Greening Dimension of Intelligent Transport

A. Janota¹, M. Dado² and J. Spalek¹

¹Department of Control and Information Systems, Faculty of Electrical Engineering, University of Žilina, Univerzitná 8215/1, Žilina 010 26, Slovakia; e-mail: {ales.janota, juraj.spalek}@fel.uniza.sk
²Department of Telecommunications and Multimedia, Faculty of Electrical Engineering, University of Žilina, Univerzitná 8215/1, Žilina 010 26, Slovakia; e-mail: milan.dado@fel.uniza.sk

Abstract

The main purpose of the paper is to show the potential of intelligent transport systems in the process of “transport greening” and possible contributions of information and communication technologies for developing the field of transport in a sustainable way. At first the problem of transport effects on environment is shown in the light of selected statistic indicators. Attention is then paid to road transport seen in the context of the latest EU green initiatives, research and standardization activities as well as the global economic crisis. The authors summarize some of available technical solutions and discuss their expected effects on environment.

Keywords: environment, intelligent transport system, information and communication technologies.

1 Introduction

Individuals and organizations produce CO₂ gases through their everyday activities such as air and car travel, burning of fossil fuels for energy, the production of cement, steel, textiles and fertilizers. The world is urbanizing rapidly, and population densities are increasing. A United Nations report estimates approximately 70% of the world’s population will live in cities by
2050 [1]. Population growth goes along with an increase in car ownership and demand for transport activities across all regions (see Figure 1).

In the European Union alone, 20% of GDP is generated by the transport sector. This equates to 1,900 billion euros, 16 million jobs, or 9% of all EU employment [2]. The automotive industry itself is the backbone of the manufacturing industries in Europe and directly and indirectly supports the jobs of over 12 million employees (direct employment over 2 million persons and indirect employment another 10 million persons). Strategic Analysis of European and North American Green Telematics Market for Passenger and Commercial Vehicles, from Frost & Sullivan, finds that the European and North American fleet green telematics market will likely increase from $80.0 million in 2008 to $700.0 million by 2015. The market is growing at a compound annual growth rate of 36.0% from 2008 to 2015, primarily thanks to growing pressure on fleet companies to reduce their carbon footprint and develop a greener image. Transport is a major consumer of fossil fuels, currently accounting for 30% of total energy consumption and 28% of CO₂ emissions in Europe. Traffic accidents and congestion are costly to society in terms of lost lives, productivity, and energy. For transport to become more efficient, safe, and environmentally sound, new ways of looking at overall transport objectives are needed. To cope with incident problems of rising pollution, traffic congestions, safety and security etc., increasingly smart (intelligent) solutions are adopted and deployed in the form of intelligent transport systems (ITS). ITS technologies include satellite navigation, mobile communication, microelectronics, and sensors. These different solutions interact and need to be managed in an integrated way. However, the ITS cannot solve all the problems alone but it will play a major role. Putting greater intelligence into transport systems and integrating into vehicles and road infrastructure, these
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technologies will be able to help monitor and manage traffic flows, reduce congestion, and help users make more intelligent choices about their journeys. Most importantly, they will give them better security, help limit the number of road traffic accidents and save lives. To serve the needs of the future, transportation systems must undergo a radical transformation, from the centralized paradigm to the asynchronous, distributed paradigm that integrates fast computers and high-performance networks through novel computer algorithms [3]. The concept of ITS is about enabling these choices and taking the first step towards meeting that challenge. To reduce congestion and make public transport more attractive means to reduce transport-generated pollution, encouraging conditions for sustainable economic growth. Generally, greening of road transport covers three main domains – Electronic Toll Collection, Navigation and Eco-driving, and Green Transport Corridors. The aim of the paper is to show potential of intelligent technical solutions implemented through intelligent transport systems for sustainable development in transport domain. Main attention is paid to road transport as one of the main sources of emissions and pollution. Some key technologies are discussed in more details.

2 Potential of ICT & ITS in the Environmental Agenda

A significant concern over climate warming and environmental sustainability issues has affected the domain of information and communication technologies (ICT). ICT is in many ways a unique technology. It has the characteristic of a threshold technology, with the potential to rapidly change the whole structure of society and reshape the way we organize our economy, in much the same manner as did inventions such as the internal combustion engine of the last century. The environmental impact of ICT under the banner of “Green ICT” has started being discussed by academia, media, industry and governments.

Intelligent transport systems (transport telematic systems) integrate ICTs and traffic engineering in such a way that it is possible within the existing infrastructure to increase traffic performance, to increase safety and comfort of passengers. There are many technologies having potential to be key technologies for reduction of road vehicle emissions. Some of them are indicated in Table 1. “Green” ICTs are applicable in many areas of transport industry: Traffic information and route guidance, Telematics and on-line services, Data monitoring and measurement, Advances driver assistance, Fleet and freight management, Traffic management and control, Demand management, and others. Currently, 3–4% of the world-wide energy is consumed by the ICT
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infrastructure (approximately 1.5–2% by wireless), which causes about 2% of the worldwide CO₂ emissions (which is comparable to the worldwide CO₂ emissions by airplanes or one quarter of the worldwide CO₂ emissions by cars). Therefore, as a typical example, lowering energy consumption of wireless radio systems is demanding greater attention [4]. Most of the work that has been done has reached one of two conclusions: either ICT will bring only good things, from solutions to world hunger and the elimination of all transportation problems to a revitalized democracy; or ICT will bring nothing but problems, accelerating resource consumption, introducing new toxic materials and resulting in greater inequity by introducing a digital divide that will worsen the already unequal distribution of wealth and influence. The impact of ICT must be viewed in a very broad sense, from cultural changes caused by the use of new technologies, to the appearance of new possibilities for shaping a new economy in which production and consumption patterns look fundamentally different.

Human lives savings together with operation and maintenance financial savings may be reached thanks to implementation of new technologies, sometimes applied on the lowest levels. As a typical example of such a “simple” infrastructure solution the new LED-based traffic lights could be mentioned. LED traffic lights are able to save lives because they are up to four times brighter than incandescents and can be seen in bright sunlight as well as foggy conditions. What is more, they last up to ten times longer than incandescents, so the danger of a burnout is greatly reduced (LED modules have a life of six years or more while the current bulbs have only a two-year life). Switching to LEDs can cut energy costs by more than 80%. Other savings result from less maintenance needs and thus saving time of maintenance staff.

For many transportation systems, the cost of expanding the infrastructure is too high. Therefore, engineers must shift their focus to improving the quality of transportation within the existing infrastructure. Focusing on highway and railway systems, a radically different approach to transportation systems design is needed – one that closely resembles reality and promises to yield an architecture that delivers the highest efficiency [3].

New construction solutions and technologies newly deployed in vehicles have brought many positive consequences, gradually increasing vehicle smartness. However, requirements for higher comfort, safety, efficiency, etc., most gradually result in higher average vehicle mass, having consecutive negative effect on road infrastructure and environment. Much effort has been made to compensate it, for example usage of:
Table 1 Key technologies for “transport greening”.

<table>
<thead>
<tr>
<th>Effects of new technologies implementation</th>
<th>Key technology examples</th>
</tr>
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<tbody>
<tr>
<td>- Advanced engine construction, fuel processing, and vehicle operation may reduce emissions (exhaust fumes and combustion gases, noise, vibration, electromagnetic radiation)</td>
<td>Vehicle monitoring (consumption, emissions)</td>
</tr>
<tr>
<td>- Passive and active measures increase safety</td>
<td>Mobile data collection</td>
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<td>- Implementation of V2V (vehicle-to-vehicle), V2I (vehicle-to-infrastructure) and/or V2V/V2I, eventually P2V (person-to-vehicle) communication increase safety, efficient use of infrastructure and other services</td>
<td>Fleet eco-management</td>
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<tr>
<td>- Different measures are taken to compensate higher mass of a vehicle</td>
<td>Driving-gear control</td>
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<td></td>
<td>New materials</td>
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<td></td>
<td>Advanced active and passive technologies (ABS, ACC, ACWIS, ADAS, ADM, ALC, ASF, BAS, EBD, e-Call, ESP, EDC, HUD, LDWS, MBA, RDC, steering boost, night vision, airbags, etc.)</td>
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2.1 Congestion Charging Systems

Using taxes and fees to control wasteful driving habits while helping the environment often results in the controversial debate. However, practical examples such as the Stockholm Congestion Charging System launched a few years ago have shown how the congestion charging system can reduce traffic volumes, decrease CO₂ emissions and improve accessibility and bring significant benefits to the city, its visitors, and residents. The Stockholm system is the largest of its kind in Europe, with 18 barrier-free control points around...
the inner city equipped with cameras to identify vehicles around a 24 km² area. It significantly improved access to the city by cutting waiting times on access roads by one-half. City traffic is down 18% and CO₂ emissions in the city were cut between 14 and 18%. It is worth mentioning that the number of “green” tax-exempt vehicles such as hybrids has almost tripled and the number of commuters using public transport increased by around 7% or 60,000 passengers per day. Thus the congestion charging system seems to be the most influential factor in the decision to choose a green car. The congestion charge is a national tax that will raise an estimated $84 million in 2010. The money is invested in the Stockholm region for further traffic investment. The majority of cities are at an early stage in understanding and realizing the full potential of ITS.

2.2 Greening the Fleets and Eco-mobility

Green telematics packages, such as vehicle and driver management services, provide complete data for driving behaviour and fuel consumption analysis for commercial vehicles. Optimizing these parameters ensures green fleet operation. ITSs have potential to provide more visibility and informedness on the occurrence of excess or unnecessary vehicle usage, unauthorized private vehicle usage, poor driving behaviours, mobile worker idling and speeding, and fuel wastage. With these being controlled and managed efficiently, a company’s fleet becomes all the more green. In addition, the use of alternative fuels (compressed natural gas, electric hybrids, etc.) may also help with greening the fleets. Although emissions from new vehicles have decreased by 13% in the last decade, old cars continue to be heavy polluters. A strategy must therefore be framed that not only focuses on new cars and vehicle technology, but also encompasses the overall reduction of CO₂ emission from all vehicles. Real-time navigation alerts also help reduce unwanted mileage. One of emerging topics being discussed in recent years concerns a future trade with personal emission quotas. The idea is based on monitoring of individual car operation, its measuring, scoring, and keeping files of “individual emission account”. Some EU-supported pilot projects have already been realized in that way (e.g. MESSAGE). Some kind of so called “button for eco-mode driving” can be expected available in future vehicles.
2.3 Safety Increase

Driver’s mistakes are undoubtedly the main causes of accidents. Therefore, the ITSs as representatives of symbiosis of the ICTs and traffic engineering should construct a car as an integral part of the ITS and reduce probability of driver’s mistakes. Generally, technologies implemented in the vehicle may be classified to pre-crash, at the moment of crash and after-crash ones. In future we can expect further technical systems able to assist a driver in his/her making decisions or manoeuvring but self-responsibility will always be held by a driver as signified in Vienna Convention from 1968. No such actions in vehicle may be performed that will reduce driver’s abilities to drive, or unexpectedly change operation of a vehicle. At presence, responsibility is held by the vehicle operator – sanctions may be given to the driver. Producer responsibility covers those cases when a technical defect will make a driver unable to drive a vehicle, i.e. producer is obliged ro respect all relevant laws, regulations and recommendations. In future we can expect government responsibility covering situations when external signals will effect vehicle functioning (e.g. satellite broadcasting). However, there is a philosophical question – will this responsibility be taken over by the state?

3 Standardization, Green Initiatives and Research

Standards work in ITS has been ongoing for more than 30 years, including such organizations as ITU, ETSI, IEEE, and ISO. The leading position in the European context belongs to the CEN/TC 278 “Road Transport and Traffic Telematics”, having at present 16 working groups. One of the aims for clean and efficient mobility is to “identify and promote the potential benefits that ICTs, applications and services can bring towards cleaner and more energy-efficient mobility for people and goods”. The actual problem is how to measure progress. The usual way to measure the environmental burden of public transport is the emission per vehicle kilometre. By applying a certain occupancy rate this can be translated into the emission per passenger kilometre. Note that both indicators are measured in average terms. Vehicle measurements could be based on [6]:

- Shorter travel time and less fuel consumption for the same mileage driven (due to smoother traffic flow, less traffic jams, less accidents).
- The same or less time and less fuel for less mileage driven.
- Less costs to come from A to B within the same time frame.
- Less empty load driving.
Less fuel consumption due to deployment of ICT measures for vehicles, infrastructure and driver behaviour.

Less fuel consumption seems to be a good observed parameter since can be easily translated into emission measurements. Best recommended measure for vehicle integrated systems is large-scale field operational tests to compare reference groups with and without system under different driving conditions.

To measure progress of infrastructure is more complex task. Infrastructure improvements should be measured against number of fewer accidents, increased traffic throughputs, less pollution, improved air quality, etc. Simulation models represent another important area to be explored.

In relation to different kinds of communication protocols mentioned above (V2V, V2I), important role is played by global, market-driven standards for the information, entertainment and communications industry. They have been initiated, introducing so called the Telecommunications Energy Efficiency Ratio, or “TEER”, as a measure of network-element efficiency. The standards provide a comprehensive methodology for measuring and reporting energy consumption, and uniformly quantify a network component’s ratio of “work performed” to energy consumed. The green wireless ICTs make possible many enhancements in the industry and everyday life; including ITSSs, office and industrial automation and wireless sensor networks (WSNs). Due to their proliferation and applications extensions, it is very important to keep wireless ICT green, i.e., to utilize technologies that allow low power consumption; as well as to use power harvesting. Among many available technologies three are known by their very low power consumption – Ultra Wideband (UWB), ZigBee, and Bluetooth. ZigBee very soon will be equipped by a “green” profile, making harvesting of power available. Bluetooth SIG provided Ultra Low Power profile; and UWB is in the winning position when a large bandwidth is required by users – this technology is the most attractive from green perspectives in large bandwidth applications.

“The European Green Car Initiative” aims to sustain progress towards a breakthrough in the use of renewable and non-polluting sources of energy, road safety and traffic fluidity. As a part of the European economic recovery plan, it aims to allocate €5 billion through a Public Private Partnership to bolster innovation in the automotive sector and sustain its focus on environmental progress. The initiative covers passenger cars as well as trucks and buses and transport systems, intelligent infrastructure and the availability of a fuelling and/or charging infrastructure. Greening road transport is necessary to achieve EU and world targets in emissions reductions. Such
“eco-innovation” will serve both to protect the environment, and to offer competitive advantage to those seeking to create new innovation-driven markets. Nanotechnology is expected to play an increasing role in making road travel greener by reducing car weight, increasing fuel efficiency, and improving battery and fuel cell functions. The funding for road transport projects under FP7 in 2010 will all be focused on the electrification of road transport and research into hybrid technologies; a critical mass which is expected to produce a step change in innovation in these technologies. In the following FP7 Calls, in 2011, the topics for projects to be funded should broaden to the other areas of the Green Cars Initiative: research into trucks, internal combustion engines, logistics, and intelligent transport systems. All of these areas are equally important and none of them can be considered independent from the others.

As a typical representative of research project we could mention the project eCoMove: “To develop a combination of cooperative systems and tools using V2I communication to help drivers sustainably eliminate unnecessary fuel consumption, and road operators manage traffic in the most energy-efficient way”, coordinated by the ERTICO ITS Europe. Energy is wasted due to inefficient deceleration, wrong gear & engine speed, excessive speed, acceleration, poor anticipation, congestion, poorly synchronized signals, choice of inefficient route and lack of know-how, motivation.

4 Conclusions

ITS make it possible to imagine a future in which cars will be able to foresee and avoid collisions, navigate the quickest route to their destination, making use of up-to-the minute traffic reports, identify the nearest available parking slot and minimize cars carbon emissions. The main motivation for ITS is the improvement of road safety; ITS may also reduce the amount of pollutions from transport by 35–50%. ITS will cause a similar transformation of mobility as the Internet caused a transformation of our communication patterns. All traffic modes will communicate with each other, the traveller will be fully connected and the mobility of people and goods will be further optimized. Cooperation is the future for mobility and cooperation will ensure that this future will take place. In the foreseeable future ITS streamline the road for a “fully networked car”, which is a prerequisite to the “fully automated car” – the car that drives with minimum human participation and is a part of “green transportation”. Energy sources are limited, so it is time to go green. The main observations could be summarized as follows:
• The easiest way of reducing fuel consumption is by changing driving behaviour (according to some research findings driving behaviour contributes up to circa 33% of fuel consumption).
• Greening of the fleets may be reached by higher visibility of the mobile means operation ensured by ITS implementation, together with usage of alternative fuels (ITSs can reduce total fleet costs by around 20% potentially).
• ITS has potential to increase safety and reduce driver’s mistakes being the main cause of accidents today.

The recession following the global financial crisis of 2008 represents a serious threat to the process of transport greening. The economic slowdown is forcing fleet companies and individuals to rethink their priorities and investments. Moreover, public awareness on the availability of green telematics systems and services remains limited. The industry is under increasing pressure from customers, shareholders and proposed legislative changes to improve their environmental credentials. It is beyond question that future functionalities will be determined by software. Within potential recommendations the following future steps are often proposed to perform:

• Explore the impact of future ITSs on safe and efficient mobility and define priorities.
• Investigate potential of cooperative systems with regard to safety and eco-efficiency.
• Especially investigate the possibilities of “green” logistics using a multimode approach.
• Expand work on R&D for environmental monitoring & modelling, methods of impact assessment and impact analysis, development/adaptation of simulation models.
• Public authorities/road operators should invest in state-of-the-art intelligent infrastructure.
• National and local governments should cooperate and harmonize the approach to environment-friendly mobility, in order to ensure interoperability, lower costs and greater impact.
• Countries should set up multi-stakeholder “Fora” for “Eco-ITS/Clean mobility” sharing best practices and promote standards for large-scale roll out across the region.
Acknowledgements

This work was supported by the project “Centre of Excellence for Systems and Services of Intelligent Transport”, ITMS-26220120028, University of Žilina, Žilina, Slovak Republic; and partly financed by the European Union, “European Regional Development Fund”.

References


Biographies

Aleš Janota received his MSc degree in “Interlocking, signalling and communication engineering” (1986) from the Faculty of Mechanical and Electrical Engineering of the Technical University of Transport and Communications in Žilina (today’s University of Žilina). His PhD thesis entitled “Knowledge base for railway interlocking and signalling” was defended in the field of Telecommunications (1998). His second doctoral thesis dealt with “Formal specification of safety-critical systems” (2003). At present he works as a full professor at the Department of Control and Information Systems at the Faculty of Electrical Engineering, University of Žilina. His present research and education activities cover different topics from the field of control systems, artificial intelligence and information and communication technologies, applied mostly in transport domains. He has been a co-ordinator and/or participant of multiple research and educational projects related to the specified fields of work.
Milan Dado received his MSc. degree in “Technical operation of telecommunications” (1975) from Department of Telecommunications at the Faculty of Mechanical and Electrical Engineering of the Technical University of Transport and Communications in Žilina (today’s University of Žilina). His PhD thesis (1990) was entitled “Diagnostic methods based on noise analyses of telecommunication channels”. Since 1997 he has been a full professor at the Department of Telecommunications and Multimedia at the Faculty of Electrical Engineering, University of Žilina. His present research and education activities are focused on different areas of information and communication technologies and services e.g. optoelectronics, signals and systems theory, information and communication technologies and services. In the field of intelligent transport systems he has initiated and managed multiple projects focused on interdisciplinary areas of transport, ICTs and new services development.

Juraj Špalek received his MSc in 1976 from the Department of Interlocking, Signalling and Communications at the Faculty of Mechanical and Electrical Engineering of the Technical University of Transport and Communications in Žilina (today’s University of Žilina). His PhD thesis (1981) entitled “Electronic logical system as an interlocking system” concerned the area of safety engineering. His research and pedagogical interests include reliability engineering, fuzzy-set theory applications, and analysis of reliability and safety of electronic systems for safety-related critical applications. His second doctoral thesis (1993) that qualified him for the post of an associate professor dealt with “Electronic systems properties in critical applications”. At present he works as a full professor and a head of the Department of Control and Information Systems at the Faculty of Electrical Engineering of the University of Žilina.