrate our independence from, but our ability to collaborate with, the US for the greater public good and global economic gain.

CONCLUSION

The public policy and wider industrial benefits of satellite navigation are substantial. They are driven by the enormous utility of the US GPS system, relative to its cost. The Galileo system will improve reliability and accuracy and will therefore stimulate even greater use of satellite navigation, which will bring global economic benefit.

Many applications, both now and in the future, will benefit significantly from having two independent but interoperable systems. The overall improvement in system robustness is critical for many safety related applications and the improved performance and availability is valuable to all users, commercial, safety and public services.

The UK has much to gain from continued full participation in the Galileo programme. The employment, economic, industrial and public service arguments above coupled with the development of the UK's position in Europe and the potential for improving the efficiency of European procurements, presents a compelling argument for continued full UK participation.

Peter Cheney
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September 2004

Memorandum by Welsh Assembly Government (GG12)

GALILEO

INTRODUCTION

The Assembly, as highway authority for Wales will be an end user of the Galileo system and associated location based services, and as such has focussed its comments accordingly. It has also contributed to the submission provided by the Faraday Pinpoint Partnership and the UKISC.

The Assembly will continue to monitor developments within the Galileo project and pursue the objective of hosting the GSA in Wales at the meeting of the EU Transport Council in 2004.

Q1 WHAT BENEFITS WILL GALILEO PHASE II BRING THAT EGNOS (EUROPEAN GEOSTATIONARY NAVIGATION OVERLAY SYSTEM) WILL NOT?

A1 Background

The European Geostationary Navigation Overlay Service (EGNOS) is being developed by ESA under a tripartite agreement between the European Commission (EC), the European Organisation for the Safety of Air Navigation (Eurocontrol) and European Space Agency (ESA).

EGNOS provides substantial added value compared with the ordinary GPS system, because it:

- improves the accuracy of positioning (from 20m to better than 5m) and increases the reliability of the positioning information, supplementing the GPS signals with signals from three separate geostationary satellites;
- offers superior reception in certain places, because additional satellites are used;
- provides the user with information about the reliability of the system by transmitting integrity messages within six seconds whenever the quality of the signals received falls below certain thresholds.

The EGNOS coverage area includes all European states and could be readily extended to include other regions, such as South America, Africa, and parts of Asia and Australia, within the coverage of three geostationary satellites being used.

EGNOS is used foremost for safety-critical transport applications, eg in the aviation and maritime sectors. EGNOS has been designed for a life expectancy of 15 years.

EGNOS contributes significantly to the success of GALILEO by acting as a precursor. It will facilitate GALILEO's entry into service by greatly increasing satellite navigation applications and contributing to the completion of the necessary certification and approval procedures. In addition to the development of a European satellite navigation technology resulting from the EGNOS programme, the study carried out by PricewaterhouseCoopers confirms the significant savings on the operating costs of the future GALILEO system. A single figure suffices to illustrate the benefits of EGNOS: as a result of EGNOS, the net present

value of revenue generated by GALILEO should increase by EUR 166 million. Lastly, EGNOS is the European vector for penetrating European markets, at a time when the equivalent American system (WAAS) is already present on several markets. Galileo Phase II covers the deployment and validation of the detailed definition and subsequent manufacture of the various system components: satellites, ground components, user receivers. The integration of EGNOS into the Galileo programme and development phase will be managed by the GALILEO Joint Undertaking, which will become the GSA

This validation will require the putting into orbit prototype satellites from 2005 and the creation of a minimal terrestrial infrastructure. It will allow the necessary adjustments to be made to the ground sector with a view to its global deployment and the launching, if necessary, of operational prototypes manufactured in parallel. During this phase it will also be possible to develop the receivers and local elements and to verify the frequency allocation conditions imposed by the International Telecommunication Union.

A1 Benefits

Offering dual frequencies as standard, GALILEO will deliver real-time positioning accuracy down to the metre range (an improvement on EGNOS), which is unprecedented for a publicly available system. It will guarantee availability of the service under all but the most extreme circumstances and will inform users within seconds of a failure of any satellite (again, an improvement on EGNOS). This will make it suitable for applications where safety is crucial, such as running trains, guiding cars and landing aircraft. The combined use of GALILEO and other GNSS systems will offer much improved performances for all kinds of user communities all over the world and naturally has the potential to develop significant new business opportunities.

Hence in summary, Galileo will offer more accurate and improved positioning data than EGNOS, which will be combined into the Galileo programme.

Q2 How Important is it for the EU to be Independent of the US GPS and Russian GLONASS.

A2

The US GPS system and Russia's GLONASS system were designed primarily to enhance the military capability of those countries. GPS is provided, subject to US national defence and other policies, a signal for the use of the global civil community. In April 2002, only 8 out of 24 GLONASS sites were in use, rendering it useless for navigation applications, however GLONASS-M has been planned.

Both GPS and GLONASS were designed with military use in mind. In particular GPS includes a capability whereby the signals can be altered to be less accurate (known as selective availability). This has been de-activated since May 2000 but could be re-activated in times of military conflict. Hence any systems using GPS or GLONASS in Europe are less likely to work if the US or Russia decide to switch on selective availability. This is particularly important if the EU uses GPS or GLONASS in safety related systems.

Several cases of GPS service disruption have been reported over the past years, which had many different origins, including unintentional interference, satellite failure, signal denial or degradation by US authorities. As an example, in 2000, no navigation signal could be received for 18 minutes over the territories of Oklahoma, Kansas and Nebraska. This service disruption was due to satellites malfunctioning. Intentional interference has also to be considered, as GPS uses very low-power signal and GPS jamming does not require complex equipment.

There were more than 6 million users of GNSS in Europe in 2001 and studies have estimated that this will grow to over 250 million by 2020 (ref to annex 1). World-wide, this figure is expected to reach 800 million users. Hence there is a high level of dependence on GPS for location based services.

Accurate time referencing is fundamentally important to the performance of digital networks that use high-speed data transmission systems, such as those used by fixed and mobile telecommunications systems, as well as digital broadcasting and the internet. The distribution of the world's time base therefore is highly dependent on the availability of GPS, which in itself puts a high risk on the reliance on single systems availability.

A GPS service disruption will affect both the location based information and time referencing applications and will have economic and organisational consequences in developed countries. Hence the use of a system such as Galileo should mean that location based systems using Galileo would not be affected by problems with GPS or GLONASS and hence are more likely to be accurate and reliable (this is particularly important for safety critical applications such as air traffic control).

Q3/1 What are the Potential Benefits of the Public Regulated Service system (PRS System)

A3/1

The PRS is a civil classified and high-security signal which may be used close or even in areas of crisis for peace operations, etc. or for the coast guard and in other sensitive areas. It is encrypted and resistant to jamming and interference, reserved principally for the public authorities responsible for civil protection, national security and law enforcement which demand a high level of continuity.

The EU and US have recently signed an agreement to ensure compatibility between the GPS and Galileo satellite systems. The US and EU will agree common operating standards for GPS and the Galileo project. The EU agreed to change the modulation of

Galileo signals intended for government use (the PRS service signals) so they would not disrupt encrypted GPS signals to be used by the US military and NATO.

Prior to this agreement it was planned to overlay the PRS signal over the GPS M-code which, certainly in the UK was not acceptable on grounds of UK national security and international obligations to NATO. This means that the US will be able to jam their GPS signal without affecting Galileo's signals and vice-versa.

Potential benefits of PRS include:

— Development of secured applications in the European Union,

— An important tool in improving the instruments used by the European Union to combat illegal exports and illegal immigration.
(http://europa.eu.int/comm/dgs/energy_transport/galileo/programme/needs_en.htm)

The PRS will provide a higher level of protection against the threats to GALILEO Signals in Space than is available for the Open Services (OS, CS and SoL) through the use of appropriate interference mitigation technologies.

Q3/2 Is it Realistic to Expect that Member States will Not Want to Cross Subsidise PRS from commercial services?

Does this mean commercial services per se or Galileo commercial services?

Q3/2

Cross subsidising PRS from commercial services may open channels for the private sector to demand a say in managing the PRS, which will then mean the Member States' public authorities do not retain full control over the system to make important decisions in times of crisis. This could potentially be a huge weakness in such an approach.

Q4 Are the arrangements to prevent military use of Galileo sufficiently robust?

A4

Galileo is intended solely for civilian use, and is the first satellite based system to do so, according to the publicity for the system.

In June 2004, the EU and US signed an agreement regarding the promotion, provision and use of Galileo and GPS satellite-based navigation systems and related systems. The majority of the agreement relates to civil use of Galileo and includes the need to prevent and protect against the misuse of global satellite-based navigation and timing services without unduly disrupting or degrading signals available for civilian uses.

The provision of military satellite-based navigation and timing services is outside the scope of the Agreement, except for radio frequency compatibility (Article 4), Article 11 and in the Annex to the Agreement.

Combined GPS/Galileo systems have been proposed as Galileo would naturally enhance the existing capabilities of GPS. Since GPS may be used for military actions, currently there is nothing to say that the combined systems would not be used for similar purposes.

Q5 Are arrangements to oversee the security aspects of Galileo appropriate?

A5

With respect to security aspects, there is a need for any GNSS service to be continuously available. In particular telecommunications, electrical energy distribution, banking and financial transactions that are dependent on GNSS time. The disruption of such services may impact on national security and so it is imperative that, in times of crisis, civil based GNSS services can be jammed.

The need for the Public Regulated Service (PRS) results from the analysis of threats to the GALILEO system and the identification of infrastructure applications where disruption to the Signal in Space by economic terrorists, malcontents, subversives or hostile agencies could result in damaging reductions in national security, law enforcement, safety or economic activity within a significant geographic area.

The objective of the PRS is to improve the probability of continuous availability of the signal in space, in the presence of interfering threats, to those users with such a need.

The introduction of interference mitigation technologies carries with it a responsibility to ensure that access to these technologies is adequately controlled to prevent misuse of the technologies against the interests of Member States. Access to the PRS will be controlled through key management systems approved by Member States' governments. Public authorities retain control over the Galileo system, so that they are able to take urgent decisions in a crisis.

The Public Regulated Service access will be controlled by the authorities to be defined at European level, through the encryption of the signals and the appropriate key distribution.

The Public Regulated Service signals are permanently broadcast on separate frequencies with respect to open GALILEO satellite-only services, so that PRS is not lost when the open service is unavailable locally. They are wide band signals so as to be resistant to involuntary interference or malicious jamming and therefore offer a better continuity of service.

The use of PRS will be restricted to clearly identified categories of users authorised by EU and participating states. Member States will authorise users through the implementation of appropriate controlled access techniques. Control of distribution of receivers will be maintained by Member States. (http://europa.eu.int/comm/dgs/energy_transport/galileo/programme/service_prs_en.htm)

Q6 What are the Potential Benefits of the Programme to UK industry, and to UK users of Galileo, such as NATS?

A6

PriceWaterhouseCoopers (PWC) has calculated that Europe's GPS system should generate revenues for the operator rising from some €66m in 2010 to over €500m in 2020 and cost Euro 3.6 billion. They estimate the total benefits at €17.8 billion in Net Profit Value, implying a strongly positive benefit cost ratio of 4.6. Galileo would generate £12.4 billion in additional value during the first 12 years in the air and maritime sectors alone.

(http://www.pwcglobal.com/uk/eng/about/svcs/pfp/pwc_Galileo_Information.pdf)

(http://europa.eu.int/comm/dgs/energy_transport/galileo/intro/viability_en.htm)

Astrium puts the figures much higher, at £51.6 billion. The EU's Directorate General for Energy and Transport places the value even higher, saying: "Galileo will create more than 100,000 jobs and will generate service and equipment contracts estimated at approximately £6.3 billion per annum." The ESA puts the job figure even higher at 140,000.

With respect to hosting the GNSS Supervisory Authority (GSA,) if the UK (and in particular Wales) are successful in their proposal to host this organisation, this will have a positive impact on the economy since it will bring visitors to the UK and an impact on employment as it will create jobs to support the staff transferred to the GSA location, as well as provide highly skilled personnel in PPP and corporate finance.

GALILEO, in the transport field, will achieve potential benefits in:

- air traffic control;
- the management of ship and lorry fleets;
- road and rail traffic monitoring;
- the mobilisation of emergency services;
- the tracking of goods carried by multimodal transport.

UK industry is already benefiting from the Galileo programme. For example,

- UK NATS is hosting one of the 4 control centres for EGNOS at Gatwick (to be moved to Swanwick). EGNOS is to be integrated into Galileo and NATS are interested in hosting a Galileo control centre at Swanwick.
- Qinetiq is keen to offer their sites for Senor/Uplink stations and NPL are interested in providing a Galileo Time facility at Teddington.
- Racal Survey (part of Thales) has been successfully operating a global commercial differential system called Skyfix.
- Surrey Satellite Technology Ltd is building the first test satellite for Galileo, and EADS Astrium and SciSys are developing a parallel system (UKWatch, Spring 2004, www.ukwatchonline.com)

— A UK consortium, which includes Raytheon Systems Ltd, Roke Manor Research, Leeds University and Helios Technology, is already working on developing a receiver for the Galileo signal, called the Receiver for High Integrity Navigation Operations (RHINO) that will have specific applications in the aerospace sector where high levels of receiver integrity are required. The consortium was funded through s@tcom programme (BNSC).

— Galileo Industries Consortium, including 10 UK firms, has been awarded a €31 million contract by the ESA, to work on 5 core activities of the Galileo programme.

— Logica CMG has been awarded a contract to design 2 sets of key ground facilities.

GLOSSARY:

UKISC—UK Industries Space Committee

EGNOS—European Geostationary Navigation Overlay System

SA—European Space Authority

GNSS—Global Navigation Satellite Systems

PRS—Public Regulation Service

PPP—Public Private Partnerships

NATS—National Air Traffic Services

RHINO—Receiver for High Integrity Navigation Operations

GLONASS—Russian National Global Navigation Satellite System

Transport Directorate

September 2004

Annex

European GNSS Supervisory Authority (GSA)

WELSH ASSEMBLY GOVERNMENT—OUTLINE LOCATION BID

BACKGROUND

Galileo is a European Union (EU) and European Space Agency (ESA) programme to develop a civil satellite navigation system, planned to be operational by 2008. It is planned that, from 2006, a European GNSS Supervisory Authority GSA would oversee the technical development of future generations of Galileo and manage the existing and future PPP concessions. The GSA would operate under directions and guidance from the Transport Council.

The Assembly proposes that Wales should bid for the headquarters of the Galileo Strategic Authority (GSA). The headquarters could be located along either the M4 or A55 corridor. Initial discussions have taken place with European Commission officials and the support of Whitehall Departments has been gained. Support has also been obtained from Assembly Ministers and Senior management, Secretary of State of Transport, British National Space Centre and UK concessionaire bidders (Logica and Inmarsat)

It is planned to have a final draft proposal available for the Autumn, which will be discussed with EC officials and used to gain widespread support.

KEY ELEMENTS OF THE PROPOSAL

Why Wales?	*Benefits*	*Risks*
Has skills and expertise (Aerospace sector within Wales, UK NATS, UK universities (Bangor, Cardiff), Racal, Qinetiq, NPL)	Allows Government and industry to influence direction of Galileo development	Minimal risk financially to stakeholders as GSA will fund itself once established
Close working relationship with US (eg ICOA GNSS Panel)	Retention of ground infrastructure will benefit future development of system	Failure of Galileo could have impact on UK politically, technically and economically.

Why Wales?	*Benefits*	*Risks*
Has skilled personnel in areas of PPP and corporate finance	Keeps satellite navigation experience and skills in universities and industry in UK	Competition potentially from other Member States and regions of the UK (who have existing EU or ESA institutions)
Good market for high calibre support personnel	Creates opportunities for UK	UK perceived as sceptic during definition phase so may need to be careful
Can provide secretarial and other support	Allows industry and academia easy access to GSA	
No language barrier	Allow UK to take full advantage of Galileo	
Well-developed transport links to European capitals	Inward investment and jobs to UK—local economic growth and employment to immediate area	
Plentiful and varied hotel and conference accommodation, attractive haven for visitors.	Involvement in Galileo will help UK fulfil political ambition to be leading information technology nation	
High quality and diverse landscape, entertainment, culture, sport, retailing and other service industries		

For further Information Contact: Leighton James

Memorandum by The Pinpoint Faraday Partnership (GG 13)

GALILEO INQUIRY

1. Introduction

1.1 This memorandum responds to the Call for Evidence regarding the Galileo Programme, issued by the Transport Select Committee on 16th July 2004. It is submitted by the Pinpoint Faraday Partnership. Background information concerning Pinpoint is given in Section 2 below.

1.2 Because of Pinpoint's focus on the downstream sector (ie user equipment, applications and services) our memorandum addresses primarily the question "What are the potential benefits of the programme to UK Industry, and to UK users of Galileo, such as NATS?". In view of Pinpoint's remit and membership, we also address the benefits of the programme to UK Universities.

2. About Pinpoint

2.1 Pinpoint is a Faraday Partnership focused on developing applications and services derived from satellite navigation systems. A Faraday Partnership is an alliance, supported by DTI and at least one Research Council, which typically includes Research & Technology Organisations, universities, professional institutions, trade associations, private sector firms, and end-users. Faraday Partnerships promote improved interaction between the UK science, engineering and technology base and industry. A key aim is to improve the competitiveness of UK industry by delivering commercially exploitable R&D. Further general information about Faraday Partnerships, is available at http://www.faradaypartnerships.org.uk/

2.2 Pinpoint was established in September 2002. Its mission is to promote and support UK research and development of applications, products and services based on Global Navigation Satellite Systems (GNSS) such as GPS and Galileo. Pinpoint's core objectives are:

— To promote the value of GNSS applications to the wider beneficiary communities, inclusive of research, training and business opportunities.

— To stimulate new business collaborations and opportunities, building on existing professional networks and expertise.

— To undertake basic and applied research into cutting-edge science and technology for GNSS applications.

— To help develop the knowledge and skills needed to exploit opportunities for GNSS applications.

2.3 Pinpoint works closely with related interest groups of GNSS technology providers and users. Pinpoint has established three foundation research projects worth £2M, and 11 industrial PhD studentships, and is currently bidding for further research funding.

2.4 The Pinpoint Faraday Partnership is supported by leading UK Companies, leading UK Universities, the Department of Trade and Industry, and the Engineering and Physical Sciences Research Council. Pinpoint currently has over 300 experts, in more than 60 organisations. The Partnership is managed by the National Physical Laboratory (NPL). Members range from SMEs to large industrial groups, and include the major UK Universities.

2.5 GNSS is an enabling technology which has vast commercial potential across many different market segments. Pinpoint is currently targeting three key market segments: transport (road, rail, air, maritime, logistics), mass-market location based services for individual users, and safety/security. Particular areas of focus for Pinpoint are:

— Tracking of individual people, things & vehicles

— Intelligent road vehicles and highway infrastructures

— Road user charging

— Operational efficiency and safety in the railways and aviation

— Integrated multi-modal transport solutions

— Personal navigation services

— Rapid and effective provision of emergency services

— Scientific & environmental monitoring

— The economic and social benefits of GNSS services

2.6 Additional information about Pinpoint and its research programme is available at: http://www.pinpoint-faraday.org.uk

3. Background to this memorandum

3.1 The capability to position objects and people accurately, in real-time, brings significant benefits for the individual and for society as a whole. The development of satellite navigation systems since the 1970s—albeit mainly for military purposes—has led to the global availability of navigation signals which are now being widely used for civilian applications. The use of satellites to provide navigation signals has major advantages, notably the ability to provide global coverage using a homogeneous system which can be actively managed. At the same time, the use of a low power radio signal, broadcast from space, presents a number of challenges. These include potentially adverse propagation conditions for the radio navigation signal (for example caused by atmospheric effects or man-made structures), interference from other radio signals (which is normally accidental, but which could be deliberate), and the (current) inability to provide consistent service inside buildings (because of the low power of the satellite-transmitted signals). In addition, there are other challenges, relating to the fundamental characteristics of satellite navigation, which are concerned with obtaining the best possible accuracy of position (ie accurate to within metres, centimetres, or even millimetres, displayed to the user in real time), maximum integrity (ie whatever information is given to the user, it should be fully trustworthy), and good availability (ie the signal should be receivable all of the time, anywhere on earth). Finally, continuity (ie the user has started a critical operation and must be able to finish it uninterrupted) is becoming increasingly important.

3.2 These and other challenges are being addressed today by the UK's research community. There is no simple "fix" for any of them. We are extremely unlikely, in the foreseeable future, to reach a point where all the challenges have been addressed and we have a perfect satellite navigation system. Much of the research work is therefore concerned with achieving gradual, incremental improvements, and making best use of the available navigation signals and technologies. Galileo therefore offers an extremely important step forward, in that it will be a new, completely independent, high-specification, globally-available system. It will go a long way towards mitigating some of the challenges (for example system and user vulnerability to interference), and finding solutions. At the same time, the full benefits of Galileo can only be realised provided Galileo is interoperable with GPS (so-called "dual-mode" operation), and provided that cost-effective dual-mode receivers are available to all categories of user. Pinpoint is conscious that a great deal of work has already been directed towards achieving interoperability, and we are confident that full interoperability will be available. It is important to note that interoperability will cut both ways: Galileo will produce significant benefits for GPS and its users.

3.3 The following sections of this memorandum touch on many of the benefits which Galileo will deliver. At the same time it should be borne in mind that there exists the potential for the capabilities offered by Galileo—and any other radio navigation system—to be misused or subverted. A common concern is that the availability of accurate positioning data will be harmful to personal privacy and contribute to the

development of the big brother state. Some of the work we are doing within Pinpoint is intended to ensure that these aspects are properly investigated and understood, and that appropriate, effective control mechanisms can be developed and deployed.

4. The Pinpoint perspective on the benefits of the Galileo programme

4.1 Given the background explained in the previous sections of this memorandum, Pinpoint is convinced that the Galileo programme offers significant benefits to the UK. Further, we believe that the beneficial effects of the programme are already becoming apparent. From our perspective we do not see Galileo as an alternative to GPS (although its capability to serve in such a role if necessary is welcome). Rather, it represents an important independent source of critical data which, when used in conjunction with data from GPS, will deliver significant improvements. These improvements would not be obtainable from any one system alone—see Notes 1, 2 and 3, Appendix 1 for evidence of this—or from smaller-scale augmentations of one or other system. Our analysis of the benefits is summarised in the following paragraphs of this section.

4.2 Additional basic resource

— At its simplest, Galileo will provide a significant number of additional satellites. In principle, with satellite navigation, the more satellites there are, the better the service given to the user will be. The mere fact of having an additional 20-30 satellites in orbit will make for improved accuracy, integrity, and availability. Improvements in these fundamentals will lead to new and better services and applications, and benefits for all users. In practice, we know that Galileo will offer much more than just some more satellites, because of its high specification, service guarantees, and its operational and regulatory infrastructure.

4.3 Independent, civil control

— The Galileo system will be entirely independent of GPS technically and operationally, and will also be under independent, civilian control. Having a totally separate system will greatly facilitate the provision of reliable, assured GPS + Galileo services, because—for example—it will be possible to check the integrity of one system against the other.

— The fact that Galileo will be under civil control, with the UK having a direct stake in the programme and its regulation, is becoming increasingly important. It will, for example, re-assure users that the system is subject to controls and regulation which will ensure performance and transparency. It will encourage confidence in the system, and its dependability.

4.4 Diversity

— Increasing dependence on satellite navigation for many aspects of daily life in a developed society means that reliance on a single system becomes unacceptable. One example of this is the use of GPS as the Primary Reference Source (PRS) for the timing and synchronisation of telecommunications networks. Future network architectures are likely to rely increasingly on GNSS systems to provide synchronous timing references. Whilst alternative solutions are feasible, having an additional GNSS system such as Galileo is attractive as it provides resilience, and can eliminate network failures.

— The requirement for and use of positioning data is becoming so prevalent that the provision of such information on a best-efforts basis—which is the current GPS offer—is no longer good enough.

— There are increasingly large economic factors at stake, which make it foolhardy to depend on a single system for critical data. One example is electronic road tolling, where satellite-positioning is seen as the long-term solution to enable the deployment of flexible charging schemes anywhere with the minimum of infrastructure. However, the revenue streams from road tolling are so large that dependence on a sole source for the vital position data would be commercially unacceptable.

4.5 Improved services, new applications

— We expect that the norm for a very large majority of commercial users will be to use both Galileo and GPS, by means of dual mode receivers. However, Galileo will be capable of providing high-quality, stand-alone satellite navigation capabilities without having to rely on any other system. In this respect it is important to distinguish Galileo from augmentation systems, such as EGNOS. Current augmentation systems, including EGNOS, are by definition incapable of serving in stand-alone mode—they are adjuncts to, and utterly dependent on the availability of GPS.

— New applications and services will be enabled which would not be possible, or which would not be marketable, with just GPS as the underlying platform. Other applications & services will be improved, to the extent that new markets can be addressed. Examples of such applications and services include:

— Traffic and capacity management systems for transport networks (notably road, rail and air).

— Anything requiring assured performance from GNSS infrastructure. (The Galileo Commercial Service, Safety of Life Service and Public Regulated Service will all use an integrity (failure warning) signal which is not available with GPS. Applications requiring the integrity signal and

better signal availability include safety-of-life services such navigation in the aviation sector, train control in the rail sector and safety-related enhancements in the car and commercial vehicle sectors.)

- Marine engineering and harbour docking, precision surveying in rail and oil and gas sectors, inland waterway services, precision agriculture, tracking of valuable or dangerous goods.
- Road navigation and personal navigation. (Improved accuracy and signal availability in urban environments—see data at Appendix 1—will result in much more reliable services, especially in urban environments where GPS reception can be poor.)
- Prisoner tagging; tracking and monitoring of vulnerable people, such as children, remote workers.
- Responding to calls to the emergency services and managing follow-up actions.
- Personal, location-based services (LBS). (The European market for LBS has recently been projected to generate up to 4 Billion Euros in annual revenues by 2010[30])
- Augmented reality (AR). (AR is a technology used to combine computer generated objects or information with the real world in a user's view. The augmented view enhances the user's perception of the natural environment, often providing information that they cannot detect with their own senses or giving instructions for a complex task. AR systems operate alongside the real world and therefore must provide real-time interaction with the user and surrounding environment.)

The existence of a second, independent system increases the scope for using satellite navigation in safety-critical applications, notably in transport systems. As of today, there are numerous examples of users trusting GPS beyond its quoted integrity / legal approval, for example in the General Aviation sector. The CAA has recently issued a paper on the needed modifications before GNSS can be accepted as a primary navigation system. Whilst Galileo will not of itself provide an instant solution, future Galileo-related research will help to effect a significant safety improvement. The ultimate objective in this context would be CAA acceptability of GNSS as a primary navigation aid.

4.6 Confidence; Willingness to Commit

- The availability of Galileo will generate greater user and service-provider confidence in the utility and value of satellite navigation services.
- There will be greater willingness on the part of research organisations to invest in developing new applications and in improving current services.
- There will be greater market potential for products services and applications worldwide, because there will no longer be a need for absolute reliance on GPS.

4.7 UK Leadership and Advancement

- The UK has a strong position already in GNSS technology, in the research community as well as in industry. Galileo delivers opportunities for the UK to develop and lead programmes with other institutions and agencies around the world—see Note 4, Appendix 1, which explains the significant research funding available at European level directly related to Galileo. UK organisations are already winning a significant part of this funding.
- It is important for the UK to maintain and develop its research expertise in this area, both in basic satellite navigation technology, and in specific applications of the technology.
- The Galileo programme is stimulating research in the UK across a wide range of important technologies, in related areas. These include: non-satellite navigation techniques, sensors and controls, mobile communications, user interfaces, mapping and Geographic Information (GI), and Geographic Information Systems (GIS). In addition, the study of economic and social considerations relating to privacy, identity, and personal location services is becoming increasingly important.

5. Summary and Conclusions

5.1 Overall, Pinpoint welcomes the Galileo programme, as a major contributor to and stimulus of the development of new and better services and applications, for a wide range of user communities. The key concluding points we would make are:

- Positioning and related technologies are a vital component of the UK's knowledge economy.

[30] Berg Insight and Locationbox report titled "The Structure of the European LBS Industry 2004", to be published September 2004.

— There is worldwide demand for applications and services derived from positioning information; thus there is a global market for UK-developed knowledge, products and services. The existence of EGNOS and the development of Galileo are helping to increase the store, and value of UK Intellectual Property, and are giving UK organisations a definite selling edge.

— The Galileo programme is already serving as a major stimulant of UK creativity and innovation.

— Assured diversity of data sources is an important requirement for the development of new services and applications.

— Galileo may not make much, if any, difference to casual or non-professional users of satellite positioning services. Such users typically have a basic requirement to know where they are with reasonable accuracy, and will be generally satisfied by using the basic information provided either by GPS or by Galileo; they may well have no particular preference as between the two systems.

— In contrast, commercial providers of equipment and services, and business and professional users will take advantage of the additional information and reliability which Galileo will provide in order to offer and utilise improved and new services which would not be possible with GPS alone.

— The development and deployment of complex systems such as Galileo inevitably takes a number of years. The benefits of Galileo will be realised incrementally, over a long period. Thus the Galileo project needs to be assessed with a long-term view, and with acceptance that it will facilitate future developments and services, some of which we can not imagine today.

September 2004

APPENDIX 1

Note 1: A paper* by Nottingham University's Institute of Engineering Surveying and Space Geodesy (IESSG), includes simulation results which show that major improvements are obtained as the result of adding Galileo to GPS:

— In one example, the number of GPS satellites in view for 95% of the simulation period over the major populated areas of the world ranged from 5 to 9. Under the same conditions, the number of GPS plus Galileo satellites in view ranged from 12 to 16.

— In a second example, the three-dimensional position accuracy obtainable from GPS for 95% of the simulation period over the major populated areas of the world ranged from 15 to 25 metres. Under the same conditions, the three-dimensional position accuracy obtainable from GPS plus Galileo ranged from 10 to 12 metres.

** This paper is due to be presented by Nottingham University IESSG later in September 2004*

Note 2: In a detailed study* of urban road traffic monitoring and management technologies, the Institute of Transport Research of the German Aerospace Centre ("DLR") found that:

— In the urban area being studied, current GPS was found to be available with an accuracy of 25 metres for 90% of the time.

— For the same urban area, and under the same conditions, the study predicted on the basis of simulations that a combination of GPS plus Galileo would be available with an accuracy of 10 metres for 99.99% of the time.

**Paper presented by DLR at the BITS Seminar, Aalborg, Denmark, December 2003*

Note 3: Research undertaken by TRL Ltd* has generated results showing that Galileo would produce a significant increase in urban signal availability, and indicating that combining Galileo and GPS could almost eliminate the problem of signal absence.

The research used 1000 sample locations in an area of central London. The results below are presented in terms of a coverage statistic. 'Coverage' equates to the proportion of the 1000 sample locations from which a receiver could determine its location at a given time. Summary statistics for GPS, Galileo, and for GPS plus Galileo, are as follows:

	Average coverage	*Minimum coverage*	*Maximum coverage*
GPS only	0.513	0.323	0.750
Galileo only	0.663	0.566	0.768
GPS + Galileo	0.961	0.900	0.995

**Paper by TRL Ltd: "Modelling GNSS signal availability in urban areas—an evaluation of Galileo"*

Note 4: Key technologies required for the implementation and operation of the Galileo Mission are being developed through research projects, carried out within the framework of the EU's main research funding mechanism, the Sixth Framework Programme (FP6).

The Galileo Joint Undertaking (GJU)—which has interim responsibility for managing the Galileo programme—provides technical management for these projects, which result from a call for tender process. The foreseen total budget for these activities is approximately €100 million, which is being allocated through three separate calls for proposals with the following budgets: 2003—€19 million; 2004—€67 million; 2005—€15 million.

These activities cover the development of mass-market user receivers, local elements, market and business developments, and mission aspects. An emphasis is given to SMEs and international activities.

For further detail see the website of the Galileo Joint Undertaking: http://www.galileoju.com

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Memorandum by QinetiQ (GG 14)

GALILEO PROGRAMME

INTRODUCTION

QinetiQ has an interest in—and an involvement with—the Galileo programme through its expertise in satellite communications and their application, its development of technologies for secure communication and its work on applying satellite data transmission for terrestrial applications particularly in the area of Transport but also other areas of note.

- QinetiQ sees significant benefits to the UK due to a Public Regulated Service (PRS) being developed and fielded, as long as the service is properly controlled.
- QinetiQ believes it is essential for the UK to be involved in the development of PRS and management procedures for it, particularly in the security aspects, including the broader infrastructure such as crypto key management and wide area denial.
- QinetiQ believes the UK should be active in EU defence fora and in NATO in establishing control mechanisms for PRS and other Galileo services.

Our response to the specific questions raised by the Committee are as follows:

1. WHAT BENEFITS WILL GALILEO PHASE II BRING THAT EGNOS (EUROPEAN GEOPOSITIONARY NAVIGATION OVERLAY SYSTEM) WILL NOT?

EGNOS will provide additional integrity to the US Global Positioning System (GPS) in operations over Europe, and could improve the accuracy for the civilian user. Galileo will be a world wide system that stands alone, will provide better geographical coverage in higher latitude regions and is independent of the GPS system.

2. HOW IMPORTANT IS IT FOR THE EU TO BE INDEPENDENT OF GPS AND THE RUSSIAN GLOBAL NAVIGATION SATELLITE SYSTEM (GLONASS)?

While there are significant technical differences between the systems, this question is primarily a political issue. Such an accurate system as GPS or Galileo is becoming a required critical resource which society and commerce are expecting to be available. GPS is controlled by a non-EU nation, Galileo will be a system controlled by the EU and available for use as directed by the EU to the commercial advantage of EU members. It will be an important element of the future integrated transport structure of Europe, and has the advantage of additional performance. There will also be greater redundancy to exploit with there being three systems.

3. WHAT ARE THE POTENTIAL BENEFITS OF THE PRS SYSTEM?

There needs to be a service which has extremely high availability for essential services (emergency services and security services), which cannot be "switched off" and is therefore exclusive to those services and other high-priority communities of interest. This is the PRS.

PRS will be encrypted and therefore less open to electronic attack through provision of false signals (spoofing). It will also contain an authentication element for additional integrity. Depending upon the final bandwidth, it is expected to provide 10-15dB extra anti-jam capacity over the normal services, and would be the signal available in times of crisis to meet one of the requirements of the Transport Council.

In comparison with GPS, the signal itself apart from the encryption benefit will be more robust than the current GPS civil equivalent (L1), but probably no more robust than the planned GPS L5 civil signal (c.2012).

PRS may provide higher integrity, availability and resilience (robustness to interference) than EGNOS or GLONASS.

4. Is it Realistic that Member States Will Not Want to Cross-subsidise PRS from Commercial Services?

Member States will probably want to have PRS associated with aircraft landing and tracking. There is ongoing consideration of the privatisation of air traffic services in some member states. Similarly, the extent of public-private partnerships in other areas of public service will vary amongst member states. Such situations will require careful distinctions to be drawn if cross subsidy is to be avoided. For instance, PRS may be used in a system along with normal civil service within a bundled offering to a public service (eg ambulance management), this bundling reducing the cost of those services that may otherwise be unaffordable.

5. Are the Arrangements to Prevent Military Use of Galileo Sufficiently Robust?

The PAS will be available for any user, and as such could have a military use, in the same way as the civil GPS signal. The full plans for protection of the encryption of the PRS are not defined and therefore whether they are sufficient to prevent use of this service by a foreign military power is not known. The current Galileo baseline design does, however, include features to deny service to particular receivers, receiver groups and geographical areas. These capabilities might be used to prevent the use of Galileo services by an aggressor. The Galileo Security Monitoring Centre is the proposed vehicle obtaining agreement on denial operations. The Terms of Reference for the GSMC are as yet far from clear.

6. Are Arrangements to Oversee the Security Aspects of Galileo Appropriate?

There is obviously a potential risk to national security from control of the Galileo system falling into the wrong hands, and this risk clearly has to be minimised. There is a Galileo Security Board that has a number of Working Groups with UK Government and MoD representatives; they would be best place to answer this question. QinetiQ could obviously play a significant role in the provision of such protection systems.

7. What are the Potential Benefits of the Programme to UK Industry, and to UK Users of Galileo, Such as NATS?

The US has the majority of production capacity for GPS receivers. UK industry should be encouraged and supported by UK government to be at the forefront of Galileo technology. The example of the US, where the annual cost of GPS support of $230 million will be more than paid back through the tax revenue on the GPS equipment sold by US industry, should be noted.

Will the production of a Galileo receiver with PRS capability be able to be carried out other than by an EU member? The production of combined Galileo/PRS receivers could be the entry by UK industry back into the production of GPS equipment. Again QinetiQ is an obvious source of world leading technology in this area providing the UK a competitive advantage. Medium to longer term economic benefits will accrue from location-based industries: tracking, location based transactions, car navigation, vehicle location, active maps, road user charging, road pricing, security tracking of individuals and property. etc.

Widespread use of Galileo within the EU should have immediate efficiency benefits in transport and distribution service.

For NATS, the increased accuracy through Galileo and the combined use of both GPS and Galileo will make air traffic control safer, and control more efficient. Galileo provides a corner stone in the eventual consolidation of European ATM away from the individual country authorities to one European Command and Control structure. This combined with new Navigational systems such Automatic Dependent Surveillance Broadcast ground receiving system ("ADS-B System") will substantially reduce the costs of operation at the same time increasing safety during a period of rapid increases in traffic density. The airline industry, and NATS, would benefit from lower costs resulting from augmented navigation systems and the potential for higher traffic densities. There is also the potential for greater augmentation of safety critical systems, offset somewhat by risk management considerations.

— QinetiQ is Europe's largest R&D organisation, with nearly 10,000 employees, over 7,000 of them scientists, throughout Britain. QinetiQ's involvement with both the transport and space sectors derives from over 50 years of pioneering defence technologies as an arm of government. Now in the market under a PPP, QinetiQ is putting these technologies—and new ones across the range of Government departments (and the European Space Agency) and in the commercial world.

Nick Comfort
QinetiQ Group plc

September 2004

Memorandum by the Department for Transport (GG 15)

THE GALILEO SATELLITE NAVIGATION PROGRAMME

1. The Government welcomes the Committee's decision to conduct an inquiry prior to the possible decisions to be taken by the Transport Council in December 2004, and its invitation to submit this Memorandum.

Background and History

2. Galileo is designed to be a European civil Global Navigation Satellite System (GNSS). It will be the second, final step, after EGNOS (the European Geostationary Navigation Overlay System), towards European independence in civil satellite navigation. All existing civil and military GNSS applications rely on the American Global Positioning System (GPS) that was originally developed for United States' military purposes but which the US government has permitted to be used for civil applications. The Russian military GLONASS, which like GPS provides an open access signal, has never been exploited commercially due to Russia's inability to find funds to maintain the system.

3. To support the development of satellite navigation, the Government has contributed to the development of EGNOS. This provides, in Europe and the immediately surrounding area, sufficient enhancement of the existing GPS for it to be used to support some safety-critical applications. Notably this applies to aviation where EGNOS allows Air Traffic Services to fulfil the integrity requirements of the ICAO Treaty by informing users of defective navigation aids—a requirement that is not currently being met. The UK National Air Traffic Services (NATS) has also provided financial support (€22 million). This has ensured that the UK has been able to influence the development of satellite navigation in Europe and that part of the ground infrastructure of EGNOS is being located in the UK (at NATS in Swanwick).

4. The Government, recognising the importance to Europe of satellite navigation and positioning (particularly for the development of downstream services and applications) and wishing to protect its investment in EGNOS, supported the Resolution adopted at the Transport Council in June 1999 on the definition phase of Galileo. This invited the Commission in conjunction with the European Space Agency (ESA) to carry out that phase.

5. ESYS plc undertook a study on behalf of the Government to assess the potential benefits of Galileo for the UK. The conclusions of that work were that UK industry could expect to pick up a significant amount of business, particularly in the "downstream" development of applications for GNSS. The study demonstrated on a cost benefit analysis that if the UK became an active participant in Galileo, in return for a relatively small financial contribution to the programme its industry could benefit from work up to 30 times the value of that contribution. If the UK did not contribute but Galileo went ahead without UK participation, that additional benefit to UK industry would be significantly reduced. It was this argument, together with the potential benefits for Government and other applications of an enhanced GNSS, that persuaded the UK to become a full participant.

6. In order to manage the development of the project on behalf of all its funders the European Commission and ESA established the Galileo Joint Undertaking (GJU), which began work in 2003. The main tasks of the GJU are to oversee the implementation of the development phase and prepare for subsequent phases of the project including the development of a public-private partnership. The organisation will be wound up after a maximum of four years, to coincide with the beginning of the deployment phase. The Statutes of the GJU indicate that the Community and the European Space Agency would contribute €1.1 billion in equal shares. The Community funding is sourced from the Trans European Networks (TENs) budget and the finance for ESA's contribution is provided by its member states in response to a call for contributions. The UK contribution to ESA is €95 million of which the Department for Transport is providing about one-third and the British National Space Centre through DTI is funding the balance. Further public sector funding is likely to be needed in the initial stages of the PPP. The consortia bidding for the concession have pledged to restrict this to no more than one-third of the cost and the provision of this money will have to be approved through the EU budget process.

7. Subsequent developments in the project have shown that even before deployment begins, the UK has gained a significant amount of work. For example the first two Galileo satellites—the Galileo System Test Bed V.2—are currently under construction in the UK (worth £26 million to the UK) and the Galileo Joint Undertaking announced in July that all the contracts (worth up to €1.9 million) for external advisers to the GJU to help with the assessment of the PPP contract for deployment and operation have gone to professional advisers based in the UK.

UK Objectives

8. Key UK policy aims at this stage are:

— to seek to gain benefit for the UK industrially and as a user through, for example, industrial contracts in the present development and later phases, the development of value for money services for users, and establishing the UK as the location for Galileo control and operational facilities;

— to facilitate the development of applications using Galileo in transport and other sectors;

— to minimise the Community funds necessary to support the initial operating phase of the project and to move as quickly as possible to a position where income exceeds operating costs and there is no longer a requirement for public money to underwrite the system—through the establishment of a successful, effective and efficient Public-Private Partnership;

— in the context of this and other international agreements, to maximise the benefits to UK industry and users of co-operation with the US, Russia, China, Israel, India and other non-EU States and to maintain a close oversight, taking into account national, NATO and EU security concerns, on future negotiations with potential non-EU participants, including any proposals for them to join the Galileo Joint Undertaking;

— to ensure that non-European countries do not have any control of the system or access to sensitive technology, including the Public Regulated Service, should Council be convinced of the case for having such a service as part of the Galileo project;

— to ensure that the frequencies used for the Galileo signals do not affect UK, NATO or EU military effectiveness by overlaying the planned GPS Military code; and

— to encourage the integration of EGNOS into the Galileo programme.

Questions Raised by the Committee

What benefits will Galileo Phase II bring that EGNOS will not?

9. EGNOS augments the data from the open access signals of GPS and GLONASS by providing integrity information on the GPS/GLONASS satellites, error correction and improved availability. It cannot work independently of these systems, both of which are not under UK or European control and are provided subject to the defence needs of the US and Russia. EGNOS was not designed to provide coverage in locations that are crucial for future uses of GNSS, including heavily built-up areas. EGNOS has been designed primarily for some safety-critical aviation applications but is finding use in other applications such as in-vehicle navigation.

10. EGNOS should be fully operational within a year but will initially cover only most of Europe and the countries bordering the Mediterranean Sea. There are plans to extend coverage to Africa and the Middle East. Other regional augmentation systems to provide global coverage are at various stages of development in the USA, India, China and Japan and all are designed to meet ICAO standards. Galileo is a global system by design bringing an additional 27 operational satellites independent of, but complementing, GPS. Galileo will provide its own integrity signal which will be available wherever Galileo is used world-wide, providing the seamless global navigation system required for global users. Galileo will not duplicate EGNOS as it will not carry any integrity information for GPS/GLONASS.

11. The EGNOS signal is transmitted from geostationary satellites at the equator. Whilst it is good for its principal use by aviation within the European region, the location of the satellites means that the signal is not easily received on the ground in mountainous terrain or urban areas nor in extreme latitudes above about 70° N (a concern to the Scandinavian countries).

12. The accuracy and improved coverage of GPS/EGNOS and Galileo working together will open the door to many more applications, especially those in urban or indoor environments and even tunnels (perhaps in combination with other technology such as relay stations or inertia sensors). The mass-market field is particularly important since it is expected that satellite navigation will become a standard feature of mobile telephones within the next few years.

How important is it for the EU to be independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?

13. Russia has a strategic military requirement to maintain a global satellite navigation capability. The GLONASS constellation reached its full operational capability of 24 satellites in 1996. However it currently consists of only eleven satellites, the average lifetime of which is about 4.5 years (compared with GPS satellites which have a design lifetime of 7.5 years but are lasting up to ten years and more). Russia has announced publicly its intention to restore the GLONASS constellation to full health, notably through the deployment of longer life satellites, but lack of funding still means that its future is uncertain. So, in practice, GPS is the only system operating at present that the global civil community can utilise.

14. GPS was initially designed for US military applications and until 2000 the US government applied "selective availability"—which intentionally degraded the open access signal for civil applications and users—in order to preserve their Armed Forces' advantage and for national defence needs. The US government has since pledged to maintain the full capability, free open service signals (and that it will give six years' notice of any change in this position). It is also planning to improve the GPS service to the civil community but the system's evolution will continue to be governed primarily by US defence requirements.

15. So far most industrial benefits have accrued to American companies in the production of the GPS system and user equipment although some UK companies have gained significant contracts in the latter. A GNSS under civil European control is vital if European industry is to develop applications and services where the guaranteed availability will allow them to exploit fully the potential of the technology for the benefit of civil users. It will also help to improve the opportunities for European industry to compete in the world market.

16. A European system will also mean that we are independent of any US policy change and strengthen Europe's position in negotiations with the US on the future development of satellite navigation. As European transport infrastructure comes to rely more on GNSS applications it is essential that an adequate level of control of the system rests with Europe. The Commission in particular sees Galileo as a vital component of future European traffic management systems for all modes of transport, in other strategic industrial and commercial areas, law and order, and in crisis and emergency applications. Hence it is important for the UK Government to be part of Galileo to ensure that our needs within these areas are fully considered and accommodated.

17. Users of GNSS will be protected from a loss of service resulting from a single point of failure. This is avoided by having a least two separate, global systems with independent command and control facilities to ensure continuance of coverage in the absence of either system.

What are the potential benefits of the Public Regulated Service (PRS) system? Is it realistic to expect that Member States will not want to cross-subsidise PRS from commercial services?

18. The objective of the proposed PRS is seen by the Commission as to improve the probability of continuous availability of the "signal in space" to governmental users requiring a continuity of service even in presence of threats to the open service or in other times of crisis. It would be a robust, encrypted service intended for use by EU Member State civil government agencies. A decision on whether PRS will proceed beyond the development stage is expected to be made at the December Transport Council.

19. The robust, encrypted signal should offer greater security from deliberate attempts to generate a false signal. Potential applications are still under discussion and it is expected that the Galileo concessionaire bidders will make proposals for the use of, and income generation from, the PRS. But the intention is that access to it will be strictly controlled, although the rules are still being discussed. No specific UK need has however been identified at the present time although if other member states specify a need and become paying users of the service, UK companies are amongst the few that have the capability to produce the necessary hardware and software.

20. By way of example, however, the Commission have suggested that the service could be used:

— by immigration and customs agencies for tracking smugglers of people and goods;

— by peace keeping forces in or close to areas of conflict where NATO military operations require all unencrypted GNSS signals to be blocked; or

— for civilian humanitarian operations in such areas.

21. On cross-subsidisation we must await the concession bids before assessing the impact but the concessionaire will not want to jeopardise the potential income from commercial services by allowing Member States to siphon money away to pay for the PRS. It is expected that the funding of the PRS will essentially be "user pays".

Are the arrangements to prevent military use of Galileo sufficiently robust?

22. We acknowledge that military use of the open Galileo signals for basic navigation cannot be prevented and indeed may bring some advantages because of the greater accuracy and coverage that will be available from the combined GPS and Galileo signals. We recognise that there are "grey areas" in some member states, where bodies such as the Italian carabinieri are essentially military in their command structure but perform many functions that in the UK are undertaken by civilian organisations.

23. However, we believe that sufficient controls are in place to ensure that Galileo is not developed with specifically military applications in mind. For example, developing the Galileo PRS for precision-guided ordnance should not be possible without the explicit authorisation of the Galileo Supervisory Authority (which will be under the control of member states). The GSA would have to define the specifications and instructions for manufacturing PRS receivers, in accordance with the policy of access to PRS to be defined by the Council, and would have to provide guidelines for the implementation of PRS management rules in the Member States. If such a question were to be put to Council—and there is no indication that it will happen in the foreseeable future—it would have to be for a decision by a competent formation of Council and as a "Pillar II" issue it would require unanimity.

24. This issue featured prominently in the recent successful interoperability negotiations between the EU and United States, where the UK Government played a key role. The subsequent agreement stresses the civil nature of the Galileo programme. Whilst military satellite-based navigation and timing services are

generally outside the scope of the agreement (these are subject to separate agreements between US-NATO and US-individual member state), it does provide for radio frequency compatibility between all GPS and Galileo signals except locally in areas of conflict.

25. More details have to be worked out through the Galileo Security Board (GSB—in which the UK is a major contributor) and during the negotiations with the PPP concessionaire. The UK Government will work to ensure that the detailed provisions work effectively to prevent the development of military applications.

Are arrangements to oversee the security aspects of Galileo appropriate?

26. A Joint Action has been agreed which allows member states or the Secretary General to raise any security concerns which they have arising from the operation of Galileo, and request that the Council issue instructions to address them. The GSA will enforce and verify compliance by the concession holder with these instructions, and will be answerable to Member States through its Administrative Board, which is composed of national representatives.

27. Developments in ESA have indicated that there is likely to be a requirement for an additional extra €150m for security requirements for the system. This is currently being evaluated as a part of the ongoing review of the development and validation phase. Ahead of any Council decision on the inclusion of the PRS in the Galileo system, and the proposals from the concessionaire for implementing the PRS, the GSB are developing arrangements based on the expectation that PRS will be included. These details cannot be finalised and agreed until decisions are made on the inclusion of the service and who will have access to it. Again it is a UK Government objective to ensure that the arrangements meet our security requirements.

What are the potential benefits of the programme to UK industry, and to UK users of Galileo, such as NATS?

28. As Galileo is a European Union lead project the cost and benefit analysis and other definition phase studies have been at a European level and carried out on behalf of the Commission and ESA by advisors such as PricewaterhouseCoopers. UK companies have been involved in these studies and in other projects through the EU Research and Development Framework Programmes and continue to be through a specific Galileo programme under the 6th FP and managed by the Galileo Joint Undertaking. UK companies continue to be actively involved in contracts from ESA on the technical development of the EGNOS and Galileo infrastructures.

29. Therefore there are benefits for the UK space industry in the design and manufacture of the Galileo system and its supporting infrastructure. This will continue through the life of the public private partnership when life-expired satellites are replaced and improvements are made as technology advances. There will also be major benefits and opportunities to UK industry in the exploitation of the downstream applications that the signals Galileo will make possible. The scale of these benefits is difficult to assess because there is potential for applications of satellite navigation and positioning technology to be used in many walks of life either alone or with other technologies. For example, it will be used by a wide range of different and unrelated users groups including:

- civil aviation navigation,
- motorists—initially for navigation but with longer term potential for such uses as pay-as-you-drive road charging and insurance or for intelligent speed adaptation,
- railways—including signalling and rolling stock management,
- freight logistics operators for fleet monitoring and security,
- leisure users for navigation and location-based services, and
- users requiring precision timing (eg power distribution).

30. The ESYS Study referred to in paragraph 5 above clearly demonstrates that UK industry is well-placed to benefit from future developments in GNSS and that these benefits will be significantly greater if the UK continues to be a full participant in the development of Galileo. The establishment of the Pinpoint Faraday Partnership, sponsored by the Department of Trade and Industry and the Engineering and Physical Sciences Research Council, is intended to help UK industry and academia to exploit opportunities for Galileo and satellite navigation and positioning applications.

31. UK government use of GPS remains patchy but increasingly new applications are being identified; the advantages of Galileo should lead to a mushrooming of applications. Some current examples include:

- all coastal EU Member States have been using GNSS for several years to monitor fishing vessels over 24 metres in length to assist in enforcing fisheries conservation and quota rules;
- the Crown Estate requires ships dredging for marine aggregates to record their position and quantity taken as accurately as possible using GNSS;

— the Home Office have introduced a pilot scheme in three areas of the country, for tagging prolific offenders, the tracking technology (currently based on GPS and mobile phone technology), monitors offenders' movements and ensures that they are complying with the restrictions placed on them—Galileo will improve the accuracy and reliability of this service particularly in urban areas where GPS coverage is unreliable;

— the Department for Transport published a study in July that recognises that the availability of Galileo could be the key element in the feasibility of a national road pricing scheme—Galileo, in combination with GPS, would offer improved accuracy, reliability, real time information and the possibility of tracing its performance in disputed cases. Local congestion charging regimes would also benefit, by reducing the amount of expensive ground infrastructure required to monitor compliance. Galileo would also provide a common standard for interoperability if road pricing is rolled out across the EU.

Other users will appear as the benefits of accurate positioning and minimal ground infrastructure become apparent.

32. Galileo services or applications will be designed to be certified by appropriate regulatory bodies, which will enable their adoption for safety of life services. This will also allow GPS/EGNOS to act as a back-up to Galileo (and vice-versa) giving more confidence in the continuity of service which in itself will, over the long term (up to 15 years) relieve the requirements to maintain traditional Air Traffic Control and other terrestrial based systems on the ground. There is already significant potential for the use of Galileo within the "Single European Sky" concept and it is expected that Galileo will become a major component of the infrastructure of Air Traffic Control in Europe. NATS has the expertise to benefit from these developments.

Conclusions

33. Although the UK Government remains very alert to questions about Galileo's costs and security implications, it is committed to the programme because of the value to UK industry in developing the infrastructure and applications for Galileo, as well as the significant change in GNSS capability that the combination of GPS and EGNOS, followed by GPS and Galileo, will bring. It is clear that Galileo will play a strategic part in transport in the future and we need to continue to participate in its development to ensure that it meets our transport needs. The UK is leading efforts to secure the success of the PPP, which will maximise the commercial potential and hence value for money to the public sector, and we are also in the forefront of ensuring that Galileo remains a civil programme within the terms of the Transport Council's conclusions. The Department for Transport is working closely with other Government Departments to ensure a fully joined up UK approach to this project.

Department for Transport

September 2004

Memorandum by the iNavSat Consortium (GG 16)

GALILEO

0. iNavSat

(0.1) iNavSat is a consortium formed for the purpose of becoming the Galileo Concessionaire, and having been successful in the Pre-selection Phase, iNavSat have submitted a comprehensive proposal to the Galileo Joint Undertaking on 1 September 2004 for the deployment, operations and the commercialisation of Galileo under a 20-year concession scheme.

(0.2) The three core consortium members—Inmarsat Ventures Limited (Inmarsat), Thales SA (Thales) and EADS Space (EADS)—are European market leaders respectively in the fields of mobile satellite communications, satellite-based navigation products and services, and aerospace. Inmarsat is a UK company, and both EADS and Thales have significant business interests in the UK. All three companies have extensive global operations and marketing activities as well as significant R&D activities in the areas of satellite and navigation technology and applications. Combined with their experience in successfully raising debt and equity and completing complex infrastructure projects, the iNavSat consortium has the capabilities and experience to address all the challenges of the Galileo Concessionaire role and give stakeholders the necessary confidence.

(0.3) Collectively, the iNavSat team has very complementary skills, with few overlaps:

— Inmarsat is the global leader in mobile satellite communications and the only satellite operator for which navigation and safety areas are part of its core business. Furthermore Inmarsat has unmatched marketing and distribution presence on a global scale, plus a world-class satellite procurement and operations capability.

— Thales is an international electronics and systems group, serving defence, aerospace, services and security markets, with outstanding experience in large systems deployment. It is the third largest GPS receiver manufacturer and a world leader in Telematics services.

— EADS has broad and relevant experience in governmental business—from defence applications and services to a large portfolio of aerospace products, as the leading civil aircraft manufacturer in the world. It has successfully completed a number of complex infrastructure projects in a multinational environment.

(0.4) EADS Space and Thales have been involved in large-scale project finance activities during the past three years within which they have successfully raised many billions of Euros in mostly long-term debt. The specific experience of EADS in setting up Paradigm Secure Communications in the UK is noteworthy as it represents the closest parallel to the Galileo Concessionaire PPP. One could also view Inmarsat's evolution from a PPP (or Inter Governmental Organisation) to a very successful, fully privately held satellite operator as a natural analogy for Galileo.

(0.5) All three companies have been actively involved in various ESA and EC sponsored Galileo activities from the early stages and are very familiar with all aspects of the project, and similarly the realisation of EGNOS.

(0.6) Thales (UK), Inmarsat, and EADS (EADS Astrium) are all members of the United Kingdom Industrial Space Committee (UKISC) and have actively participated to the memorandum submitted by UKISC. iNavSat fully endorse the UKISC memorandum, but wish to elaborate on certain points from a concession perspective which were not appropriate to include in the UKISC document, and in particular, issues regarding the Public Regulated Service (PRS).

1.0 What Benefits will Galileo Phase II Bring that EGNOS (European Geostationary Navigation Overlay System) Will Not?

(1.1) Please refer to the UKISC Memorandum.

2.0 How Important is it for the EU to be Independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?

(2.1) Please refer to the UKISC Memorandum.

3.0 What are the Potential Benefits of the Public Regulated Service (PRS) System? Is it Realistic to Expect that Member States will not want to Cross-Subsidise PRS from Commercial Services?

(3.1) PRS will have a strong impact on European / national security, it will:

— foster the creation of European security and safety authorities and will provide a mission critical enabling technology supporting the European Common Foreign and Security Policy (CFSP),[31]

— create new European standards to which any future member state or third country could adhere to, providing a common, flexible and independent security concept for the European Union and its allies,

— be subject to European export regulations creating a complement to the US International Traffic in Arms Regulations (ITAR) and other current agreements,

— provide a valuable redundant backup for other allied security organisations, given the existence and interoperability of two robust, governmentally controlled services

(3.2) PRS will be a strategic tool for Europe, a counter to the US dominance in this field and as an opportunity for European industry. The Galileo PRS will therefore:

— provide Europe with independence and sovereignty[32], while being interoperable with GPS,

— protect its citizens and those of third countries,

— enhance Europe's integration process by supporting the CFSP and allied security organisations,

— increase the confidence of the US and of potential users in the EU and allied nations,

— foster European industrial and export policies complementary to US,

— support governments in improving the mission capability of their security related organisations (all government-controlled uses of PRS, Homeland Security, Civil Protection, Border Control, Customs, etc.),

— close the technology gap between Europe and the US, not only in satellite navigation but also in security and adjacent technologies,

[31] Lindström, G.; Gasparini, G.: The Galileo Satellite System and its Security Implications. Paper 44, EU ISS, April 2003.
[32] European Commission, DG TREN: GALILEO—An imperative for Europe. Information Note, 2001.

— have an important part of the macro-economic benefits of Galileo, which until today have not been discussed in detail,

— be essential to the future of European industry.

(3.3) European industry masters the available PRS technology (navigation, crypto, key management). With PRS, an end-to-end security capability will be available in Europe, providing technological advances in public safety. PRS will create a balance between US and European industry, with potential access to the US market for European industry. The existence of the Galileo PRS is crucial to the European industry for technology developments, enhanced competitiveness with regards to US industry, growth and the associated creation of jobs, regulated exports to European allied nations including the US.

(3.4) The question of cross-subsidies for the PRS perhaps anticipates that the PRS service will need to be subsidised by revenues from other services. It is conceivable that the PRS can be operated on a commercial basis. iNavSat have proposed a PRS Business Plan to the Galileo Joint Undertaking as part of our concession tender, the details of which cannot be disclosed herein but iNavSat would be pleased to provide a verbal briefing to the Transport Committee. PRS is fundamental to the PPP of Galileo, as it represents a service to the governmental organisations of EU member states and the EU.

4.0 Are the Arrangements to Prevent Military use of Galileo Sufficiently Robust?

(4.1) The Galileo PRS is projected to be a service for the European Union member states and designed so as:

— to be compatible with a future European navigation warfare policy intended to preserve national security and to protect European citizens against the consequences of hostile misuse and intentional or un-intentional interference of Galileo signals,

— to guarantee a continuity of service to governmental users, also throughout times of crises.

(4.2) Galileo is a critical infrastructure susceptible of dual use applications. As such it is a legitimate concern of the EU Member States and their allies, to protect their citizens against possible hostile misuse of the Galileo services. As Galileo will be operated under a concession contract, business imperatives must coexist with homeland security imperatives.

(4.3) While all other services could be denied, PRS will remain the only service available to different groups of authorised users, which implicates that PRS users shall be effectively managed under governmental control. The enhanced performance will be ensured by an encrypted signal with a specific design structure and broadcasting power. At user level, PRS receivers will be fitted with specific security modules featuring a secure access control mechanism. The requirements set above eventually match the current requirements of military users. Therefore, it is envisaged that PRS should:

— be under European public control through a dedicated Supervisory Authority to be set up by the EU and its member states,[33]

— be an authorised service for EU governmental and military users,

— provide enhanced protection against misuse and interference through encryption and other techniques

— ensure the availability of the service in times of crisis

(4.4) Galileo PRS policy and access will be closely controlled by the Galileo Supervisory Authority (which will have its own security advisory committee), political oversight and control will be performed by the Council, with delegation to the EU High Representative/Secretary General of the Council when urgent security-related, decisions are needed. iNavSat would be uniquely capable of implementing that policy on behalf of the EU, since EADS and Thales have developed long term business activities based on military P(Y) code of GPS and therefore possess an exceptional background and position from which to develop the PRS capability and markets.

(4.5) Furthermore, iNavSat founding members are involved in the security design of the Galileo system. From this standpoint, we are confident that:

— the technical features of the Galileo system are sufficiently robust to prevent interference with operation of the system, and will prevent unauthorised use of the PRS service;

— that the iNavSat consortium have the necessary skills and experience to implement and operate the Key Management Facility, to control access to the PRS service

(4.6) Independent of the PRS, military forces throughout the world will use the freely available Galileo services (Open Service and the Safety of Life Service) for many applications, albeit not in the true "military" sense. This is the case with the GPS open service today, and with the introduction of Galileo new possibilities will arrive due to the increased performances which will be achieved by using a dual-constellation of navigation satellites from GPS and Galileo.

[33] General Secretariat of the Council, EU Council: Galileo Management Structures, W.Doc. 2004/01, 9 January 2004.

5.0 Are Arrangements to Oversee the Security Aspects of Galileo Appropriate?

(5.1) Currently, the Galileo Security Board is mandated by the EU Member States to make the necessary arrangements for the security aspects of the Galileo system. In this respect, iNavSat has noted a major participation of UK representatives who have contributed to establish the requirements for a secure and protected Galileo infrastructure. Whilst the arrangements, and consequently the requirements, for the Galileo system are not yet finalised, the current results give iNavSat the confidence that the eventual security arrangements will appropriate.

(5.2) Nevertheless, today much emphasis is set on developing the necessary security elements for the system, with less attention being paid to secure operations in harmony with the future decision making process, and the need for the UK government to control the security. iNavSat is very confident that it can provide its expertise and capability in secure operations of satellite systems to complement these initial activities (note that EADS Space operates the Paradigm Secure Communication satellite system for the UK MoD).

(5.3) European industry has the know-how and technologies to successfully achieve PRS implementation and to create a valid business that will ultimately benefit all European citizens (eg in security and jobs).

6.0 What are the Potential Benefits of the Programme to UK Industry, and to UK Users of Galileo, such as NATS?

(6.1) Over the last years, the GNSS market has grown impressively and many GPS based applications have been developed. With Galileo and the modernisation of GPS the scope of applications and the quantity of users is foreseen to increase dramatically. At the same time, demand for continuous availability of accurate positioning, has lead to increasingly integrated navigation products through hybridisation of technologies. This trend requires companies to master both GPS and other navigation technologies.

(6.2) The UK has perhaps been the most successful country outside of the US to exploit market opportunities that GPS has presented. UK-developed products and services not only address our home markets, but these have developed into global services generating significant export revenues. Specifically, London-based Inmarsat is the world's leading operator of mobile satellite communications. As UKISC has reported, the UK is very active in all Galileo studies and pre-development contracts, and is leading the project to develop and launch the first Galileo Satellite to secure the Galileo frequencies.

(6.3) By combining UK successes in satellite navigation products and services with our large system capabilities, and using the UK's unique expertise in PFI programmes and satellite operations, significant UK contracts will result should iNavSat be selected as the Galileo Concessionaire. In addition to our core members, several UK companies are Associate Partners to the iNavSat consortium and have actively contributed to our Concession proposal.

(6.4) Even though the civil GPS market share dominates, the governmental, homeland security and defence market is significant in its own right and moreover in its strategic technological importance. This is underlined by the specific rules (eg Foreign Military Sales) the US DoD has set for security reasons, especially for the development and manufacturing of GPS-PPS receivers. This and the numerous contracts that the US DoD has placed to the US industry, has indeed supported US dominance in this field. US DoD policy has triggered a tremendous US industry consolidation, leaving only a few companies with the related know-how.

(6.5) For European companies it is currently not possible to access the complete military GPS technology, due to the restricted access to information. The integration of different technologies in the same device meanwhile leads to an increasing dependence on the US, which is reinforced by the introduction of a new military GPS technology in 2003 and the upgrade to GPS III. The current on-going discussion on technology transfer between the US and the UK indicates the sensitivity and importance of the issue.

(6.6) Satellite navigation technologies have become mission critical components that will be embedded in every future military platform.[34] Therefore, without the Galileo PRS, the European forces will loose operational capability by being dependant on third parties' technologies. Meanwhile the European industry will be excluded from major defence and security markets in this field.

(6.7) European industry masters the available PRS technology (navigation, crypto, key management). With PRS, an end-to-end security capability will be available in Europe, providing technological advances in public safety. PRS will create a balance between US and European industry, with potential access to the US market for European industry. The existence of the Galileo PRS is crucial to the European industry for:

- technology developments,
- enhanced competitiveness, with regards to US industry,
- industry sector growth and the associated creation of jobs,
- regulated exports to European allied nations including the US.

[34] N.N.: CJCS Master Positioning, Navigation, and Timing Plan, 2000.

(6.8) US confidence in Galileo will gain momentum. The PRS implementation will trigger new cross-European industrial cooperation during the development phase. Interoperability between GPS and Galileo is key to maximise performance benefits for the end-user. New applications will arise, such as safety critical guidance of transport vehicles or even autonomous navigation of unmanned vehicles including coupling with other technologies for in-door or urban canyons (ie where satellite navigation signals are not available).

(6.9) UK industries are therefore well placed to capitalise on the vast range of opportunities which Galileo will present.

Patrick McDougal
Inmarsat

September 2004

Memorandum by EADS Astrium & Amicus (GG 17)

GALILEO

A Introduction

A.1. EADS Astrium is the UK's largest manufacturer of satellites, employing over 2,000 people in the UK and over 5,000 in Europe, operating key sites in Portsmouth, Stevenage and Poynton. The Company also uses space technology to develop practical solutions to everyday problems and is the leading industrial player for the Galileo project in the UK. EADS Astrium is the principal shareholder in Galileo Industries, the European joint venture company designated to become prime contractor for developing and manufacturing the Galileo space and ground infrastructure.

A.2. EADS Space Services manage and operate, on behalf of the UK MoD, the Skynet military communications satellites, and are, together with Inmarsat, the UK's largest commercial satellite operator, founding members of the iNavsat consortium, competing for the Galileo Concession contract.

A.3. Amicus is the UK's largest union representing over 1.3 million members in British business. Amicus is also the largest single affiliate to both the Labour Party and the TUC. Many of its members are employed in High Technology jobs in the Aerospace sector. EADS Astrium was the first company to sign a National Recognition Agreement with Amicus.

A.4. EADS Astrium and Amicus very much welcome the opportunity to make a joint submission to the Transport Committee's inquiry into Galileo. We believe this inquiry is timely, corresponding with the imminent start of Galileo's in-orbit validation. Our joint submission reflects a shared belief that progressing the Galileo programme will bring enormous benefits to Europe's citizens, and that EADS Astrium's continuing involvement in this programme will bring substantial benefits to UK plc.

1. What Benefits Will Galileo Phase II Bring that EGNOS (European Geostationary Navigation Overlay System) Will Not?

1.1. EGNOS and Galileo are fundamentally different systems that have been developed for different purposes: EGNOS simply improves upon, but is dependent on, GPS. Galileo on the other hand is a fully independent satellite navigation system.

1.2. EGNOS is Europe's first step into satellite navigation and its prime mission is to enhance and augment the reliability and accuracy of the positioning signals transmitted by GPS. However, the performance and continuity of EGNOS, as a secondary system, is reliant on the availability of GPS. EGNOS is targeted for, and sponsored by, the aviation sector, but the system will be available to any user with an EGNOS receiver. EGNOS is available only in the European region.

1.3. Galileo is designed as a civilian, fully independent, primary satellite navigation system, providing global coverage. The system's compatibility with, yet independence from, GPS will allow many more users to benefit from satellite navigation. Galileo offers users five different services in a market-driven approach, responding to diverse user requirements. The five services are the free of direct user charge Open Service (OS) for the mass market, the Commercial Service (CS) and the Safety of Life Service (SoL) for high-end users, the Public Regulated Service (PRS) for governmental users and the Search and Rescue Service (SAR) as Europe's contribution to the International COSPAS/SARSAT rescue service.

1.4. Leisure and mass-market users are likely to be satisfied with the basic Open Service which of itself will be superior to GPS through technology advances and additional signals. However, the real benefit to these users will be through the use of receivers that offer combined GPS and Galileo, taking benefit from the compatible signals and more than twice the number of satellites compared to GPS alone.

1.5 More demanding commercial and public service users will benefit from Galileo's more sophisticated signals which are presently unique and are not offered by either GPS or GLONASS. Safety-critical transport users, for example, can take advantage of Galileo's integrity messages that will alert users immediately to

any errors in the system. Galileo will also for the first time allow users to enter into a contractual service agreement with the system's operator. The option of safety certified services and contractual responsibilities between the individual user and operator are an important requirement for modern business users and for safety-critical applications, where high economic or life dependence is placed on the satellite navigation signals.

2. How Important is it for the EU to be Independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?

2.1. The more important question to consider is not so much whether the EU should be independent, but rather whether Europe (and the rest of the world) can accept the risk of total dependence on a single system. Many believe, and it is the opinion shared by EADS Astrium and Amicus, that a second independent system is essential to mitigate against the risks of GPS becoming unavailable for any reason (political, economic, catastrophic failure, terrorist attack etc). In this context, user communities around the world, including from within the US, are united in welcoming the development of a second independent system.

2.2. The US Air Force fully funded the development and deployment of GPS, and continues to fund the operations and technical evolution. A next-generation GPS III is envisaged to match the capabilities of Galileo, but funding for this is not yet assured, and in any case GPS III will not become operational until at least 2015.[35] The Air Force is required to go before Congress each year with budget requests for GPS in competition to other defence procurement needs. Although GPS is able to react in a limited way to civil market demands, it is clear that GPS is first and foremost a military system and the demands of the military come first.

2.3. The GLONASS system was also developed primarily for military purposes. Due to the comparatively short design lifetime of the GLONASS spacecraft and the lack of funding following the collapse of the Soviet Union, the performance of the system has been declining ever since its completion in 1995. At present there are only eleven operational satellites in orbit, and the limited number of satellites available severely restricts the performance of the system. The Russian administration published plans calling for a 24-satellite constellation by 2007. The current economic situation in Russia, however, and in particular the lack of funding for all space projects, does not give any confidence that the 24-satellite constellation will be realised as planned.

2.4. Satellite navigation is quickly becoming a crucial element in the effective management of modern transportation infrastructure. In a few years it will be an indispensable asset for millions of users in Europe. In addition public authorities and institutions will use satellite navigation to control transportation networks and manage traffic, making travelling faster, safer and more reliable. HM Customs and Excise is considering the introduction of a road user charge for lorries (LRUC) in the UK, using satellite navigation to determine the location and movements of vehicles. The economic dependence by relying on the provision of free GPS signals is already significant and expected to grow at an increasingly faster rate. It is estimated that the cost for complete or temporary GPS outage will accumulate to more than £ 300 million for a single day in Europe by 2015.

2.5. Furthermore, the provision of precise timing signals is a crucial backbone to synchronise telecommunication and electricity networks, and to timestamp financial transactions accurately. GPS is currently the only system fulfilling this function. The existence of a monopoly in this area is hindering the development of a commercial and competitive market. The use of European timing standards for Galileo will form a critical cornerstone of Galileo's independence, helping to mitigate potential vulnerabilities in the European infrastructure.

2.6. Many countries in Europe and elsewhere have acknowledged the need for a separate system under civilian control, providing seamless global coverage. Israel and China have already signed cooperation agreements with the European Commission whilst India, Brazil, Mexico and others have expressed a genuine interest in becoming a partner in the Galileo programme. It is significant that India and China have decided to join Galileo, rather than develop their own systems. The broad international interest representing some of the biggest markets and economies in the world underpins the viability of Galileo as an independent system, and will ultimately contribute to establish Galileo as a global standard.

3. What are the Potential Benefits of the Public Regulated Service (PRS) System? Is it Realistic to Expect that Member States will not want to Cross-Subsidise PRS from Commercial Services?

3.1. As previously indicated, Galileo will offer five different services with different signal characteristics. The PRS is designed as a civil signal for governmental use. This would primarily include civil users in the field of public security services such as border surveillance to prevent illegal immigration or drug trafficking, or co-ordination of disaster relief forces for example.

[35] EC GALA study: GALA-MMS-DD133.

3.2. The PRS signal will be securely encrypted and will offer a more robust service with a higher degree of protection against signal interference. The EU Transport Council will make a decision about the inclusion of the PRS in the agreed service features of Galileo at its meeting in December 2004.

3.3. PRS is designed to provide service to government users even in situations where other satellite navigation services might be denied for reasons of security or in the event of any natural or deliberate signal degradations. EADS Astrium and Amicus believe that the key benefits of PRS will primarily materialise outside the borders of the European Union—for example for humanitarian aid missions. Foreign security operations often involve large scale of logistics and its management, including obtaining and using up to date knowledge of the location and status of the managed assets (vehicles, personnel, supplies, equipment,) and their proximity and accessibility to zones of crisis. In many cases there is no clear separation between humanitarian civil and other tasks with military elements (eg using Galileo to clear areas from land mines). Users cannot rely on the availability of terrestrial infrastructure and global systems such as GPS and Galileo provide therefore huge advantages before, during and after the operation.

3.4. The deployment and operation phase of Galileo will be delivered through a public private partnership, with a large element of private money expected to be invested giving a return to equity investors and lenders. Two teams have recently submitted bids to become the Concessionaire and both are preparing business plans and detailing expected revenues. The sale of PRS-based services can be expected to feature in all the business plans as a major source of income for the Concessionaire.

3.5. Independently from the decision of UK government bodies and agencies to utilise PRS, the prominent position of the UK industry, including EADS Astrium and other UK-based subsidiaries of EADS, see advantages in exploiting potential export markets in this field. The UK plays a leading role in Europe in protecting against terrorism through sophisticated security technologies.

3.6. A number of Member States have expressed an interest in using PRS, including national law enforcement applications. The number of Member States supporting PRS will have a major impact on the selected funding scheme of the service. PRS could either be declared part of the overall system cost funded by all Member States, or alternatively be solely funded by those expressing interest in exploiting this service. The Galileo Joint Undertaking (GJU) is eager to avoid any cross-subsidies between services and is actively encouraging the bidding consortia for the Galileo Concession to develop a viable business case without cross-subsidising PRS and commercial services in any way. The proposed Supervisory Authority likely to be established in the first half of 2005 will have responsibility to ensure that the Galileo Concessionaire adheres to the funding rules.

4. Are the Arrangements to Prevent Military Use of Galileo Sufficiently Robust?

4.1. The EC Council Resolution of 5 April 2001 on Galileo states in its preamble that Galileo is "a civil programme under civil control".

4.2. Just as anyone can use a mobile phone, the open signals from both GPS and Galileo are freely available to any user who buys a receiver. Therefore there are no effective means to prevent access by specific individuals or types of user. This includes military staff who could buy a commercial receiver to determine their position. This should not, however, be seen as an argument against either GPS or Galileo. Whilst it is theoretically possible for military uses to be found for Galileo, the system will remain under civilian control and during its development the benefit has been focused on non-military uses.

4.3. The developers and manufacturers of the receivers can, however, impede the functionality of the terminal under certain conditions, and to restrict the use to user-typical criteria. These procedures are already common practice for GPS receivers for both commercial and security reasons. Low-cost GPS receivers sold for hikers, for example, do not work above a certain altitude, forcing aviation users to buy terminals specifically designed for use on aircraft. Similarly, commercial GPS receivers are not able to guide missiles, as the as they would not function the high velocity and altitude typical of such applicaitons. Galileo receivers would follow the same principle and include similar features.

4.4. The Missile Technology Control Regime (MTCR) is an informal association established in 1987 to prevent the proliferation of unmanned delivery systems capable of delivering weapons of mass destructions. The association rests on an adherence by all partners to common export policy guidelines that are applied to a common list of controlled items. This list includes under paragraph 11.A.3. "Receiving equipment for Global Navigation Satellite Systems (GNSS; eg GPS, GLONASS or Galileo) [. . .]" applying to components capable of providing navigation information at high speeds [. . .], gaining access to secure GNSS signals or specially designed to employ anti-jam features.

4.5. While it is the responsibility of the manufacturing industry to propose and implement all necessary technical precautions, it will remain the competence of the Member States' governments and the EC to establish a functioning and effective administrative process for Galileo.

4.6. The EC proposed the establishment of a Supervisory Authority that will come into being in the first half of 2005. This body will represent all Member States involved in the Galileo programme, and will control and monitor the activities of the Concessionaire. Its jurisdiction will include ensuring the security of the system.

4.7. The agreement between the US and the European Community signed on 26 June 2004 ensures the inter-operability of GPS and Galileo for civilian users. The provision of military satellite-based navigation and timing services is not within the scope of this agreement. GPS will remain for the foreseeable future the primary means of satellite navigation for all NATO forces. This agreement does ensure that Galileo and GPS can co-exist harmoniously with each other, including some classified agreements to ensure military capability is not compromised by the introduction of Galileo.

5. Are Arrangements to Oversee the Security Aspects of Galileo Appropriate?

5.1. Neither Amicus nor EADS Astrium are in a position to answer this question competently. Appropriate technical measures are being taken by the industry to ensure the security of the signal in space against unauthorised attempts to control or hack the Galileo spacecraft and the associated uplink stations and control centres. Similar security means apply equally to any civil telecommunication satellite to prevent misconduct. Official bodies including the Galileo Security Board were established to oversee the technical and regulatory aspects of Galileo, and of course the establishment of the Galileo Supervisory Authority is expected to be established in 2005. We have no detailed visibility of the regulatory measures taken by national and European administrations.

6. What are the Potential Benefits of the Programme to UK Industry, and to UK Users of Galileo, such as NATS?

6.1. The benefits of Galileo to UK industry and users are manifold, and include benefits to both infrastructure providers (upstream) and the industry dedicated to provide services and applications to users (downstream).

Upstream users

6.2. The UK space industry has world-class expertise in many space related areas including civil and military telecommunications, satellite multimedia, earth observation & science missions and navigation systems and applications. The UK industry is very diverse with more than 220 companies across the UK involved in space with a total annual space turnover of £3.9 billion during 2002–03. The upstream sector generated £500 million, while the remaining £3.3 billion account for real downstream turnover for the supply and operation of space-based services and the commercial exploitation of space assets[36].

6.3. EADS Astrium Ltd. is the UK space subsidiary of the European aerospace company EADS and the major prime contractor for space projects in the UK. In this role EADS Astrium selects and coordinates most of the UK supply chain. Together with the German subsidiary, the company is the principal shareholder in Galileo Industries, a European consortium, designated to act as the industrial prime contractor to deliver the Galileo core infrastructure. UK companies have acquired 25–30% of the Galileo contract values, considerably exceeding the 17% contribution made by the UK Government.

6.4. EADS Astrium have been the leading UK industrial entity in Galileo since the programme inception in 1998, leading satellite payload and ground control segment feasibility and definition work, winning all relevant contract, including the payload and ground control segment within the Galileo Industries GSTB V2 experimental satellite. UK companies have acquired 25–30% of the Galileo contract values, considerably exceeding the 17% contribution made by the UK Government.

Downstream Users

6.5. Whilst the production of the Galileo infrastructure is creating around 500 highly skilled jobs in the UK upstream industry,[37] the programme has not been designed as a European job protection scheme for the space industry. Independent studies on the macroeconomic and commercial viability of Galileo conducted by PricewaterhouseCoopers[38] show a benefit:cost ratio of 4.63 creating up to 100,000 jobs across Europe. The findings suggest that Galileo will have a strong leverage effect on downstream applications and services. EADS Astrium takes great pride to support UK Government in its vision to "bring space to life" to the benefit of every UK citizen.

6.6. EADS Space Services is a founding member of the iNavsat consortium competing for the Galileo Concession in partnership with Inmarsat and Thales. UK industry has unrivalled expertise in the establishment of successful public private partnerships and it is envisaged that Europe's leading finance and consulting community in the City of London will also play a key role.

6.7. Satellite navigation and timing technology is increasingly used in industrial, public and consumer sectors. The overall decrease in the cost and size of receivers will continue to drive market development towards applications for high-volume markets, resulting in increasing levels of integration of satellite

[36] Source: Size and Health of the UK Space Industry, 2003 update study, British National Space Centre.

[37] Source: EADS Astrium estimate.

[38] Source: Inception Study to Support the Development of a Business Plan for Galileo, PricewaterhouseCoopers, September 2001.

navigation technologies with communications networks, geographic information and transport systems. The global turnover for satellite navigation products in 2001 amounted to €15 billion and is expected to rise to €140 billion by 2015. In 2001 approximately 30% of the global revenues were generated in Europe.[39]

6.8. The GPS monopoly has given U.S. manufacturers of receivers a significant head-start through fully-funded government programmes, and they now dominate the world market for satellite navigation equipments. The deployment of an independent European infrastructure will, in combination with the navigation-related expertise already accrued during the technology developments for Galileo over the past years, allow European equipment manufacturers to compete in this rapidly growing market.

6.9. As well as the commercial benefits of Galileo, satellite navigation will prove to be a versatile technology enabler, helping to deliver Government policy.

6.10. Home Secretary David Blunkett, for example, unveiled plans for a "prison without bars" scheme in September 2004, using a combination of communications and satellite positioning technologies to track repeat and minor offenders. In a pilot scheme 120 offenders will be fitted with devices that can pinpoint the wearer's position within a few metres on an Ordnance Survey map.

6.11. In 2002 the Chancellor of the Exchequer announced plans to modernise the taxation of the haulage industry. The Lorry Road User Charge (LRUC) envisages that hauliers pay an amount related to the distance that they travel on UK roads. Satellite navigation is seen as a key technology to deliver this challenging scheme for introduction in 2007–8.

7. Delivering the Vision for Galileo

7.1. The UK's participation in the Galileo programme will help to maintain and develop this country's position as a leader in commercial space. The leverage effect on the British economy is forecast to result in a significant net benefit which will enhance the long-term competitiveness of UK companies against US and European firms and facilitate an improvement in domestic productivity.

7.2. A fundamental conclusion of our analysis of this project is that satellite navigation is an important enabling technology which will open up new opportunities in many sectors, and will encourage entrepreneurs, investors and government to create and implement innovative products and services across the UK and worldwide. The versatility of applications and decreasing receiver prices make satellite navigation a ubiquitous accessory, both accessible and affordable for every UK citizen.

7.3. Galileo is a cornerstone in delivering the Government's "UK Space Strategy 2003-2006 and beyond" to become "the most developed user of space-based systems in Europe for science, enterprise and environment. UK citizens will provide and exploit the advanced space-based systems and services which will stimulate innovation in the knowledge driven society."

7.4. Amicus and its members are fully supportive of the Galileo project. As the project proceeds the union would expect existing jobs to be maintained and indeed increase by about 500 within EADS Astrium UK and its UK supply chain. Downstream, as Galileo comes into operation we would expect jobs to be generated in the UK in tens of thousands in both the high technology and service sectors, providing new and exciting opportunities to industry, business and "the man in the street". This opportunity for continued involvement in Europe's most ambitious and rewarding technology project should not be missed.

7.5. EADS Astrium and Amicus believe that the potential benefits of Galileo to UK plc will be dependent on continued and committed UK government support. In particular we would urge the government to:

- Ensure the UK continues to play a full and influential role in both EGNOS and Galileo, and that UK influence is used to ensure both programmes proceed in a timely, pragmatic and efficient manner
- Encourage the process to award the Galileo Concession benefits from UK PPP expertise and that it results in best overall value for the European public.
- Take a high profile role in ESA and EU to ensure that Galileo services support the multiple objectives of successful commercial exploitation, strategic priorities as outlined in the UK Space Strategy and the public good
- Ensure that the benefits of satellite navigation play a central role in Government innovation and transport policy

Dr Michael Healy
Director Earth Observation Navigation & Science (UK)

September 2004

[39] Source: Business in Satellite Navigation, European Space Agency, 2003.

Memorandum by the UK Industrial Space Committee (UKISC) (GG 18)

GALILEO

0 UKISC

(0.1) The United Kingdom Industrial Space Committee (UKISC) is the Trade Association of the British space industry. Founded in 1975, UKISC is sponsored jointly by the Society of British Aerospace Companies (SBAC) and Intellect (the trade body of the information technology, telecommunications and electronics industry). UKISC represents over three-quarters of the UK space industry by both turnover and people employed.

(0.2) The Objectives of UKISC are:

- To represent space industry interests to other sectors and to national and international institutions and organisations. These include national government, the European Union, the European Space Agency (ESA) and Eurospace (the Trade Association of the European space industry).
- To support the work of the Parliamentary Space Committee (PSC) and other parliamentary bodies in promoting better understanding of space issues.
- To identify and promote actions which will improve the sector's competitiveness.
- To promote public interest and awareness of the sector.
- To promote appropriate standards and cooperate with relevant bodies on their effective establishment.

(0.3) British Industry has accumulated world-class expertise and know-how in satellite navigation throughout the technical development phases and the economic feasibility studies for the EGNOS and Galileo programmes. The vast majority is represented by UKISC and is the justification for this submission. A comprehensive background to satellite navigation and Galileo, with an overview of the involvement of UK industry in the programme and a list of all UKISC members, is included in an annex for reference.

1.0 Summary

UKISC strongly supports the UK commitment to the Galileo programme. We consider Galileo to be a key element of the future mobile society, underpinning applications of strategic importance such as road user charging, as well as applications of social and economic importance such as providing location-based services to citizens.

Galileo is not a competitor to United States GPS, but the two are complementary systems, providing mutual back up for each other. UKISC believe that the risk of over-dependence on any single system is so high that a second independent system is essential.

UK industry is at the forefront of the development of Galileo, enabling the UK to understand its technical and commercial considerations, and positioning UK industry for long-term benefit from the programme.

2.0 What Benefits will Galileo Phase II Bring that EGNOS (European Geostationary Navigation Overlay System) Will Not?

(2.1) GPS is the US controlled global satellite positioning system that has fostered many military and civilian applications. GPS has created an extensive market in navigation and positioning products and services, which is currently growing at 24% per annum.[40] There is now extensive reliance on GPS and its augmentations across such market sectors as aviation, maritime, rail, road, public safety, law enforcement, mass market, agriculture and scientific/timing.

(2.2) Despite its great success, GPS does have limitations; examples include performance weaknesses in urban environments, it cannot provide timely warnings when system errors occur (integrity), it has insufficient accuracy specifications for many applications, and lacks system certification and service guarantees. The vulnerabilities of GPS are well researched and documented in the US Volpe Report.[41] It should be noted that GPS has suffered well-documented periodic malfunctions with range errors from 10 to over 100 km.[42] In January 2004 some users experienced horizontal position errors of more than 47 km.

(2.3) EGNOS, the European regional GPS augmentation service mitigates some of these limitations to deliver cost-effective services for safety-critical aviation applications. Three EGNOS satellites providing quasi-GPS signals improve availability. A ground-monitoring network continually monitors GPS to

[40] Market Reference: ESYS 2003, Satellite Navigation Market Intelligence Briefing

[41] Reference.

[42] Basker S et al. GPS Horizontal Accuracy—Gross Errors and Aviation Collision Risks. Proc GNSS2004, Rotterdam, May 2004.

provide an integrity service with a 6 second warning and corrections to improve accuracy. EGNOS has been designed to be certified and to offer service guarantees. EGNOS is, however, dependent on GPS for its operation. If we lose GPS, we lose EGNOS.

(2.4) Galileo has been designed as a fully independent, civil-controlled, global navigation satellite system (GNSS) capable of being certified and providing service guarantees linked to high-levels of availability, accuracy and integrity. Galileo is market-focused and will offer several types of service. These include the free Open Service (OS) similar to that offered by GPS at present, the Safety of Life (SoL) service, the enhanced Commercial Service (CS), the Public Regulated Service (PRS), and Search and Rescue (SAR) service.

(2.5) It is important to understand that Galileo is not a competitor to GPS, and many of the benefits to be gained from Galileo are when used co-operatively with GPS. Galileo and GPS will be compatible and interoperable meaning that users of the combined GNSS service will enjoy much higher levels of performance than that provided by either of the individual services. Combining GNSS services will secure many of our current applications as well as providing a platform for innovation that will undoubtedly foster new applications.

(2.6) Galileo will significantly improve the stability and robustness of the current radio-navigation environment based on GPS and EGNOS. Galileo will improve availability and performance for applications that are currently dependent on GPS plus EGNOS. The vast majority of users will use these combined services.

3.0 How Important is it for the EU to be Independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?

(3.1) The global satellite navigation user community (including notably those in the US) is widely supporting the establishment of Galileo as a second independent system. The agreement signed between the US and the European Community in June 2004 ensures the joint working of GPS and Galileo. This agreement is hence the cornerstone enabling GPS and Galileo to act as ultimate backups for each other in case of extraordinary system problems. The additional dependability will allow satellite navigation to be used in more critical applications such as those where safety of life is at stake. Satellite navigation is becoming a critical technology for the mobile society, which will also be utilised to enforce government policy such as road tolling. Reliability and independence remain therefore important aspects.

(3.2) Both GPS and GLONASS were originally conceived as military systems, being owned, operated and controlled by military authorities. Whilst GPS has evolved over the years, the performance of GLONASS has declined since being declared fully operational due to lack of funding and extremely short lifetime of the GLONASS spacecraft and it has lost credibility with users. Hence GPS is the only operational Global Navigation Satellite System (GNSS) until Galileo becomes available.

(3.3) Today, our growing dependence on GPS has created significant political and economic risks for UK and European users, policy makers and governments. The economic damage that would result from even a short outage of GPS is prohibitively high, estimated at €42 million for the first hour by 2015.[43] There are many political, economic and technical reasons why total reliance on a single system operated by a foreign government should be avoided including US policy changes (eg removal of Selective Availability[44] in May 2000), terrorist attacks on the GPS infrastructure and catastrophic system failures. An inescapable conclusion of this is the development of Galileo is essential to mitigate these economic risks and to secure safety and mission critical applications. This is not only true for the EU but also for the US and the rest of the world and has prompted the investment interest worldwide.

(3.4) GPS is a de facto monopoly and most of us would agree that monopolies are bad for consumers. There is already anecdotal evidence to suggest that the development of Galileo is having a very positive impact on planned US government improvements and enhancements to GPS. In any event, significant enhancements to the GPS civil service are planned for the future, demonstrating that the US agrees with Europe's assessment that there is a huge global market for an improved satellite navigation service. Without Galileo, European industry will be disadvantaged in the global market place. Similarly, UK industrial exploitation of satellite navigation products and services is highly dependent on continued UK government participation in, and support for, the Galileo programme.

[43] EC GALA study: GALA-MMS-DD133.

[44] Selective Availability = accuracy degradation.

4.0 What are the Potential Benefits of the Public Regulated Service (PRS) System? Is it Realistic to Expect that Member States will not want to Cross-subsidise PRS from Commercial Services?

(4.1) PRS allows Galileo to provide navigation signals that are quite separate to the general open signals and that can be made available, by encryption, only to a select group of authorised users with specific receivers. The selection of users and the management of their receivers are under the control of the PRS authorities and can be changed as required. Thus the availability of PRS can be managed while the open service is being denied. Several European governments have expressed an interest in the PRS service.

(4.2) Some parts of UK industry see a large market potential for supplying PRS equipment and services to authorised users, eg receivers and service management facilities.

(4.3) As concerns the funding of PRS, our understanding is that the EU Transport Council will have the final say on the rules for financing Galileo. There are a number of approaches that avoid cross subsidies. Examples include the payment to the Concessionaire of an availability fee in return for the PRS service being available, direct funding by those governments requiring the service, or direct payment to the Concessionaire in return for a "key" to enable the service. The EU Transport Council has to approve the payment levels of all of the various Galileo services, and similar questions can be asked about the funding of Galileo's Search & Rescue or Integrity services. The Galileo Joint Undertaking (GJU), the entity formed by ESA and the EC to select the concessionaire, appears to be working hard to avoid cross-subsidies between PRS and other services.

5.0 Are the Arrangements to Prevent Military Use of Galileo Sufficiently Robust?

(5.1) Galileo's open signal is (like GPS) available to everybody including UK or allied armed forces in their war-fighting and peace-keeping activities or even hostile military forces or terrorist organisations. However, the PRS and its associated security arrangements have been designed specifically to prevent unauthorised use.

(5.2) For the UK or allied armed forces, Galileo could complement GPS to deliver operational efficiencies and performance improvements for a wide range of applications that have parallels in the civil sector. It is expected that preventing unauthorised military use of Galileo will be based on institutional frameworks, system design, receiver availability and the development and deployment of countermeasures.

(5.3) A number of institutional frameworks exist to control GNSS and dual use technologies in general, including the recent GPS-Galileo co-operation agreement and the Missile Technology Control Regime (MTCR). It is the understanding of UKISC that PRS receivers will be subject to the MTCR agreement.

(5.4) UKISC is aware of the Galileo signal and security task forces that have been established. UKISC understands that the UK Government has strong representation on both task forces and can reassure the Committee that the system is being designed to resist attack of all forms (eg hacking and spoofing).

(5.5) The GPS authorities in the US have been addressing countermeasures through both their NAVWAR and their GPS modernisation programmes. UKISC understand that the UK authorities have also addressed these issues in their own NAVWAR strategy.

6.0 Are Arrangements to Oversee the Security Aspects of Galileo Appropriate?

(6.1) UKISC is aware of the significant influence of national security experts on the Galileo system design and architecture. Security arrangements are still under development, and we are confident that the result will be a system that is secure in terms of preventing damage and malicious access to the system itself, under the direction of Galileo's Security Board and its Supervisory Authority.

(6.2) Like any important national utility, particularly one of such strategic importance, the system is being designed to be highly resilient to both physical and electronic attack, and it will have equipment and procedures for ground station location security, personnel security and IT security (hacking, viruses etc). Some of these safeguards will be mandated as part of the Concession contract and others will be normal commercial safeguards added by the Concessionaire to enable it to deliver its high reliability, safety critical obligations and to protect its revenues.

7.0 What are the Potential Benefits of the Programme to UK Industry, and to UK Users of Galileo, such as NATS?

Specific Benefits to UK Industry

(7.1) UK industry and employment is already benefiting both from the core Galileo development activities which lead to providing the navigation signal, and from the activities which exploit that signal by providing product services and also applications to the navigation market. Although the revenue from the exploitation is expected to be many times greater than the core activities, it is essential UK industry is deeply involved in the core activities to position itself credibly for the exploitation business.

(7.2) The UK is currently very well positioned in the core development activities and has so far won nearly 30% of all the work in the ESA programme compared to its contribution of 17%. UK industry is already leading the production of one of the experimental satellite and its ground control and is making major contributions to the satellite electronics of the other prototype as well as leading in its ground control.

(7.3) UK industry will lead and make major contributions to the main Galileo ground segment development and operations. The UK will also lead the Galileo satellite electronics development. UK companies will also make major contributions in high-reliability (ie space) parts procurement and precise timing.

(7.4) Exploitation activities are essential for the Galileo programme to generate revenue. They are also the area where the UK has traditionally benefited enormously (eg in the satellite communications market).

(7.5) UK companies are key players one of the two Galileo concession teams. The UK's expertise in PFI programmes is unmatched in Europe and will help that part of the UK private sector to get a major role in the Galileo service delivery eg financing, legal and insurance business.

(7.6) The location of the Galileo Control Centre—a key UKISC objective—in the UK would provide long-term revenues to the UK and also act as a catalyst for companies supporting it and providing Galileo related services.

(7.7) UK companies have key roles in several of the EU Framework Programme's R&D activities for Galileo, oriented towards exploitation. The UK is well placed to provide value added services for mass-market applications such as location-based services and road user tolling as well as professional applications such as agriculture, geodesy and surveying. UK companies currently provide GPS end-user equipment such as professional and military user receivers, high-sensitivity receivers for use indoors, signal simulators and innovative antennae. Galileo will open-up new capabilities and markets for these manufacturers.

(7.8) Innovative UK Small-Medium Enterprises are defining new applications that will be able to benefit from GPS, EGNOS and Galileo's enhanced capabilities. These include offender tracking, integration of satellite navigation with terrestrial and satellite communications, integration of satellite navigation with other sensors measuring position, velocity and/or time. Galileo will facilitate these services and applications becoming ubiquitous and available in locations that are currently poorly served by GPS (eg indoors, urban canyons).

(7.9) Positioning and Time are strategic technologies that will profoundly affect the way we live and work. The Pinpoint Faraday Partnership has forged close links between UK industry and universities fostering industry access to the latest research into Global Navigation Satellite Systems (GNSS) technologies. Education is also essential to underpin this technology; the UK also hosts the sole Marie Curie Training Site for satellite navigation technologies and applications in Europe.

User Benefits

(7.10) There are widespread commercial user benefits from Galileo especially in conjunction with GPS:

- Enabling new and securing existing applications. Together, Galileo and GPS services will enable new safety or mission critical applications that have previously been denied due to a lack of performance and service guarantees (eg road tolling). They will also secure existing applications by improving availability (eg location based services in urban environments);
- Market-focused products and services. Today, users have access to inflexible (ie you get what you are given) GPS signals without service level guarantees. Commercial drivers will ensure that Galileo products and services are market-focused and service level guarantees will secure markets for safety and mission critical applications;
- Potential cost-savings arising from rationalisation of navigation aids. Today, many market sectors (eg aviation and maritime) deploy a large number of radio-navigation and other aids because they cannot rely on GPS. Improved services from Galileo will allow them to rationalise their current service environments thus reducing service provision and user costs;
- Improved business planning and investment scheduling. Historically, UK's commercial GPS augmentation service providers have had to react to changes in US GPS policy. Stable Galileo policies and plans will give service providers and users confidence to plan for the future and develop business cases.

Numerous studies undertaken at both EU and UK level have clearly identified the need for new GNSS capabilities. Galileo has been specifically structured and designed to meet this user demand and thereby offer substantial user benefits. Within the UK itself, statements of support for Galileo have been received from the following groups of users:[45]

[45] Report from UK British National Space Centre (BNSC) Galileo user workshop, March 2002.

— Safety critical transport users: "The air and marine community have adopted GPS already . . . If GPS failed it would have catastrophic consequences . . . the UK should support Galileo without qualification and that it represented a valuable addition enabling some control to be obtained over the combined [GNSS] system."

— Public sector users: "The integrity of positioning information is very important both as evidence and to support real-time operational decision making. Integrity will be required to demonstrate the credibility of the system ... to enforce speed limits, parking fines, road tolls etc."

— Consumer users: The additional performance offered by Galileo in urban environments "...would be of enormous value". "There is significant revenue to be gained from service/equipment development";

— Professional users: "There are clear benefits to Galileo, but in combination [with GPS] rather than as a system on its own."

In addition to these specific examples of user benefits, it is important to note that Galileo will be operated as a Public Private Partnership (PPP), unlike GPS today. This means that the Galileo concessionaire will be obliged to operate the Galileo system against an agreed specification whilst also enjoying the freedom to offer commercial services. These potential sources of revenue provide a clear financial incentive for the Galileo concessionaire to deliver services that are of value to the market and will offer significant user benefits over the 25-year lifetime of the concession.

Contact

UKISC would welcome the opportunity to invite Members of the Transport Select Committee to visit the UK manufacturing sites of the two Galileo test satellites in Guildford and Portsmouth to gather hands-on "visual evidence" of the UK industrial involvement in Galileo and to assess the already positive impact on British jobs.

Alan Hicks
Secretary General

September 2004

Annex

A Background and Introduction to Satellite Navigation

(A.1) Satellite systems provide an indispensable component of global infrastructure in terms of communications, navigation and earth observation. Use of satellite systems for applications such as global fixed and mobile communications, direct-to-home TV broadcasting, and weather forecasting are well established key components of everyday life for UK citizens. In a similar way, positioning by satellite is rapidly becoming an accepted part of everyday life as an every increasing number of products ranging from cars to mobile phones embed navigation and location-based technology. Satellite navigation systems also provide another vital service: a highly accurate time signal, which is used to synchronise telecommunication or electricity networks and to timestamp financial transactions on a global scale.

(A.2) At present there is a single operational satellite navigation system: the US Global Positioning System (GPS) initially designed for military purposes but now widely accepted in the civil community supporting a very broad range of applications. A similar Russian system known as GLONASS was developed during the Cold War period, but this has rapidly deteriorated since declared fully operational in the mid 1990's, such that less than half the required number of satellites are now functioning. Although GPS today is widely used, further growth of new applications is constrained by a number of intrinsic shortcomings of GPS.

(A.3) In 1994 the European Space Agency (ESA), the European Commission (EC) and the European Organisation for the Safety of Air Navigation (EUROCONTROL) agreed to develop Europe's first generation of a Global Navigation Satellite System (GNSS-1) delivering a regional augmentation of GPS and GLONASS over Europe known as EGNOS (European Geostationary Navigation Overlay Service). The Galileo programme (GNSS-2) is Europe's contribution to the further evolution of satellite navigation systems, and it will be the first worldwide system to be fully controlled by civilian authorities.

(A.4) Galileo is a joint initiative by the European Space Agency and the European Commission to develop and launch an independent constellation of 30 navigation satellites, providing continuous global coverage. Galileo will enable users to pinpoint their location generally to a metre or so everywhere on earth. Being fully interoperable but independently operated from the US owned GPS, the system provides significantly enhanced accuracy and reliability and users can receive signals from both systems with a single hand-held terminal. The new system is also designed to accommodate the demanding requirements for safety-critical applications for example in the field of air transportation. The programme is often rated the

EU's most significant technology project. The UK Government is a major contributor to the Galileo programme, comparable with France, Germany and Italy, whilst being active in its development to ensure its success.

(A.5) Over the past years the European Commission and the European Space Agency have conducted in close cooperation with national agencies and UK and European industry intensive research, studying the commercial business case and to develop Galileo and its critical core technologies. The European Transport Council's decision in March 2002 to go ahead with Galileo was made on the basis of market trends, the positive experiences from the EGNOS programme and detailed analysis of the technical and financial feasibility. In the summer of 2003, ESA awarded contracts to manufacture two experimental satellites in order to prove a number of the key technologies and to produce an early signal in space. UK industry is playing a major role in both of these experimental contracts valued in excess of £70 million. The success of these missions is vital to secure European priority on the filings with the International Telecommunications Union (ITU) allocating global radio frequencies to Galileo.

(A.6) The deployment of the infrastructure after the completion of the initial development and the in-orbit validation is to be financed through a Galileo concession contract on the basis of a public-private partnership. This concessionaire will bring together public and private investors from the finance, telecommunications and various other sectors to deploy, operate and maintain the system and to develop Galileo into a viable business through the sale of value-added services to public and commercial users.

(A.7) The cost of the development and deployment of the Galileo infrastructure was estimated in 2000 at £2.1 billion (€3.2 billion). The price is equivalent to the construction cost of approximately one hundred miles of semi-urban motorway and similar to the anticipated government subsidies of £2.4 billion required to host the Olympic Games in London in 2012.[46] As a joint investment of all pre-expansion European Member States, Galileo will deliver benefits to every citizen across Europe and globally.

B UKISC Members

(B.1) UK Space Industry has world-leading expertise in many space areas including satellite navigation, telecommunications, earth observation and science missions. The majority of companies engaged in the space sector in the UK are member of UKISC, representing a broad spectrum across manufacturing and service industries. UKISC members comprise both large corporations as well as small and medium enterprises.

(B.2) Full and Associate Member Companies:

- EADS Astrium
- British Telecom
- ComDev Europe
- ERA Technology
- ESYS
- Helios Technology
- IGG Component Technology
- Infoterra
- Inmarsat
- LogicaCMG
- Nottingham Scientific Ltd (NSL)
- QinetiQ
- Roke Manor Research
- Raytheon
- SciSys
- Serco Europe/NPL
- Sira Technology
- Surrey Satellite Technology Ltd (SSTL)
- Systems Engineering & Assessment (SEA)
- Thales
- The 425 Company
- Vega Space Systems

Memorandum by Ordnance Survey (GG 19)

GALILEO

1. Background

Ordnance Survey is a Government Department and Executive Agency, and since 1999 has operated as a trading fund. Ordnance Survey is Britain's national mapping organisation. We maintain and make available the definitive geographical framework for Great Britain. The Director General and Chief Executive of Ordnance Survey is official advisor to Ministers on all aspects of survey, mapping and geographic information.

[46] http://www.culture.gov.uk/global/press__notices/archive__2003/olympic__statement.htm

Ordnance Survey collects, manages and makes available data on roads, buildings, addresses, boundaries, water courses, height and many other aspects of the landscape of Britain. Our geographic information is used extensively by governments, businesses and citizens.

Ordnance Survey provides the fundamental geographic information (GI) for Great Britain through its' products including OS MasterMap™. This provides a platform on which to build applications and services and contributes to the success of the GNSS application industry. The ability to cross reference disparate data on a geographic basis and undertake detailed analysis adds considerable value to data, making it ideal for many applications including spatial planning, transport management, crime reduction and the allocation of funding.

Ordnance Survey has had some involvement in the development of GALILEO, in that in 2000 we were contracted to do a market analysis and quantification of the usefulness of GALILEO for land and cadastral surveying, GIS and mapping as part of the GALILEO Overall Architecture (GALA) study. To do this work we conducted interviews with surveyors and users of geographic information all around the world. This information, along with other market studies led to the definition of GALILEO as it is today.

Neil Ackroyd , our Director of Data Collection and Management has been involved in the GPS Industry from its earliest operational stages in 1984. Between 1990 and 2001 he was the European Technical Manager for the largest US based GPS receiver manufacturer and has been involved in commercial and market development activities across all application areas including transport, navigation, surveying and military uses. He was actively involved during the 1990's in the development of the European Radio Navigation plan—the precursor to the GALILEO proposal. He has worked on many of the standards defined to facilitate the adoption of GNSS technologies.

In preparing our evidence we have assumed some understanding of how GNSS works. The Parliamentary Office of Science and Technology Briefing Note 150, published in December 2000 (Ref 1), provides a useful summary.

1.1 *The use of GPS by Ordnance Survey*

Ordnance Survey has been at the forefront in developing the use of the Global Positioning System (GPS) as a positioning tool over the last 18 years. The key contribution of GPS (and the more generic Global Navigation Satellite Systems (GNSS)) to Ordnance Survey is as a fundamental building block for our data—through defining the location reference framework in Great Britain—and as a tool to aid data collection.

The introduction of GPS technology to our 350 field surveyors has resulted in a 40% efficiency gain in their working practices; we anticipate further improvements in our business processes with the introduction of GALILEO as a result of reduced signal acquisition times and greater satellite availability.

Ordnance Survey uses GPS specifically to:

- define the 3-D reference framework for Britain as well as providing an explicit link to European and Global co-ordinate systems,
- provide a positioning tool to aid data capture for both on the ground and photogrammetric survey,
- provide the transformation between Great Britain's reference framework and those used by GPS.

1.2 *Ordnance Survey GPS services*

Ordnance Survey provides a countrywide GPS service "The National GPS Network" which can be accessed via www.gps.gov.uk. This provides free access to a service which enables all GPS users to post-process GPS signals in order to work seamlessly between Britain's National Grid and the GPS co-ordinate system. The creation of this service was initially part funded by the National Interest Mapping Service Agreement (NIMSA).

Ordnance Survey is also providing the ability to enhance the accuracy of positions derived from the raw GPS data that is received from the satellites through the progressive introduction of OSNet. This service is currently implemented across most of England and will enable improved positioning in real-time throughout the country by providing GPS corrections to users. The end user accuracy depends on the GPS equipment in use, but can be from 1cm to 1m. This means that a user no longer needs two GPS receivers to improve their positioning. The user receives the GPS corrections at their receiver from OSNet via a communications mechanism (wireless, internet, radio, etc). When GALILEO is operational, OSNet will provide combined GPS and GALILEO functionality. OSNet will deliver increased flexibility and efficiency to both Ordnance Survey and to the wider areas of transport, construction and the utilities.

2. Evidence Relating to Specific Questions Asked by the Committee

2.1 *What benefits will GALILEO Phase II bring that EGNOS (European Geostationary Navigation Overlay Service) will not?*

EGNOS is an augmentation of the existing GNSS systems focusing on improving precision, whereas GALILEO is a completely new satellite service. EGNOS will mainly improve the accuracy of GPS and GLONASS by providing differential corrections. It also provides 3 new satellites to improve the probability of obtaining a position in situations where the view of the sky might be limited. EGNOS also delivers GPS and GLONASS integrity information eg warning of system failure, so that users can reliably trust the measurements that these systems deliver. This service will be operational in 2004.

Combining the GPS/GLONASS integrity information through EGNOS with the same information received directly from GALILEO will ensure that safety critical operations, as well as commercial navigational users, will have a reliable level of service. When combined with the GALILEO Safety of Life service this will provide independent and complementary integrity information on the GALILEO and GPS constellations respectively. As a result the high level of signal redundancy and continuity of service will enable use of GNSS as the primary navigation aid for new applications eg precision approach and other operations in the aviation sector.

GALILEO and EGNOS are complementary systems. Some users of GALILEO will also make use of GPS and GLONASS and will therefore still benefit from EGNOS as to do so will provide more accurate and reliable solutions.

Both EGNOS and GALILEO are designed for commercial rather than military applications. As an independent global positioning system, GALILEO will also provide the whole raft of high accuracy services and capabilities enabling the possibilities presented in our answer to question 6 below.

2.2 *How important is it for the EU to be independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?*

GNSS positioning is becoming just another utility which users expect to be available and reliable. It reaches all of our lives already today and is integral to many key government initiatives and improvements for the future, for example reduced cost of offender tracking, transport management and accurate timing.

Current GNSS are operated primarily for defence purposes. GPS and GLONASS are owned and operated by the United States and Russian military agencies respectively. Whilst assurances have been made, especially by the Americans, regarding the continued availability of these navigation systems, there are no guarantees. Until this problem is overcome, and the number of GNSS signals are increased, the growing needs of Member States for satellite positioning and navigation cannot be met.

GALILEO has been developed by the EU for the EU citizen to benefit from. It will have guaranteed levels of service and the legally binding operational assurances that are needed for safety of life as well as commercial services. GALILEO will therefore provide a stable GNSS and the resulting user confidence which is necessary to stimulate investment in the development of end user applications.

2.3 *What are the potential benefits of the Public Regulated Service (PRS) system? Is it realistic to expect that Member States will not want to cross-subsidise PRS from commercial services?*

The Public Regulated Service (PRS) is essential to the emergency services and to support other critical operations. It ensures reliability of services and guaranteed access. The nature of the current GPS signal and its weak reception on the earth's surface, coupled with interference (intentional or not) and the ease with which signals can be jammed, means that GPS is not adequate for such use.

It is a vital requirement that an important utility like GALILEO is secured for authorised activities. The PRS will do this by improving the probability, in the presence of interference or jamming, malicious or otherwise, of obtaining continuous position and timing from GALILEO. This will be achieved through encrypting the broadcast codes and data. Access will be made through mechanisms approved by the Member States.

The PRS can support a wide range of applications including, at both the Member State and Trans European level;

- Law Enforcement eg by EUROPOL, Customs, European Anti-Fraud Office—OLAF;
- Preservation of Life eg for Emergency response on land and on sea.

If other applications are dependent on the reliable delivery of positions that cannot be interfered with, for example road lorry user charging or car monitoring, there may be a call in future for other users to have access to the PRS.

Ordnance Survey has no comment to make in respect of cross subsidisation of PRS and commercial services.

2.4 *Are the arrangements to prevent military use of GALILEO sufficiently robust?*

Ordnance Survey has no comment to make on this question.

2.5 *Are arrangements to oversee the security aspects of GALILEO appropriate?*

The term "security" encompasses many issues including signal availability, anti-jamming technology, physical attack etc. Ordnance Survey is not in a position to comment on all aspects of security.

What we can say is that as far as signal availability is concerned, the arrangements for GALILEO are better than for GPS with the redundancy in the ground infrastructure (the most vulnerable element) being built into the design. The PRS will also provide protection against threats to GALILEO signals in space for the most critical applications. It is deemed important, however, to invest in research into anti-jamming technology.

2.6 *What are the potential benefits of the programme to UK industry, and to UK users of GALILEO, such as NATS?*

The key benefits of GALILEO are:

- More signal availability, as GALILEO itself will have more satellites than current GNSS systems and it can also be combined with the existing GNSS systems. This brings huge potential in environments where line of sight signals are restricted at present eg in built up areas and under tree canopies.
- Improved accuracy, as a result of having two civilian codes, will give better raw standalone positional accuracy than current GNSS systems.
- Improved reliability or service due to increased redundancy, and integrity monitoring.
- Wider breadth of services than current GNSS systems, ie the Public Regulated Service, the Safety of Life Service, etc because GALILEO will be in European civilian control, designed for civilian, Member State and commercial applications, and operated for the benefit of the European citizen.

UK's strength in both pure and applied research can benefit from the huge potential that exploiting this capability provides. Our experience in the implementation and commercialisation of GNSS-based applications provides a strong background on which to exploit the major expansion predicted in the GNSS market (Ref 2).

Currently knowing the time of day is something that is ubiquitous to us all, in the future knowing our position could be just as omnipresent. Ubiquitous knowledge of location provides major benefits to good governance, business success and citizen services by, for example:

- Improving personal safety,
- Reducing traffic congestion,
- Faster life critical response,
- Reducing distribution costs,
- Cheaper offender management.

Significant commercial markets are therefore expected to develop to support these and other applications which GALILEO will underpin. The following provides more details for some.

2.6.1 *Transport*

The management of traffic and transport systems features prominently on the government agenda through initiatives such as road lorry user charging, congestion charging and road tolls. One of the prospective positioning tools for the implementation of these initiatives is undoubtedly GNSS. Using one system only may be seen as too much of a risk—a second provides the redundancy and added availability that would be required. Thus the linking together of reliable GPS and GALILEO positions, with accurate and intelligent geographic information is seen as crucial to the successful delivery of these initiatives.

Transport management systems, whether they be for boat, plane, ship, train, car or people are already using GPS for either their primary navigation/tracking system or to augment traditional systems. A second, independent and quality assured system will mean that many potential applications become a reality which could lead to future transport infrastructure being solely navigated using remote GNSS techniques. We are not in a position to comment in detail on the user of GALILEO for aviation and sea navigation but anticipate that these industries will seek to exploit the added benefits of GALILEO appropriately.

2.6.2 *Emergency Services*

The US E-911 regulation already requires all emergency calls to provide position information to assist the emergency services in finding the citizen in trouble. Article 26 from the European Commission Directive on universal service and user's rights relating to electronic communications networks and services (2002/22/EC—22/03/02) introduces a similar requirement for Member States. Although the implementation of these services has been slow as a result of both technology and the costs involved, when they are implemented, it is seen that GALILEO will play a major part in ensuring a reliable and accurate location.

Navigation of the emergency services using GNSS tied to geographic information, already used by many UK emergency services, would become much more reliable with a second GNSS system. This is because, currently, emergency crews often encounter blind spots whilst relying on GPS alone. Using GNSS expanded by GALILEO would eliminate many of these blind spots enabling emergency service crews to locate accidents more accurately, quickly and consistently.

2.6.3 *Streetworks*

Better co-ordination between utilities, local authorities and central government departments in planning and executing work on the public highway is high on the Government agenda and would result in less digging, less interruption and less congestion. There are, for example, around 4 million utility road openings per year in the UK which cause millions of pounds in congestion (Ref 3). This issue is addressed in the New Roads and Street Works Act (1991) and subsequent secondary legislation. The accurate location of both surface and buried plant is essential to support this. For example in the telecommunications industry, the underground cable position could be, and in some cases is, captured and stored using GNSS. GALILEO would provide the improved positioning and availability on top of what GPS is giving now. Once these geospatial positions are recorded, the location and relocation of these assets provides for significant financial savings as well as reducing the risk of breaking cables and potential lost business time.

Along with raw positioning capability, users need a robust geospatial framework such as OS MasterMap™ to create and share information, enabling intelligent decision making.

2.6.4 *Insurance and Finance*

The finance industry already uses GPS timing to accurately co-ordinate banking transactions. A completely independent system would provide valuable redundancy to these operations. Intelligent motor insurance charging based on where vehicles have been and the distances travelled is already being researched and would be aided by the legal guarantees that GALILEO will enable.

2.6.5 *Social benefits to the citizen*

These will be many and varied. Ordnance Survey is working on a number of projects applying satellite-based positioning technology for citizen benefit. One example, which we have explored with Brunel University, enables blind pedestrians to travel more safely. This uses real time GPS positional information and a live video feed from a webcam worn by the blind person and sent to a sighted, office based, individual. They are able to monitor the pedestrian's position against our OS MasterMap™ which provides intelligent mapping, and watch what their webcam "sees" for them. The blind person can then be warned of, and "steered" around potential hazards and obstacles.

The increased number of satellites from GALILEO will improve the availability of this type of service in built-up areas. Similar citizen tracking applications (offender tracking for example) are being tested by the Home Office.

Neil Ackroyd,
Director of Data Collection & Management and

Paul Cruddace,
Geodetic Advisor

September 2004

GLOSSARY

GNSS: (Global Navigation Satellite Systems): The generic term for satellite navigation systems, for example GPS, GLONASS and GALILEO

EGNOS: (European Geostationary Navigation Overlay Service): EGNOS is a joint project of the European Space Agency, the European Commission and Eurocontrol and is an augmentation of GPS and GLONASS. The strategic vision for European GNSS services was agreed by ESA Member States through the combination of the EGNOS and GALILEO systems (Ref 4). EGNOS will provide 3 types of services:

— Ranging service: The EGNOS geostationary satellites will provide additional GPS-like ranging sources;

— Wide area differential corrections: EGNOS will improve the accuracy of GPS and GLONASS providing differential corrections;

— Integrity: a warning of system malfunction (integrity) of the GPS and GLONASS constellations. The provision of this quality control service is essential for safety critical applications.

GLONASS: (Global'naya Navigatsionnaya Sputnikovaya Sistema): Global navigation system owned and operated by the Russian Department of Defence.

GPS: (Global Positioning System): Global navigation system owned and operated by the US Department of Defense.

Location reference framework: a method of defining the relationship between points in space using coordinates.

OS Master Map(tm): an intelligent digital map designed, created and supplied by Ordnance Survey for use with geographical information systems (GIS) and databases.

Photogrammetric Survey: the process of making maps or scale drawings from photographs (esp. aerial).

Transformation: a mathematical model used to change from one coordinate system to another.

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Memorandum by the Royal Astronomical Society (GG 20)

GALILEO PROGRAMME

Introduction

The Royal Astronomical Society (RAS) has the aim, as expressed in its charter, of "the encouragement and promotion of astronomy". Those aims have been extended to embrace the study of geophysics (ie the physics of the Earth as a planet), and this include subjects (a) where scientific research is relevant to the development of Galileo and (b) where scientific research will be advanced by the higher quality data that Galileo will produce. Members of the Society are actively working on both of these aspects.

The following evidence consists of two parts: first an explicit response to the questions asked by the Committee, and second annexes providing concise summaries of some key science issues for Galileo.

RESPONSE TO THE COMMITTEE'S QUESTIONS

Q1. What benefits will Galileo Phase II bring that EGNOS (European Geostationary Navigation Overlay System) will not?

R1. Galileo will bring a significant improvement in the accuracy of position measurements. The Galileo aim is to provide a routine accuracy of 1 metre. This should be compared with the 5 metre accuracy provided by EGNOS and the 20 metre accuracy provided by the basic GPS service. Improved accuracy will be a great benefit for science because it will help scientists to understand phenomena that involve small scale movements. This is important in many geophysics disciplines including geodesy, seismology and vulcanology.

We also note that there is much interest in developing advanced applications of Galileo that can give accuracy at the centimetre level. These applications will be of great interest to both industry and science—but will require scientific research to improve understanding of the sources of position uncertainty and to develop ways to mitigate those sources.

The potential value of Galileo to scientific research is recognised by the Galileo Joint Undertaking. It currently (September 2004) has an open call for proposals to study and promote use of Galileo by Special User Communities including Scientific Research [reference 1].

Q2. How important is it for the EU to be independent of the US Global Positioning System (GPS) and the Russian Global Navigation Satellite System (GLONASS)?

R2. Independence will intensify competition in the provision of services. This is likely to drive up quality and reliability—and drive down costs. These improvements will be of benefit to science as much as other users.

Q3. What are the potential benefits of the Public Regulated Service (PRS) system? Is it realistic to expect that Member States will not want to cross-subsidise PRS from commercial services?

R3. This topic is outside the scope of the Society's competence.

Q4. Are the arrangements to prevent military use of Galileo sufficiently robust?

R4. This topic is outside the scope of the Society's competence.

Q5. Are arrangements to oversee the security aspects of Galileo appropriate?

R5. These arrangements must include the ability to distinguish between human threats to Galileo and disruption of the system by extreme but rare natural phenomena, eg severe radio scintillation events during the large magnetic storms that occur from time-to-time. The threats to the security of Galileo are very similar to the threats to the GPS system in the US, which have been subject of open study (Volpe report—reference 2).

Q6. What are the potential benefits of the programme to UK industry, and to UK users of Galileo, such as NATS?

R6. The programme will scientific research in the UK both by stimulating research to support Galileo and by providing better tools for scientific research in other areas. The first benefit is already underway:

- through funding of research by the Galileo Joint Undertaking and by EPSRC
- through DTI's establishment of a Faraday partnership (Pinpoint) to coordinate academic and industrial research on GNSS applications

The scope of UK research to support Galileo is not limited to quantifying and improving the accuracy and reliability of position data. As an important space-based application Galileo is stimulating research in broader areas of space science and technology, eg a better understanding of the Earth's radiation belts and their impact on spacecraft operations (the Galileo spacecraft will operate in the outer radiation belt, where our scientific understanding is limited and further research is needed). The UK community is a strong player in these areas and works closely with colleagues in other countries.

Galileo will be an important tool in many areas of scientific research. As already noted the basic position data is of great interest in many geophysics disciplines such as geodesy, seismology and vulcanology. The higher accuracy of Galileo will act as further stimulus to existing UK work in these areas. But position data are not the only Galileo output that science can exploit. The signals from Galileo can be used to monitor a range of geophysical phenomena including the density of the ionosphere, the distribution of water vapour in the lower atmosphere and the roughness of the sea surface.

Thus the higher performance of Galileo will improve data quality and thus stimulate research.

In summary Galileo has great potential to stimulate scientific research both in support of Galileo development and through exploitation of the higher quality data that Galileo will produce. The UK scientific community is well-positioned to exploit this potential.

Finally we note that the scientific exploitation of Galileo data should not conflict with commercial exploitation. The industrial interest in Galileo applications lies mainly in near-real-time use of its data, so the commercial value of those data decline quickly with time. In contrast, the scientific interest lies mainly in careful analysis after the event and thus will rarely require access to high-economic value real-time data.

September 2004

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1. GALILEO Research and Development Activities, Call 2412, GNSS for Special User Community

2. Vulnerability assessment of the transportation infrastructure relying on the global positioning system, Report prepared by the John A. Volpe National Transportation Systems Center, August 2001.

Annexes—science issues for GNSS

A1. Space Weather. The radio signals from the Galileo spacecraft (as for GPS) will have to traverse the Earth's ionosphere[47] and plasmasphere[48] to reach receivers on ground and sea or in the air. This traverse affects the signals in two main ways:

— It introduces a small but variable delay in the time taken for the signal to travel the approximately 20,000km from spacecraft to receiver. If not corrected, this can give an error of many metres in the measured position. Various correction schemes are already in operation, eg EGNOS. The Galileo system will provide a further and significant advance.

— It causes the frequency and strength of the signal to vary slightly. In severe cases, this "scintillation" can cause temporary loss of the radio signal and thus loss of position data. It is most likely to occur in polar and equatorial regions.

These effects are one aspect of "Space Weather"—namely the effect of solar activity on phenomena in near-Earth space and the consequential effects on a growing range of technologies. The study of Space Weather is proceeding at a European level through a number of ESA initiatives to promote assessment studies and develop pilot systems. UK scientists are playing an active role in these initiatives.

A2. Use of GNSS position data for science. Data from the existing GPS service is widely use as a tool in disciplines such as geodesy, seismology and vulcanology, where accurate position measurements allow scientists to monitor movements of the Earth's surface and interpret these in terms of geophysical phenomena such as earthquakes and volcanic activity. The higher accuracy of Galileo will act as further stimulus to that work. UK scientists are active in this area of science. For example:

— NERC has funded a Centre for the Observation and Modelling of Earthquakes and Tectonics (COMET—http://comet.nerc.ac.uk/) whose remit includes the exploitation of position data from the existing GPS service.

— The University of Nottingham hosts a major research group, the Institute of Engineering Surveying and Space Geodesy (IESSG—http://www.nottingham.ac.uk/iessg/) and is now working to create a new Centre for Satellite Navigation.

Supplementary note by Peter Blair (GG 21)

GALILEO AND AIR TRAFFIC CONTROL RADARS

Further to my appearance before the Committee on 27 October, here is the note on the Radar Interference Issue.

The authorisation to put in place RNSS (space to earth) systems such as Galileo in terms of the frequency spectrum that they occupy comes from the World Radio Conference (WRC), held every 4 years.

In 2003 it resolved that systems such as Galileo should have primary status in the band 1260 to 1300 MHz (which is where the PRS service is located) BUT it also resolved that these systems might have to have restrictions placed on them (for example power levels, types of signal allowed) in order not to interfere with Air Traffic Control (ATC) radars operating for many years in this band. These radars are the long range type, 100–200 miles and have good weather penetration. The Royal Academy of Engineering submission referred to this interference issue.

The ITU, the International Telecommunications Union . . . effectively the technical coordinator for the WRC, requested states to undertake studies of the likely interference to radars for consideration at WRC 2007. I have recently seen two papers, ITU doccuments 8B/60 and 8B/57 which were submitted to the ITU in August this year by the USA. Document 8B/60 covers trials carried out on a working ATC radar in the US network which does show adverse effects on its performance, for example, some loss of cover on aircraft targets, when signals replicating the planned Galileo type are injected into the radar. I understand that other states are also conducting studies of this problem.

ESA and the EU (and concessionaires?) must surely have taken into consideration the possible effects of any restrictions likely to be placed on the PRS channel, E6, of Galileo? However these could be quite significant, for example reduced power level or restricted frequency band and these would have some effect on the services to be offered or on the likely timescale for Galileo implementation as the next WARC does not meet until 2007.

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[47] The ionised part of the Earth's upper atmosphere at altitudes between 100 and 800 km.

[48] The plasmasphere is the tenuous extension of the ionosphere up to altitudes of 20,000 km or more, but with very different physics controlling its behaviour. Although more tenuous than the ionosphere, its much greater size means it has an almost equal effect on propagation of radio signals.

I appreciate that this topic may have been covered in the evidence from NATS and that you may therefore be aware of the potential problem, certainly they are in a better position than I to give you a fuller, more definitive, input.

I hope this is of assistance

Peter Blair OBE

3 November 2004

Supplementary note by the Parliamentary Under Secretary of State (GG 15A)

GALILEO INQUIRY

When I gave evidence to your Committee last Wednesday I offered to write to you on two points. As subsequently confirmed by your Committee Clerk, these are:

(i) "claims that the cost-benefit analysis of the Galileo project included some benefits which should in fact be attributed to other programmes, such as EGNOS"

I understand that Graham Stringer was referring to a claim made in earlier oral evidence from Paul Thomas of NATS. I have established that he was referring to a concern that the UK had already raised with the Commission in 2001.

Phase 1 of the "Galileo Study" by PricewaterhouseCoopers had identified aviation as one of the largest and most robust beneficiaries of the Galileo programme. It forecast benefits of some €5 billion per annum by 2020 made up of cost savings to airlines and time savings to passengers. This calculation seems to have been based on the assumption that Galileo would be an enabler of RNAV (area navigation) routes in Europe, but the report failed to consider that most commercial aircraft are already able to perform RNAV operations using systems such as GPS/EGNOS. The report appears also to have misunderstood how the benefits of Galileo could be realised through the air navigation charge.

In discussions on the report with the Commission and PWC in early 2002 we warned that they had significantly over-estimated the benefits to the aviation community. We recognised that the level of benefits correctly attributable to Galileo itself would rise towards the PWC level, but over a longer timescale than predicted by PWC, and this would still depend on the removal of other constraints, such as restricted air space in Europe, which might hold back the full potential of Galileo.

No new cost-benefit analysis of the case for public investment in Galileo has yet been produced. The UK's commitment to the Galileo programme is based as much on the clear benefits in developing the UK's lead in industrial expertise, but we must obviously have maximum clarity as well on the downstream returns to transport and other sectors. As I said in my evidence, we will need to see an updated exercise, corrected as necessary, to underpin the final commitment by Member States to Community investment in the deployment and operation of Galileo.

(ii) "a note on the industrial benefits of the Galileo Project to the UK"

I offered to provide more detail in response to Mrs Ellman's question about the 1,000 jobs to be generated by Galileo in the UK, as I mentioned in my opening remarks. As Phil Carey indicated at the hearing, some 500 people are already working in Galileo, in industrial, consultancy and research/academic roles. This figure draws on the memorandum from Astrium, who confirm that the main players involved are Astrium, Thales, Logica, SSTL, SciSys, the National Physical Laboratory and universities such as Nottingham and Leeds. In line with the assessment from the consultants ESYS, which we referred to in the Department's own memorandum, this figure should reach around 1,000 before Galileo becomes fully operational. We would expect these additional jobs to come from both upstream UK suppliers to the direct contractors to the In Orbit Validation phase, and in work to develop downstream applications and services and in other ways such as consultancy work related to the concession.

Your Committee Clerk also brought to our attention the assertion from another witness last Wednesday that the EU had originally offered to play a part in enhancing the US GPS system. There is little I have been able to establish on this in the limited time available, but I understand that there were indeed initial discussions between the EU and US authorities on this. I believe they did not progress because there would have been no opportunity for the European side to take part in the decision-making structure for GPS, and, as I indicated in my oral evidence, insufficient prospect of securing a major role for European industry.

I hope this is helpful.

David Jamieson

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