Role of Telematics in Reducing the Negative Environmental Impact of Transport

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Abstract. With development of society increase the demand for the movement of people and goods. From years the transportation expand rapidly and is crucial to economic development. Unfortunately, it is also an economic sector with the most harmful effects on the environment. The various modes of transport in different extent impact negative on the environment, which depends mainly on the technical-operating conditions. The up-to-date telematics systems provide the transport industry a revolutionary opportunity to effectively manage. Appropriate use of these systems can help to substantially improve the efficiency of transport and its operating costs, in consequence lead to reduce the negative environmental impact of transport.

Keywords: Transport, transport politics, environment protection, ITS, Eco-telematics.

1 Transport in Environmental Protection Perspective

1.1 Environmental Impact of Transport

Social development is accompanied by the growing need to move and relocate people and goods. Transport, which has been developing rapidly for years, has become a determinant of economic growth. Sadly, it is also the economic sector which has the most detrimental influence on natural environment; its environmental impact has been observed at many levels for years. Main environmental degradation risks are noticeable in the form of:

- air pollution,
- water and soil pollution,
- noise pollution,
- risk of accidents.

The negative environmental impact of transport is manifested on three levels:

- locally – deterioration of the conditions of living, leisure and work,
- internationally – by acid rain or sea water pollution,
- globally – by environmental problems such as global warming.

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Individual branches of transport generate significant adverse effects on the environment, which depend on technical and operational conditions such as: power consumption, structural characteristics, consumable products applied, required infrastructure, demand for a given means of transport.

Globally, the automotive industry emits hundreds of millions tonnes of toxic exhaust fumes per year. Transport ranks very high in terms of greenhouse gas emissions. Allowing for the production of cars, road construction and renovation, transport generates a third of total emissions.

Research studies unanimously point to road transport as the most harmful for the environment. Currently there are 1 billion cars driving on the roads all around the world. It is estimated that the number will have doubled by 2050 [1].

At present, despite considerable effort, greenhouse gas emission levels, in particular those generated by road transport, are still growing. Note that emission level caused by the development of air transport is increasing with equal speed. The increasing availability of jet plane travel, mainly in tourism, results in a huge consumption of fuel, and, consequently, in millions of tonnes of emitted pollutants. Rail transport remains the least harmful for natural environment. Another notable example is water transport, whose effectiveness and haulage capabilities are increasingly growing.

In terms of road transport categories, there is little doubt that cargo transport, especially transport of goods, is the most energy-consuming and environmentally harmful. Its excessive toxicity is exacerbated by bad technical condition of vehicles, numerous cases of overloading as well as damage to road surfaces. Pollution emission is closely connected with considerable consumption of energy by transport.

1.2 Classification of Environmental Risks Due to Transport Activities

Ever year the transport industry releases millions of tonnes of pollutants into the atmosphere. They include lead, carbon monoxide, carbon dioxide, methane, nitrogen oxide, dinitrogen monoxide, carbon compounds and volatile matter, heavy metals (zinc, chromium, copper and cadmium) and solid particles (ash, dust). The extent to which such emission could contribute to global warming is still subject to debate.

The emission of sulphur dioxide and nitrogen oxide is accompanied by the formation of diverse acidic compounds, which – in combination with air vapour – create acid rain, and the precipitation of acid negatively affects the entire environment.

Transport has a significant effect on hydrological conditions. Fuels, chemicals and other hazardous substances released by cars, ships, airplanes and trains in motion or during other activities in ports, airports and terminals may contaminate rivers, lakes and oceans. Since the demand for transport services is on the increase, the emission of pollutants caused by water transport significantly affects the quality of water. Water quality is determined mainly by channel deepening, waste, ballast water and oil leaks.

Waste generated by the activity of ships at sea or in ports is a cause of severe environmental pollution. In addition, the biodegradation of disposed metal or plastic components is very slow, so those parts pollute seas and oceans for many years, making marine navigation difficult.

Ballast is a load element used in ships. Ballast waters accumulated in one region may contain invasive aqueous plant and animal species. Discharging ballast waters in another region may lead to their growth in the new environment and thus disruption to the natural ecosystem of the location.

Oil spills, mainly petroleum leaks caused by accidents or illegal discharge activity, are one of the most severe types of contamination caused by air transport activities. Oil pollution affects marine environment over short distances, but can frequently be propagated by long-range winds and currents, resulting in severe contamination along the entire shoreline.

Degradation of natural environment by transport is caused mostly by the car sector. Soil contamination may occur as a consequence of the emission of exhaust fumes, whereby soils are contaminated by lead compounds and harmful hydrocarbons during petroleum and oil leaks from motor vehicles or the release of cleaning agents directly into the soil. Soil contamination does not affect only areas located in direct vicinity of roads. Research suggests that contamination by harmful dust and exhaust fumes can still be observed over long distances from the road.

Hazardous chemicals, materials and heavy metals are also found in areas adjacent to railways, sea and air ports.

Noise is defined as every unwanted or harmful sound caused by human activity in the open air, including noise emitted by means of transport, traffic, rail traffic, plane traffic and noise originating from industrial activity areas.

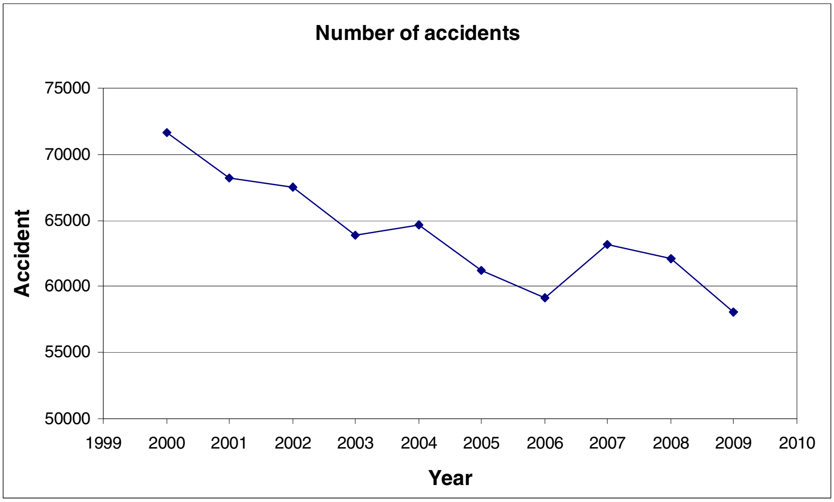
Overall, transport as such largely contributes to noise generation – life in the vicinity of motorways, railways and airports may tremendously influence the incidence of hearing disorders and defects, and due to associated nuisance and harmfulness it has been classified as pollution. It is estimated that one in three EU inhabitants is exposed to excessive noise. According to research, a noise level of approximately 60 dB causes insomnia and fatigue, headache, nervousness, increased blood pressure, mental retardation in children; it also has a negative influence on work and learning efficiency. In case of transport noise it can be said that it creates a scale effect, because intense traffic in main streets and congestion lead to the relocation of transport activities to local streets, which frequently go through residential areas, where increased noise is even more perceptible. Noise also affects animals, distorting their natural ecosystem, frightening them away and often leading to serious accidents.

As a result of the development of transport, the constant need to move and the escalation of overcrowding, the number of transport accidents is increasing. For many years, the highest number of accidents has been reported for road transport.

Each year 1.3 m accidents take place on the EU roads, with 43 dead and 1.7 m injured. Over the last 17 years in Poland there have been almost a million road accidents with a total of more than 110,000 people killed and over a million injured. Each day 15 people die and 160 are injured in road accidents.

According to a police publication on road accidents in Poland, in 2008 there were 49,054 accidents, in which 5,437 people died [2]. However, the number of road accidents decreases year by year. Latest reports inform that in 2009 the number of road accidents was 44,196, with 4,527 deaths, which is over 15% less in comparison to the previous year [3]. Fig. 1 presents the number of accidents in the years 2000–2010.

Road accidents not only cause pain and suffering, but also financial losses paid for by society in the form of national budget expenditure on health and social care. Poland loses 2% of GNP only due to road accidents, since the social cost of a single dead person is almost 1 m PLN.



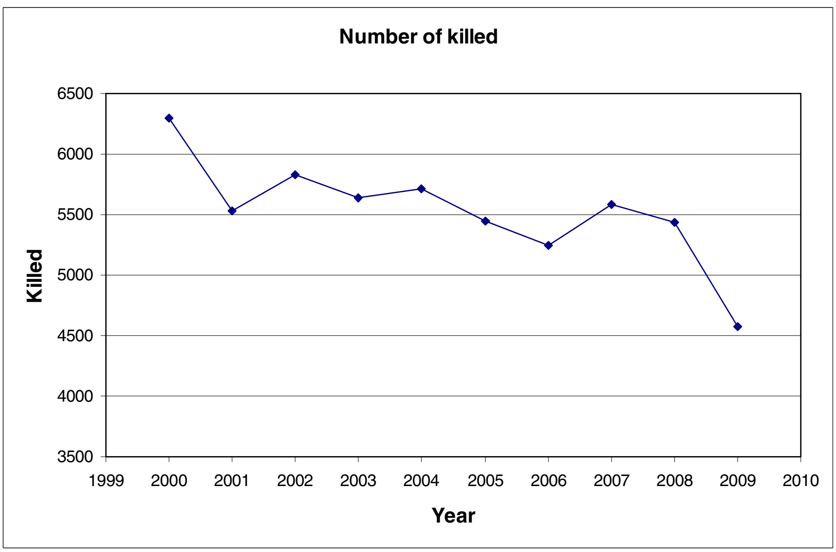


Fig. 1. Number of accidents and number of killed in 2000–2009. Source: own work based on [2].

1.3 Classification of Environmentally Significant Transport Costs

Overall division of costs of transport is the division by cost-bearing entity. In this perspective, the following classification applies:

- internal costs – private expenses paid pay the traveller, company or its owner due to transport activities, and by service providers and their customers,

- external costs – social expenses, generated by the user but paid by the whole society; they are mainly referred to in the context of adverse environmental phenomena caused by transport.

Table 1 shows cost types by cost-bearing entities.

Table 1. Classification of costs and respective bearing entities. Source: own work based on [4].

Cost type	Internal costs (paid by the user)	External costs (paid by society)
Air pollution cost - human health, - animal health.	Generally, users do not pay; they incur their own losses.	Population exposed to air pollution, companies selling health insurance, public authorities.
Climate change costs - natural disasters, - reduced harvest.	Generally, users do not pay; they incur their own losses.	Society, insurance companies, public authorities and future generations.
Noise pollution costs - stress.	Generally, users do not pay; they incur their own losses.	Society exposed to noise.
Accident costs - injuries, - property damage.	Partly as insurance and user's own loss.	Individuals (costs due to pain, administrative costs, etc.), public authorities, insurance companies.
Congestion costs - stress, - reduced efficiency.	Partly by reduced efficiency, costs of user's own time.	Individuals, time loss, companies.
Operating costs	Cost of fuel, infrastructure maintenance, tickets.	Costs incurred by other users and society.
Costs of using infrastructure	Costs covered by charges for using infrastructure, tickets sales.	Costs partly uncovered.

External costs of transport, which are predominately related to the difference between social and private costs, deserve a more profound analysis. They are important due to their connection with environmental activities.

A commonly approved definition says that external costs are generated by undesirable by-products of business activity, do not affect the parties involved and cannot be compensated. This definition also applies to external costs of environmental impact.

In terms of economic analysis, external costs concern the activity of individuals who have a positive or negative effect on other individuals. This concept has considerable significance for environmental issues, since many negative effects are experienced by the entire society In terms of transport activities, external environmental costs need consideration as regards physical damage to natural environment and the assessment of social contribution to such costs. Identifying sources of external costs is a fairly easy task, whereas the assessment of damage and their estimation are yet to reach comparative standards between government and non-governmental organisations.

Table 2. External costs of transport by transport branches. Source: own work based on [5].

	Road	Rail	Air	Water
Infrastructural limitations	Individual transport increases congestion	Timetabled services, making it impossible to provide enough coverage to satisfy demand, different kinds of delays	Timetabled services limit the possibility of travelling outside the schedule and cause time losses	If ports are not filled, congestion occurs individually
Accidents	Loss coverage from insurance, compensation for casualties	Insurance covers most costs incurred by casualties	Insurance covers most costs incurred by casualties	Insignificant
Air pollution	Inhabited areas are located near roads	Costs of generating electricity and internal combus-tion units	Pollution generated at higher altitudes	Pollution in har-bour areas
Noise pollution	Inhabited areas near roads, ex-posed to noise.	Railway noise causes less nuisance in comparison to other transport branches	More nuisance than in the case of other transport branches	Insignificant
Climate change	Largest greenhouse gas emission	Greenhouse gas emission and costs of generating electricity	Greenhouse gas emissions at high altitudes	Greenhouse gas emission

Therefore, external costs of transport are those who affect society, although they are not directly linked to the user who generated them. They may constitute of the following elements:

- environmental costs (damage due to air pollution, climate change, noise, electromagnetic fields and other environmental consequences),
- uncovered accident costs (grief and suffering),
- congestion (time losses caused by other participants in traffic).

According to other cost types, external costs can be divided into fixed or variable costs. Variable external costs of transport depend on the real use of a given means of transport. Fixed external costs usually appear at earlier or later stages of the transport cycle.

As estimated by the EU, total external environmental costs (excluding congestion) in investigated countries amount to €650 per year, which constitutes 7.3% of GDP of the studied European countries (15 countries of the EU, Switzerland and Norway) [5]. By 2010 it is forecast that without a change in the current European transport policy, total external costs of transport will have increased by 40%.

Studies unanimously demonstrate that car transport generates most external costs of transport.

The distribution of individual cost categories in total external costs is as follows [5]:

- accidents – 24%,
- air pollution – 27%,
- climate change – 30%,
- greenhouse effect – 7%,
- noise – 7%,
- landscape change – 3%,
- the so-called urban effect – 2%.

Fig. 2 presents structure of external costs by type.

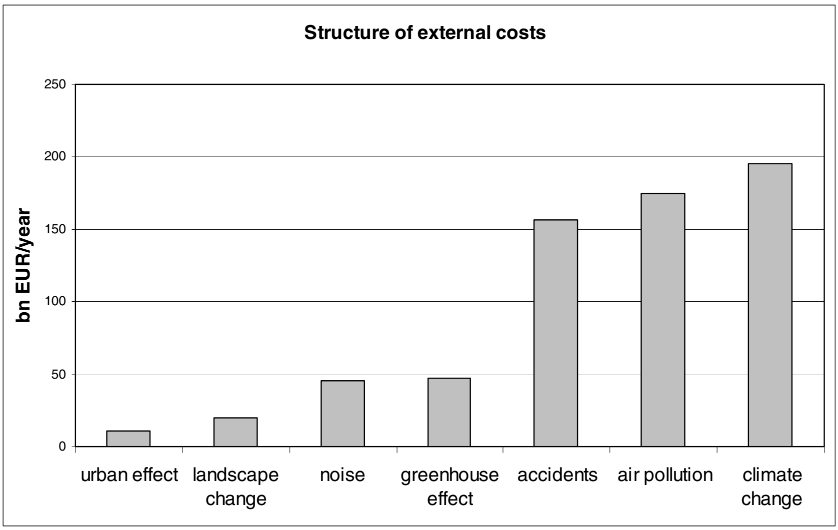


Fig. 2. Structure of external costs of transport by category. Source: own work based on [5].

External cost internalisation is 'delegating' responsibility for the negative impact of transport to users who triggered it. The idea is then to subjectively transport, according to the 'polluter pays' principle. The said subjectification is aimed at fair principles of free market competition, obtaining resources to remedy the negative impact of transport (such as road accidents, air, water, soil pollution, excessive noise, etc.) and focusing on environmental protection as a result of increased awareness of the damage. Main principles of the internalisation of (uncovered) environmental costs are aimed at [6]:

- pollution prevention – transport demand must be satisfied without generating emission which puts public health, biodiversity or the integrity of basic ecological processes at risk and results in global climate change,
- heath and safety protection – transport systems should be designed and operated in a way which protects physical and mental health as well as social welfare, ensures safety of all individuals and enhances quality of life in a community,

- saving natural resources and areas – transport systems must make effectively use of land and other natural resources while preserving natural habitats of living creatures and maintaining biodiversity.

1.4 Poland and EU's Transport Policy in Terms of Minimising the Negative Impact of Transport on Natural Environment

The significance of transport for the global economy is so great that its regulation takes place at all levels, from global through national through municipal.

The fact that transport contributes enormously to the degradation of the environment makes the measures aimed at limiting its negative impact one of the key determinants of economic development. Environmental effects due to transport activities caused EC countries to adopt a common transport policy in order to eradicate the destructive impact of transport on natural environment.

Key Elements of the EU's Transport Policy. Key principles of the European Union's transport policy until 2010 include mainly [7]:

- Sustainable systems:
  - encouraging ecologically friendly branches of transport,
  - integration of means of transport,
  - controlling competition in rendering public services.
- Care for transport system users:
  - improving safety (particularly on roads),
  - appropriate legal service and protection,
  - improving travel quality,
  - transparent charge system.
- Eliminating bottlenecks in architecture:
  - extension or modernisation of transport network,
  - improving traffic conditions,
  - improving the conditions for financing investments in this field.
- Managing transport globalisation:
  - the need to implement global scale programmes such as Galileo,
  - global outlook on transport issues.

Transport as a Component of Sustainable Development Policy. The idea of sustainable development has risen in significance in the recent years. Sustainable development is the fulfilment of the needs of the present generation without impairing the development opportunities of future generations. The notion of sustainable development is based on several elements – the protection of the environment, social development, economic growth and respect for civil rights, all of which should constitute both locally- and globally-integrated process.

Under the common European transport policy for sustainable mobility, a sustainable transport system was defined as a system which should [8]:

- ensure availability of transport goals in a safe way without threatening human health or the environment, equally for the present and future generations,

- enable effective functioning, offer the possibility of choosing a means of transport, support the economy and regional development,
- limit emissions and waste to levels absorbable by Earth, use renewable resources in reconstructive quantities, use non-renewable resources in quantities replaceable by renewable substitutes while minimising the occupation of land and forest areas.

Among quantitative aims of the sustainable transport policy, the following are quoted:

- reducing transport-related carbon dioxide emission, which should not be higher than 50% of emissions in 1990,
- atmospheric aerosol emission level resulting from transport activities should not exceed 10% of emissions in 1990,
- limiting noise to level of no more than 55 dB during daytime and 45 dB at night (outdoors),
- the entire transport infrastructure, including machines for transporting, handling and parking vehicles, should meet air, water and ecosystem protection requirements. Less area should be allocated to transport infrastructure than in 1990.

Among measures intended to support sustainable transport, the following deserve special attention:

- *Introducing clean and effective technologies to transport services*
  The idea is to make transport less traditional and more "intelligent" using advanced technologies, including transport telematics. Measures should focus on improving road safety, including use of advanced active safety solutions in vehicles, limiting emission of pollutants, reducing fuel consumption as well as integrating intelligent transport systems across different transport branches.
- *New road safety technologies*
  Special emphasis is put on the possibility of using state-of-the-art technologies including telematics and ITC, supporting traffic, monitoring and installing devices recording vehicle performance parameters or automatic speed limiters. The European Union also supports launching safe cars fitted with modern safety devices.
- *A real turnaround in combined transport*
  The necessity to look for solutions which could provide an enhanced integration of transport branches and increased interoperability, and oriented at innovative initiatives.
- *Improving traffic conditions*
  The possibility of using telematics when searching for specific traffic management measures, making it possible to precisely manage transport infrastructure.
- *Diversification of energy for transport*
  Actions supporting experiments and promoting "greener" vehicles equipped with hybrid engines, electrical motors or using substitute fuels with lower emission levels.

Principles of Poland's Transport Policy and Their Relation to Natural Environment. In recent years many documents have been devoted to transport policy in Poland. Most important of them include:

- transport policy – an action plan towards transforming transport into a system adapted to the requirements of market economy and new economic cooperation conditions in Europe; a document enacted by the Council of Ministers in 1995,
- alternative transport policy in Poland according to the principles of sustainable development, presented in 1999,
- national transport policy for the years 2001–2015 for sustainable development of the country; a document enacted by the Council of Ministers in 2001,
- infrastructure – a key to development; part of the national economic strategy, enacted by the Council of Ministers in 2002,
- strategies and development programmes for the years 2004–2006 and beyond,
- national transport policy for the years 2006–2025; a document enacted by the Council of Ministers in June 2005,
- strategies and programmes from the years 2006–2008, including a draft of the updated National Land Development Concept.

The objective of the Polish transport policy established in 2005 is to improve the quality and extend the system of transport according to sustainable development principles in the following aspects:

- society,
- economics,
- land development,
- ecology.

In the above mentioned documents the main objective comprises six aims, out of which of special interest are those concerning the improvement of the effectiveness, safety and limiting the negative environmental and health impact of transport.

Among the principles stated in the transport policy, emphasis is put on supporting energy-saving forms and means of transport which create less environmental nuisance and as well as supporting eco-friendly technologies. The focus is also on the necessity of using the opportunities offered by technical development, which provides assistance in organising and managing transport in terms of:

- means of transport, improving effectiveness and safety, reducing negative environmental impact and
- innovative technological and organisational solutions.

As regards means of transport, the role of the state should involve using suitable stimuli to drive the purchase or operation of means of transport having appropriate, desirable performance characteristics and supporting experiments, scientific research and development of new beneficial technological solutions. Advanced technological and organisational solutions, referred to as Intelligent Transport Systems, are also mentioned as the most effective way of supporting transport systems, enhancing their quality and effectiveness, to quote such solutions as:

- advanced road, rail, collective transport, air and vessel traffic management methods,
- fleet management and cargo transport management,
- advanced driver assistance systems,
- automatic toll collection systems,

- automatic control of compliance with regulations,
- dynamic user information systems.

Since the implementation of intelligent transport solutions in Poland is slow, an acceleration is expected in the rate of introducing the above solutions by means of a number of actions, which include:

- designing a nation-wide, long-term modern solutions implementation plan, later also in quantitative assumptions,
- creating national architecture of Intelligent Transport Systems to increase compatibility of transport systems,
- execution of pilot projects pertaining to Intelligent Transport Systems,
- supporting projects related to advanced traffic management systems,
- supporting the development of IT systems enabling the growth of multimodal transport such as cargo tracking features.

Due to the growth of individual transport and the necessity of developing road infrastructure, transport policy assumes the possibility of toughening the climate policy of the EU together with consequences of limiting the rate of the increase of greenhouse gas emission level, supports activities related to the protection of the environment against the negative impact of transport and transport-related activity. In light of the protection of the environment against the negative impact of transport, the following points are of exceptional importance:

- the principle of developing and improving transport system and its branches must be observed by implementing long-term action plans and strategies,
- increasing competitiveness of transport branches other than road and air transport, mainly rail transport, and supporting logistic operators and multimodal transport operators,
- supporting the idea of integrating external cost and eliminating environmentally harmful subsidies with the decision making process, both in relation to transport development directions and transport habits of society and transport companies,
- taking into consideration, to the maximum extent possible, environmental considerations, in particular protecting the environment and building transport infrastructure,
- introducing the obligation to establish transport policy (in the form of statute) on various levels of local government structures, with consideration to the principle of sustainable transport system,
- promoting solutions for spatial and functional integration of transport subsystems,
- publicising best practices and expertise, promoting innovative transport system solutions.

2 Application of Modern Technologies in Limiting the Negative Environmental Impact of Transport

Car manufacturers, research institutes and the automotive industry work on a number of future-proof and modern technologies for vehicles and drive systems. Such technologies unveil the potential of new generation vehicles, which could improve environmental performance levels such as greenhouse gas emissions, exhaust fumes emissions, noise levels and active/passive safety in vehicles. Fig. 3 presents key issues concerning future road vehicles.

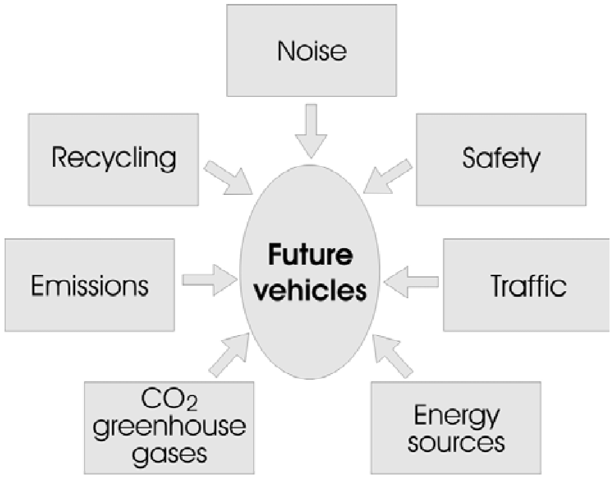


Fig. 3. Key issues concerning technical and performance characteristics of future road vehicles. Source: [11].

In order to influence the future shape of road transport, the global impact of automotive technologies should be taken into account, according to the following categories:

- energy sources and recycling
  - efficiency in manufacturing and recycling processes,
  - economic effectiveness of recycling,
  - future availability of energy sources and their costs;
- infrastructure
  - availability,
  - technological level differences between individual countries and regions,
  - costs;
- environmental impact
  - compromise with future environmental goals,
  - emissions (waste, gas emissions, noise, etc.),
  - presence of entirely new environmental problems in connection with new technologies;
- social and political aspects
  - compliance of new technologies with current and future environmental, social and tax policy,
  - acceptance of new technologies in different cultures and regions (global aspect);

- safety
  - compliance of future technologies with applicable safety standards;
- energy consumption
  - availability,
  - costs,
  - transport and distribution.

All new technologies for classic petrol-powered engines and diesel engines are the first step towards the improvement of future fuel consumption levels and the reduction of greenhouse gas emissions in the near future. When equipped with modern technologies, those engines will have their place on the market until alternative energy sources are made available for mass production. Consequently, telematic solutions for engine control should be constantly developed.

2.1 The Purpose of Telematics and Intelligent Transport Systems

The idea of telematics appeared more than a decade ago and it is possible to define it, in general and simple way, as a communication system for collecting, processing and distributing information.

The transport services market is definitely the most important area for telematic applications. Transport telematics issues constitute a field of knowledge of transport which integrates information technology and telecommunications in applications for managing and controlling traffic in transport systems, stimulating technical and organisational activities which ensure improved effectiveness and safe operation of such systems [9]. Key functionalities of telematic systems include information-operating features. These involve obtaining, processing, distributing information along with its transmission and use in decision-making processes. Such processes encompass both processes managed in a pre-defined way (e.g. automatic traffic control) or processes resulting from dealing with situations as they arise (decisions of administrators, dispatchers, independent infrastructure users such as drivers or pedestrians, etc.) supported by current information [10]. Integrated and cooperating telematic applications constitute Intelligent Transport Systems (ITSs). The basis of Intelligent Transport Systems is to efficiently collect and process information and to manage its flow within the system. This enables supplying information from almost all areas of private and public transport activities in real time.

The characteristics of Intelligent Transport Systems are as follows:

- integration of technology, applied tools and software for efficient flow of information,
- "intelligence" understood as a system’s ability to makes autonomous decisions in varying circumstances,
- flexibility and high adaptability – the possibility of adjusting configuration as necessary,
- effectiveness understood as universality of benefits.

Intelligent transport, supported by a number of integrated telecommunications, IT measurement and control engineering solutions, supported by appropriate tools and software, comprises telematic applications. The have an extensive range of use in many areas of transport, allowing the integration of means and types of transport, infrastructure, business organisation and management processes.

2.2 The Role of Telematics and Benefits Associated with Its Use

The latest telematic systems provide the transport industry with a cutting-edge opportunity for more effective asset management. The proper use of these systems results in a significant improvement of the fleet, a decrease in its mileage, operating costs and fuel consumption, consequently leading to a reduction of the negative environmental impact of transport and increased safety. Note, however, that telematic systems do not form a substitute for a reasonable use of fuel and suitable driver training. Diligent transport operations management, also with the aid of telematics or other technological means, is the key to fleet productivity and effectiveness as well as ecological management. Various telematic applications, depending on their use, produce a number of environmental, functional and financial benefits, both for individuals and for companies.

Transport telematics has an immeasurable impact on natural environment through attempts at achieving maximum use of roads, minimum traffic intensity, assistance in bringing down air and noise pollution and helping to create uncongested traffic zones.

Advantages of using transport telematics:

- time-saving,
- more effective and faster notification of incidents,
- reduction of the number of road accidents and collisions,
- transport cost reduction,
- reduction of environmental pollution and fossil fuel consumption,
- limiting congestion and the number of traffic jams.

Telematic services are constantly developing and will soon become standard features of future cars. Telematics bridges a gap between the vehicle, communications and mobile devices with internet-access. Continuing technological development and the popularity of portable communications devices will make manufacturers try to use telematic services to ensure greater safety, comfort and compliance with environmental requirements.

In order to achieve this, cooperation between car manufacturers and suppliers of telematic services – who will provide open and standard methods for supplying services – is necessary. Next-generation telematics should focus on four basic assumptions:

- **flexibility** of choice between equipment suppliers, call centres, content providers and wireless operators,
- **scalability** – adding services, content and capacity easily,
- **adaptability** in neutral technological platform with normalised interfaces and protocols encouraging the development of new services and easy integration with existing systems,
- **reliability**, which of fundamental importance when providing emergency services for consumers in life-threatening situations.

2.3 Types and Characteristics of Telematic Services

Among key services presently available in the field of transport telematics, the following categories can be listed:

- *Safety and security*
  Safety and security applications include Automatic Crash Notification services, emergency and medical assistance. It is the first set of services offered in the field of telematics. At the same time, these services constituted the basis for the development of the concept of car telematics. Automatic crash notification service monitors a set of sensors in the vehicle. If an accident occurs, information is sent about its severity and location to a centre, simultaneously initiating a telephone call with call centre, where the operator starts to organise suitable rescue operations. If necessary, a request for emergency services to intervene can be sent manually by the driver or passengers. The vehicle unit is frequently equipped with an alternative power supply, so that it can operate also when the car battery or electrical system is faulty. Security features offered by telematic solution suppliers include mainly stolen vehicle tracking, theft alarm notification, remote door control. The unit installed in the vehicle can remotely send periodical information on the exact location of the vehicle, or it can be started automatically by anti-theft sensors fitted in the car. A part of remote door control feature, the unit can also be programmed to open and close the door by remote control.
- *Information and navigation*
  Navigation and information services provide direct access from the vehicle to a number of perfectly integrated features, thanks to which the driver as well as the passengers receive information and content on location. An example of this could include personal access to a network of WiFi/Bluetooth devices inside the vehicle and enabling Internet access by means of a wireless connection. This category also includes a range of services provided for utility vehicles and fleet. Vehicle monitoring and fleet tracking are among services used for improving efficiency and effectiveness of utility vehicles.
- *Diagnostics*
  Diagnostics is another developing area of prospective telematic services. It comprises remote diagnostics, collecting performance data and remote scanning feature. A unit installed in the vehicle is able to perform a detailed diagnostic scan on demand or when certain key threshold values have been exceeded, e.g. the distance covered, previous scanning time, or the time that has passed since the last service.

2.4 The Concept and Purpose of Eco-telematics

For years vehicle manufacturers have focused on improving engine performance and efficiency and have been looking for an alternative drive system in order to reduce exhaust fumes emissions. Meanwhile, for over 10 years ITS technologies have been developing. However, they concentrated mainly on the improvement of safety and comfort of vehicles. Recently their potential for better fuel consumption performance and emission control, also known as "green driving" or "eco-driving" have met with acclaim.

Eco-telematics comprises applications and solutions aimed at reducing negative environmental impact of transport:

- through the driver by providing feedback,
- additionally as navigation and telematic components,
- additionally as drive system components,
- by integrated systems constituting an element of the vehicle's design.

3 Classification of Eco-telematic Applications

There are many telematic systems which may contribute to eco-driving. Generally, they can be grouped according to their role in the driving cycle (Fig. 4).

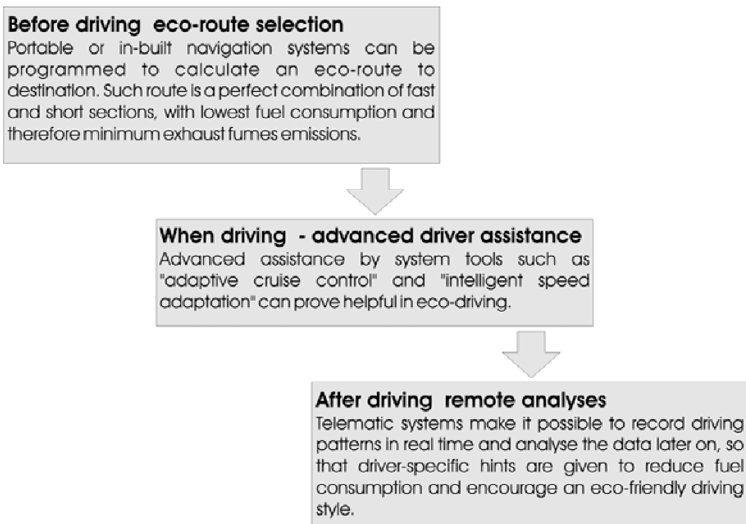


Fig. 4. Division of eco-telematic applications according to the driving cycle. Source: [11].

It is also possible to divide eco-telematic solutions by their function in the vehicle, namely:

- eco-monitoring,
- eco-advice,
- eco-drive.

Fig. 5 presents the suggested division:

- Eco-monitoring
  - eco-compliance,
  - monitoring fuel consumption,
  - monitoring exhaust fumes emissions,
  - monitoring driver's behaviour.

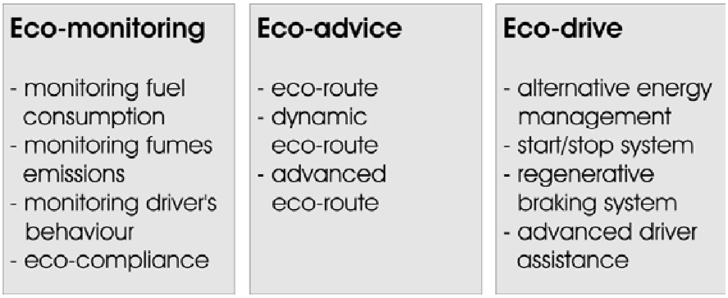


Fig. 5. Suggested division of eco-telematic applications. Source: [11].

- Eco-route
  - route properties integrated in maps: curves, slopes, speed limits, number of roundabouts, etc.,
  - statistical traffic information,
  - possibility of using some vehicle parameters for reducing fuel consumption,
- Eco-drive
  - regenerative braking system,
  - start/stop system,
  - active energy management,
  - controlling the engine by means of the appropriate software.

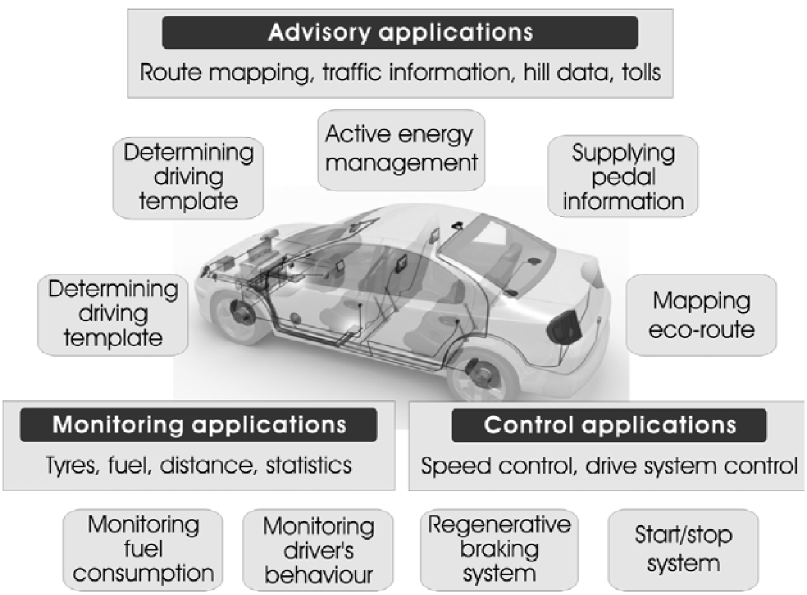


Fig. 6. Eco-telematic applications. Source: [11].

4 Conclusions

Together with growing number vehicles and the development of information technologies, telematics has recently become a "hot" research subject in IT and the car industry. Telematics has gone a long way from providing navigation solutions/assisting the driver to becoming an integral part of the vehicle. Today's telematics ensures safety, comfort and convenience of the driver and the passengers.

Table 3. Eco-telematic applications, their properties and implementation possibilities. Source [11].

	Basic properties	Advanced properties	Implementation possibilities
Eco-monitoring	• On-board driving computer • Monitoring resources: • Fuel consumption • Tyre pressure • Other	• Navigation devices, • Monitoring the ride, • Transmitting data via an Internet website, • Wireless real-time data transmission	• On-board computer is a widespread feature, • Websites are already being set up, • Wireless data transmission 2010+
Eco-compliance	• Remote emission test by means of telematic systems	• Real-time monitoring • Communicating reservations.	• 2011 or later, • state involvement necessary.
Eco-route	Route calculation: • fuel consumption, • emission level.	Route calculation: • traffic information, • weather information, • traffic prediction.	• eco-route mapping is already appearing, • PNDs are already in use today, but will be more widespread in the future.
Eco-drive	Optimising fuel consumption: • engine load, • climate, • air pressure, • other	The use of MAP sensor • An example in Navteq MPE (Map and Positioning Engine Strategy)	• Some systems are already in use.

Explanation of acronyms used in the Table 3:
MAP sensor – a sensor in engine control system is the basic sensor informing of engine load.
PNDs – portable Personal Navigation Devices.

However, due to the environmental protection aspect which is a more and more frequently recurring theme in the field of transport (encouraging eco-friendly, "green" solutions and means of transport), it is quite important to turn attention to the opportunities offered by telematics and Intelligent Transport Systems in this respect. There is a possibility of expanding this vision by other applications, which could directly or indirectly support the protection of the environment against negative impact of the transport industry. Until recently, telematics was associated mainly with navigation services, so focusing its use on transport ecology raises considerable expectations and provides huge space for its development.

Many analyses suggest that telematic applications which allow users to save money will gain popularity in the next few years. Among such applications of special importance are eco-telematic applications which make it possible to economise on fuel.

Both creating and implementing telematic systems is a long-term and enormously complicated process. There are economic as well as social barriers involved, not to mention technological and educational barriers. Creators of telematic services face technological problems, while being fully aware of the need to offer reliable solutions, since in certain situations these solutions will decide on people's life or health. Service purchasers, namely car manufacturers, include additional functionalities in car features, while car owners would like to pay as little as possible. The way forward in this field requires immense effort on part of motor car manufacturers, telematic service providers and governmental administration bodies.

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