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## INCREASE IN ROAD TRANSPORT SAFETY – WAY TO REDUCTION OF EXTERNAL COSTS

*Satellite navigation and prepared navigation system Galileo is the key technology that has to open the gate to new applications. It has to ensure Europe to not be too dependent (in term of economic and safety) on nonmember states of EU, to establish new applications and create new markets with integrated navigation and communication services. In our article we will deal with the opportunities that the new navigation system Galileo will offer for the road transport.*

**Keywords:** GPS, GALILEO, external cost, safety

### 1. Introduction

The building up of Europe has brought us peace but the war against road rage is far from an end: over half a century, in some countries of Europe, more than two million persons died and almost one hundred million of others were injured in road accidents.

In spite of progress in the long term the overall situation is still a disaster -from the human, social and economic points of view: Europe has now more than 40,000 fatalities and 1.7 million persons injured every year in road accidents, at a total cost estimated at 160 billion €/year.

Some categories of road users or population groups are particularly at risk: young persons between 15 and 24 year of age (10.000 fatalities/year), pedestrians (7.000 fatalities), motorcyclists and moped users (6.000 fatalities), and cyclists (1.800 fatalities). The unacceptable behaviour of road users is the first cause of mortality: excessive speed (15.000 fatalities), consumption of alcohol or drugs, fatigue (10.000 fatalities), non-wearing of seat belts or of protective helmets (7.000 fatalities) [these figures are not cumulative because of the interaction between several causes].

It is obvious that action taken to date has not sufficiently met such a challenge. This is why the Commission has proposed an ambitious target to reducing by 50% the number of road fatalities by the year 2010 [1]. In order to contribute to achieving this target the Commission has published a European road safety action programme. Such a programme offers a framework for all partners and it guides the EU action where its added value is at its most. It aims at

- stimulating road users towards a more responsible behaviour in particular through a better respect of existing rules, initial and continuous training of private and professional drivers and a better enforcement against dangerous behaviour;

- making vehicles safer through improved technical performance standards;
- improving the road infrastructure, in particular through the identification and diffusion of best practices and the elimination of black spots. [1]

### 2. External cost

One of the most significant factors affecting increase in road transport safety is reduction of external costs. External costs are described as follows.

When consumers decide to purchase an item or take a trip, they examine the price of a given option and compare it to the gain or satisfaction they expect to derive from the item or trip. For instance, an individual wishing to get from A to B will consider the price (of using public transport or his/her private car) and quality of the service provided before opting for a given transport mode. Users are willing to accommodate a whole array of parameters (speed, frequent/regular service, quality, flexibility, etc.) in the transport price they pay.

Conversely, consumers of goods or services do not generally foot the full bill for the costs their decision imposes on society and the environment. Such costs are defined as external because they are not reflected in the price paid by users and are not factors in the market. The main sources of external cost in the transport sector are accidents, congestion, air pollution, noise and climate change. Individuals using a given form of transport are not generally aware of the external cost generated and indeed it is possible that some of these costs have never been defined.

Nonetheless, external costs do exist and since they are not met by the parties responsible, they must be borne by society as a whole.

Significant external costs are: [2]

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- accidents, when transport systems are used, accidents occur, generating a whole range of costs which are only partly covered by mutual risk insurance schemes (loss of life, medical care and disabilities sustained by victims, loss of production, etc.),
- air pollution, emission of particulate matter, carbon monoxide, lead, volatile organic compounds, nitrogen oxides and sulphur dioxide, damaging health, the environment and buildings,
- climate change, greenhouse gases (mainly carbon dioxide - CO<sub>2</sub>) have an enduring impact on the earth's climate, resulting in increased desertification, raised sea levels, serious harm to agriculture and other destructive environmental and health-related side-effect.
- noise, transport generates noise, which adversely affects humans in a variety of ways, causing disturbances, stress and more serious health problems,
- congestion, more vehicles are being added to already dense traffic flows, particularly car traffic flows, paralysing the system and leading to substantial wastage for all users. Congestion makes the entire transport system inefficient.

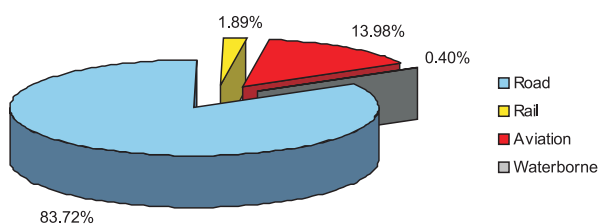


Fig. 1 Share of particular transport sectors in generating external costs

The following figures present the results for total and average costs for year 2000. Total external costs (excluding congestion costs, with climate change high scenario) amount to 650 billion € for 2000, being 7.3% of the total GDP in EU 17 (5%). The most important mode is road transport, causing 83.7% of total cost, followed by air transport, causing 14% of total external costs. Railways (1.9%) and waterways (0.4%) are of minor importance. Two thirds of the costs are caused by passenger transport and one-third by freight transport, see Fig. 1.

In road transport climate change is the most important cost category with 30% of total cost, if high shadow prices are used. Air pollution and accident costs amount to 27% and 24% respectively.

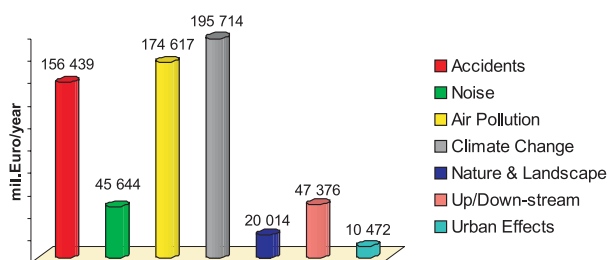


Fig. 2 Share of particular external costs in road transport

The costs for noise and up- and down-stream processes each account for 7% of total costs. The costs for nature and landscape and additional urban effects are of minor importance, see Fig. 2. [2]

### 3. Satellite navigation systems

Introduction of satellite technologies into road transport is one of possible ways safety increase and external costs dereduction. Present-day satellite navigation systems GPS and GLONASS are known to road transport users. Navigation system GPS is nowadays widely used in vehicles and, together with a digital map of a territory, enables a large amount of before unimaginable applications which make drivers' activities easier. The main disadvantage of GPS and GLONASS systems is their relatively low accuracy with some applications (about 22.5 m) and with augmented system about 5 m.

In 1999 European Space Agency - ESA and European Transport Council - ETC, joint body of European ministers of Transportation, started GALILEO program. Galileo represents global European satellite navigation system, which will meet all high demands for precision, integrity and time alert, continuity and availability to eliminate dependency on to US GPS and provide full utilization of all satellite navigation possibilities focused mainly on civilian applications. Accuracy of the system depends only on the choice of service. Free Open services provide approximate horizontal accuracy from 4 to 15 m and from 8 up to 35 m. vertical accuracy according to the receiver type (single frequency or double frequency). Fee-based Commercial service CS enables significant accuracy improvement in relation to local components. Horizontal location accuracy will be between 0,8 m up to 7 m, vertical accuracy between 1 m and 15 meters according to receiver type. Time accuracy should fluctuate from 10 to 100 ns.

We are not going to describe the whole system, which can be found in particular references [3], [4], etc. but we will point out some possibilities of the Galileo's applications in road transport.

The road sector is a major potential market for GALILEO applications. By 2010 there will be more than 670 million cars, 33 million buses and trucks and 200 million light commercial vehicles worldwide.

Satellite navigation receivers will provide new services to people on the move: electronic charging, real-time traffic information, emergency calls, route guidance, fleet management and Advanced Driving Assistance Systems (ADAS). GALILEO will offer urban travelers an increased availability of satellite signals, reducing the effect of shadowing by buildings. New services to people on the move: electronic charging, real-time traffic information, emergency calls, route guidance, fleet management and Advanced Driving Assistance Systems (ADAS). GALILEO will offer urban travelers an increased availability of satellite signals, reducing the effect of shadowing by buildings. Route guidance using satellite navigation is already a well-established product offered by car manufacturers. The majority of these systems are based on satellite navigation

systems and onboard sensors (odometer and gyros) to compute optimal routes in real-time. However, GPS does not offer sufficient coverage in urban areas to be used alone. GALILEO with its 30 satellites will increase the coverage and accuracy. This will enable manufacturers to use cheaper sensors to fill the satellite navigation gaps (tunnels, narrow streets). Many additional services can be offered, including emergency calls with automated transmission of location, breakdown assistance with communication of the car position together with other information such as the nature of the vehicle's malfunction, and recovery after theft (500,000 cars are stolen and not recovered in Europe alone each year). The monitoring and management of traffic fluidity will be significantly facilitated when a great number of cars are equipped with satellite navigation receivers and guidance systems. For example, if the average speed of the cars equipped with GALILEO receivers in a road sector drops significantly, a control centre can anticipate a traffic jam and suggest that approaching vehicles choose a different route. A very important application will be tracking and managing emergency and rescue vehicles. Combined with dynamic traffic information, an ambulance with a GALILEO receiver and communication link will be able to reach its destination much faster. Traffic lights could be controlled to speed the arrival of an emergency vehicle. Advanced Driving Assistance Systems (ADAS) combine vehicle capabilities to improve mobility and active safety. GALILEO will provide important additional data to ADAS on the vehicle's environment. ADAS then warns the driver of imminent danger or takes full or partial control over the vehicle. For instance, the speed could be reduced by ADAS under bad visibility conditions if the car approaches a tight turn too fast. This function will be possible only with accurate position data of guaranteed integrity furnished by GALILEO and local elements. It is expected that half of the vehicles operating in Europe by 2020 will carry ADAS. GALILEO will offer the possibility to implement new and more advanced methods of user-friendly road charging: charge for the use of particular roads at particular times with particular vehicles, or charge users traveling in a certain urban zone, according to the distance driven. Although there are other techniques for road tolling, only satellite navigation leads to a reliable seamless service thus avoiding isolated system implementation, which puts a burden on user equipment. The vehicle will use GALILEO to determine its location and to store the distance driven on every type of road (charged or free).

Then it reports the results to a monitoring center for a central charging entity to invoice the user. This would work on both inter-urban and urban roads [5].

Using local components of GALILEO will enable. Even sub-meter accuracies. One of the basic requirements for such development is existence of digital map documentation in order to support safe and quick decisions of a driver. This was the aim of Next MAP project – enhanced digital maps for driver assistance applications (2000–2002). It is project of ERTICO and companies Navigation Technologies, TeleAtlas, BMW Group, Daimler Chrysler, Jaguar, Fiat and Renault. Table 1 shows demanded accuracy of geoinformation so that GALILEO system may enable all stated road applications also beyond 2010, including automatic vehicle driving.

#### 4. Conclusion

Last but not least, since a huge number of entities have a role to play towards road safety the Commission has proposed that everyone in authority, with decision-making powers, or acting in an economic, social or representative function should give solemn undertakings and subscribe to a European Road Safety Charter.

Effective operation is dependent on exact determination of real costs in each transport sector. Experiences show that investments in infrastructure draw more vehicles and so there is no decrease in external costs, which means that is hardly possible to solve the problems by means of new road infrastructure. Various studies indicate that a half empty passenger car needs five or six times more energy than a train or public transport.

Externalities interfere with effective distribution of means sources. This brings 2 contradictions:

- society demands more mobility but it
- is less tolerant of increase in external costs.

The main goal is to provide efficient transport one of the most significant is application of satellite navigation. It is estimated that 40 % of new passenger vehicles bought in Western Europe will be equipped with navigation system.

Demanded accuracy of digital maps

Table 1

Roadmap Requirements	2001	2004	2006	2008	2010	2012
Vehicle-position-accuracy (GPS, DGPS, ...)	15 m	3 m	3 m	1-2 m	1-2 m	1 m
Absolute accuracy	5-25 m	4 m	4 m	2-4 m	2-4 m	2 m
Relative accuracy	5-15 m	1-2 m	1-2 m	0.5-1 m	0.5-1 m	0.5 m
Map objects	5-25 m	5-10 m	5-10 m	1-5 m	1-5 m	1 m
Lane width	–	0.5 m	0.5 m	0.3 m	0.3 m	0.3 m
Speed limit	–	5 m	5 m	3 m	3 m	1 m
Priority regulations	–	–	–	Incl.	Incl.	Incl.

It is well-known that geoinformation plays an important role in road transport navigation systems, transport safety systems but also for emergency systems. Information infrastructure which

enables to generate and give interactive information about current situation on the roads is necessary to have desired effect.

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