



## **GALILEO**

### **Impacts on road transport**

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## List of abbreviations and acronyms

ADAS	Advanced Driver Assistance Systems
ANPR	Automatic Number Plate Recognition
AVG	Advanced Vehicle Guidance
CS	Commercial Service
CWS	Collision Warning System
DG JRC	Directorate-General Joint Research Centre
DSL	Digital Subscriber Line
DSRC	Dedicated Short-range Communication
EC	European Commission
EGNOS	European Geo-stationary Navigation Overlay Service
ERP	Electronic Road Pricing
ESA	European Space Agency
EU	European Union
EU-25	25 Member States of the European Union
FCD	Floating Car Data
GJU	GALILEO Joint Undertaking
GPRS	General Packet Radio Service
GLONASS	Russian Satellite Navigation System
GMO	GALILEO Market Observatory (part of the GALILEI project)
GNSS	Global Navigation Satellite System
GNP	Gross National Product
GOC	Galileo Operating Company
GPS	Global Positioning System
GREAT	GALILEO: Research on Effects And Impacts on Road Transport
GSM	Global System for Mobile communication
HGV	Heavy Goods Vehicle
ICAO	International Civil Aviation Organisation
IPTS	Institute for Prospective Technological Studies
ISO	International Standardisation Organisation
LBS	Location Based information Services
LCV	Light Commercial Vehicle
LE	Local Element
NADICS	National Driver Information and Control System (Scotland)
OBU	On-Board Unit
OS	Open Service
PMR	Personal Mobile Radio
PRS	Public Regulated Service
PSTN	Public Switched Telephone Network
R&D	Research and Development
SA	Selected Availability
SAR	Search and Rescue Service
SoLS	Safety of Life Service
SP	Service Providers
TCAR	Third Carrier Ambiguity Resolution
UMTS	Universal Mobile Telecommunications System



## EXECUTIVE SUMMARY

GALILEO is the European Global Navigation Satellite System (GNSS), which has been under development since 2002 and will be implemented by 2008. The applications of GALILEO can be a vital tool in meeting the requirements for both the Common Transport Policy and National Policies in road transport.

The GALILEO project is a major priority for the European Commission due to the significant direct and indirect economic and strategic benefits it will bring, and the synergies to be achieved with sectoral policies – in particular transport policies – at European level.

This report summarises the main effects GALILEO is expected to have on road transport by the year 2020. The analysis includes:

- an investigation of the potential applications of Galileo in road transport;
- quantitative estimates of the effects of Galileo applications on road transport costs;
- an analysis of how GALILEO can help deliver transport policy;
- risks and obstacles to deployment and possible solutions;
- a discussion of main policy issues related to market penetration and effects on road transport.

The European Commission's White Paper "European Transport Policy for 2010, Time to Decide" (2001) has identified several areas to be addressed by European transport policy for all modes of transport. The areas of the White Paper most relevant to road transport include:

- improving quality in the road sector;
- unblocking major routes;
- improving road safety;
- effective charging for transport, and
- developing high quality urban transport.

Several road transport applications have been identified, for which GNSS technology in general and GALILEO in particular could be used, including:

- road monitoring;
- freight and fleet management;
- traffic management and control;
- incident and emergency management;
- electronic payment systems;
- traveller information systems;
- intelligent vehicles;
- parking management;
- public transport;
- internal services for road and infrastructure operators, and
- safety (pay-as-you-go insurance).

A number of alternative scenarios were considered in order to cover a wider range of penetration estimates for Europe and the world until 2020. The analysis carried out suggests that the most likely market penetration for GALILEO in road transport is around 40%. In order to take account of the risks and obstacles identified, a more pessimistic scenario was also developed, estimating a market penetration of around 20%. A more optimistic scenario is based on a market penetration of around 60%. An increased regulation scenario identifies particular applications for which corresponding legislation could increase the penetration of GALILEO in road transport.

Based on these scenarios, the absolute benefits have been estimated for the following areas:

- improvements in safety;

- reductions in congestion, and
- reductions in unnecessary fuel usage.

These are all areas in which a monetary value can be attributed to the benefit. Other beneficial impacts including reductions in noise, air pollution and stress have not been quantified, as no agreement has yet been reached at national or European level on common monetary values. The total value attributed to the benefits of GALILEO is therefore a conservative estimate.

The total value of the anticipated benefits for road transport in the EU-25 for 2008-2020 range from €160bn (pessimistic scenario) to €350bn (increased regulation scenario) as shown in Figure 1 below. This means that the savings per vehicle in the EU-25 vary from €780 (pessimistic scenario) to €1690 (increased regulation scenario) for the same period. These values are higher than the projected future price of GALILEO-supported in-vehicle systems (and higher than some systems already available today), confirming the market potential of such systems. Regarding the distribution of benefits across the EU-25, the greatest benefits are likely to be felt in Central Europe, the UK and Ireland, but are likely to be less great in Scandinavia and Southern Europe. Eastern Europe is expected to feel the least benefit.

A significant share of the benefits of each GALILEO-based application will come from the freight industry. The total benefit for freight transport in the EU-25 is estimated to range from €38bn (pessimistic scenario) to €64bn (increased regulation scenario) between 2008-2020.

	Scenario			
Indicator	Pessimistic	Central	Optimistic	Increased Regulation
Reduced accident costs	€95bn	€141bn	€198bn	€202bn
Reduced congestion costs	€49bn	€78bn	€109bn	€112bn
Reduced fuel costs	€16bn	€25bn	€35bn	€36bn
<b>Total cost saving</b>	<b>€160bn</b>	<b>€244bn</b>	<b>€342bn</b>	<b>€350bn</b>

Figure 1: Total estimated absolute benefits of GALILEO for road transport in Europe for 2008-2020 (rounded to full € billion)

For 2008-2020 the estimated worldwide benefits vary from €431bn (pessimistic scenario) to €941bn (increased regulation scenario) as illustrated in Figure 2 below. The greatest benefits are expected to be felt in the Pacific Rim and Europe, whereas North America, the Indian Subcontinent and the Middle East are expected to feel less benefit. Central and South America, Africa and Russia and Central Asia will feel the least benefit.

	Scenario			
Indicator	Pessimistic	Central	Optimistic	Increased Regulation
Reduced accident costs	€256bn	€379bn	€533bn	€543bn
Reduced congestion costs	€132bn	€210bn	€293bn	€301bn
Reduced fuel costs	€43bn	€67bn	€94bn	€97bn
<b>Total cost saving</b>	<b>€431bn</b>	<b>€656bn</b>	<b>€920bn</b>	<b>€941bn</b>

Figure 2: Total estimated absolute worldwide benefits of GALILEO for road transport for 2008-2020 (rounded to full € billion)

The key benefit of using GALILEO in road transport will be the improvement in road safety: a major objective of European road transport policy. Even for the conservative penetration estimate, the benefits from reducing accidents are expected to be significant, reaching at least

€5bn for all vehicles in the EU-25 and €7bn for freight transport in the EU-25, both based on the pessimistic scenario for the period 2008-2020.

A precondition for the extensive use of GALILEO is the timely launching of operations in 2008 and the early availability of high quality and affordable receivers. As it is likely that those Member States which do not yet use electronic road pricing will introduce some form of electronic charging within the next five to ten years, any delay in the system becoming operable or any problem with the development and supply of receivers may considerably reduce the benefits in this area.

However, the successful deployment of GALILEO, particularly for the abovementioned areas of road transport, could be affected by major risks:

- **technical risks** such as GALILEO failing to meet the stated performance requirements and the absence of standards or complementary technologies, in particular for traffic data fusion and Advanced Driver Assistance Systems.
- **commercial risks** such as consumers and commercial users failing to accept the system. Several factors, such as the availability, quality and cost of receivers, privacy concerns, or the perceived usefulness of the service, could affect the take-up of GALILEO in road transport.
- **political risks** such as a failure to mandate GNSS technology in general and GALILEO in particular. This risk only will be relevant if the take-up of GALILEO is slower than expected and might need to be stimulated by incentivising or subsidising the use of GALILEO-based systems.
- **institutional risks** such as the service provision, commitment and management of the GALILEO Operating Company, the timely introduction of GALILEO and its acceptance by society.

The analysis of the policy issues in this study suggests various policy measures to support the deployment of the GALILEO system and its widespread use in road transport and to minimise the risks. These include the need to address data protection concerns and to consider subsidising or – if necessary – mandating the use of GNSS technology for some applications in order to avoid the parallel use of different systems. In addition, the need for a comprehensive dissemination strategy prior to the launch of the system in 2008 has been identified as a key issue, to raise awareness of GALILEO's technical and institutional features and increase expertise among manufacturers.



## **PREFACE**

This report summarises the findings of a study carried out on behalf of the European Commission's Joint Research Centre, Institute for Prospective Technological Studies (JRC/IPTS) by a research team from FaberMaunsel (United Kingdom), ICCR (Austria) and ISI (France).

The overall aim of the study was to identify applications for GALILEO in road transport and estimate the impact of its use. The objectives and methodology of the study were defined by JRC/IPTS in collaboration with the Intelligent Transport and GALILEO Unit of the European Commission's DG Energy and Transport. The management and supervision of the research activities, as well as the analysis of the findings and the editing of the final report were carried out by JRC/IPTS.

Several experts from the European Commission and related organisations have provided input at various stages, and the JRC/IPTS would like to express its appreciation for their contribution: Paul Flament and Keith Keen (DG Energy and Transport), Mario Musmeci, Xavier Alfonsi and Evaggelia Karamali (Galileo Joint Undertaking), Juhani Jaaskelainen, Peter Johnston and Emilio Dávila (DG Information Society), Laurent Beslay (European Data Protection Supervisor) and Alejan Gercama (European Investment Bank).

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## 1 INTRODUCTION

GALILEO is one of the biggest investments ever made by European governments and industry. GALILEO has been under development since 2002 and will go into operation in 2008.

In transport, GALILEO is expected to act as a catalyst for a whole range of new services, such as satellite navigation and emergency location, thus helping to achieve the goals of the European transport policy as well as the transport policies of Member States, especially in the road sector. To make the most of this opportunity, both the Commission and key stakeholders need to look ahead to develop a vision of the future. For this, they need detailed scenarios of how GALILEO will improve services and, in turn, how it might be used to deliver policy.

In recognition of the significance of GALILEO for road transport, the Institute for Prospective Technological Studies (IPTS) of the DG Joint Research Centre (DG JRC) commissioned the GREAT study to produce quantitative estimates on the impact of GALILEO on road transport and investigate how GALILEO can support European transport policy. This is the final study report, setting out the study's findings in the context of transport policy.

This report forms part of the overall output produced by the 'GREAT' Consortium (**G**ALILEO: **R**esearch on **E**ffects **A**nd impacts on road **T**ransport).

The objectives of the GREAT project were to:

- provide robust quantitative estimates of the impacts of Galileo;
- show how it will help to deliver transport policy;
- develop a vision of the use of Galileo in 2020 to assess impacts in detail;
- identify risks and obstacles to deployment and recommend solutions; and
- provide guidance on actions required.

The work was divided into seven work packages.

- Work package 1 – Overview of Market Studies;
- Work package 2 – Overview of Applications;
- Work package 3 – Evaluation of Impacts;
- Work package 4 – Comparison of Alternatives;
- Work package 5 – Obstacles to Penetration;
- Work package 6 – Quantitative Scenarios; and
- Work package 7 – Policy Issues.

The methodology of the GREAT study and the interdependencies between work packages are shown in Figure 3 below.

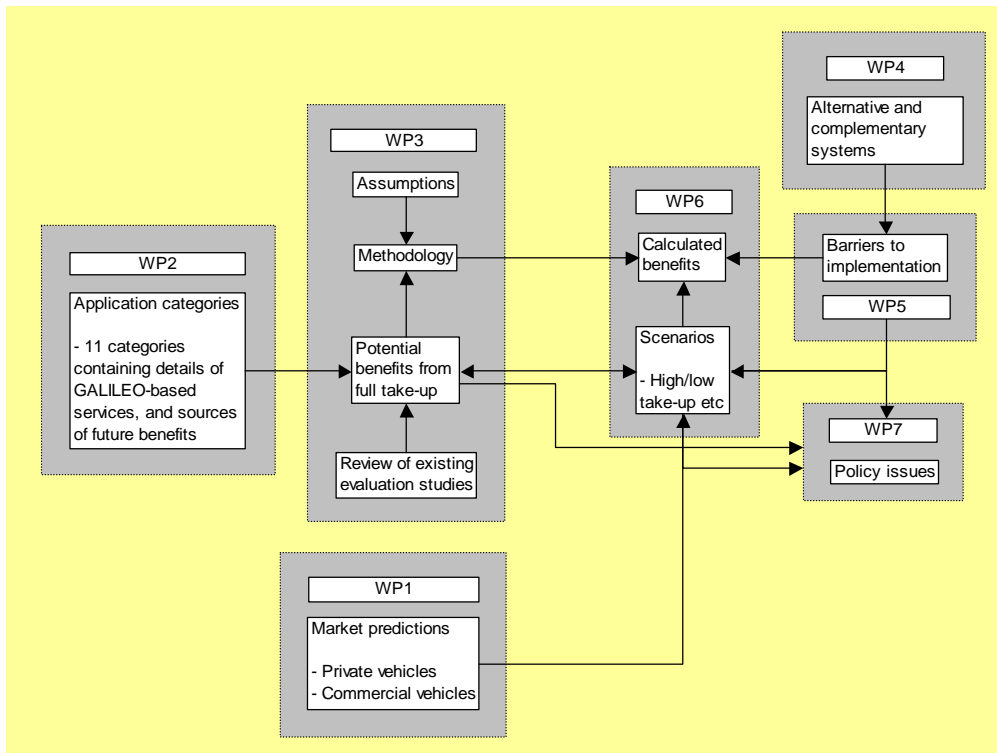


Figure 3: Approach of the GREAT study

This report summarises the results achieved in the different work packages of the GREAT study. Please consult the reports for each work package for more detailed information.

## 2 KEY FEATURES OF GALILEO

There are currently two satellite navigation systems allowing a receiving unit to calculate its location – the American GPS and the Russian system, GLONASS. Both of these were originally designed and used for military purposes. Signals from both systems are available globally, free of charge, for civilian use.

The first GPS satellite was launched in 1978 and declared operational for civilian users in 1995. It currently uses 24 satellites (three of which are spares) in orbit 20 200 km above the Earth. The GPS signal was initially degraded so that users could only receive a reduced accuracy of about 100m. However, the accuracy for civilian users improved to around 20m in May 2000 when the US Government ceased using the Selective Availability (SA) feature. The SA was used to artificially degrade the accuracy of GPS signals. GPS is generally reliable but it is not designed for ‘safety of life’ operations. It has no performance guarantee as it is wholly controlled by the US Government. In particular, it does not transmit timely integrity data to enable users to detect if a satellite is malfunctioning.

GLONASS (Global Orbiting Navigation Satellite System) is managed for the Government of the Russian Federation by the Russian Space Forces. The full GLONASS constellation comprises 24 satellites in three orbital planes. Each GLONASS satellite operates in a circular, 19 100 km orbit. The orbiting satellites are arranged so that a minimum of 5 satellites are in view to users worldwide, with adequate geometry, i.e. the GLONASS constellation can provide continuous and global navigation coverage.

### European Geostationary Navigation Overlay Service (EGNOS)

GPS and GLONASS are independent and do not include performance guarantees and there is, therefore, a perceived need for the two systems to be augmented. Augmentation over Europe is via EGNOS, a joint project between the European Space Agency (ESA), the European Commission (EC) and Eurocontrol, the European Organization for the Safety of Air Navigation. EGNOS represents Europe’s contribution to the first stage of GNSS and is a forerunner of GALILEO.

### GALILEO

Since GALILEO is under civilian control, it can provide a highly accurate and guaranteed global positioning service. GALILEO receivers can determine position in terms of latitude, longitude, altitude and time.

Key features include:

- **Service guarantee** – due to its exclusively civilian usage and its planned operation by a private consortium within a Public-Private Partnership (PPP), the service will be guaranteed and independent from (but interoperable with) the existing GPS/GLONASS systems and other political entities.
- **Improved accuracy and availability** – compared to the existing generation of GPS/GLONASS, the accuracy will improve from approximately 20m (GPS) to 5m without augmentation (for example using EGNOS). Simulations demonstrate that the availability of

positioning services in ‘urban canyons’ (satellite visibility obstruction by high buildings and skyscrapers) increases from a typical 50% with GPS to over 95% with GALILEO.<sup>1</sup>

- **Integrity** – GALILEO is able to broadcast integrity information for certain critical applications, assuring the quality of positioning accuracy. Users can receive a timely warning whenever the system fails to meet its stated accuracy. The GALILEO system guarantees that this warning is sent out quickly enough even for the most demanding of applications such as aircraft landing.

GALILEO will provide five different services:

- **Open Service (OS)** – designed for mass-market applications, this free service will provide positioning, velocity and timing information. This competitive service will be accessible to any user equipped with a receiver and will improve performance in severe environments such as ‘urban canyons’ and rural valleys;<sup>2</sup>
- **Commercial Service (CS)** – aimed at high-performance market applications, this will provide value-added services for a fee;
- **Safety-of-Life Service (SoLS)** – providing the same horizontal accuracy as the OS, this will be used for transport applications where lives could be endangered if the performance of the navigations system is degraded without real-time notice;
- **Public Regulated Service (PRS)** – this service is a robust, access-controlled service for governmental applications, and
- **Search and Rescue Service (SAR)** – this will allow near real-time reception of distress messages from anywhere on Earth, precise location of alerts and multiple satellite detection to overcome terrain blockage in severe environments.<sup>3</sup> In addition, GALILEO will introduce a new SAR function, namely the return link from the SAR operator to the distress emitting beacon, thereby facilitating the rescue operations and helping to identify and reject false alarms.

A detailed description of the GALILEO services is provided in Deliverable D2 of the GREAT project.

The GALILEO implementation schedule is as follows:

2002 to 2005	GALILEO development and in-orbit validation
2004	EGNOS fully operational
2006 to 2007	GALILEO deployment
From 2008	GALILEO starts commercial operations

This is the currently published schedule. It may be revised once the Galileo Operating Company (GOC) is in place.

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<sup>1</sup> GALILEO Joint Undertaking, et al., Business in Satellite Navigation

<sup>2</sup> European Space Agency, et al., GALILEO Mission High Level Definition

<sup>3</sup> European Space Agency, Galileo – The European Programme for Global Navigation Services

### 3 EUROPEAN TRANSPORT POLICY

European transport policy is the result of a complex interaction between a number of institutions, most importantly the European Commission, the European Parliament and the European Council (i.e. the representatives of the Member States). The large body of strategies, ideas, legislative initiatives and regulations generally referred to as ‘European transport policy’ comprises several official documents. The most important and comprehensive of these in terms of agenda-setting is the White Paper *European transport policy for 2010: Time to Decide*. A summary of the aspects of this White Paper which are most relevant to this study is given below.

The second EU policy document of relevance to this study summarized below is the recently adopted EU Directive on the interoperability of electronic road toll systems in the Community, which mandates certain technologies for road-user charging.

#### 3.1 The White Paper on European Transport Policy

The 2001 White Paper covers all modes of transport and emphasises the need for a shift from road transport to modes which are more environmentally friendly. This study has focused on the effects and impacts of the GALILEO system on road transport. In the White Paper, the issue of road transport is covered from a number of different perspectives. Each area addressed in this central European policy document is summarised in turn below.

##### 3.1.1 Improving quality in the road sector

Much of the growth in road freight transport is due to international road haulage. As highlighted in the White Paper, forecasts for 2010 point to a 50% increase unless action is taken to alter the trend. Transport by lorry is unavoidable over short distances, where there is no alternative mode sufficiently tailored to the needs of the economy. By contrast it is not entirely obvious what factors are sustaining the expansion of road transport over middle and long distances. This seems to be related to the perpetuation of competition-distorting practices leading to price dumping. Ending these practices requires not more regulation but rather more effective enforcement of existing regulations by tightening up and harmonizing penalties.

Haulage companies compete fiercely against other modes and against each other. In the context of ever-rising operating costs (for fuel and new equipment), some companies may be tempted to side-step rules on working hours and authorizations as well as to ignore the basic principles of road safety.

A large number of Commission proposals are designed to provide the EU with full legislation to improve working conditions and road safety and ensure compliance with the rules on the operation of the internal market. In particular, they seek:

- to reorganize working time;
- to harmonize weekend bans on lorries;
- to introduce a ‘driver’s certificate’;
- to develop vocational training.

EU regulations on road transport are currently poorly enforced. In order to improve the situation the Commission proposes increasing the number of checks, promoting efficient implementation and monitoring of Community road transport legislation, harmonising penalties and encouraging the systematic exchange of information between Member States.

New technologies will have an important role to play in this context. The introduction of the digital tachograph will bring significant improvements in monitoring. Account will also have to be taken of the new opportunities opened up by satellite navigation. The GALILEO programme will make it possible to trace goods wherever the lorry is, and to monitor various parameters relating to driving and other conditions.

### **3.1.2 Unblocking major routes**

The revised Community guidelines on the trans-European network form a part of an environmentally sustainable policy, which should tackle rising levels of congestion and encourage the use of environmentally-friendly modes of transport. To this end, they must redirect Community action to allow the development of multi-modal corridors giving priority to freight and a high-speed passenger network. The most important European routes will also need to be provided with traffic management plans to make better use of existing capacity.

Specific traffic management measures coordinated at European level can produce an overall improvement in traffic conditions on major inter-city routes, whatever the cause of congestion (accidents, weather conditions, one-off or recurring incidents, etc.). For a number of years, the European Union has provided financial incentives to introduce such measures on international corridors. By 2006, all the main trans-European links should have traffic management plans. For heavy goods vehicles, precise traffic management at peak times will make it possible to offer more suitable routes, better schedules and driver assistance. This could result in capacity gains while reducing the risks of accidents and pollution.

### **3.1.3 Improving road safety**

Of all modes of transport, transport by road is the most dangerous and the most costly in terms of human lives. Viewed as something of a fact of life, it is only recently that road accidents have aroused any particularly strong reaction. Studies indicate that drivers in Europe expect stricter road safety measures, such as improved road quality, better training of drivers, enforcement of traffic regulations, checks on vehicle safety, and road safety campaigns.

The European Union must, over the next 10 years, pursue the ambitious goal of reducing the number of deaths on the road by half, by way of integrated action taking account of human and technical factors and designed to improve the safety of the trans-European road network.

According to the EU White Paper (2001), the directly measurable cost of road accidents is around €45 billion per year. Indirect costs (including physical and psychological damage suffered by the victims and their families) are in the order of €140 to 180 billion per year. The eSafety project (2002) produced similar results, putting the annual accident costs at about €160 billion. This is equivalent to 2% of the EU's GNP.

Though responsibility for taking measures to halve the number of road deaths by 2010 will rest primarily with the national and local authorities, the European Union needs to contribute to this objective, not just through the exchange of good practice, but also through action at two levels:

- harmonization of penalties; and
- promotion of new technologies to improve road safety.

Work is needed to harmonise certain regulations, penalties and controls, first and foremost on the trans-European motorway network, which enjoys Community co-financing and is used by a growing number of people from different Member States and not least by international road haulage. This implies approximating the technical characteristics of the infrastructure as well as harmonising signs and road markings.

Technological developments such as the introduction of automatic devices and on-board driving aids are expected to enhance the usual methods of monitoring and imposing penalties. In parallel, the black boxes which will eventually be fitted in road vehicles, as in other forms of transport, to record parameters which help explain the causes of accidents, will make motorists more responsible, make court proceedings following accidents quicker and cheaper and facilitate more effective prevention measures.

The European Union encourages the use of innovative technologies to improve the safety of new vehicles placed on the market. Intelligent transport systems represent another opportunity – their wide dissemination is the aim of the eEurope plan adopted by the Feira European Council in June 2000. One example is the introduction of active safety systems for all new vehicles to be facilitated through an agreement with the automotive industry at Community level. In its White Paper, the European Commission expresses the hope that vehicles fitted with active safety devices such as traffic management and collision-avoidance systems could help to achieve the objective of 50% fewer deaths between 2002 and 2010.

As the volume of traffic increases, better vehicle speed management is an essential aspect of safety that will also help tackle congestion. In addition to improving road safety, observing speed limits also significantly reduces greenhouse gas emissions. The most promising prospects here are offered by new technologies that can determine optimum speed at any moment with reference to traffic conditions, road features and external conditions (such as the weather) and get this information to drivers via display boards or on-board communication systems. Roads and vehicles throughout the Union must be equipped with these new technologies as soon as possible and information systems must be made accessible to everyone.

#### **3.1.4 Effective charging for transport**

The fundamental principle of infrastructure charging is that the charge must cover not only the infrastructure costs, but also external costs, that is, costs connected with accidents, air pollution, noise and congestion. This applies to all modes of transport and all categories of user, both private and commercial.

Due to the principle of subsidiarity, the Community can act most usefully by identifying, disseminating and encouraging good practices, for example, through research programmes. In the case of commercial transport, on the other hand, in order to avoid the distortion of competition, the Community needs to establish a framework whereby Member States can gradually integrate external and infrastructure costs and guarantee consistency in their initiatives.

Systems to locate, identify and monitor vehicles and their loads will become increasingly reliable through the use of information and communication technologies, especially satellite navigation systems (GALILEO). Tariff schedules can then be more targeted and be drawn up according to infrastructure category and use (distance travelled, length of time used). Other objective factors can also be taken into account, such as vehicle category (environmental performance, factors influencing infrastructure deterioration, even the loading ratio), level of congestion (period of the day, week or year) and location (urban, suburban, interurban or rural).

International standards are being adopted on short-range communication equipment for electronic toll collection, and work is underway to establish the contractual and legal aspects of network interoperability. Following the publication of the White Paper, new European legislation on the interoperability of electronic infrastructure charging systems was adopted in 2004.

### 3.1.5 Developing high quality urban transport

Increased traffic and urban congestion go hand in hand with higher levels of air pollution, noise and accidents. Urban transport alone accounts for 40% of carbon dioxide emissions from road vehicles.

Even if the subsidiarity principle dictates that responsibility for urban transport lies mainly with the national and local authorities, the problems associated with transport in urban areas cannot be ignored. The key challenge for national and local authorities is that of traffic management and, in particular, the role of the private car in large urban centres. The subsidiarity principle allows the European Union to take initiatives, including regulatory initiatives, to encourage the use of diversified energy in transport.

## 3.2 EU legislation on the interoperability of electronic road toll systems

In April 2004 the European Council and Parliament adopted a new Directive on the interoperability of electronic road toll systems in the Community.<sup>4</sup> In terms of technological solutions this directive states that:

"All new electronic toll systems brought into service on or after 1 January 2007 shall, for carrying out electronic toll transactions, use one or more of the following technologies:

- (a) **satellite positioning;**
- (b) **mobile communications** using the GSM-GPRS standard (reference GSM TS 03.60/23.060);
- (c) **5.8 GHz microwave technology".**

It recommends that on-board equipment available to users should be interoperable with all the systems operating in the Member States which conform with Article 2. It also recommends that new electronic payment systems brought into service after the adoption of the Directive should use satellite positioning technology. This is only a recommendation, and there is no obligation for the time being for toll systems using 5,8 GHz short-range communication to migrate to satellite-based technology, due to the large investments required. However, by 31 December 2009, the Directive states that the Commission should draw up a report on the different technologies used and undertake a cost-benefit analysis, and if appropriate propose a migration strategy.

This clearly means that, if GALILEO can prove that there would be a real advantage in using satellite positioning, it will open the market for millions of new users. The potential of GALILEO for electronic pricing systems are theoretically proven, as it reduces the need for roadside equipment. However, GALILEO needs to prove that it will meet the required performance levels in practice.

This also means that in the medium term, the use of satellite navigation systems for road-user charging in the EU will not be mandatory and those countries which have recently introduced microwave systems or which are about to do so may continue to use and extend their systems for an unlimited period.

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<sup>4</sup> Directive 2004/52/EC of the European Parliament and of the Council of 29 April 2004 on the interoperability of electronic road toll systems in the Community.

## 4 OVERVIEW OF APPLICATIONS IN ROAD TRANSPORT

The different uses for GALILEO in road transport are called ‘applications’. The ISO list of services was used as a starting point to generate a list of applications, and several other applications have been added based on research.

### 4.1 Potential Applications for GALILEO

The use of GALILEO in road transport is expected to have the following benefits over the use of GPS today:

- More data sets: Floating Car Data (FCD) has already been collected using GPS/GSM in the past. However, only a few services have become operational. The number of vehicles fitted with GALILEO-enabled receivers, and consequently the amount of traffic data available, is expected to increase.
- New and improved data types: Due to the increased accuracy and greater availability of GALILEO in urban environments, new data types will emerge; for instance, FCD for urban areas and public transport data.
- New services: New services such as pay-as you go services for road use and parking will be developed using the high accuracy and availability of GALILEO described above.
- Evolving services: In addition to the new services, other services will evolve based on GALILEO and advanced technology, mainly in the area of advanced driver-assistance services.

#### 4.1.1 Applications using More Data

##### Road Monitoring

High-quality road monitoring data is crucial for effective traffic management and accurate information services. More detailed, high-quality services require travel time data and traffic forecasts, whereas until now, the most important input was information on traffic volumes.

The conventional technology used for traffic data collection is inductive loops. These have been extensively deployed over the last decade across many Member States. However, the implementation and maintenance of inductive loops is expensive, and investments in rural areas or on the urban road network are often unjustified. Other, more innovative and less intrusive technologies are currently under development; one of the most promising is the use of Floating Car Data (FCD), enabled by an in-vehicle GNSS/GSM device.

##### Traffic Management and Control

GALILEO could have significant implications for traffic management and control systems. It offers the prospect of complete, accurate journey-time data across all road networks for private, commercial and public transport vehicles. This could provide an unprecedented quality of information to inform traffic managers of actual-route journey times and other floating car data. the following services are included, among others:

- Traffic Control;
- Policing/Enforcing Traffic Regulations;
- Infrastructure / Maintenance Management, and

- Route Guidance with Integrated Traffic Control Measures.

#### Internal Services for Road and Infrastructure Operators

As well as the benefits to the road user, network and service operators will also benefit from the improved performance of GALILEO. The main areas of applications on which the deployment of GALILEO might have an impact are

- highway/road maintenance management;
- provision of location Information of (short-term) roadworks;
- use of probe car data to guide timing and location of planned roadworks and road closures;
- traffic sign asset management, and
- personnel security.

### **4.1.2 Applications using New and Improved Data**

#### Freight and Fleet Management

The tracking and tracing of goods, vehicle scheduling and control and improved “just-in-time” delivery processes are potential areas for the use of GALILEO. The European economy is very closely linked to the performance of our freight and fleet management systems. The free movement of goods within an expanding European Union relies heavily on road transport. While measures are planned to shift more of our goods away from the roads, the efficiency and effectiveness of road-based distribution will continue to be a major aspect of our transport system.

#### Incident and Emergency Management

Emergency and incident management is part of providing satisfactory levels of service for road users. The “golden hour” for getting high-quality medical support to accident victims is a key aspect of saving lives and reducing the consequences of accidents. GALILEO could, for instance, be used for emergency notification, hazardous goods management and emergency vehicle management.

#### Traveller Information Systems

The availability of improved and new, accurate, real-time traffic information due to GALILEO based traffic data collection by FCD could provide significant opportunities for added value traffic information services. The location information provided by the GNSS receiver could also be embedded in a location-based information service allowing the Service Provider to customise information provided according the user’s current position. Location-based information services have been identified in the GALILEI study as a major application.

#### Public Transport

Although this study focuses on the use of GALILEO in road transport, GALILEO could also be used for public transport, for instance for the real-time management of public transport vehicles.

### **4.1.3 Applications using New Services**

#### Electronic Pricing Systems

Demand management using electronic pricing systems is one of the cornerstones of EU transport policy and has been identified as one of the main applications for GALILEO. The use of GALILEO for electronic pricing systems would allow the introduction of more flexible pricing policies and reduce the need for roadside infrastructure.

Safety (pay-as-you-go insurance)

Using GALILEO-enabled receivers, driving behaviour could be tracked and more flexible insurance policies could be devised. This might help ensure safer roads, as at-risk drivers might improve their driving behaviour if means they can save on insurance.

**4.1.4 Applications using Evolving Services**

Intelligent Vehicles and Advanced In-vehicle Technology

The application of intelligent vehicles and advanced in-vehicle technology comes under the Advanced Driver Assistance Systems (ADAS), identified as one of the most important applications for the GALILEI project (ESYS Consulting 2003). In particular, ADAS could make use of the GALILEO Safety of Life Service (see Appendix).

Parking Management

In recent years, many cities have been equipped with dynamic parking guidance systems in order to decrease the amount of traffic searching for parking spaces.

As in-vehicle navigation systems evolve, and the market penetration of GALILEO receivers to support them increases, parking management can be improved and optimised to reduce these unnecessary journeys as far as possible.

**4.2 Qualitative Estimate on the impact of EU policy features**

The applications for which the use of GALILEO has been investigated are grouped according to the benefits GALILEO is expected to bring. A qualitative estimate has been made of the impact of the use of GALILEO in road transport, based on our professional experience.

There is some evidence that GALILEO would support EU transport policy key features, as shown in the table below:

Benefits of using GALILEO	Application	EU Policy Features					
		Improve Quality in Road Transport	High-quality urban Transport	Promoting Intermodality	Manage Demand	Improving Road Safety	Sustainable Transport System / Environment
More data	Road Monitoring Infrastructure	✓✓	✓✓	✓	✓	✓	✓
	Traffic Management and Control	✓✓	✓✓	✓✓	✓	✓✓	✓
	Internal Services	✓	✓			✓	
Improved data	Freight and Fleet Management	✓		✓		✓	✓
	Incident and Emergency Handling	✓✓	✓✓			✓✓✓	
	Traveller Information Services	✓✓	✓✓	✓✓✓	✓	✓✓	✓✓✓
	Public Transport	✓✓	✓✓✓	✓✓✓	✓	✓✓	✓✓✓
New Services	Electronic Pricing Systems	✓✓✓	✓✓✓	✓✓	✓✓	✓✓	✓✓✓
	Safety	✓✓	✓	✓✓	✓✓	✓✓✓	✓✓
Evolving Services	Intelligent Vehicles	✓✓✓	✓			✓✓✓	✓✓✓
	Parking Management		✓✓✓		✓		✓

✓ no impact  
 ✓✓ low impact  
 ✓✓✓ medium impact  
 ✓✓✓ strong impact

Figure 4: Overview on the estimated impacts of the use of GALILEO on EU policy

There is some evidence that the use of GALILEO would support EU transport policy, leading us to draw the following conclusions:

- the development of new services based on GALILEO for electronic pricing systems may strongly support EU policy, particularly as regards the improvement of road transport and safety, high quality urban transport, and sustainable transport;

- the future evolution of services using GALILEO, especially for intelligent vehicles equipped with advanced driver assistance systems, may strongly support the improvement of road safety and the quality of road transport; whereas the impact on other EU policy guidelines, for instance as regards inter-modality, is expected to be less marked;
- traffic management and control services in particular may benefit from the generation of more traffic data based on the use of GALILEO to help improve road transport and safety and to support high quality urban transport;
- public transport management, travel information services and incident and emergency management may benefit from the generation of new data and could therefore help to support EU policy, particularly as regards inter-modality, sustainability, road safety and high quality urban transport; and
- of all applications, the EU road transport policy features which could benefit most from the use of GALILEO are the improvement of road transport and safety and the provision of high-quality urban transport.

The conclusions of the qualitative estimate are supported by the results of the quantitative evaluation of impacts presented in Chapter 8.

## 5 ALTERNATIVE AND COMPLEMENTARY TECHNOLOGIES

This section provides an overview of the comparison with alternative and complementary technologies. The applications can be grouped as follows:

- applications using data obtained from Floating Cars and other vehicles as probes (FCD); and
- other applications using location information.

### 5.1.1 Applications using the Floating Car Data concept

The study provides an analysis of the data collection techniques that are currently used in road transport, in order to describe the areas in which GALILEO can bring alternative or improved solutions. The technologies currently used include:

- magnetic loops;
- pneumatics;
- piezo cable;
- video camera and image processing;
- video camera and image processing with ANPR;
- radar;
- infrared sensors and other type of sensors (passive);
- active beacons and tags, and
- FCD – existing providers using GPS.

Their characteristics are shown in Figure 5.

Data collection techniques	Traffic flow	Occupation rate	Vehicles categories	Speed	Travel time	O/D information	Incident detection
<b>Magnetic loops</b>	Yes	Yes	If speed available	With 2 consecutive loops	No, estimation by algorithms	No, except with specific algorithms: require high number of sensors	Yes, except with specific algorithms (response time: in minutes)
<b>Pneumatics</b>	Yes	Indirect (derived from axles numbers)	Partly (number of axles)	With 2 detectors, not accurate	No, (not accurate)	No, (not accurate)	No, (not accurate)
<b>Piezo cable</b>	Yes	Yes	Yes (axles weight)	With 2 detectors	No, estimation by algorithms	Not used	Not used
<b>Video camera and image processing</b> <sup>5</sup>	Yes	Yes	Yes	Yes	No, estimation by algorithms	No, except with specific algorithms: require high number of sensors	Yes, particularly when image processing is dedicated to incident detection (response time: few seconds)

<sup>5</sup> Video cameras with image processing are able to emulate one or more magnetic loops.

Data collection techniques	Traffic flow	Occupation rate	Vehicles categories	Speed	Travel time	O/D information	Incident detection
<b>Video camera and image processing with ANPR<sup>6</sup></b>	Yes	Yes	Yes	Yes	Yes (by tracking number plates)	Yes (by tracking number plates)	Yes if combined with Incident detection algorithm
<b>Radar<sup>7</sup></b>	Yes	Yes	Yes	Yes	No (except derived from local speed using specific algorithms)	No, except with specific algorithms: require high number of sensors	Yes (by tracking moving vehicles)
<b>Infrared sensors and other type of sensors (passive)</b>	Yes	Yes	No	No	No	No, except with specific algorithms: require high number of sensors	No
<b>Active beacons and tags</b>	Yes (if enough vehicles are equipped)	Yes (if enough vehicles are equipped)	Yes as far as the information is on the tag	Yes	Yes	Yes (entry exit)	Yes
<b>FCD (existing providers using GPS)</b>	No	No	Yes	Yes	Yes	Yes	Yes (where enough vehicles are equipped)

Figure 5: Current data collection techniques

Most of these techniques are used to collect local data on site. Data processing can be local, for example in order to activate traffic signs or feed traffic light controllers. However, in general the collected information has to be transmitted to a remote centre. This transmission requires the use of communication technologies such as:

- PSTN (Public Switched Telephone Network) using a modem (point to point or with Internet and DSL access);
- dedicated network: copper cable, fibre optics, coaxial cable (analogue video); and
- wireless technologies: dedicated radio transmission or public networks (GSM, GPRS, etc).

Ever since vehicles have been equipped with GPS and various means of communication (dedicated fleet radio or public wireless communication such as GSM/GPRS), experiments and pilot tests have been conducted into the use of moving vehicles as probe vehicles:

- using of GSM communication to track vehicles (cell position, triangulation, etc), and
- using GPS to collect local data. If real-time transfer is required, GSM/GPRS or other radio links which support data transmission are used. Otherwise, the collected data is stored in the vehicles and downloaded at a station.

Several pilot projects have experimented with the use of GSM to track vehicles. Recent trials in Scotland using the RODin24 system and Estimotion to measure road traffic conditions have been undertaken, but in general, the use of GSM does not yet have the coverage to replace proven infrastructure-based techniques.

<sup>6</sup> ANPR: Automatic Number Plate Recognition.

<sup>7</sup> Radar includes different technologies: radar used as a simple presence detector (similar to magnetic loops, but installed on gantries), radar used for speed measurement or large beam radars able to track the number of moving vehicles (many trials, but not in real use due to high implementation costs).

The second technique using GPS to collect local traffic data is widely used by professionals, emergency services, maintenance companies and delivery firms to track their fleet and optimise their journeys. For the time being this information is mainly used for private purposes and in some cases it is then transmitted to authorities for public-sector use (e.g. for NADICS in the UK). Some agreements have already been concluded to provide traffic information providers with travel times (ITIS in UK, Médiamobile in France with a taxi fleet, etc). This paves the way for using FCD for better traffic-data collection using GALILEO's better performance in relation to GPS, and better coverage in urban areas.

However, in addition to the medium required to transmit the positioning data, new types of algorithms also have to be developed to reconstruct the data required by traffic engineers, traffic operators, information service providers, etc. In addition, FCD is not used in isolation but as a supplement to data obtained by more traditional means. The data must therefore be processed using data fusion techniques which, while in development, are not yet widespread.

### 5.1.2 Applications using location information

This group of applications uses the location system for its primary purpose, i.e. locating a person, vehicle or specific piece of equipment. The objective may be operation and maintenance (pavement monitoring), safety and comfort (lateral collision avoidance) or enforcement/payment.

Some applications use positioning information at fixed points such as access points, toll gates, etc. At present, these points are equipped with beacons which locate and communicate with each vehicle (access authorisation, payment, download of data relating to the drive itinerary, etc). For other applications, the positioning information is not linked to a particular point so it is not possible to use infrastructure-based systems. Catering for these would require a high density of beacons, public communication networks or wireless access technology (e.g. WiMAX for high-throughput broadband connections over long distances).

#### a. Applications which do not refer to a predetermined point

Many navigation applications now make extensive use of GPS information. It would be no problem to replace this with GALILEO's better accuracy and coverage. A more sophisticated service that requires better accuracy than today's navigation systems will therefore benefit from GALILEO's performance.

On the other hand, ADAS applications have very high-level requirements in terms of accuracy, integrity, coverage, etc. It will not be possible to provide the information required for these services with GALILEO's proposed performance levels. ADAS relies on the accurate derivation of the relative position of vehicles to their surroundings (infrastructure, equipment, other vehicles, etc). ADAS requires complementary sensors to reach the required accuracy (to the centimetre, in some cases). Current research and demonstration projects are using radar and laser sensors for mid- to long-range detection and ultrasonic sensors for very short-range detection. Complementary sensors for ADAS applications are

- radar;
- laser;
- ultrasound;
- cameras;
- micro-electro-mechanical systems;
- lane markers, and
- digital maps.

Lane markers and digital maps are also used to relate the vehicle to a geographical reference.

Although ADAS has been identified as one of the most important applications in the GALILEI project as it makes particular use of the GALILEO Safety of Life Service (see Appendix), research and more work will be necessary before GALILEO data can be used in ADAS applications, with their high reliability requirements.

b. Applications which refer to a predetermined point

Access control is managed by infrastructure-based equipment (infrared or microwave beacon systems) while electronic toll collection is performed using the EU standard (or close to standard) DSRC operating at 5.8 GHz. Currently no satellite-based system exists for access control to car parks or special areas, as an access tag has to be online in order to be able to give/prohibit access to specific vehicles.

Concerning electronic payment, for parking or other payment schemes for road use (tolled infrastructure, road pricing, congestion pricing etc.) the amount to be charged is generally processed off-line: there is no need to process on the spot. This opens up opportunities for the use of systems able to trace and record the position and itinerary of vehicles.

Satellite positioning with a communication system for reporting and invoicing can therefore be used instead of electronic toll systems based on short-range communication. The first example of this application is Toll-Collect in Germany, where lorries using the motorways are charged by means of an on-board unit equipped with a GPS receiver and GSM/GPRS communication.

### 5.1.3 Conclusions

For the a vast majority of applications using FCD, only GALILEO will meet or exceed most of the related requirements – other technologies are unlikely to provide the penetration or accuracy needed.

FCD is already expanding and being developed and many of the early technical hurdles are being overcome with relatively small vehicle fleets – this provides a sound foundation for future developments with far bigger penetration levels.

GALILEO will allow FCD to become a much wider, more accepted data source to help achieve a variety of policy objectives. The availability of data will increase and people's understanding of the theory and practice of processing it will improve, bringing it into line with more traditional data sources. A key issue then will be the management, filtering and interpretation of extremely large volumes of data of a type not currently used in mainstream traffic applications. This contrasts with the current situation, where data is scarce but is fed directly into the relevant applications. However, until the market penetration of vehicles fitted with GALILEO-enabled equipment is 100%, traffic flows and occupancy will still have to be measured in the traditional way.

Deploying FCD will require additional communication facilities to collect real-time positioning data on individual vehicles, and upgraded data-processing tools that will integrate the enhanced and new data collected. In-depth research is needed into the new data processing requirements for data fusion, and the real-time use of traffic data.

Besides applications using FCD, there is a range of applications that do not rely on FCD for operation and maintenance (pavement monitoring), safety and comfort (lateral collision avoidance) or enforcement/payment services. The first move from GPS to GALILEO-based services is most likely to be for navigation applications already making extensive use of GPS. In contrast, the use of GALILEO for ADAS applications, given the stated proposed performance

levels of GALILEO, will require complementary technologies. Other applications which currently use GPS are expected to switch to GALILEO, however, taking advantage of the greater accuracy, better coverage, enhanced reliability and integrity. These applications may include road maintenance management, pavement monitoring, roadworks location information, freight and fleet management, demand management, toll collection, road-user charging, congestion charging and access control. These applications are the first natural market for GALILEO and will certainly pave the way for extended or new services.

Current communication facilities will need to be upgraded since, for example, current mobile phone networks have a very low integrity for navigation signals, and emerging communication facilities should take the requirements into consideration.

Finally, there is a clear need for more in-depth research into the requirements for new data processing techniques for data fusion, and the real-time use of traffic data.

## 6 RISKS AND OBSTACLES

### 6.1 Introduction

Throughout the work done in this study we have identified certain risks to the deployment of GALILEO in road transport, which have been categorised in as follows.

- technical risks;
- commercial risks;
- political risks, and
- institutional risks.

The major risks for each category are summarised below.

### 6.2 Technical Risks

The major technical risks likely to have a high impact on the use of GALILEO in road transport are

- GALILEO failing to operate properly (e.g. signal availability, accuracy etc.);
- complementary technologies not being adequately developed, and
- GALILEO not being sufficiently protected against terrorist attacks or piracy.

The technical risks likely to have the greatest impact on the use of GALILEO in road transport mainly relate to associated technologies failing to provide the expected service at the required performance level.

This could, for example, apply to the software tools required to exploit GALILEO data. There is currently a lack of tools, due to the lack of research and development in this area. This could affect the quality of the final service provided. The likely consequence is that users will seek other alternatives, jeopardizing GALILEO as a whole. A similar situation could arise with digital maps: if their accuracy is not improved, the enhanced quality of GALILEO will not be visible to the final user, who will not see any improvement. In order to address these risks, R&D and specific targeted development must be undertaken to produce the tools necessary to make the most of GALILEO.

In addition, there is also the inherent risk of GALILEO failing to meet user expectations. This is a particular danger in places where today the existing GNSS does not always meet user expectations today:

- lack of coverage in urban areas;
- poor accuracy in certain zones, and
- lack of integrity.

At the stakeholder workshop held on 27 October 2004, attention was drawn to the high risk posed by the vulnerability of GALILEO and all GNSS systems in general. The danger of terrorist and activist attacks jamming/spoofing the system in particular could decrease the level of service which could be guaranteed. This would have a particularly high impact on Safety of Life applications and cause – apart from tragedies – a fall in the acceptance and use of GALILEO. These risks could be reduced by investing in jamming rejection technology and creating a European Radio Navigation Plan to define redundant technologies (e.g. GNSS and Loran-C).

Finally, expertise in how to use and develop GALILEO-based systems is a key to the success of all innovative system deployment. Stimulating the expert market through R&D projects can reduce this risk. This naturally cannot affect the quality of the service offered: care must be taken to ensure that GALILEO services live up to expectations.

To summarise, these risks mainly can be managed and reduced by:

- developing new standards / complementary technologies;
- monitoring the development and ensuring that GALILEO meets the specified performance targets;
- creating expertise among system manufacturers, and
- ensuring the system can resist jamming and spoofing, e.g. by introducing an additional terrestrial navigation system.

### **6.3 Commercial Risks**

The commercial risks of GALILEO mostly relate to the uptake of the services by the road transport market. Essentially this is the response of the demand side to the technology and the services offered by GALILEO. All commercial risks are borne by the institutions and companies which have a financial stake in the development and operation of the system. These are the ESA, the GJU, the EC, the operators of the system and, indirectly, the national governments who are the "owners" of the ESA and the GJU.

The main commercial risk and uncertainty is the acceptance of the system by consumers and commercial users. There are several factors that could lead to a low uptake in road transport, such as competition with GPS, the perceived usefulness of the system, the availability, quality and cost of receivers, etc. If, for a combination of those reasons, the uptake of GALILEO in road transport remains below a certain level, most services will be unprofitable to operate and the EU Member States and the EC will be faced both with the financial burden and the decision as to whether to operate certain services for non-commercial reasons.

The analysis of the commercial risks identifies a number of potential issues and measures to be considered for risk management. However, the scope for government / public intervention in the area of commercial risks is considerably lower than for the political, institutional and technical risks. Nonetheless some key issues emerge, most notably

- the quality of the GNSS enabled systems;
- the cost / price;
- the time frame for market introduction, and
- the GNSS marketing / information policy.

As regards the latter point in particular, the EC and the Member States can contribute to a successful introduction of the system. In terms of the quality, price and timing, the European and national institutions should develop a clear strategy and schedule for supporting the early development and availability of consumer products. This could include regular monitoring of the private sector to identify at an early stage where the bottlenecks are for the development of high-quality GNSS systems by 2008.

### **6.4 Political Risks**

The study identified four significant political risks whereby none of them has a high likelihood of becoming a serious obstacle to the successful deployment of GALILEO. Each of the risks is described in turn below.

The main conclusion from the analysis of the political risks is that the European institutions and the national governments have an important role to play in terms of mandating certain technologies for applications of public interest in the road transport sector. Many of those road transport applications, such as electronic road pricing, safety of life services and navigation systems may use GALILEO as positioning technology, although alternative and complementary technology may be applied as well.

Stimulating demand by mandating or subsidising may have a large impact on the market penetration of GALILEO in road transport, but would only be required if the expected benefits are insufficient or the market penetration of GALILEO falls short of expectations.

It will also be important to continue the co-operation with the US to ensure that GPS and GALILEO are compatible, complementary systems rather than competing ones.

## 6.5 Institutional Risks

The institutional risks are manifold and are mainly due to the complex nature of the interaction between national governments, European institutions, private companies and semi-public organisations. In many cases the risks are shared between several different players. The crucial point is therefore for each player, particularly the EC and the national governments, to develop fallback positions so that a failure of one of the private partners does not lead to a (temporary) collapse of the system.

The conclusions for minimising the institutional risks are closely related to the structure and setup of the Galileo Operating Company and its legal and contractual relationship with the EC, the ESA and the GJU. Arguably the most important role of the GALILEO system is to provide a reliable and continuous Open Service signal, free of charge. The institutional framework must guarantee delivery of this service regardless of any commercial or contractual problems of the GOC or any other involved party. While being important for road transport, this point is crucial for other applications, such as aviation.

Another conclusion stressed the importance of a comprehensive dissemination strategy to be developed prior to the launch of the system in 2008. This is important both in terms of raising awareness of the existence of GALILEO and in terms of counteracting the creation of a "Big Brother" image.

## 6.6 Summary

Various risks were identified in this study and their likelihood and possible impact on the use of GALILEO in road transport were estimated. In addition, recommendations were made as to how the risks could be managed. Risks were categorized as technical risks, commercial risks, political risks and institutional risks.

The major **technical** risks relate to GALILEO failing to meet the stated performance requirements and there being a lack of standards or complementary technologies, particularly with regard to traffic data fusion and ADAS. More research is needed on such techniques. An additional issue concerns the vulnerability of GALILEO to jamming and spoofing due to military interventions. This might necessitate the implementation of an additional terrestrial navigation system.

The major **commercial risks** relate to the acceptance of the system by consumers and commercial users. Several factors, such as the availability, quality and cost of receivers, or the perceived usefulness of the service, could affect the take-up of GALILEO in road transport. If the market penetration of GALILEO in road transport – identified by previous GALILEO

studies as one of the mass markets – remains below a certain level, the operation will not be profitable. The EC and Member States can contribute to the successful introduction of the system by adopting a proactive marketing and information policy on GALILEO. European and national institutions can take steps to ensure the high quality of GALILEO-based systems and services, affordable services and receivers and a timely market introduction.

The major **political risk** would be a failure to mandate GNSS technology in general and GALILEO in particular. This will be relevant if the take-up of GALILEO is less than expected. In this case additional incentives will be necessary, including possibly subsidising the use of GALILEO-based systems. It will also be important to continue the co-operation with the US to ensure that GPS and GALILEO are compatible systems that complement each other rather than compete.

The major **institutional risks** identified relate to the service provision, commitment and management of the GOC, the timely introduction of GALILEO and its acceptance by society. For the use of GALILEO in road transport, the most important factor is a reliable and continuous Open Service signal, free of charge. The institutional framework must guarantee delivery of this service. In order to reduce societal concerns about satellite tracking technology, a comprehensive dissemination strategy has to be developed prior to the launch of the system in 2008.

## 7 MARKET PENETRATION

This project reviews relevant studies of market penetration, the GALILEI study currently being the most up-to date.

The expected penetration levels of GALILEO/GNSS applications in road transport are the central factor for any policy consideration, as the benefits increase with the number of vehicles equipped through line-fitting or retrofitting. Most applications only become cost efficient with high market penetration, others are not even feasible below certain levels (e.g. real-time traffic monitoring or fleet management).

According to the GALILEI study (2003), the worldwide penetration for commercial vehicles and private cars will be 50% by 2020, and 60% in the European continent. The current study is more conservative in this respect in order to provide a robust estimate of the benefits. Our results suggest that the most likely scenario will be 40% penetration in Europe for the same year.

This market forecast, as well as other studies and input from an expert workshop held on 27 October 2004, formed the basis for the development of scenarios describing the estimated market penetration of GALILEO.

### 7.1 Development of Scenarios

Three market scenarios have been developed to illustrate the estimated market penetration. These include:

- a central scenario, which is the most likely;
- a more optimistic scenario, and
- a more pessimistic scenario.

In an additional regulation-focused scenario we have identified areas in which the introduction of regulatory measures could lead to a higher penetration of vehicles equipped with GALILEO-enabled receivers.

### 7.2 Central Scenario

The central scenario represents the most likely scenario. The key drivers and assumptions for this scenario are:

- GNSS is the standard for positioning (and timing) information for road transport.
- the demand for in-vehicle equipment with GNSS/GALILEO for passenger and freight transport is high.
- most new cars are being equipped with combined GPS/GALILEO receivers with a broad range of telematics services (e.g. navigation, information services).
- the after-sales market is small due to the high cost of retrofitting. This assumption was confirmed by the experts who attended the workshop on 27 October 2004, Brussels.
- electronic pricing for HGV will be introduced in most European countries by 2020. The use of GNSS technology is only one of three technological solutions considered by the EU directive for interoperable EFC systems.
- urban congestion pricing schemes will be introduced in major European capitals. The introduction of congestion pricing schemes for medium-sized cities is slow, however.

- GALILEO will not be used for ADAS before 2015, as ADAS systems still need further development and as GALILEO will only meet the requirements for these applications if used in conjunction with complementary technology.

The maximum penetration for the use of GALILEO by in-vehicle equipment will be around 40% by the year 2020 .

### 7.3 Optimistic scenario

The key drivers and assumptions for the optimistic scenario are:

- GNSS is the standard for positioning (and timing) information for road transport.
- the demand for in-vehicle equipment with GNSS/GALILEO for passenger and freight transport is very high due to equipment manufacturers pushing market development by implementing aggressive telematics strategies and producing affordable products for mass-market vehicles.
- most newer cars are fitted with combined GPS/GALILEO receivers with a broad range of telematics services (e.g. navigation, information services).
- retrofitting is widely accepted by users.
- electronic pricing for HGV will be introduced in most European countries by 2020. The use of GNSS technology is the only technological solution considered by the EU Directive for interoperable EFC systems.
- urban road pricing schemes are being introduced all over Europe for large and medium-sized cities.
- the demand for ADAS and safety systems is very high. Most of these systems make use of GNSS/GALILEO positioning technology. However, ADAS will not be used before 2015.

The maximum penetration for the use of GALILEO by in-vehicle equipment will reach 60% by the year 2020.

### 7.4 Pessimistic Scenario

The key drivers and assumptions for the pessimistic scenario are mainly based on the risks and obstacles identified in the study:

- UMTS / G3 or any other alternative technology will be the standard for positioning.
- sabotage by terrorists and activists of the vulnerable GNSS technology will reduce its reliability and lead to a high number of system outages. The service will therefore no longer be guaranteed and SoL applications, road pricing and other applications will be endangered.
- the use of a terrestrial system (e.g. Loran-C), which is more difficult to jam/spoof than GNSS, together with GNSS positioning systems, as a means of reducing the vulnerability of GNSS to jamming and spoofing, requires the deployment of dual mode receivers, which may be more expensive than dedicated GALILEO/GNSS receivers. This means that the cost to the end user would be higher which could reduce the expected demand for combined GNSS/GALILEO receivers.
- there will be no reliable software available for GALILEO-based ADAS applications.
- low demand for GNSS for in-vehicle telematics; GNSS remains a high-end commodity for private vehicles.
- low demand and low acceptance for retrofitting vehicles delays the market take-up of GALILEO.
- perceived as "Big Brother" monitoring by the public, therefore little political support.

The maximum penetration for the use of GALILEO by in-vehicle equipment will reach 20% by the year 2020.

## 7.5 GALILEO Market Penetration 2008-2020 in the EU-25

For the development of scenarios we have focused on central measures for the applications likely to have the same level of penetration through the same in-vehicle unit and have grouped them as follows:

Measures	Applications
Road Monitoring	Floating Car Data
Traffic Management and Control	
Internal Services for Road Operators	
Freight and Fleet Management	Freight and Fleet Management
Incident and Emergency Handling	Emergency caller location combined with pay-as-you go insurance policy
Safety (pay-as-you-go insurance)	
Traveller Information Services	(Dynamic) Route Navigation
Electronic Payment Systems	Road Pricing
Intelligent Vehicles	ADAS
Parking Management	Guidance to the nearest car park as addition to Dynamic Route Navigation

### 7.5.1 Floating Car Data

Fitting vehicles with a receiver able to collect floating car data will mainly support the following applications:

- Road monitoring;
- Traffic Management and Control, and
- Internal Services for Road Operators.

The estimated take-up of GALILEO in these applications between 2008-2020 is shown in Figure 6.

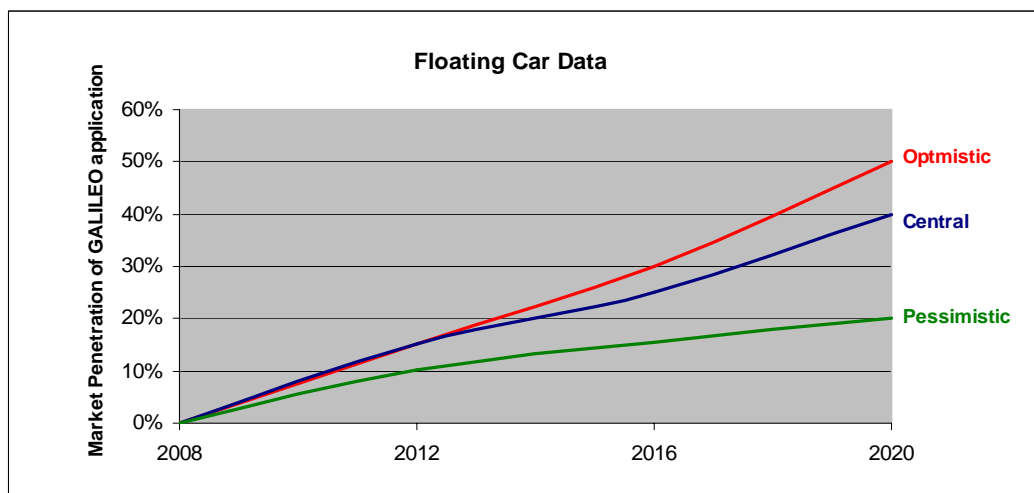


Figure 6: Estimated market penetration of GALILEO for all vehicles in the EU-25 for applications benefiting from the collection of FCD

A GALILEO-enabled receiver can be installed for customer and security reasons. FCD is already in use with GPS, but does not yet have significant market penetration.

## 7.5.2 Freight and Fleet Management

The use of GNSS/GALILEO for freight and fleet management only considers freight transport, which has used GPS for several years. As optimising freight and fleet management helps reduce costs, it is expected that GNSS/GALILEO will be increasingly deployed, in particular for large fleets. Receivers for freight and fleet management can be retrofitted in commercial vehicles.

The estimated take-up of GALILEO in freight and fleet management over the time between 2008-2020 is shown in Figure 7.

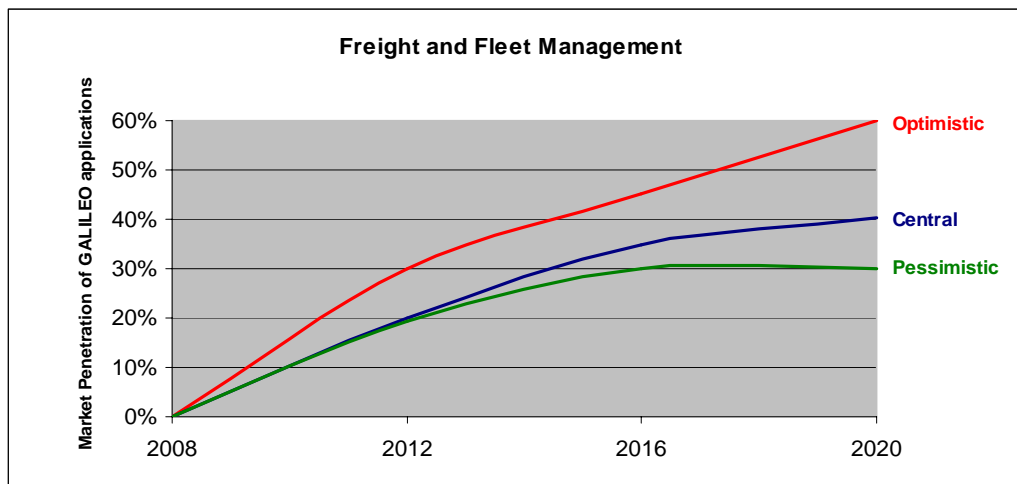


Figure 7: Estimated market penetration of GALILEO for freight vehicles in the EU-25 for Freight and Fleet Management

## 7.5.3 Emergency Caller Location + Pay-as-you-go insurance

Fitting vehicles with a GALILEO-enabled receiver able to provide emergency caller location and to support pay-as-you-go insurance will mainly support the following applications:

- Incident and Emergency Management, and
- Safety.

Where emergency location notification systems supported by GNSS positioning are to be linked to other systems in the vehicle, e.g. automatic triggering of the airbag, they must be fitted into new vehicles. There will therefore only be limited scope for this in vehicles retrofitted with GALILEO-enabled receivers. Mandating the provision of automatic emergency caller location could accelerate the market penetration of GNSS technology.

Pay-as-you-go insurance using GPS tracking is already available in several countries, e.g. from AXA insurance in the Republic of Ireland and Norwich Union in the UK. If users can make considerable savings with such insurance, market penetration may reach a significant level by the year 2020.

The estimated take-up of GALILEO for incident and emergency management (emergency caller location) and safety (pay-as-you-go insurance) between 2008-2020 is shown in Figure 8.

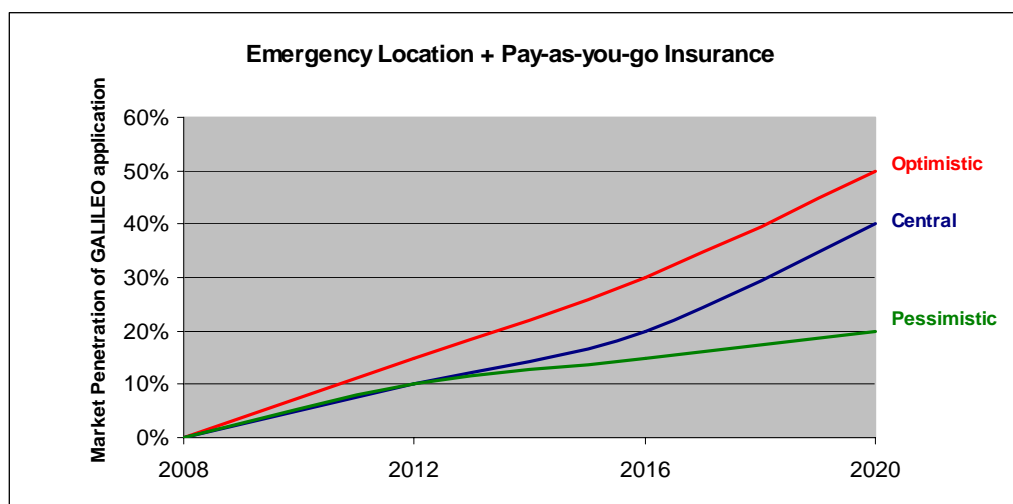


Figure 8: Estimated market penetration of GALILEO for all vehicles in the EU-25 for Incident and Emergency Management and Pay-as-you-go Insurance

#### 7.5.4 Road Pricing

The introduction of road pricing is policy led at local (for urban congestion pricing schemes) and/or national level (for inter-urban road pricing for HGV and/or passenger cars). Different technologies can be used, for instance DSRC-technology, requiring significant investment in roadside equipment, or GNSS technology, requiring less roadside equipment. The use of GNSS technology means that pricing strategies can be more flexible due to the reduced need for fixed roadside infrastructure. For instance, urban congestion pricing zones can be defined more flexibly depending on the time of day, environmental parameters etc.

After overcoming initial problems GNSS technology was introduced for distance-related lorry road-user charging on 1 January 2005 in Germany. If a similar tolling system were to be introduced for the passenger car sector in a few other European countries, it would be a significant breakthrough for all the other road transport applications using GNSS receivers.

The estimated take-up of GALILEO for road pricing between 2008-2020 is shown in Figure 9. Each scenario has considered the introduction of pricing schemes as summarised below:

	Lorry road user charging	Urban congestion charging schemes	Inter-urban charging schemes
Optimistic scenario	✓	✓	✓
Central scenario	✓	✓	
Pessimistic scenario	✓		

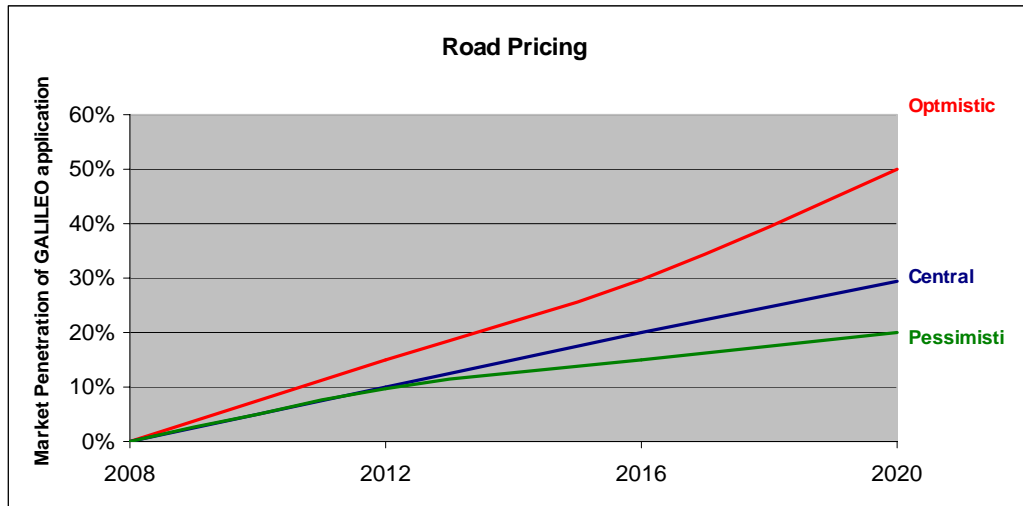


Figure 9: Estimated market penetration of GALILEO for all vehicles in the EU-25 for Electronic Pricing Systems

### 7.5.5 ADAS

Although some vehicles are already being equipped with ADAS (e.g. lane departure warning assistance for the Citroen C4), the use of GALILEO for these systems is unlikely to be realized before 2012 because GALILEO would need complementary technology to meet the requirements of ADAS systems.

ADAS systems cannot be retrofitted, as they are linked to other vehicle functions. Therefore, the use of GALILEO for ADAS can only be introduced by line-fitting vehicles. Market penetration is estimated to accelerate after 2012, with significant take-up between 2016-2020.

The estimated take-up of GALILEO for ADAS for all vehicles in the EU-25 between 2008-2020 is shown in Figure 10.

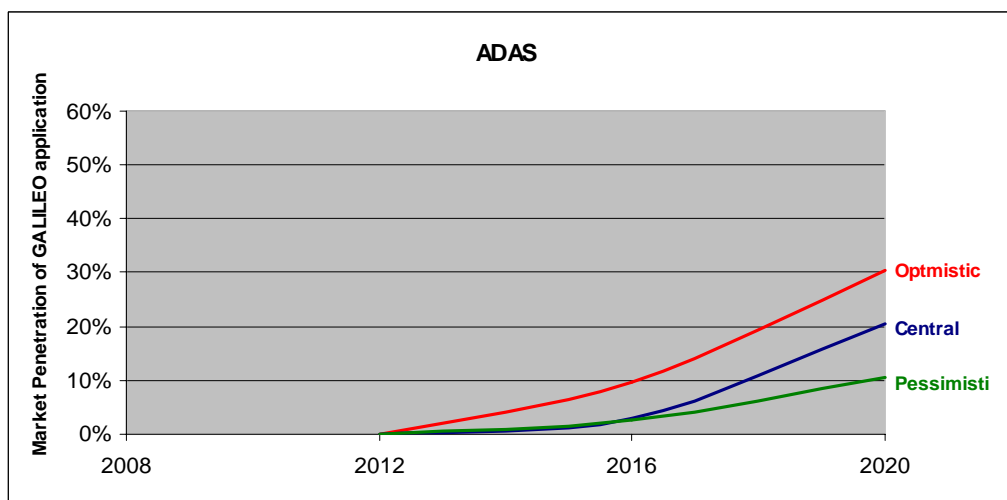


Figure 10: Estimated market penetration of GALILEO for all vehicles in the EU-25 for ADAS

### 7.5.6 (Dynamic) Route Guidance and Parking Management

Fitting vehicles with a GALILEO-enabled receiver for (dynamic) route guidance will support the following applications:

- Traveller Information Services, and – as a subset –
- Parking Management.

Satellite navigation is already line-fitted in some vehicles. Traditionally being a feature mainly of luxury cars, the trend is moving towards satellite navigation systems becoming standard equipment for the mass market.

Guidance to the nearest car-park as a central element of parking management is added as a subset of route guidance. It will have a lower market penetration as it is only relevant for drivers in conurbations, and not all car-parks will participate.

The estimated penetration of GALILEO for all vehicles in the EU-25 for (dynamic) route guidance (Traveller Information Services) and parking management between 2008-2020 is shown in Figure 11 and Figure 12.

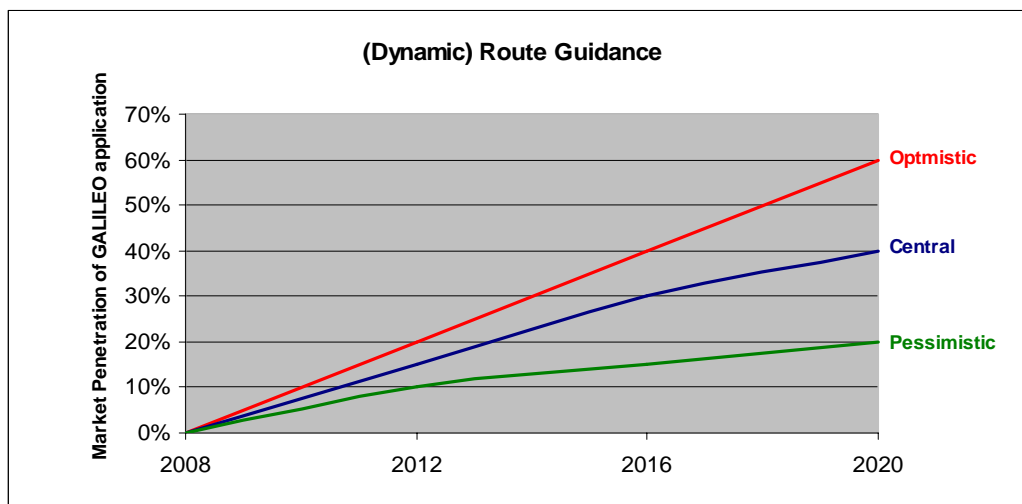


Figure 11: Estimated market penetration of GALILEO for all vehicles in the EU-25 for Traveller Information Services

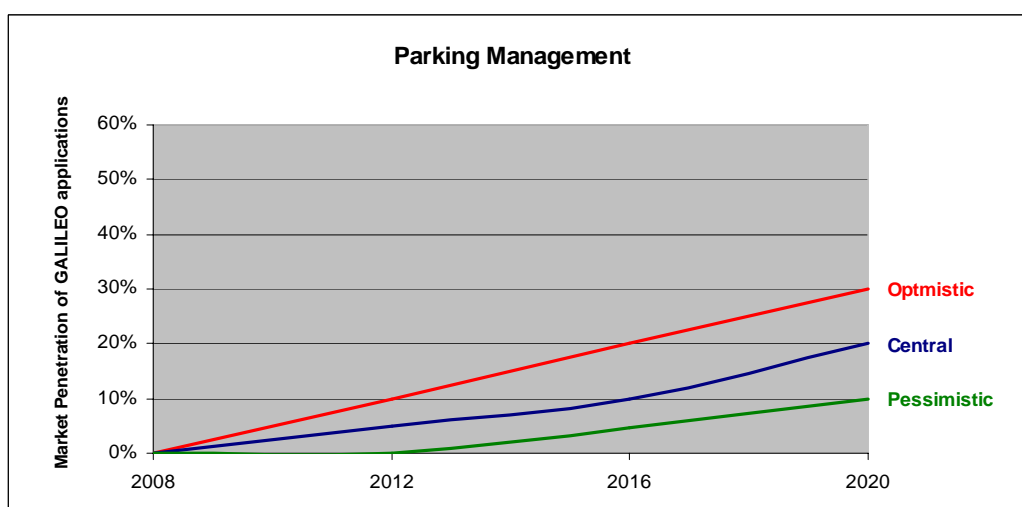


Figure 12: Estimated market penetration of GALILEO for all vehicles in the EU-25 for Parking Management (as a subset of Traveller Information Services)

## 7.6 Influencing Market Penetration by Additional Legislation

In addition to the market scenarios, we have identified areas in which mandating could accelerate the market penetration of GALILEO in road transport. This regulation scenario has to be seen as an extension of the central market scenario.

We have focused on applications for which high potential benefits for safety, congestion and fuel consumption have been identified, in order to maximise these benefits. These are:

- Traveller Information Systems;
- Incident and Emergency Management;
- Safety (pay-as-you-go insurance);
- Intelligent Vehicles, and
- Electronic Pricing Systems.

### 7.6.1 Traveller Information Systems

Governments are already investing heavily in studies and pilot projects to investigate and demonstrate in-vehicle technologies for disseminating traffic information and traffic management strategies. Some studies have developed scenarios in which roadside infrastructure is replaced by in-vehicle information systems able to receive traffic management information.

We consider it unlikely that the technology will be mandated. However, legislation incentivising or subsidising in-vehicle equipment might be introduced to support these applications and the market penetration of GALILEO might therefore increase.

We have estimated that the potential increase in GALILEO market penetration – depending on the incentives and subsidies – is an additional 10% of all vehicles in the EU-25 by the year 2020 compared to the central scenario. The estimated difference between the market penetrations under the market-led scenarios and that under the additional legislation scenario for 2008-2020 is shown in Figure 13.

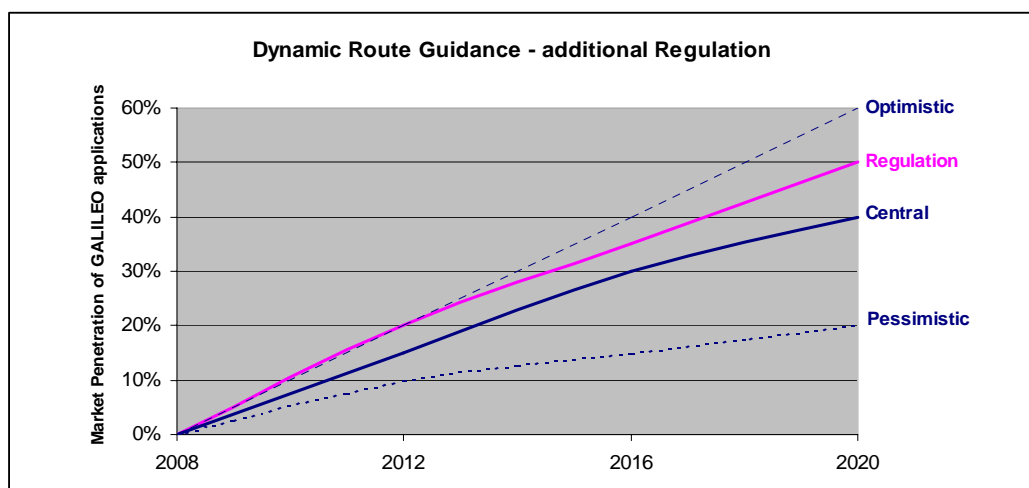


Figure 13: Estimated market penetration of GALILEO for Traveller Information Systems in the additional regulation scenario compared to the market-led scenarios

## 7.6.2 Incident and Emergency Management and Safety (pay-as-you-go insurance)

Current legislation on emergency caller location (EU Directive 2002/22/EC) only considers the provision of emergency caller location information by telecommunication operators where “technically feasible”.

The introduction of legislation mandating GNSS for in-vehicle equipment for the provision of automatic emergency location information could increase the market penetration of GALILEO. We estimate that the potential increase in penetration for the year 2020 is an additional 20% of all vehicles in the EU-25 compared to the central scenario.

The difference between the market penetrations under the market led scenarios and that under the additional legislation scenario for 2008-2020 is shown in Figure 14.

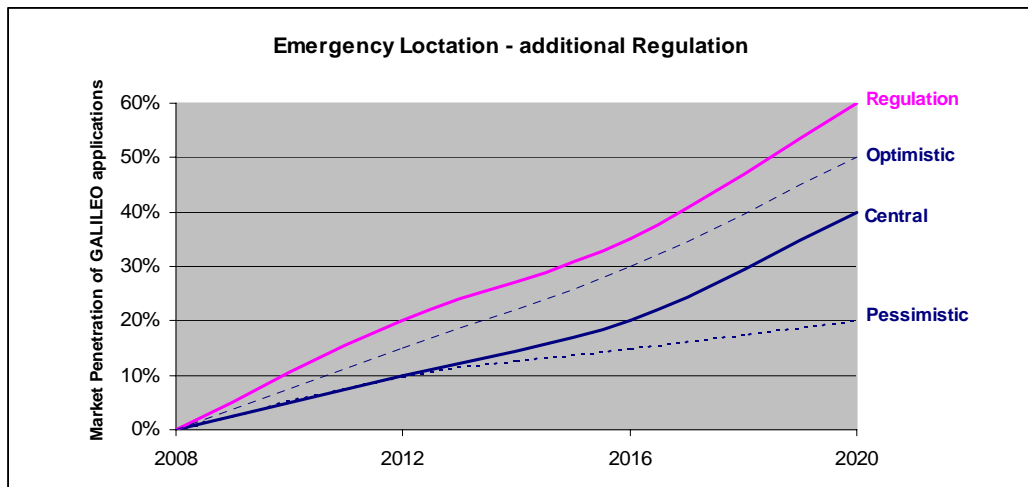


Figure 14: Estimated market penetration of GALILEO for all vehicles in the EU-25 for Incident and Emergency Management for the additional regulation scenario as compared to the market-led scenarios.

## 7.6.3 Intelligent Vehicles

Higher traffic volumes and the associated higher accident and congestion costs may result in ADAS becoming mandatory in vehicles. A less strong intervention may be subsidizing or incentivising ADAS e.g. by reducing taxes. However, GALILEO would only be one sensor and might not be used in all the ADAS products being developed.

Therefore, a small increase in market penetration of about 10% of all vehicles in the EU-25 in the regulation scenario as compared to the central market scenario is estimated for the year 2020, but an accelerated take-up is predicted after 2020.

The estimated difference between the market penetrations under the market-led scenarios and that under the additional legislation scenario for 2008-2020 is shown in Figure 15.

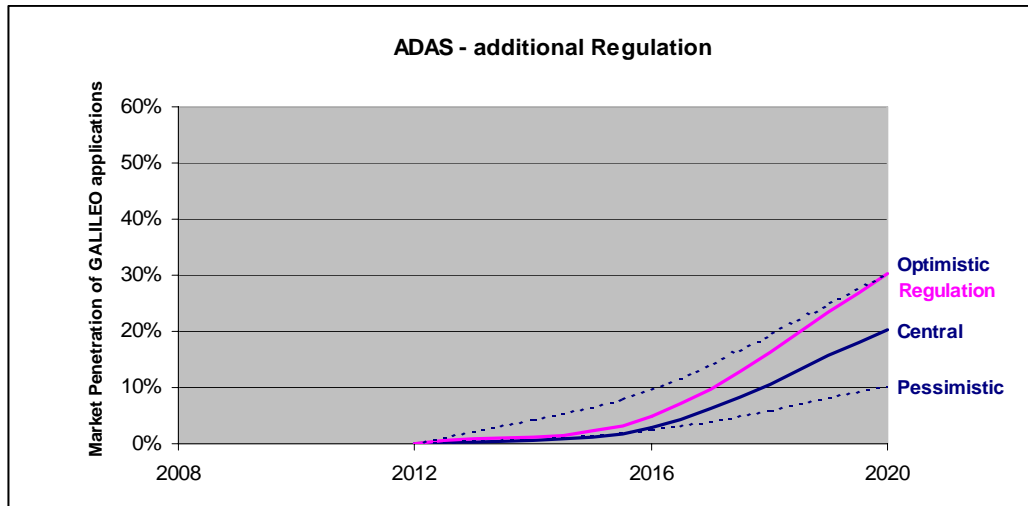


Figure 15: Estimated market penetration of GALILEO for all vehicles in the EU-25 for Intelligent Vehicles for the additional regulation scenario as compared to the market-led scenarios.

#### 7.6.4 Electronic Payment Systems

Following the introduction of urban congestion charging schemes in London, several other European cities (e.g. Stockholm) are carrying out field trials or studies investigating the effects of the introduction of road pricing schemes.

For freight transport, several European countries have introduced or are preparing the introduction of pricing schemes for HGVs. The successful launch of these systems and the increasing need for funding to maintain road infrastructure has given rise to political discussions, for instance in Germany, on whether to introduce distance-related charging for passenger vehicles as well.

We estimate that additional regulation in the area of Electronic Payment Systems, e.g. mandating GNSS technology for urban or distance-related pricing schemes for passenger cars, which would go beyond the current EU Directive, would result in the highest potential additional market penetration for GALILEO in road transport.

The estimated difference between the market penetrations for all vehicles in the EU-25 under the market-led scenarios and that under the additional legislation scenario for 2008-2020 is shown in Figure 16. However, the real figures, especially in the early years after the introduction of GALILEO, will largely depend on how many countries decide to introduce electronic pricing systems and how quickly they become operational.

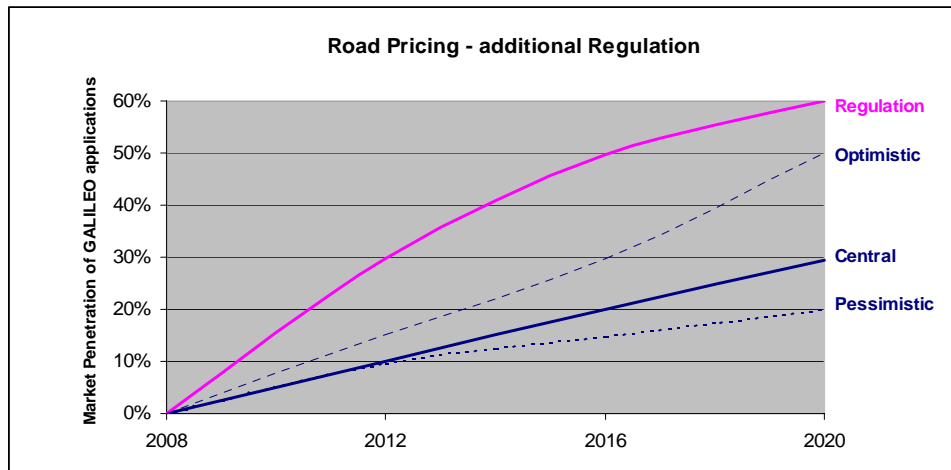


Figure 16: Estimated market penetration of GALILEO for Electronic Pricing Systems for the additional regulation scenario as compared to the market-led scenarios

With the widespread use of GALILEO for road pricing, other applications would also be supported, thus helping to achieve the benefits of those applications for road safety and reduced congestion and fuel consumption.

## 7.7 Summary

The scenarios represent the estimated minimum and maximum rates at vehicles can be expected to be fitted with GALILEO-enabled equipment.

Three market scenarios have been developed:

- a central scenario (most likely) - expected penetration of GALILEO is around 40% of all vehicles in the EU-25;
- an optimistic scenario - expected penetration of GALILEO is around 60% of all vehicles in the EU-25;
- a pessimistic scenario - expected penetration of GALILEO is around 20% of all vehicles in the EU-25.

In addition to the market scenarios we have highlighted applications for which legislation mandating or incentivising the use of GALILEO for in-vehicle equipment could result in higher penetration. These are mainly:

- Traveller Information Services – particularly regarding the reception of traffic management measures by in-vehicle receivers. By 2020 the market penetration could be an additional 10% of all vehicles in the EU-25 compared to the central scenario;
- Incident and Emergency Management – particularly mandating GNSS for emergency caller-location information. The market penetration by 2020 could be an additional 20% of all vehicles in the EU-25 by 2020 compared to the central scenario;
- Intelligent Vehicles – particularly initially subsidising and then mandating GNSS for Advanced Driver Assistance Systems (ADAS). The market penetration by 2020 could be an additional 10% of all vehicles in the EU-25 compared to the central scenario, with a much higher take-up after 2020;
- Electronic Payment Systems – particularly introducing road pricing schemes on a large scale and mandating GNSS. In the light of the cost of infrastructure maintenance and growing environmental pressure, the introduction of Electronic Pricing Systems seems to be gaining increasing political acceptance. We estimate that the highest potential market

penetration by 2020 could be an additional 30% of all vehicles in the EU-25 compared to the central scenario.

The penetration of vehicles equipped with GALILEO receivers may vary by country depending on user-demand and the level of regulation. The applications for which legislation mandating or incentivising the use of GALILEO has been identified as being useful are independent of each other.

We have estimated a more conservative market penetration for GALILEO than the market forecasts reviewed within this project, in order to provide robust estimates of the benefits of GALILEO in road transport (see Chapter 8, Evaluation of Impacts).

## 8 EVALUATION OF IMPACTS

This section assesses the impacts of the GALILEO system on road transport. The figures presented in this section are the results of the analyses and calculations made in the framework of this study,<sup>8</sup> and are based on the scenarios presented in the previous section.

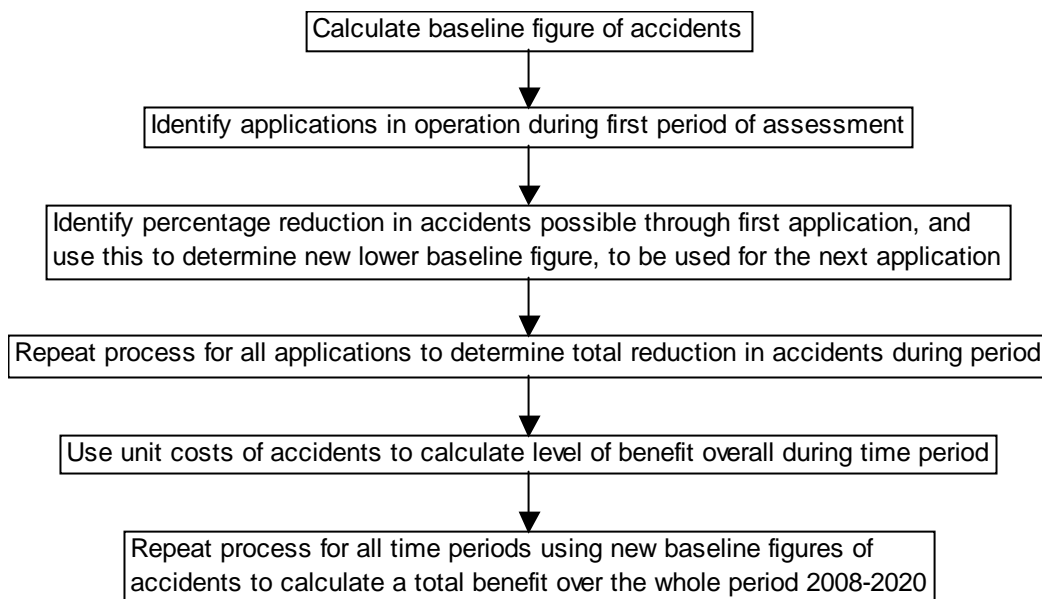
The methodology developed to assess the impacts focussed on the following types of benefit:

- improvements in safety;
- reductions in congestion; and
- reductions in unnecessary fuel usage.

These are all areas in which a monetary value can be attributed to the benefit. Other beneficial impacts including reductions in noise, air pollution and stress have not been quantified, as no agreement has yet been reached at national or European level on common monetary values. This means that the total benefits of GALILEO are a conservative estimate.

We have estimated the potential benefits of the use of GALILEO in road transport based on existing evaluation results from systems being used for the applications identified in Chapter 4 and our own professional experience. Absolute benefits have also been determined based on the impact of scenarios and an assessment of the financial advantage of each type of benefit.

The following diagram shows the procedure applied, using accident reduction as an example:



The benefits have been determined in a first step for the EU-25 countries for the period 2008-2020 as:

- total absolute benefits for road transport;
- estimate of absolute freight-specific benefits; and
- estimated distribution of the benefits across European regions.

<sup>8</sup> For details on the methodology and the calculation of the results please see Deliverable D3 of the GREAT study.

## 8.1 Absolute Benefits in the EU-25

The total benefits of GALILEO are the difference between the total costs of each indicator remaining after all benefits attained by GALILEO-based applications have been taken into account (for each time period) and the ‘do nothing’ costs. The figures presented in this section are the results of the analyses and calculations made in the framework of this study<sup>9</sup>.

Figure 17 lists the benefits of GALILEO-based applications in terms of reducing accidents, congestion and fuel costs for each scenario for 2008-2020. Figure 18 illustrates the savings per vehicle in the EU-25 for the same period.

Indicator	Scenario			
	Pessimistic	Central	Optimistic	Increased Regulation
Reduced accident costs	€95bn	€141bn	€198bn	€202bn
Reduced congestion costs	€49bn	€78bn	€109bn	€112bn
Reduced fuel costs	€16bn	€25bn	€35bn	€36bn
<b>Total cost saving</b>	<b>€160bn</b>	<b>€244bn</b>	<b>€342bn</b>	<b>€350bn</b>

Figure 17: Total absolute benefits of GALILEO for road transport in Europe for 2008-2020 (rounded to full € billion)

Indicator	Scenario			
	Pessimistic	Central	Optimistic	Increased Regulation
Reduced accident costs	€460	€680	€960	€980
Reduced congestion costs	€240	€380	€530	€540
Reduced fuel costs	€80	€120	€170	€170
<b>Total cost saving</b>	<b>€780</b>	<b>€1,180</b>	<b>€1,660</b>	<b>€1,690</b>

Figure 18: Total absolute benefits of GALILEO for road transport in Europe per vehicle for 2008-2020 (rounded to €10)

The absolute benefits for road transport in the EU-25 for the period 2008-2020 vary from €160bn (pessimistic scenario) to €350bn (increased regulation scenario) as shown in Figure 18. The scenario with the highest levels of benefits is thus the increased regulation scenario. Compared to the central scenario, benefits of an extra €1bn in accident cost savings, €34bn in congestion savings and €11bn in fuel cost savings can be achieved by introducing appropriate regulation; a total saving of €106bn. The savings per car vary from €780 (pessimistic scenario) to €1690 (increased regulation scenario) for the same period (see Figure 18 below).

The value of the benefits experienced in different countries within the EU will not be directly proportional to their populations or vehicle fleets. Some parts of the EU will experience comparatively higher benefits than expected, and vice versa, due to factors prevalent in that region. For example, a region with a higher than (EU) average accident rate and more congestion would see greater benefits than one which had a low accident rate and comparatively little congestion. Similarly, a region with a higher and faster take-up of GALILEO-based applications would logically expect a higher level of benefits.

The 25 countries in the EU have been split into 5 groups, depending on underlying cultural and economic characteristics. These 5 groups are then judged as to the relative likely benefits compared to the EU average, based on 5 variables: accident rate, congestion level, fuel costs,

<sup>9</sup> For details of the methodology and the calculation of the results please see Deliverable D3 of the GREAT study.

level of penetration of GALILEO-based applications and rate of deployment of GALILEO-based applications.

The five groups of European Member States are as follows:

1. Central Europe (comprising France, Germany, Austria and the Benelux Countries)
2. Eastern Europe (comprising the Czech Republic, Slovakia, Poland, Latvia, Lithuania, Estonia, Hungary and Slovenia)
3. Scandinavia (comprising Sweden, Finland and Denmark)
4. Southern Europe (comprising Spain, Portugal, Italy, Greece, Malta and Cyprus)
5. The UK and Ireland

Figure 19 illustrates subjectively the expected relative benefits for each group of countries compared to the EU as a whole, with the < and > arrows in each column describing rates for each variable that are less than or greater than the EU average.

Region	Accident Rate	Congestion	Cost of Fuel	Level of Penetration	Rate of Deployment	Relative Potential (Compared to EU Average)	Total Number of Vehicles
Central Europe	=	>	=	>	>	120%	89400000
Eastern Europe	>>	<<	<<	<<	<<	50%	20700000
Scandinavia	<<	<<	>	>	>	90%	8100000
Southern Europe	>>	>	<	<<	<<	70%	61300000
UK and Ireland	<<	>>	>>	>	>	130%	27000000

Figure 19: Factors affecting relative benefits of GALILEO within regions of Europe

Regarding the estimated distribution of benefits across Europe, the greatest benefits are expected to be felt in central Europe, the UK and Ireland, whereas they will be less great in Scandinavia and Southern Europe. The least benefits are expected to be felt in Eastern Europe.

## 8.2 Estimate of Freight-Specific Benefits

A percentage of the benefits of each GALILEO-based application will go to the freight industry and it is useful to estimate what level of benefits could be achieved, depending on the scenario being examined. The following table shows the estimated freight-specific benefits (savings) for the EU-25 for each scenario for the 3 different indicators between 2008 and 2020 (rounded to full €bn):

Indicator	Scenario			
	Pessimistic	Central	Optimistic	Increased Regulation
Reduced accident costs	€27bn	€36bn	€50bn	€43bn
Reduced congestion costs	€8bn	€13bn	€17bn	€16bn
Reduced fuel costs	€3bn	€4bn	€6bn	€5bn
<b>Total cost saving</b>	<b>€38bn</b>	<b>€53bn</b>	<b>€73bn</b>	<b>€64bn</b>

Figure 20: Total potential benefits for freight for GALILEO-based applications for 2008-2020 (rounded to full €bn) in the EU-25

The total benefit to freight transport is around 20% of the total benefit to the EU-25 between 2008-2020, depending on the market penetration scenario.

### 8.3 Estimate of Worldwide Benefits

Applying the process used for the EU to the rest of the world, the following (qualitative) table can be produced:

Region	Accident Rate	Congestion	Cost of Fuel	Level of Penetration	Rate of Deployment	Total Number of Vehicles (2004)*	Annual Increase in Vehicle Usage	Total Vehicles in 2014 (Midpoint)	Relative Potential (Compared to EU Average)	Benefits in Ratio to European Benefits
Europe	=	=	=	=	=	193000000	2%	229000000	100%	1
North America	<	=	<	=	=	187000000	4%	267000000	80%	0.930
Central and Southern America	>	<<	<	<	<<	273000000	-5%	159000000	50%	0.035
Africa	>>	<<	<<	<<	<<	87500000	2%	110000000	40%	0.019
Pacific Rim (inc. China)	>	>	>	=	=	105000000	0%	102000000	130%	0.576
Middle East	>	<	<<	<	<	142000000	4%	215000000	60%	0.056
Indian Subcontinent	>>	>	<	<<	<<	100000000	4%	148000000	80%	0.052
Russia and Central Asia	>>	<<	<	<<	<<	100000000	0%	100000000	50%	0.022

Figure 21: Factors affecting the relative benefits of GALILEO worldwide

\*Assuming a comparable increase in the number of vehicles, doubling the vehicles purchased between 1997-2001 gives an estimate of the total purchased between 1995-2004, thus giving a figure for the total number of vehicles on the road in 2004.

The ratios in the final column give an indication of the relative benefits in each region compared to those in Europe. As all these ratios are less than 1, this implies that Europe will see higher levels of benefit than any other region (marginally higher than those in North America). Adding all the benefit ratios in this final column gives an estimate of the total worldwide benefits. The total ratio is approximately 2.69:1, so multiplying European figures by a factor of 2.69 gives an indication of total worldwide benefits.

To validate the accuracy of this ratio, a rough 'sense check' can be used, i.e. comparing the number of road vehicles in Europe fitted with GALILEO-enabled devices to the number in the rest of the world.

Previous market forecasts, most notably the GALILEI study, consider the likely penetration of GALILEO into the European and world markets for GNSS devices in vehicles up to 2020. This provides some insight into the relative benefits achievable from GALILEO services at European and global level. The GALILEI study suggests there will be approximately 450 million vehicles (including private cars and commercial vehicles) equipped with GALILEO-enabled receivers by 2020, of which approximately 150 million will be within the EU. This suggests that total world benefits could be around three times those in the EU.

## 9 POLICY ISSUES

This chapter deals with the policy issues related to the use of GALILEO in road transport. It covers three main aspects:

- the contribution of GALILEO to EU policy;
- policy measures to accelerate the introduction of GALILEO, and
- policy recommendations.

### 9.1 The contribution of GALILEO to EU transport policy

The contribution of GALILEO to EU transport policy objectives will largely depend on the penetration rates of the various applications (see sections 4.2. and 4.3. above). Nonetheless, even with the comparatively low but robust penetration rates put forward by this study, the potential contribution of GAL

The following table gives an estimate of total global benefits from GALILEO-based applications between 2008-2020. It is based on Table 9, with European benefits converted into global benefits using the 2.69 conversion factor.

Indicator	Scenario			
	Pessimistic	Central	Optimistic	Increased Regulation
Reduced accident costs	€256bn	€379bn	€533bn	€543bn
Reduced congestion costs	€132bn	€210bn	€293bn	€301bn
Reduced fuel costs	€43bn	€67bn	€94bn	€97bn
<b>Total cost saving</b>	<b>€431bn</b>	<b>€656bn</b>	<b>€920bn</b>	<b>€941bn</b>

Figure 22: Total estimated absolute worldwide benefits of GALILEO for road transport for 2008-2020

## 9.2 Summary

The absolute benefits for road transport in the EU-25 for the period 2008-2020 vary from €160bn (pessimistic scenario) to €350bn (increased regulation scenario) as shown in figure 15. This means that the savings per car vary from €780 (pessimistic scenario) to €1690 (increased regulation scenario) for the same period (see figure 16 below).

Regarding the estimated distribution of benefits across Europe, the greatest benefits are expected to be felt in central Europe, the UK and Ireland, whereas they will be less great in Scandinavia and Southern Europe. The least benefits are expected to be felt in Eastern Europe. Freight-specific benefits have been estimated at around 20% of the total benefits in the EU-25, varying from €38bn (pessimistic scenario) to €64bn (increased regulation scenario) for the period 2008-2020.

For the period 2008-2020 the worldwide benefits vary from €431bn (pessimistic scenario) to €941bn (increased regulation scenario). The greatest benefits are expected to be felt in the Pacific Rim and Europe, whereas they will be less great in North America, the Indian Subcontinent and the Middle East. The least benefits are expected to be felt in Central and South America, Africa and Russia and Central Asia.

The results presented in this study are sensitive to the different factors and assumptions described in this report. However, they represent the best estimate for the impact of GALILEO on road transport which can be given within the scope of this study. Overall, they show that GALILEO has significant benefits, particularly for improving road safety. The use of GALILEO in road transport can therefore strongly support EC policy for improving road safety. Further benefits can also be expected, such as reduced congestion and fuel consumption.

ILEO is expected to be considerable. The following sections are organised according to the policy priorities of the European Commission in its White Paper on the European Transport Policy (see section 3 above). Special consideration is given to the role and impact of the different GALILEO applications in road transport and their potential for contributing to certain policy objectives.

### **9.2.1 Improving quality in the road sector**

Several EU policy documents highlight the fact that poor quality in the road sector is primarily due to a existing rules and regulations not being properly enforced rather than to insufficient legislation. The GALILEO system can make a significant contribution to solving this problem. In theory, the use of satellite navigation in conjunction with modern data communication and processing technologies could eliminate many of the problems associated with the EU policy objective of improving quality in the road sector and looking into ways of reducing congestion and fuel consumption. More specifically, the widespread use of GNSS receivers in road transport vehicles would be a very cost-effective way of increasing the number of checks on compliance with driving times and rest periods and would facilitate the systematic exchange of information between Member States. In comparison with the use of digital tachographs, GNSS systems are less easy for road transport operators to manipulate.

According to the European Commission's 2001 White Paper, the effective monitoring of road transport should also support an economically sound restructuring of the European road freight transport industry and balance the competitive advantage over other modes of transport.

The two main obstacles to realizing these potential benefits are the expected development of penetration rates and privacy concerns. The former problem can only be solved by legally requiring a 100% penetration rate with GNSS-enabled equipment for lorries in Europe. Otherwise the competitive disadvantage of those vehicles equipped with GNSS and thus regularly monitored by the police would cause legal problems and provide an incentive for not using the system.

Regarding the privacy concerns, it is important to distinguish between commercial freight transport and private passenger transport. While privacy is a vital consideration in passenger transport this may not be the case for commercial operations. As the EU policy objective of 'improving quality' is primarily targeted at road freight transport, privacy concerns do not appear to pose a significant problem.

### **9.2.2 Unblocking major routes**

The GALILEO system will make a major contribution to one of the policy measures demanded in the relevant EU documents, namely traffic management. The issue of penetration rates is not as crucial for traffic management as for most other policy measures. Any significant penetration rate and vehicles travelling a high mileage will provide modern traffic management systems with sufficient real-time data to increase the efficiency of infrastructure use.

A prerequisite for realizing the potential benefits for traffic management will be the ability of policy makers to deal with privacy concerns. In contrast to infrastructure charging or the enforcement of traffic rules, the collection of data for traffic management purposes can be used anonymously. The challenge for policy makers will be to provide a credible legal framework for data protection, which convinces at least a large part of the population that private data will not be used in any way other than for the purpose of anonymous traffic management.

### **9.2.3 Improving road safety**

There are two ways in which the GALILEO system can contribute to the policy objective of improving road safety. Firstly, it can help to enforce traffic rules, such as speed limits. This could well be realised for road freight transport where constant monitoring does not raise major problems, either in terms of privacy or in terms of the costs of requiring all vehicles to be equipped with GNSS-enabled on-board units (see also section 5.2 above). For private cars, however, this contribution to road safety is unlikely to be realised in the near future.

Secondly, the GALILEO system paves the way for a number of new road transport applications which could help to improve road safety. Examples are ADAS and emergency management applications. Those applications do not require a 100% penetration rate to be feasible. Significant road safety improvements can be achieved, even applying the GREAT project's conservative penetration rates, as shown in Chapter 4. The overall road safety benefit increases more or less proportionally with the penetration rate. Privacy concerns also seem to be less of a problem for those applications because they do not operate on the basis of constantly monitoring the movement of specific vehicles on a central computer. Rather they communicate location information on demand to specific decentralised systems.

#### **9.2.4 Effective charging for transport**

Satellite navigation systems offer a vital contribution to effective infrastructure charging schemes. The big advantage of using those systems is that more flexible pricing policies can be applied and less roadside infrastructure is required.

Apart from privacy concerns, recent EU legislation suggests that the use of satellite navigation technology will not be mandatory for infrastructure charging in Europe in the medium term (see section 3.3. above).

Nonetheless, Member States which have not yet introduced electronic infrastructure charging are increasingly likely to opt for satellite-navigation-based systems, especially after the recent successful launch of the German system. For these countries, GALILEO will be a major factor in establishing effective and cost-efficient charging schemes.

A precondition for this positive contribution of GALILEO is the timely launching of operations in 2008 and the early availability of high quality, affordable GNSS receivers. As most Member States will probably introduce some form of electronic infrastructure charging within the next five to ten years, any delay in the system becoming operable or problem with the development and supply of receivers may considerably reduce the benefits in this area.

#### **9.2.5 Developing high quality urban transport**

GALILEO paves the way for new traffic management applications for urban transport. Benefits are expected both in terms of more efficient urban car transport, thereby reducing congestion and energy use, and in terms of more user-friendly public transport. Due to the subsidiarity principle, the direct influence of EU transport policy on urban transport is limited. However, European transport policy measures, such as specific quality criteria for public transport or the exchange of best practices, can indirectly support GALILEO's positive contribution towards rationalising urban transport.

### **9.3 Policy measures to accelerate the introduction of GALILEO**

This study found that the main issues affecting the penetration and the impact of GALILEO on road transport were as follows.

#### **9.3.1 Standardisation / Regulation of technology**

The results of the GREAT study show that the standardisation of technology can have a major impact on the uptake of GALILEO-based services in road transport. More specifically, legally mandating GNSS technology for certain applications, and additional regulation in general, can lead to higher uptake and benefits. This was shown by the positive results of the "Regulation Scenario" in this study as compared with three other scenarios (see section 4 above).

For instance, location-based emergency services can make a contribution to road safety and are technologically easy to implement. Any legislation mandating emergency services should consider specifying the technology in order to avoid compatibility problems across Member States and the unnecessary cost of running different systems in parallel.

This also applies to most other application and therefore, in order to maximise the benefits of standardisation, the coordination of regulation activities should be carried out at the European level.

### 9.3.2 Subsidising / incentivising the use of technology

Incentives and subsidies for the use of GALILEO in road transport will be most cost effective in supporting the widespread use of safety applications, i.e.

- traffic management and control,
- incident and emergency management,
- intelligent vehicles and
- safety (pay-as-you-go-insurance).

Possibilities for incentives include:

- direct monetary incentives

Direct monetary incentives would essentially involve subsidising the cost of GNSS receivers. Users would benefit directly from this measure by paying lower prices. Assuming a certain price elasticity this would lead to higher penetration rates but not necessarily to a corresponding increase in revenues for GOC because the additional users may choose to use only services based on the Open Service Signal.

- indirect monetary incentives

Indirect monetary incentives include measures such as lowering certain taxes or charges for vehicles using the system or using pay-as-you-go-insurance. Depending on the purpose and the design of the incentive it can be targeted directly at a certain service that the public chooses to support. In this case the user will only benefit by using this specific service but in most cases the GOC will benefit directly from an increased number of users.

- Attractive "public" GNSS services

"Public" GNSS services may include traffic information, help with finding parking and similar services. Such services would be provided free of charge in order to maximise their use and thereby the benefits to congestion, safety, etc. The positive effects of such measures on the transport system are expected to be high but the financial benefits to the GOC will be small.

The scope for providing monetary incentives to users or subsidies to operators could be ascertained from the external benefits of the GALILEO system to society, i.e. benefits which go beyond the direct users who pay for the equipment and/or service. In practice, the overall benefits estimated in this study are difficult to translate into subsidies, but the order of magnitude could provide a guideline for further investigations.

### 9.3.3 Privacy and data protection

Privacy concerns are the single most important potential obstacle to the successful deployment of GALILEO services because many useful applications rely on monitoring the location of each vehicle at all times (i.e. floating car data). Theoretically this allows all road vehicle movements

to be tracked. Privacy concerns mean that the general public is very unlikely to accept the use of such a system without having credible guarantees that it will be used only for very specific applications. A first step toward gaining acceptance for the system should be the introduction of transparent data-protection policies at European level aimed at avoiding the misuse of data. Experience shows, however, that this may not be sufficient to win consumer confidence in this new technology. In addition to data-protection legislation it would be helpful to consider the following options:

- entrusting public authorities rather than private companies with data collection and direct access to data which is not anonymous; and
- using separate decentralised systems for different applications, where possible and economically feasible.

### **9.3.4 Stimulation of technological development**

Measures should also be taken to reduce the risk associated with the production and the quality of GNSS-enabled receivers. As the recent introduction of 3G mobile telephone standards has shown, the timely production and quality of handsets can become a serious problem for market development even if the network infrastructure is already in place. This factor is somewhat difficult to influence but awarding demonstration projects for the development of GNSS receivers and otherwise promoting the early launch of high quality products could have a positive influence.

For GALILEO's road transport applications in particular, the stimulation of technological development is expected to have the greatest effect as regards safety features and Advanced Driver Assistance Systems (ADAS). To support the successful introduction of those applications, a standardisation of the technical specifications at European level would be beneficial.

Beyond the scope of transport, the market for equipment and services resulting from the GALILEO programme is expected to be around 10 €bn per annum, with the creation of 100 000 highly skilled jobs, as stated in the GALILEO brochure [10]. Conversely, it is expected that many electronics and aerospace jobs would ultimately disappear if Europe were to miss out on these new developments.

### **9.3.5 Harmonisation of road transport legislation**

Harmonising road transport legislation, particularly the rules and regulations on monitoring lorries, could be an instrument to support the introduction of GNSS receivers. More specifically, the mandatory use of GNSS satellite navigation in combination with digital tachographs would be a very effective and reliable means of monitoring road freight transport.

Recent EU legislation suggests that the use of satellite navigation technology will **not** be mandatory for infrastructure charging in Europe in the medium term (see section 3.3. above). However, the Directive recommends that GNSS technology be used for all systems brought into operation after the adoption of the Directive.

In addition, Member States which have not yet introduced electronic infrastructure charging are increasingly likely to opt for satellite-navigation-based systems, especially after the recent successful launch of the German system. For these countries, GALILEO will be a major factor in establishing effective and cost-efficient charging schemes.

A precondition for this positive contribution of GALILEO is the timely launching of operations in 2008 and the early availability of high quality, affordable GNSS receivers. As most Member States will probably introduce some form of electronic infrastructure charging within the next five to ten years, any delay in the system becoming operable or problem with the development and supply of receivers may considerably reduce the benefits in this area.

### **9.3.6 Institutional set up and commercial viability**

The conclusions for minimizing the institutional risks are closely related to the structure and setup of the Galileo Operating Company (GOC) and its legal and contractual relationship with the EC, the ESA and the GJU. Arguably the most important role of the GALILEO system in road transport is to provide a reliable and continuous Open Service signal, free of charge. In the road transport sector, most mass market applications, such as road monitoring, traffic management, road user charging and emergency services, are expected to operate on the basis of the Open Service signal.

Thus, the institutional framework must guarantee the delivery of this service regardless of any commercial or contractual problems of the GOC or any other involved party. While being important for road transport, this point is even more crucial for other applications, such as aviation.

### **9.3.7 Information and Marketing**

It is important to develop a comprehensive dissemination strategy prior to the launch of the system in 2008, both in terms of raising awareness of the existence of GALILEO and in terms of counteracting the creation of a “Big Brother” image. The strategy should be developed and implemented in cooperation between the EC, the GOC, car manufacturers and the electronic equipment industry.

The role of the stakeholders in this process should be clearly defined according to their function and interest in the introduction of the new system. The Commission's role would mostly be to inform the public about measures it has put in place to protect privacy and prevent the misuse of data.

The GOC is likely to focus on providing information about the accuracy, reliability and integrity of the GNSS signal as compared to other available alternatives as well as about the range of potential applications. The job of marketing specific equipment and specific applications can be done most effectively by the private companies either selling equipment (i.e. the car and electronics industry) or offering specific location-based services.

## 10 CONCLUSIONS AND OUTLOOK

The 2001 White Paper identified several areas to be addressed by European transport policy for all modes of transport. It emphasises the need for a modal shift to road transport, and to more environmentally-friendly modes of transport. This study focuses on the effects and impacts of the use of GALILEO on road transport. The areas of the White Paper most relevant to road transport include

- improving quality in the road sector;
- unblocking major routes;
- improving road safety;
- effective charging for transport, and
- developing high quality urban transport.

This study investigates the impact of the use of GALILEO on road transport and analyses how GALILEO could help implement transport policy.

### 10.1 Overview of Applications

Several road transport applications have been identified, for which GNSS technology in general and GALILEO in particular could be used, such as:

- road monitoring;
- freight and fleet management;
- traffic management and control;
- incident and emergency management;
- electronic payment systems;
- traveller information systems;
- intelligent vehicles;
- parking management;
- public transport;
- internal services for road and infrastructure operators, and
- safety (pay-as-you-go insurance).

The analysis of alternative and complementary technologies confirms that for a vast majority of applications, the use of FCD GALILEO will meet most of the related application requirements. GALILEO would allow FCD to evolve from its present relatively low level of use in specific markets and for specific services to become a much wider and more accepted data source to help achieve a variety of policy outcomes. A key issue will become the management, filtering and interpretation of extremely large volumes of data of a new type not currently used in mainstream traffic applications.

GALILEO can meet the requirements of most applications which use location information. In particular it will bring benefits to applications using GPS today. For certain applications it can replace infrastructure-based systems (access control, infrastructure charging etc.) provided that the necessary complementary technologies are economically advantageous and provided that the end user is ready to pay. For some applications, especially ADAS, the use of GALILEO requires further investigation and validation, as complementary technologies for precise positioning are required.

### 10.2 Risks and obstacles

The major technical risks mainly relate to GALILEO failing to meet the stated performance requirements and there being a lack of standards or complementary technologies, in particular

for traffic data fusion and ADAS. R&D will have to be continuous in order to bridge the gap between GALILEO and the final services offered, and the development of GALILEO needs to be monitored.

The major commercial risks relate to the acceptance of the system by consumers and commercial users. Several factors, such as the availability, quality and costs of receivers, or the perceived usefulness of the service, could affect the take-up of GALILEO in road transport. The EC and Member States can contribute to the successful introduction to the system by adopting a proactive marketing and information policy on GALILEO. European and national institutions can take steps to ensure the high quality of GALILEO-based systems and services, affordable services and receivers and a timely market introduction by developing a clear strategy and schedule for the early introduction of consumer products.

The major political risk would be a failure to mandate GNSS technology in general and GALILEO in particular. This risk will be relevant only if the take-up of GALILEO is less than expected and needs to be stimulated by incentivising or subsidising the use of GALILEO-based systems. It will also be important to continue the co-operation with the US to ensure that GPS and GALILEO are compatible systems that complement each other rather than compete.

The major institutional risks identified relate to the service provision, commitment and management of the GOC, the timely introduction of GALILEO and its acceptance by society. For the use of GALILEO in road transport, the most important factor is a reliable and continuous Open Service signal, free of charge. The institutional framework must guarantee the delivery of this service. In order to reduce societal concerns about satellite tracking technology, a comprehensive dissemination strategy has to be developed prior to the launch of the system in 2008.

### **10.3 Estimated Market Penetration**

In terms of policy relevance, the most important result of this study is a more conservative but robust assessment of GALILEO's expected levels of penetration in road transport in relation to previous studies. Unlike the GALILEI project, which forecasts worldwide penetration of around 50% for commercial vehicles and private cars by 2020 and 60% penetration in Europe, the results of this study suggest 40% penetration in Europe in order to provide a robust estimate. In order to take account of the risks and obstacles identified in this study, a more pessimistic scenario has been developed, based on around 20% penetration of GALILEO in road transport. A more optimistic scenario predicts a market penetration of about 60%. An additional regulation scenario identifies particular applications for which corresponding legislation could increase penetration.

### **10.4 Evaluation of Impacts**

The conclusion, based on the applications identified and the scenarios describing the expected market penetration, show that in spite of the conservative but robust scenarios, significant benefits can be obtained by using GALILEO in road transport.

The absolute benefits expected for road transport in the EU-25 for the period 2008-2020 vary from €60bn (pessimistic scenario) to €350bn (increased regulation scenario), as shown in Figure 23 below. The savings per vehicle therefore vary from €780 (pessimistic scenario) to €690 (increased regulation scenario) for the same period (see Figure 24 below).

Regarding the distribution of benefits across Europe, the greatest benefits are expected to be felt in Central Europe, the UK and Ireland, but will not be so great in Scandinavia and Southern Europe. The least benefits are expected to be felt in Eastern Europe.

Indicator	Scenario			
	Pessimistic	Central	Optimistic	Increased Regulation
Reduced accident costs	€95bn	€141bn	€198bn	€202bn
Reduced congestion costs	€49bn	€78bn	€109bn	€112bn
Reduced fuel costs	€16bn	€25bn	€35bn	€36bn
<b>Total cost saving</b>	<b>€160bn</b>	<b>€244bn</b>	<b>€342bn</b>	<b>€350bn</b>

Figure 23: Total absolute benefits of GALILEO for road transport in Europe for 2008-2020 (rounded to full € billion)

Indicator	Scenario			
	Pessimistic	Central	Optimistic	Increased Regulation
Reduced accident costs	€460	€680	€960	€980
Reduced congestion costs	€240	€380	€530	€540
Reduced fuel costs	€80	€120	€170	€170
<b>Total cost saving</b>	<b>€780</b>	<b>€1,180</b>	<b>€1,660</b>	<b>€1,690</b>

Figure 24: Total absolute benefits of GALILEO for road transport in Europe per vehicle for 2008-2020 (rounded to €10)

Freight-specific benefits for the EU-25 have been estimated at around 20% of the total benefits in the EU-25, varying from €38bn (pessimistic scenario) to €64bn (increased regulation scenario), whereas around 80% of the benefits relate to passenger transport. Even under the pessimistic scenario, there are significant freight-specific savings in terms of road safety, with an estimated €27bn for the period 2008-2020 in the EU-25.

Between 2008-2020 the worldwide benefits vary from €431bn (pessimistic scenario) to €941bn (increased regulation scenario), as shown in Figure 25 below.

Indicator	Scenario			
	Pessimistic	Central	Optimistic	Increased Regulation
Reduced accident costs	€256bn	€379bn	€533bn	€543bn
Reduced congestion costs	€132bn	€210bn	€293bn	€301bn
Reduced fuel costs	€43bn	€67bn	€94bn	€97bn
<b>Total cost saving</b>	<b>€431bn</b>	<b>€656bn</b>	<b>€920bn</b>	<b>€941bn</b>

Figure 25: Total estimated absolute worldwide benefits of GALILEO for road transport for 2008-2020 (rounded to full € billion)

The greatest benefits are expected to be felt in the Pacific Rim and Europe, whereas they are expected to be less great in North America, the Indian Subcontinent and the Middle East. The least benefits are expected to be felt in Central and South America, Africa, Russia and Central Asia.

The evaluation results are sensitive to different factors and assumptions. However, they represent the best estimate of the impact of GALILEO on road transport which can be given within the scope of this study.

## 10.5 Contribution of GALILEO to EU transport policy objectives

The key benefit of using GALILEO in road transport will be the improvement in road safety. Even with the conservative but robust estimates of the penetration of GALILEO in road transport arrived at in this study, the benefits in terms of reduced accidents are significant, varying from €5bn (pessimistic scenario) to €20bn (increased regulation scenario). There are several ways in which the GALILEO system can contribute to the policy objective of improving road safety. Firstly, it can help enforce traffic rules, such as speed limits. This could well be realised for road freight transport but very unlikely to be realised for private cars. Secondly, the GALILEO system paves the way for a number of new road transport applications, which could increase road safety. Examples are ADAS and emergency management applications, such as automated incident detection.

In theory, the use of satellite navigation in conjunction with modern data communication and processing technologies can eliminate most of the problems associated with the EU policy objective of improving quality in the road sector. The two main obstacles to realising these potential benefits are the expected development of penetration rates and privacy concerns. The former problem can only be solved by legally requiring all lorries in Europe to be fitted with GNSS-enabled equipment. As regards privacy concerns, the EU policy objective “improving quality” is primarily targeted at road freight transport, so privacy concerns should not pose a significant problem.

A precondition for the extensive use of GALILEO for electronic infrastructure charging is the timely launching of operations in 2008 and the early availability of high quality, affordable GNSS receivers. As Member States which do yet use electronic road pricing are likely to introduce some form of electronic charging within the next five to ten years, any delay in the system becoming operable or problem with the development and supply of receivers may considerably reduce the benefits in this area.

## 10.6 Where next?

This study shows that GALILEO has considerable potential for deployment in road transport and will have a significant impact on transport policy. The key benefit of using GALILEO is the improvement in road safety, even under conservative (but robust) penetration scenarios.

The analysis of the policy issues in this study suggests policy measures to support the deployment of the GALILEO system and its widespread use in road transport and to minimise the risks. Among the most important recommendations are the need to address privacy and data protection concerns and to consider subsidising or – if necessary – mandating the use of GNSS technology for some applications in order to avoid the parallel use of different systems. In addition, the need for a comprehensive dissemination strategy prior to the launch of the system in 2008 has been identified as a key issue, to raise awareness of GALILEO's technical and institutional features and increase expertise among manufacturers.

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