UNECE's role in the promotion of Intelligent Transport Systems

Background document

Backgrou

document

Aims

The world's citizens depend on safe, efficient and secure transport systems. Whether we travel by road, boat, rail or air we rely on our transportation systems to get us where we need to go. The same systems play an important role in our national economic well-being, making it possible to move goods from place to place and to succeed in the global marketplace. Starting from an overview of the actions so far initiated by the United Nations Economic Commission for Europe (UNECE) on Intelligent Transport Systems (ITS), the final aim of this document is to produce a policy vision summarizing and addressing the opportunities created by the application of new technologies in transport, and consequently to draft action proposals for the implementation of ITS.

"There must be a reason why some people can afford to live well. I only feel angry when I see the waste" (Mother Teresa of Calcutta)

Different systems of transport can be improved and made more efficient, providing safer travelling conditions, avoiding the waste of material resources and energy and protecting and enhancing human lives. Intelligent Transport Systems are integral to achieving this target.

This paper serves as an outline of existing literature and current technologies. The opinions expressed by the authors are in no way binding to the Transport Division, the Inland Transport Committee of the UNECE, the Italian Ministry of Infrastructures and Transport or SINA.
The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers and boundaries.

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1. Introduction

When we look at transport systems, it is easy to see that the greatest challenge we currently face is enhancing the quality and safety of mobility itself, by improving vehicles and all relevant transport infrastructures.
Any steps forward should take into consideration the concept of efficiency, which is linked to energy consumption and the use of land. This forces us to consider the general impact that the mobility of people and the transportation of goods have on the environment around us.
In this document, we will refer frequently to the concepts of safety and security in transport. Road safety is a concern that affects us all in our everyday lives. Security is also important to us; both the general public and businesses alike need to know that their vehicles and goods are safeguarded and that they themselves are protected from fraudulent acts connected to transport and its infrastructure.
Information and Communication Technologies (ICT) relating to road transport usage are often internationally referred to as Intelligent Transport Systems (ITS). These include a wide range of organisational and technology-based systems that are designed to facilitate the realisation of efficient, seamless transport systems with optimised traffic flows, doing away with the bottlenecks and queues to which we have become accustomed. The deployment of ITS provides for the better usage of both existing road networks and available energy while also helping to curb accidents and improve the efficiency of transport as a whole. Intelligent Transport Systems provide state-of-the-art customised devices that can relay real-time information to road users and law enforcement agencies, while also facilitating remote access to pre-paid accounts and electronic payments.
Technologies that allow authorities and operators to achieve managed transport networks and more sustainable land mobility generally come under the umbrella of ITS. In-vehicle and roadside ITS include all technologies that improve vehicle and infrastructure safety, enabling smooth and comfortable transportation by making use of specific vehicle functions and interacting with roadside infrastructure and sometimes other vehicles.

Intelligent Transport Systems solutions utilise advanced information technologies related to driver assistance, traffic management and vehicle control, which are constantly improving the quality of interaction between highway systems and vehicles.

This document provides an overview on:
(a) ICT for transport and logistics.
(b) Concrete solutions for achieving better quality, more secure and more efficient road transport.
(c) Different transport modes and how they can be twinned with road transport policies.
(d) The extent to which ITS and ICT may be integrated to enable better transport monitoring.

2. Long-term and wide-ranging transport objectives

UN General Assembly resolutions have stated that over the coming decades transportation is expected to be the major driving force behind a growing world demand for energy. All over the globe adequate, efficient and effective transport systems will make a huge difference in the way we live our lives. Transport will play a key role in emerging economies, where the improvement of transport networks will lead to - amongst other things - the reclamation of marshes and unusable land, improved access to markets, improved employment and education opportunities and the establishment of basic services critical to poverty reduction.

Road accidents: the No. 1 policy challenge

UN Secretary-General Ban Ki-moon[1]: *"This year, more than one million people across the world will die from road traffic injuries. This total includes about 400,000 people under 25 years old, and road traffic crashes are the leading cause of death for 10 to 24-year-olds. Several million more men, women and young people will be injured or disabled. In addition to the human suffering, the annual cost of road traffic injuries worldwide runs to hundreds of billions of dollars. In low and middle-income countries, the economic cost of road injuries will be more than the development aid they receive. [...] urge UN member States and global road safety partners to foster cooperation under UN auspices".*

Road traffic injuries are a major but neglected public health concern requiring concerted multi-sectoral efforts for effective and sustainable prevention. In Europe alone, every year road traffic accidents[2]:

- Kill around 127,000 people.
- Injure some 2.4 million.
- Kill more children and young people aged 5-29 than any other cause of death.

In EU Member States road traffic accidents are the leading cause of death and hospital admission for EU citizens under the age of 45. Mobility comes at a high price: 1,300,000 accidents a year cause 40,000 deaths and 1,700,000 injuries on the roads in the EU. The direct and indirect costs have been estimated at EUR 160 billion, i.e. 2% of the GDP. Road safety continues to be a priority area for action in the EU[3].

Road traffic injury levels of this magnitude not only present a pressing health issue, but affect society as a whole. In lower-income countries budget constraints and lack of resources result in poor infrastructure investment.

In order to achieve leverage of costs, traffic planners are still designing road networks largely from the perspective of motor vehicle users rather than taking into account the spectrum of different vehicle types and patterns of road use. For instance, making sure that pedestrian and cycle paths connected to public transportation systems have sections separate from roads as well as sections running parallel to roads, with particular attention devoted to safe crossings at junctions, would drastically reduce the number of traffic accident victims[4].

With this in mind, during its 87th Plenary Meeting on 31 March 2008, the General Assembly adopted resolution 62/244 on improving global road safety. Through this resolution the General Assembly "*reaffirms the importance of addressing global road safety issues and the need for the further strengthening of international cooperation, taking into account the needs of developing countries by building capacities in the field of road safety and providing financial and technical support for their efforts*".

When we look at EU institutions, their transport policies not only aimed at halving traffic-related casualties by 2010, but also set of transport efficiency as an absolute priority, leading the way to better, more cost-effective transportation. In the future, evident improvements in environmental protection and consequently the beneficial effects on citizens' daily lives could be directly linked to the EU's action plan for ITS and the EU directive on ITS which was adopted on 7 July 2010 (Directive 2010/40/EU and COM (2008)886).

The UN is deeply involved in the challenge presented by environmental sustainability and climate change. Moreover, it is committed to the crucial necessity of

(1) UNECE, *UNECE Transport Review - Road Safety*, First edition - New York and Geneva, November 2008
Available from **www.unece.org/trans/doc/2008/UNECE-Transport-Review-1-2008.pdf**
(2) Available from **www.euro.who.int/violenceinjury/injuries/20030911_1, August 2009**
(3) Available from **http://ec.europa.eu/transport/road_safety/observatory/doc/rsap_en.pdf, 2010**

1. Millennium Development Goal 7

2. UN Secretary General Ban Ki-moon

3. Reference manual of the Kyoto Protocol[9]

Decade of Action for Road Safety 2011-2020

Road safety is one of the most serious challenges facing society today with more than one million fatalities every year. United Nations General Assembly resolution 64/255 declared the period 2011-2020 as a decade of action for Road Safety, with a goal to reduce road traffic fatalities worldwide.

UNECE has pioneered road safety activities in the UN system. As the only UN intergovernmental body concerned with road safety, it develops and administers international legal instruments in the area of traffic regulations, construction and technical inspection of vehicles as well as safe transport of dangerous goods. These instruments have assisted member States across the world to harmonize and enforce traffic rules, produce safe and clean road vehicles, reduce the risk of accidents with dangerous goods and hazardous materials and ensure that only safe and well maintained vehicles and competent drivers are allowed to participate in traffic. Moreover, transport infrastructure agreements developed under UNECE auspices, have given Europe coherent pan-European and safer road transport networks. The UNECE attaches great weight to the Decade of action increasing road safety and it has ambitious plans for a series of road safety activities to educate, to raise awareness, to induce action and to create dynamic and effective responses.

directing all possible efforts, in any field and by any means, towards curbing the impact that urbanization, technological development and industrialization have on the environment. The Millennium Development Goals have been defined as key policy objectives for the UN and include a specific goal dedicated to "Environmental Sustainability". The UN considers the achievement of this goal as one of the fundamental principles for world development.

Environmental sustainability: a policy for current and future generations

From remarks[6] made by UN Secretary-General Ban Ki-moon to the Global Environment Forum on 11 August 2009: *"Reykjavik in Iceland... Curitiba in Brazil... Kampala in Uganda... Sydney in Australia. Whenever I visit these places, I am impressed. People everywhere are accepting that we must all live cleaner, greener, more sustainable lives. This is our future". [...] "I promise you my best effort as Secretary-General of the United Nations - my best effort to push, pull and cajole national leaders into acting in our common global interest".*

UN Secretary-General Ban Ki-moon in addressing the University of Copenhagen, Denmark, on 3 October 2009: *"If there is one lesson that we must learn from the climate crisis and our great challenges, it is this: we share one planet, one small blue speck in space. As people, as nations, as a species: we sink or swim together".*

Since the introduction of Agenda 21 in 1992[5], a comprehensive plan of actions has been gradually realised globally, nationally and locally by the organizations of the United Nations, governments, and stakeholders. These measures are set to make significant contributions to the quality of life of the world's citizens through caring for the Earth's ecosystems.

During the Ministerial Conference on Global Environment and Energy in Transport (MEET), held in Tokyo, Japan on 15-16 January 2009, as well as MEET 2010, held in Rome (Italy) on 8 and 9 November, the ministers and relevant representatives responsible for environment and energy in the transport sector, stated: *"Transport is an important foundation of our society, supporting a wide range of human activities, and contributing to economic and social development. It is, at the same time, responsible for considerable emissions of carbon dioxide (CO_2), which impacts global climate, and air pollutants, which impact public health and the environment of many urban areas"*[7].

Urgent action is required to address these issues while also adhering to sustainable development principles. One of the ways in which this can be achieved is through a shared long-term vision of realizing low-carbon and low-pollution transport systems. If we look at environmental policy targets while considering the general principles of the Kyoto Protocol, environmental planning and management policies related to transport should also be established.

Applying new technologies to transport could indeed be seen as an efficient tool for realizing the plans set during the United Nations Framework Convention on Climate Change (UNFCCC) summits in Bali (2007) and in Poznań (2008), as well as in Copenhagen (2009), Cancun (2010) and Durban (2011). Within this framework, the UNECE region could play a pivotal role in contributing to the fight against climate change and lead the way in

(4) WHO report (2004)

(5) Agenda 21, the *"Rio Declaration on Environment and Development,"* and the *"Statement of principles for the Sustainable Management of Forests"* were adopted by more than 178 Governments at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janerio, Brazil, 3 to 14 June 1992 **http://www.un.org/esa/dsd/agenda21**

(6) Available from **www.un.org/apps/news/infocus/sgspeeches/statments_full.asp?statID=557**

(7) Available from The Ministerial Conference on Global Environment and Energy in Transport, Tokyo, Japan, 14th-16th January 2009


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achieving the targets set by UN Millennium Development Goal 7, balancing the socio-economic needs brought by radical industrial changes with a policy of sustainable development and efficient transport networks. This also includes consideration of the critical limits imposed by the Gothenburg Protocol in 1999 on the environmental effects of acidification, eutrophication and ground-level ozone through emission cuts in SO_2, NO_X, NMVOCs and ammonia.

This vision of placing transport in a challenging venture with environmental issues is also being pursued practically through the gradual accomplishment of the UNECE Pan-European Programme on Transport, Health and Environment (THE PEP). This programme includes the transport, health and environment sectors currently implementing innovative technological policies aimed at curbing CO_2 emissions and makes a remarkable contribution to global climate change.

When discussing the policy direction and environmental approach that transport should take, it is important to consider the recent Amsterdam declaration on Transport Choices for Health, Environment and Prosperity (January 2009[10]), where the priority goals of reducing the emission of transport-related greenhouse gases, air pollutants and noise were set to improve the quality of life in urban areas. Cultural change, therefore, has to be achieved through planning clean and efficient public transport, intermodal connections and infrastructure for environmentally friendly and health-friendly transport.

Priority Goal No. 2 of the Amsterdam Declaration

"To manage sustainable mobility and promote a more efficient transport system by promoting mobility management schemes for businesses, schools, leisure activities, communities and cities, raising awareness of mobility choices by improving the coordination between land use and transport planning and promoting the use of information technology". Here we can clearly observe that the use of ITS is key to the proposed policy.

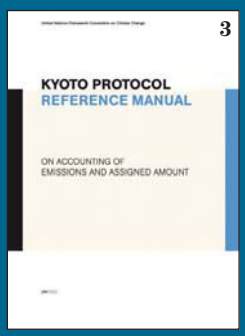
In order to reach all these objectives, governmental policymakers, together with international bodies such as the World Forum for Harmonization of Vehicle Regulations of the United Nations Economic Commission for Europe (UNECE/WP.29), encourage the research, development and deployment (RD&D) of innovative technologies and promote the use of concrete measures such as ITS technologies.

It is clear that technological development, or the upgrading of the technological infrastructure of a transport network, is an essential component for enhancing quality of life and integral to achieving a transport network that is both efficient and complies with environment and energy ideals.

Sharing the same vision, the European Commission (EC) issued a White Paper in 2001 (reviewed in 2006)

Kyoto Protocol

The Kyoto Protocol[8] is an international agreement linked to the United Nations Framework Convention on Climate Change, that sets commitments, binding targets and mandatory actions for 37 industrialized countries and the European Community in order to reduce greenhouse gas (GHG) emissions. Each Party signing the Protocol, in achieving its quantified emission limitation and reduction commitments (see Protocol art. 3), is bound to implement and/or further elaborate the policies and measures listed in article 2 of the Protocol. The first of the policies undertaken by Parties signing the Protocol is the: *"Enhancement of energy efficiency in relevant sectors of the national economy".* Kyoto Protocol article 2, a, (i). In the field of transport the promotion and deployment of ITS is a measure fully consistent and compliant with this policy.



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(8) Available from http://unfccc.int/resource/docs/convkp/kpeng.pdf
(9) Available from http://unfccc.int/resource/docs/publications/08_unfccc_kp_ref_manual.pdf
(10) Available from http://www.unece.org/press/pr2009/09env_p01_Add1_e.htm See http://www.euro.who.int/document/E92356.pdf

asserting that member States and operators need to work on all modal areas as a whole. The 2006 revised of the White Paper[11] allocates a wide window of possibility for the use of ITS. In addition, halving the number of road fatalities on EU roads in the period up to 2010 was one of the strongest commitments EU policy makers made in the White paper. While approaching the end of the 10-year period covered by the 2001 White Paper, the EC thought that it was time to look further ahead and define a vision for the future of transport. Therefore, they published the Communication on the Future on Transport in June 2009. With other actions, this led to the new White Paper *"Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system"* COM (2011) 144 as well as their Road Safety programme 2011-2020.

Halving the number of EU road fatalities has not been achieved in all EU countries by 2010, but it can be noted that since 2001 the number of road fatalities has decreased dramatically across the EU. Today there are 35 per cent fewer accidents than there were 10 years ago. Some countries have even seen more dramatic reductions, such as Latvia with 55 per cent and Portugal, Estonia and Spain with half the number of fatalities than of 2001.

As already mentioned, in December 2008 the EC proposed the ITS Action Plan and Directive to the European Parliament and European Council. This was a step toward the deployment and use of ITS in road transport for the European Union. The action plan suggests a set of concrete measures, supplemented with a proposal for a directive laying down the framework for their implementation. The EC deems that ITS can significantly contribute to a cleaner, safer and more efficient transport system.

Indeed, Antonio Tajani, former Commission Vice-President responsible for transport, stated when presenting the Action Plan: *"Making transport greener, reducing congestion and saving lives on Europe's roads are high priorities for the Commission. Intelligent Transport Systems will help us make progress towards achieving these goals. Today's initiative will therefore foster a more efficient, safer and more sustainable mobility in Europe"*[12].

At an international level, key figures from government and politics, business and industry, research organizations and civil society are debating the worldwide strategic importance of transport. The International Transport Forum[13] (ITF) is a global platform and meeting place at the highest level for discussing transport, logistics and mobility. In this respect, it is worthwhile referencing two products from the forum:

1. *"Resolution 2003/1 on assessment and decision making for integrated transport and environment policy"*, in which it is recommended that a systematic evaluation of economic, social and environmental effects is carried out for all transport plans and programmes and all major transport sector investments.
2. The OECD/RTR publication: *"Delivering the Goods - 21st century challenges to urban goods transport"* - an outcome of the Working Group's efforts to identify "best practices" in dealing with challenges facing urban goods transport, recommending measures to develop sustainable goods transport systems in Organisation for Economic Cooperation and Development (OECD) cities. The mission is to promote economic development in OECD member countries by enhancing transport safety, efficiency and sustainability through a cooperative research programme on road and intermodal transport.

Both of these recommendations have been realized in order to promote integrated development in global transport, a drive for which ITS harmonization is integral. The OECD/RTR publication also recommends[14] a wide range of compliance/assurance mechanisms that need to be investigated, including on-road enforcement, audit systems and surveillance methods (including the use of ITS/electronic monitoring systems). Transport systems are a major factor in economic development and the promotion of the sustainable development of transport networks, which should be the overall aim of efficient transport policies, systems and travel services.

When looking at the three major aspects of road safety (vehicles, infrastructure and the behavioural traits of road users) it appears evident that the use of new technologies and the deployment of ITS would facilitate progress in all three domains. Improvement in road safety and transport would be a consequence. The experiences of member States and road operators show how even relatively small investments in ITS provide for a better use of existing infrastructure. ITS could offer a swift answer to the demand for more efficient, cleaner and safer transport, both for passenger and freight services. Thanks to the strategic opportunities offered by ITS and its relative cost-efficiency, many institutions and stakeholders consider the deployment of ITS to be a key opportunity for transport policymakers in terms of delivering seamless and efficient cus-

(11) Communication from the Commission to the Council and the European Parliament - Keep Europe moving - Sustainable mobility for our continent - Mid-term review of the European Commission's 2001 Transport White paper [COM(2006)314]
Available from **http://ec.europa.eu/transport/strategies/2006_keep_europe_moving_en.htm**

(12) Available from **http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/1979&format=HTML&aged=0&language=EN&guiLanguage=en**

(13) Formerly the European Conference of Ministers of Transport, the International Transport Forum is an inter-governmental organization within the

tomized transport solutions across large geographical areas. Intelligent Transport Systems offer the possibility of providing road users with several state-of-the-art technological services, thus accelerating the advancement of economic, environmental and social benefits. The potential benefits that can be gained from real-time information (position of vehicles, relevant itinerary, information on goods, etc.) must not be limited to the classic ITS mainstays of safety and efficiency; there is also the possibility of electronically integrating road freight traffic within the overall administrative framework of intermodal transport, creating a more integrated and automated process and facilitating automatic procedures that are both more efficient and user-friendly.

Consequently, ITS applications have a major role to play in the abovementioned policy goals; new technologies are indispensable tools for quickly performing otherwise long-winded transport objectives. The use of advanced ITS technology could also provide an opportunity to promote the concept of a model where road transport fully integrates with other transport modes, where each mode complements the next, enabling a more efficient global transport system - a system that is also environmentally friendly. Furthermore, the deployment of ITS has to be valued as a winning factor for countries with economies in transition, where the high-tech upgrading of infrastructure could help bypass existing hindrances and gaps in road networks, providing safer and faster mobility which, as explained before, is one of the pillars of building a society based upon equity and social justice.

The Economic and Social Commission for Asia and the Pacific (ESCAP) Conference held in June 2007 in Bangkok, Thailand focused on the utilization and advancement of the transport potential of the corridors in Western Asia. The occasion acted as a special awakening, where the ESCAP Regional Forum of Freight Forwarders, Multimodal Transport Operators and Logistics Service Providers lay out (as they did at the Ministerial Conference on Transport held in Busan, South Korea, in November 2006) the crucial need to concentrate on the development of an international integrated infrastructural road network able to support the intermodal transport and logistics system of the South Western Asia region, under the overall framework of sustainable development. The deployment of ITS is a key factor for shaping a competitive and proper sub-regional, regional and international network for safer and more cost-effective transport systems. In this way, under the auspices of the UN and its regional commissions, information sharing, best practice and further opportunities can be nurtured through a culture of mutual assistance in ITS-focused programmes that enhance the concept of transport corridors, the application of time-cost/distance methodologies and provide customized assistance for development.

OECD family. Its founding member countries include all the OECD members, as well as many countries in Central and Eastern Europe
In addition, Brazil, China and India are being invited to participate. The involvement of more than 50 Ministers of Transport ensures direct links and strong relevance to policy making at both national and international levels. The aim is to foster a deeper understanding of the essential role played by transport in the economy and society

(14) Available from **http://www.internationaltransportforum.org/Pub/pdf/05Standards.pdf** Chapter *"Executive summary and recommendations"*, page 13

3. Technical overview of Intelligent Transport Systems

3.1 Basic definitions and preliminary considerations

Technological innovation and the use of Information and Communication Technologies (ICT) for transport relate to the whole set of procedures, systems and devices that enable:

(a) Improvements in the mobility of people and transportation of passengers and goods, through the collection, communication, processing and distribution of information.

(b) The acquisition of feedback on experiences and a quantification of the results gathered.

References shall be made to assessments conducted on the impact that ICT have on the quality of transport services, energy consumption, the efficiency of road transport, safety, cost-effectiveness and environmental friendliness.

Information and Communication Technologies applied to transport[15] are therefore essentially based upon a series of supporting communication systems, which can be considered as the foundations developing any piece of technological equipment or ITS service. These systems include:

- Telecommunication Networks (TLC).
- Automatic identification systems (AEI/AVI[16]).
- Systems for automatically locating vehicles (AVLS[17]).
- Protocols for the electronic exchange of data (EDI[18]).
- Cartographic databases and information sytems providing geographical data (GIS[19]).
- Systems for the collection of traffic data, including Weigh-In-Motion (WIM) and systems for the automatic classification of vehicles.
- Systems for counting the number of users of a public transport system (APC[20]).

The above listed information and communication support systems, which can be integrated with one another in specific configurations depending on the requirements and features of different transport modes and services, can be applied to help increase efficiency and competitiveness, prevent human error, limit pollution and improve overall quality of service. The individual "foundation stones" can be assembled according to different architectural needs in order to perform specific services.

Among such support systems, telecommunication networks are key elements that provide a backbone for associating some of the other above listed systems. Intelligent Transportation Systems encompass a broad range of wireless and wireline communication-based information and electronic technologies. When integrated into the infrastructure of transportation systems and in vehicles themselves these technologies relieve congestion, improve safety and enhance transport system productivity.

The EC's "e-safety" initiative Working Group on "Intelligent Infrastructure", co-chaired by the European Association of Tolled Motorway, Bridge and Tunnels (ASECAP) and the Conference of European Directors of Roads (CEDR), issued the following definition[21]:

"Intelligent Infrastructure is roadside organisationsal structure and technology for ICT-based, cooperative services that are beneficial for both road users and road network operators".

According to a definition from the Research and Innovative Technology Administration (RITA[22]), ITS is made up of 16 types of technology-based systems. According to this classification, these systems can be further divided into the subcategories "intelligent infrastructure" and "intelligent vehicle". Each definition has several components, according to RITA.

Intelligent infrastructure includes:

- Arterial management (surveillance, traffic control, lane management, parking management, information dissemination, enforcement).
- Freeway management (surveillance, ramp control, lane management, special event response, transportation management, information dissemination, enforcement).
- Crash prevention & safety (road geometry

(15) Here the broad range of on-board applications using ICT is relates only to infrastructure, transport and traffic
(16) Automatic Equipment Identification, Automatic Vehicle Identification
(17) Automatic Vehicle Locating System
(18) Electronic Data Interchange
(19) Geographic Information System
(20) Automatic Passenger Counters

warning, highway-rail crossing warning systems, intersection collision warning, pedestrian safety, bicycle warning, animal warning).

- Road weather management (surveillance, monitoring & prediction, information dissemination, advisory strategies, traffic control, control strategies, response & treatment - treatment strategies).
- Roadway operations & maintenance (information dissemination, surveillance, work zone management).
- Transit management (operations & fleet management, information dissemination, transportation demand management, safety & security).
- Traffic incident management (surveillance & detection, mobilization & response, information dissemination, clearance & recovery).
- Emergency management (hazardous materials management, emergency medical services, response & recovery).
- Electronic payment and pricing (toll collection, transit fare payment, parking fee payment, multi-use payment, pricing).
- Traveler information (pre-trip information, en route information, tourism & events).
- Information management (data archiving).
- Commercial vehicle operations (credentials administration, safety assurance, electronic screening, carrier operations & fleet management, security operations).
- Intermodal freight (freight tracking, surveillance, freight terminal processes, drayage operations, freight-highway connector system, international border crossing processes).

Intelligent vehicle includes:

- Collision avoidance (intersection collision warning, obstacle detection, lane change assistance, lane departure warning, rollover warning, road departure warning, forward collision warning, rear impact warning).
- Driver assistance (navigation/route guidance, driver communication, vision enhancement, object detection, adaptive cruise control, intelligent speed control, lane keeping assistance, roll stability control, drowsy driver warning systems, precision docking, coupling/decoupling, on-board monitoring).
- Collision notification (mayday/automated collision notification, advanced automated collision notification).

If we look at roadside ITS applications and services, the European project "EasyWay[23]" classifies them as follows:

- Traveller information services provide travellers with comprehensive real-time traffic information allowing well-informed travel decisions (pre-trip information) as well as information during the journey (on-trip).
- Traffic management services provide real-time guidance information to the traveller and hauler, detecting incidents and emergencies to ensure the safe and efficient use of the road network. Enforcement is part of traffic management.
- Freight and logistics services aim to optimise the capacity and efficiency of goods transport by providing safe and easy access to intermodal terminals (ports, rail and road connections, etc.).
- Connected ICT infrastructure that works efficiently is a prerequisite for ITS deployment providing the end user services with information from systems that monitor the road situation in real time and enabling different operators at national or cross-border level to ensure interoperability and continuity of services through harmonized data provided by connected systems.

(21) Available from **www.esafetysupport.org/en/esafety_activities/esafety_working_groups/intelligent_infrastructure.htm**

(22) The Research and Innovative Technology Administration (RITA) coordinates the U.S. Department of Transportation's (DOT) research programs and is charged with advancing the deployment of cross-cutting technologies to improve the transportation system of the United States. The classification of ITS technologies as consolidated and proposed by RITA is summarized on its website (**www.its.dot.gov/index.htm**)

(23) Project co-financed by European Commission DG TREN, available from **www.easyway-its.eu**

3.2 Road transport: the growing interest in safety, security, quality and efficiency

Transport is a key tool for most services related to trade, information and finance. Trade between different continents may require air or sea transport, whereas intra-continental trade is heavily reliant on road and rail freight.

In European countries, the past few years have demonstrated a growing demand for road transport - a demand that has been rising even more rapidly than GDP itself - undoubtedly due to the growth of private traffic (industrialized countries' citizens have become more and more accustomed to the convenience and flexibility of private vehicles) and to the increased demand for available goods (which implies commercial import/export traffic). Before the economic crisis, the EC estimated a minimum growth of 15 per cent in road traffic in the decade starting in 2010[24].

The 2008 economic downturn, which has influenced productive assets all over the globe, significantly reduced traffic on motorways, specifically among heavy-goods vehicles.

Considering this reduction in traffic we can expect that in the forthcoming years traffic growth will cause the transport system to recover towards the traffic levels of 2007, before starting to significantly increase once again.

Transport is an essential asset of the economy of the European region. According to the EC[25] the transport industry as a whole accounts for around 7 per cent of GDP and for over 5 per cent of total employment in the EU (of which 4.4 per cent corresponds to transport services and the rest to transport equipment manufacturing) while 8.9 million jobs are created by transport services and 3 million by transport equipment manufacturing.

If we examine employment by mode of transport from EU statistics[26], road transport (both freight and passenger) accounts for around 52 per cent of overall employment in the different transport modes. Road transport is an essential element of the global economy.

In fact, it has major economic, social and environmental implications.

Economically, the more a country is able to increase its overall infrastructural estate, the more the economic system appears to be in transition from a context prevailingly based upon the production of new, directly tangible assets - both industrial and civil (the latter concerning both buildings and transport infrastructure) - to another based upon the operation, maintenance and servicing of such assets.

The second economic state can be labelled the "optimization phase", where safety, security, quality and efficiency become the main watchwords for operators. This model is true for those developed countries that have a widely branched transportation network and consequently need to continuously devote resources to its maintenance, operation and upgrade.

The concept of efficiency, which is intrinsically linked to energy consumption and the use of land by infrastructure and the vehicles on that infrastructure, leads to a need to assess the impact made on the environment caused by the mobility of people through the operation of motor vehicles and the transportation of goods.

The priorities of transport policies throughout the European region in the forthcoming decade should be based on the following factors:

(a) In the years ahead, it is likely that a rise in demand for the provision of transport infrastructures could challenge traffic planners - as happened in previous decades, especially in emerging economies. This is an assumption that could only be brought about by the greater future average mobility of people and therefore a greater level of displacement from and to workplaces and households through a rise in the amount of goods that need to be moved.

(b) There is a need to focus on the maintenance, improvement and completion of existing projects while at the same time pursuing greater safety, security and quality in terms of fluidity in movement and waiting times, as well as pursuing efficiency, mainly in terms of savings in energy and consequently the quality of the environment.

A single correct approach that takes these into account does not exist. Each developed country or emerging economy needs a specific solution responsive to its own economic growth trend, public needs and demand for sustainable development.

ITS cannot offer the solution to all transport

(24) Eva Molnar, *"Becoming wise about ITS"*, Intelligent Transport ISSN 1757-3440

(25) Communication *"A sustainable future for transport: Towards an integrated, technology-led and user friendly system"* adopted by the Commission on 17 June 2009, available from **http://ec.europa.eu/transport/strategies/2009_future_of_transport_en.htm**

(26) DG TREN, *"EU Energy and Transport in figures"*

Developed and developing countries

Road networks in developed economies are usually well evolved but the high level of registered traffic means greater and greater measures are required to ease congestion, remove bottlenecks, achieve overall optimization of the network and realize safer and more energy-efficient transport solutions both in rural and urban areas. Highly branched road networks, together with roads already equipped with a basic or advanced level of ITS and communication systems, present the opportunity to operate smarter and more efficient services. Traffic volume in developing countries is usually lower, and infrastructure less evolved when compared to developed countries. Consequently, congestion levels are not necessarily lower and resultant pollution, specifically in urban areas, is a significant concern. Developing countries are usually in a phase of infrastructure deployment. The cost of technology is limited when compared to the cost of civil engineering work. This situation presents an important opportunity for building state-of-the-art infrastructure and implementing all necessary equipment. In both cases, high levels of traffic congestion can cause a reduction in economic activities and the augmentation of transport costs, which strongly affects the local economy. In this eventuality there is a critical need to conduct research into safety, security, quality control and efficiency.

problems, but ITS can ameliorate in a wide range of situations with an intelligent use of existing capacity and infrastructure, reducing the waste of energy and resources from the improper and inefficient use of the transport system as a whole.

Finally, the efficiency promoted by ITS is normally linked to the productivity of macro-economic systems and consequently assumes a greater economic multiplier effect. The effects resulting from the process should not only be visible when observing the direct impact, but also when one recognises the leverage exerted on the economy.

3.3 The concepts of safety and security in transport: the role of the Intelligent Transport Systems

Safety and security in Information and Communication Technologies (ICT) should distinguish between:

(a) Safe driving and (in the broadest sense) the safety of people.

(b) Security and the protection of both vehicles and goods, also in relation to incidents resulting from fraudulent acts.

Safety in a transport system entails being able to travel or perform the displacement of one or more vehicles or goods under safe conditions (i.e. where the level of hazards is as low as possible). Naturally, the long-term target is to achieve negligible or zero risk but common experience dictates that no human activity is completely risk-free. When vehicles are in motion, hazards may be caused by:

(a) The driver, or any users of the transport infrastructure.

(b) The vehicle or the means of transport, including what the vehicle is transporting (passengers, goods, etc.).

(c) The infrastructure and the surrounding environment.

If we look at the role of the driver, safety issues typically arise from a sharp variation in one or more factors other than the driver's actual behaviour (the driver's reaction itself linked to other prerequisites such as driving skill, psychological and physical condition, behavioural approach to driving, etc.) and the performance of the vehicle they are driving.

Tools and devices - typically for real time information and normally made up of ICT tools (both for on-board and roadside ITS) - can be used to support to the driver:

(a) To influence the behaviour of a single driver or to intervene to aid them.

(b) To make up for their temporary inability/inattention or for the possible occurrence of weak psychological and physical conditions and irregular behaviour.

(c) To influence public behaviour, promoting the better use of alternative infrastructures or to

4. Evolution of the operation with the involvement of ITS

delay the displacement of people or goods in the case of unavailable road capacity, preventing major queuing and lowering the risk of possible consequent uncomfortable and unsafe driving conditions.

(d) To monitor the correct use of the road, alerting the driver or regulating their behaviour if inappropriate actions occur.

The study of transport system safety focuses on a number of factors, including the following:

(a) The human factor: ability, psychological and physical conditions and behaviour.

(b) The vehicle or means of transport:
- Grip between tyres and road.
- Running performance (acceleration, braking or headway, stability).
- Mechanical features of the structure (vehicle shell, equipment).

(c) Infrastructure: structural parameters (surface, slope, elevation in curve, cross-section), safety equipment (roadside barriers, lighting), availability of facilities (toll barriers, service areas), current traffic levels and environmental conditions (humidity, frost, fog, blinding sunlight) - environmental factors that typically influence the grip and stability of the vehicle or the clarity of the driver's field of vision. Traffic can also distract the attention of the driver and create misperception and miscalculation of the relative movements of other vehicles.

When an event changes current driving conditions the response of the vehicle is dictated by both the driver (whose response depends on their individual attributes and various other conditions affecting them) and by the vehicle (the response of which is influenced by design criteria, maintenance levels, grip and environmental conditions). If an event that alters current conditions occurs, an accident during transportation usually transpires when the overall system (driver/car) is required to respond with a faster reaction time than is possible.

It appears clear - as in the case of all objects with the potential to be dangerous - that it is possible for drivers to raise their own awareness levels of the risks associated with the inappropriate use of a vehicle (sense of responsibility).

Therefore, the leading principle of road safety is careful or cautious driving accompanied by compliance with the rules of the road and by the appropriate psychological and physical conditions for driving.

The role of engineering, including ITS, is to prevent the occurrence of accidents (i.e. through traffic information systems and road design) or to be able to smooth the consequences of errors and be capable of studying and determining the causes of problems in order to facilitate a continuous process of safety improvement.

Cars and other means of road transport were created to meet one of the primary needs of mankind: communication by displacement. When a vehicle is no longer used for such a primary purpose, when basic prerequisites of road use are not met and there is a misperception of the hazard, then risk conditions normally arise. Human behaviour is recognised worldwide as the No. 1 factor influencing road safety[27], being fully or partially responsible for 93-95 per cent of accidents[28]. It is a fact that man is not a machine designed for driving.

Drivers are the main target of ITS through the provision of information and alerts. The performance of drivers in terms of safety can be greatly improved thanks to real-time information, warnings and automatic sanctions brought on by improper driving behaviour. ITS operate primarily to better road safety, aiming to give rise to the best possible cost/benefit ratio.

(27) *"Recommendations of the Group of Experts on Safety in Road Tunnels"*, p 21, drafted by the UNECE ad hoc Multidisciplinary Group of Experts on Safety in Tunnels (available from **www.unece.org/trans/doc/2002/ac7/TRANS-AC7-09e.pdf**)

(28) PIARC *"Road safety manual 2003"*, p 47, or *"Recommendation of the Group of Experts on Safety in Road Tunnels"*, drafted by the UNECE ad hoc Multidisciplinary Group of Experts on Safety in Tunnels (available from **www.unece.org/trans/doc/2002/ac7/TRANS-AC7-09e.pdf**)

3.4 A short outlook on ITS

Intelligent Transport Systems involve a wide range of technological and organizational systems, applications and services. The authors know that it is not possible to give a full overview of ITS. This chapter shall provide some highlights of a few typical cases.

3.4.1 Roadside contribution to the safety of transport: the role of ITS

ITS has a direct impact on road activity and consequently represent a tool for the improvement of traffic efficiency and safety.
Roadside equipment and related value-added services performed by road operators represent a significant contribution to a modern state-of-the-art way of operating roads.
Figure 4 demonstrates the evolution of ITS operation. In the past, road operators always performed the surveillance of roads themselves; now they can have remote monitoring and automatic incident detection-technologies that are making operators more vigilant and faster to respond. Operators of toll motorways can now perform electronic toll collection using systems that automatically recognise each individual user, avoiding time- and energy-consuming transactions.

Roadside ITS

In summary, we can observe that at the process level, by passing from the traditional approach to the technological approach the operator can achieve an increased level of efficiency and gain an enhanced capability to act in terms of time and resource management. Roadside ITS is a tool that helps to scale down the processes that authorities and operators handle in order to perform traditional services in a more efficient way. What's new, is that ITS allows the operation of new services that were not previously possible. In a way it can be said that while operators used to handle traffic in the past, they are now increasingly handling individual cars and users.

Applying of these measures and services presents the opportunity to facilitate rapid response measures, mainly when dangerous situations occur suddenly or when an irregular situation is known in advance. Many accidents occur because the system (driver/vehicle) requires more time to

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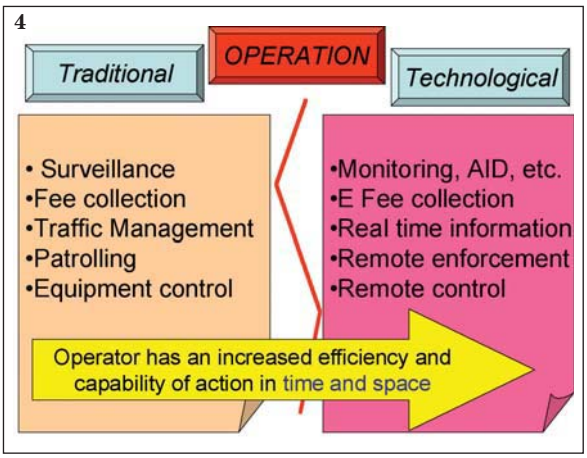


avoid collision. Several technological solutions are the disposal of the driver or have been proposed for increasing the amount of reaction time that a driver has to react to emergencies or road accidents. These include radio channels and data systems, Variable Message Signs (VMS), blinking roadside markers and, in the future, on-board direct messages. Such technologies aim to reduce the perception-reaction time of a driver, thereby increasing safety time, the time available for the user to safely drive the car.
There are also other ITS technologies that allow for better monitoring of traffic and weather conditions on motorways, faster response times to emergencies and easier communication between operators of contiguous roads and networks.
Below are some examples from the roadside technology "family".

Traffic Control Centre

Traffic Control Centres (TCC) are the cornerstone of road activity operations. Modern TCCs receive and circulate multimedia information (data, radio, telephone and video signals) on the status of roads and traffic. TCCs pave the way for the state-of-the-art operation of roads, collecting various data concerning meteorological and other environmental conditions (i.e. pollution inside road tunnels). The efficiency of TCCs assures the correct flow of information to and from different stakeholders (traffic police, authorities, etc.) which in turn contributes to timely and appropriate decisions during the operational phase.
Most TCCs are operated around the clock by one or more agents. The TCC agents continuously monitor all technological facilities, such as the video images

5. Examples of Traffic Control Centres (Autostrada dei Fiori and SATAP - Italy)

6. Examples of Traffic Information Centres (DGT - Spain, ASPI - Italy)

7. Video camera for traffic monitoring with images transmitted onto TCC's video wall

from traffic monitoring cameras located at critical intersections and throughout road networks.
Obstructions, accidents and other incidents are detected by either the TCC agent, the technological systems operator or through reports from traffic police, the road operator's agents or road users.
In responding to real-time events and the resulting overall scenario, the TCC agent can activate:

- Contingency plans (activating all competent authorities, measures and services for managing traffic safety and handling accidents or other abnormal events).
- Traffic management plans (activating, in cooperation with the competent authorities at regional level, all measures necessary for managing traffic, minimising congestion and delays, and optimizing the use of the available infrastructure).
- Remedial plans (activating maintenance crews to restore infrastructure and, if necessary, bring in contractors).

In some cases TCC agents have the option to directly intervene at the scene of the event: i.e. by delivering information to users through VMS, remotely controlling traffic lights, changing the ventilation in tunnels or controlling other localised equipment.

The main objectives of TCCs are to:

- Collect all useful information and consequently activate all pertinent internal and external services.
- Provide accurate real-time traffic information to the public, using a variety of different media.
- Utilise all available information to promote the safety of traffic, ensure the safety of the road operator's agents on the road and quickly perform the actions defined in the operator's manual of procedures in order to minimise the congestion caused by accidents, road works and other events.

Traffic Information Centres

Traffic Information Centres (TIC) are operational centres managed either by road authorities or road operators. TICs are charged with collecting real-time information and checking, validating, and diffusing it to the general public through all possible media outlets (radio, TV, call centres, internet etc.). The collection and coordination of information is particularly important because information can arrive from various sources (although usually from road police and road operators). The collection and distribution process involves many different partners at regional or national level. The task facing TICs also largely consists of managing and pro-

cessing the information and maintaining proper communication contacts with all involved parties. Information is collected according to specific standards and the centre's multimedia products are created in real-time in order to be broadcasted via radio, television or web-based platforms.

Monitoring

In order to continuously monitor motorway conditions, road operators install detectors capable of collecting information on the operation's main points of interest: traffic, weather and environmental monitoring. The video monitoring system for road traffic is a network composed of remotely operated Closed Circuit Television (CCTV) cameras. Using the video monitoring system, the TCC agents have access to continuous video footage that allows them to monitor the flow of traffic and to immediately check specific sections of the network when automatic alerts are generated from ITS, or when a warning is issued by agents on the road or users who have asked for help.

Benefits of video monitoring for traffic

Video monitoring allows TCC agents to detect irregular circulation or perform fast checks on the validity of a received alarm or warning. Consequently, an agent can initiate an early activation of the appropriate contingency plan and can issue early alerts to the operator's emergency staff as well as an early alert to the related emergency services. The overall reaction time of the process is made far faster by the use of video monitoring, which is essential in the case of dangerous events. In this way, delays in intervention are reduced and safety is improved while energy and transport efficiency is promoted through the reduction of queues.

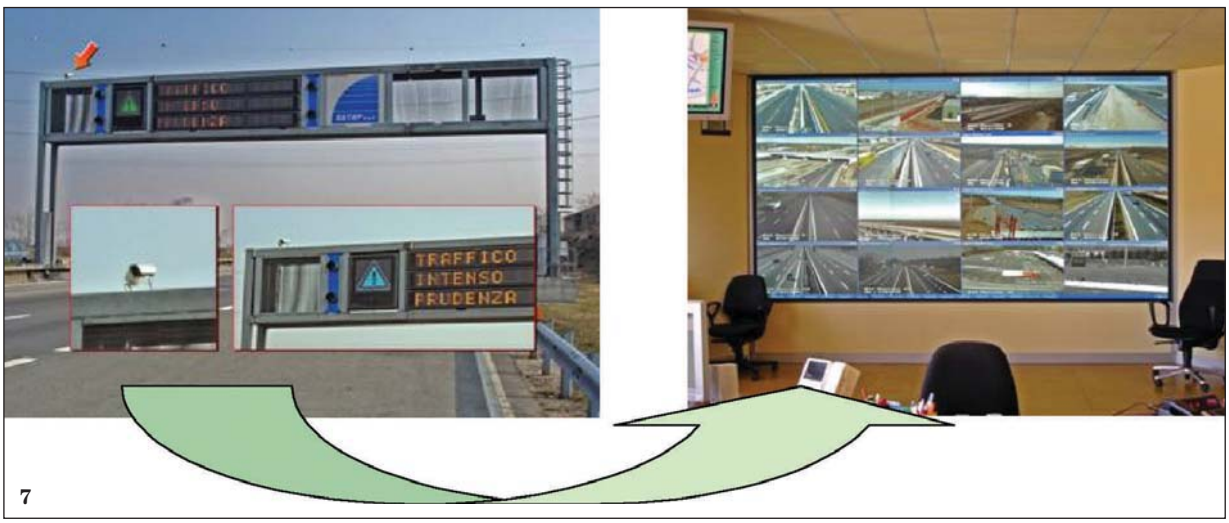
In order to achieve the best possible assessment of traffic circulation, a TCC can also benefit from a numerical count given by traffic detection systems made up of sensors. These sensors use various technologies inductive loops placed under the road surface, radar sensors, "cooperative" vehicle-mounted units, etc.); and are designed to perform the real-time, precise monitoring of vehicles in terms of traffic volumes and types of vehicle in transit. Data is collected, registered and computed by local units that transmit the information to the TCC. In doing so, the TCC is able to perform real-time traffic management according to current traffic volumes.

Weather monitoring devices can either be standard high-accuracy sensors for gauging the main weather conditions of interest (wind speed and direction, precipitation type and strength, etc.) or sensors specifically designed for the operation of roads (such as sensors for estimating the current condition of road surfaces - dry, wet, icy, etc.).

Monitoring performed with the various sensors aids the smooth operation of road networks through the best possible use of roadside technological equipment (local photometers are used for the control of road lighting, air quality sensors are used for the control of tunnel ventilation equipment, etc.).

Variable Message Signs

Variable Message Signs (VMS) are electronic traffic signs that allow the TCC to distribute information concerning particular events in a timely fashion. Such signs can warn of traffic congestion, accidents and incidents, roadworks or speed limits on a specific highway segment. In urban areas, VMS are incorporated into parking guidance and information



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8. VMS for lane management (left - ring road of Venice) and for traffic information (right - near Imperia)

9. Equipment for the broadcasting of isofrequency traffic channel and bulletins from the National Italian Traffic Information Centre (CCISS)

10. Road accident

systems to guide drivers to available car parking spaces. Variable Message Signs allow the road operator to immediately reach users in transit on a specific section of road, making it possible for accidents that could occur as a result of any known incidents to be prevented. Variable Message Signs can also advise users on the best route to take in a given situation.

Automatic Incident Detection

Automatic Incident Detection (AID) systems are used to detect vehicles that have come to a stop, vehicles that are slowing down or pedestrians that are in locations that are off-limits. In general, any anomaly present on the network can be quickly detected so as to prevent or at least mitigate any potential adverse effects. Automatic Incident Detection systems constantly analyse road footage captured by cameras. The software is able to discern whether or not an object is a vehicle, and is consequently able to estimate its speed. When vehicles slow down, stop or when a "ghost driver" (somebody going the wrong way) appears on the footage, an automatic alarm is generated for the attention of the TCC agent. The software can also identify pedestrians that are in the wrong place and debris lost from vehicles on the road surface. The system helps agents to properly monitor a higher number of cameras. Technical problems in the software or in the installation can cause the system to produce false alarms that can undermine the confidence that TCC agents have in the system if they appear too frequently.

ITS in tunnels

A number of different ITS technologies can be deployed to improve the operation of road tunnels. At EU level, ITS is defined among the different provisions included in the Minimum Safety Requirements for Tunnels in the Trans-European Road Network that the European institutions defined in adopting directive 2004/54/EC. According to the directive, tunnels longer than 500 m need specific safety measures that have been identified in this common European approach. Several ITS technologies are prescribed, under specific conditions, by the technical annexes of the directive (i.e. video cameras, VMS at gates, emergency telephones etc.). In the case of standard operations, tunnels are normally safer than other road sections, but the confined environment can exacerbate the consequences of a major accident (i.e. those involving fire, dangerous goods).

ITS in the event of tunnel accidents

The physical phenomena resulting from major tunnel accidents evolve very fast and can rapidly cause people great harm. The time-saving automation achievable through ITS could be helpful, if not vital, in specific cases.

Radio Channels

In the field of radio communications in ITS there are both radio channels that provide information to road users and radio channels used for service communications purposes.

Information regarding traffic and traffic-related events collected by TCCs can be provided to users through radio channels, thanks to:

- Specific agreements among road operators and conventional radio broadcasters.
- Information broadcasted by TICs.
- Other service providers.

The service is made possible - and maintains a reasonably consistent quality - through the deployment of a number of pieces of equipment dispersed along

motorways, all broadcasting at the same frequency (i.e. 103.3 MHz in Italy, 107.7 MHz in France, etc.). This roadside equipment allows users to benefit from traffic channels and keep up to date on traffic conditions and accidents without changing their radio frequency along their journey.

In order to implement this system, the network needs:

- Numerous road-side installations (placed at varying distances apart, depending on the lay of the land).
- Fibre-optic signal distribution of the previously modulated signal to the broadcasting equipment.
- The use of leaking cables all along tunnels in order to broadcast in confined spaces.

The information is distributed through voice and data services. The Radio Data System (RDS) is a communication protocol standard for embedding small amounts of digital information in conventional FM radio broadcasts. The Radio Broadcast Data System (RBDS) is the official name given to the U.S. version of RDS. The RDS system standardises several types of transmitted information, including time, station identification and programme information. The Traffic Message Channel (TMC) is digitally encoded with traffic information using this system. This is also often available in automotive navigation systems.

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The TMC may be broadcast through either RDS or Digital Audio Broadcasting (DAB), but most commonly (because of the large bandwidth) it is distributed through Digital Video Broadcasting (DVB).

The radio channel reserved for service communication allows interaction between road agents and the operational centres of all actors cooperating on road operations (i.e. the road operator, traffic police, fire department, ambulance, etc.). For security reasons, each actor normally caters for its own independent radio channel and cross-communication is provided by TCCs and other operational centres.

Roadside equipment for speed enforcement

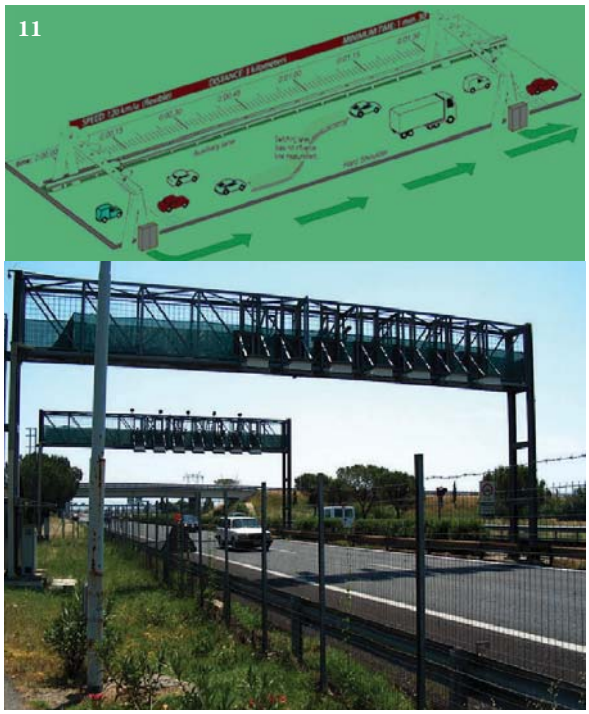
Intelligent Transport Systems are implemented to improve overall levels of safety and efficiency. In most cases communication with the driver is the main aim of ITS applications or services, and sometimes ITS is used to improve the effectiveness of enforcement when traffic violations occur. According to an estimate made by Italian traffic police[29], high-speed driving is either the main cause or one of the leading factors in approximately 60% of all road fatalities.

10

Traffic police officers all over the world use radar or other technological systems to measure drivers' speed, and if necessary enforce the law when speed limits are exceeded. Nowadays, video cameras and other pieces of fixed equipment are increasingly able to perform related functions in a semi-automated way. For example, a system[30] that is able to detect the average speed of vehicles travelling on monitored sections of road (sections in the range of 10-25 km in length) in any weather condition has been implemented on Italian motorways. The system records the number plates of vehicles in two consecutive locations at each end of a monitored stretch of road. The first piece of equipment automatically detects and registers the plate numbers of all passing vehicles; the next piece of equipment, at the end of the monitored section, again logs all vehicles that pass through its field of vision. The exchange of information between the two devices allows an immediate calculation, in real time, of the average speed maintained by the driver while passing through the allotted section. If the result

(29) http://poliziadistato.it/articolo/51-Tutor

(30) The system was activated in 2005 on the Autostrade per l'Italia motorway network and is operated by the Italian traffic police. Users know this system as "Tutor", a name alluding to the tutorial role of enforcement



11. Equipment for speed enforcement on Italian motorways (ASPI)

12. Winter maintenance operation in snow (SALT)

13. Application of a traffic management plan (flow-chart)

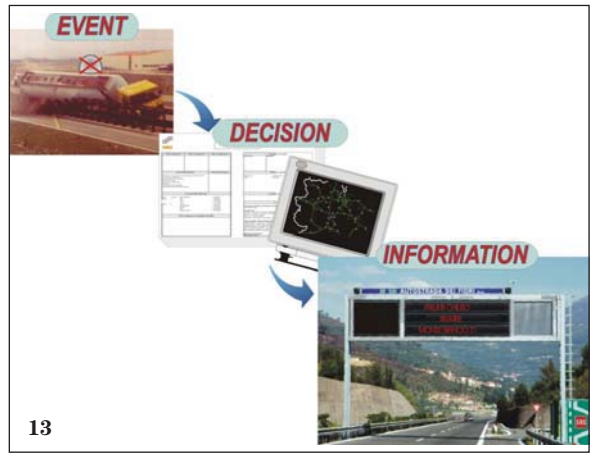
14. Contingency communication process adopted by Italian authorities and road operators of ASTM/SIAS group

15. Web-based pre-trip information services, (top, left: weather information; right: traffic webcams)

is lower than the maximum speed limit for the section then the data is deleted. Otherwise the images are made available to the traffic police for enforcement procedures.
The aim of roadside enforcement is not only to punish road traffic infringements, but also to help persuade drivers maintain a constant speed whilst travelling, making the flow of traffic more homogeneous and therefore safer.
According to data collected by traffic police and motorway operators, it has been estimated that the positive effects of ITS implementation have resulted in a 51% decrease in fatalities, a 27% reduction in accidents resulting in casualties and an overall fall of 19% in accidents of all kinds[31].

Re-routing of traffic in case of events preventing the standard operation of roads

Traffic re-routing eases the level of disruption caused by certain events on identified stretches of road (i.e. accidents, bad weather conditions) by providing road users with information on alternative routes. Re-routing brings about direct benefits such as reduced driving time but also results in lower operating costs and decreased environmental impact. More specifically, the level of benefits derived from re-routing depends on the length of the possible alternative routes, on the capability of the road operator to deliver relevant information to users, and in the case of longer detours, on the flexibility of the traffic demand.



In addition, there are also non-quantifiable benefits derivable from such a service. These include better accident information and better and more consistent traveller information that in turn leads to the improved movement of traffic across a region. In terms of organisational cooperation, the benefits include improved working relations between the various authorities and traffic operators in the affected regions. The necessity of developing a solid knowledge base of pre-defined strategies and an acceptable framework for the activation/de-activation of various measures - based on the assessment of needs and resources - is another essential element for the success of re-routing traffic. Considering the high number of co-operating authorities and operators, the wide range of events and the complexity of the subjects, specific traffic management plans are usually drafted in advance in order to establish a predefined coordination plan of the necessary actions that should be taken in the event of an accident.

Contingency plans/emergency plans

Intelligent Transport Systems are invaluable for the organisation of available technical and non-technical resources. The same principle applies to more than just traffic management plans. Contin-

(31) Data from www.autostrade.it/assistenza-al-traffico/tutor.html

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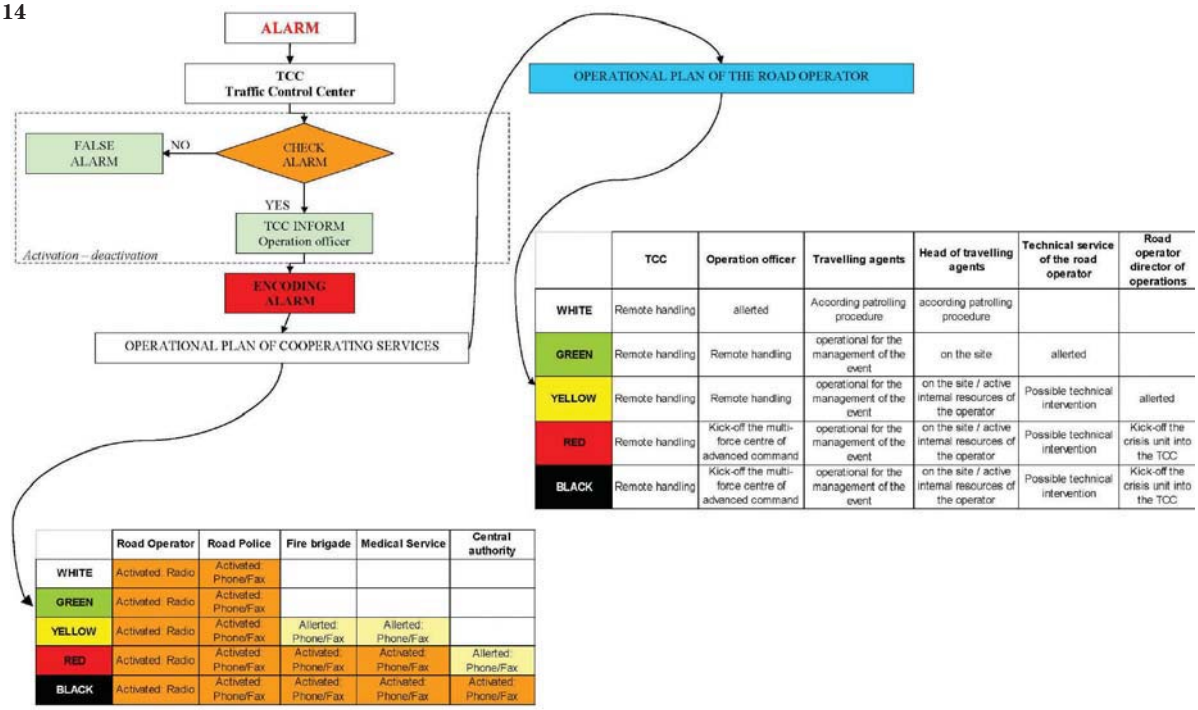

	TCC	Operation officer	Travelling agents	Head of travelling agents	Technical service of the road operator	Road operator director of operations
WHITE	Remote handling	allerted	According patrolling procedure	according patrolling procedure		
GREEN	Remote handling	Remote handling	operational for the management of the event	on the site	allerted	
YELLOW	Remote handling	Remote handling	operational for the management of the event	on the site / active internal resources of the operator	Possible technical intervention	allerted
RED	Remote handling	Kick-off the multi-force centre of advanced command	operational for the management of the event	on the site / active internal resources of the operator	Possible technical intervention	Kick-off the crisis unit into the TCC
BLACK	Remote handling	Kick-off the multi-force centre of advanced command	operational for the management of the event	on the site / active internal resources of the operator	Possible technical intervention	Kick-off the crisis unit into the TCC

	Road Operator	Road Police	Fire brigade	Medical Service	Central authority
WHITE	Activated: Radio	Activated: Phone/Fax			
GREEN	Activated: Radio	Activated: Phone/Fax			
YELLOW	Activated: Radio	Activated: Phone/Fax	Allerted: Phone/Fax	Allerted: Phone/Fax	
RED	Activated: Radio	Activated: Phone/Fax	Activated: Phone/Fax	Activated: Phone/Fax	Allerted: Phone/Fax
BLACK	Activated: Radio	Activated: Phone/Fax	Activated: Phone/Fax	Activated: Phone/Fax	Activated: Phone/Fax

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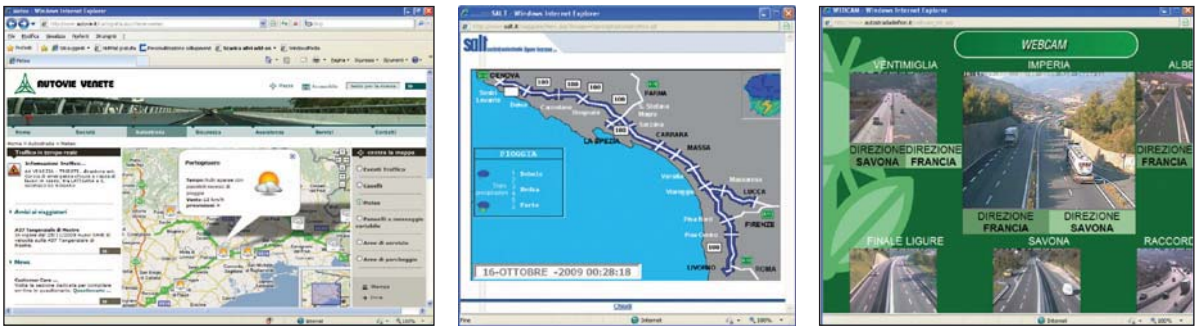

gency plans coordinate the joint management of the different organizations[32] that shoulder the responsibility of returning the situation back to normal after a road accident or incident in the minimum amount of time, at the minimum possible cost and with the minimum disruption to traffic. This requires careful preparation and planning. The clear identification of a chain of responsibility and communication strategies essential to the operation are key factors in the planning process.
Intelligent Transport Systems technology needs to be integrated into the process in order to make connections fast and reliable and facilitate direct action from TCCs.

Pre-trip traffic information systems

The objective of pre-trip information is to make drivers aware of the traffic situation and travel conditions so they can assess their travel options. Using this information a person can assess their route, mode of transport, departure time or even decide on whether or not to make the journey.
Advanced travel information systems can enhance pre-trip travel information by providing more detailed contents through different types of media.
Traditional pre-trip traffic information targets a broad audience, primarily through radio, which means that the information is usually not sufficiently detailed to serve trip-planning purposes, except in the case of major events.
Other systems (i.e. web-based platforms) provide users with detailed data on traffic and meteorological conditions and stream traffic webcams.

(32) Services involved include road police, emergency medical services, fire brigade, etc.

3.4.2 Passive, active and preventive safety for vehicles: the role of on-board Information and Communication Technologies

To understand our future, we must study the past. Below is a list of the major developments that have shaped the evolution of motor vehicle safety:

(a) Restraint systems (from around 1960-1975)[33]: this period saw the introduction of crashworthy systems and devices to prevent or reduce the severity of injuries when a crash is imminent or actually happening (passive safety). The first systems were restraint systems such as safety-belts, and later air-bags, to limit the forward motion of an occupant, stretch to improve the occupant's deceleration and prevent occupants from being ejected from the vehicle.

(b) Bio-mechanical criteria (from around 1975-1990): in order to better protect occupants in the event of impact, crash test dummies were introduced as tools to aid vehicle design. These are full-scale Anthropomorphic Test Devices (ATD) that simulate the dimensions, weight and articulation of the human body, and are usually equipped with instruments that record data about the dynamic behavior of the ATD in simulated vehicle impacts. Biomechanical criteria were identified in order to simulate injuries using the dummies.

16. Car accident

(c) Other protection (starting around 1995): vehicles started to be designed to take into account the protection of vulnerable road users (cyclists, pedestrians). Moreover, crash compatibility concepts were integrated into vehicle design in order to reduce the tendency of some vehicles to inflict more damage on another vehicle (the "crash partner vehicle") in two-car crash scenarios such as crashes between Sport Utility Vehicles (SUV) and city cars.

(d) Holistic approach (starting recently), incorporating the need to consider additional factors concerning elements other than the vehicle itself:
- Traffic infrastructure and control.
- Citizen training.
- Information provided to drivers (through ITS and relevant technical standards).
- Checks on the use of alcohol and drugs.
- The social cost of accidents.
- Integrated transport systems, including information and communication technologies, assisting driving.

Today's vehicle design criteria have progressed past simple measures such as safety belts, headrests and air bags. Modern safety concepts include:

(a) *Active safety*: provides the driver enhanced control of the vehicle, thus decreasing the likelihood of accidents. This kind of technique provides the vehicle with a dynamic capability to adapt to extreme conditions (i.e. better road-holding, braking capacity, manoeuvrability on low grip surfaces, resistance to tilting, etc.). Two examples of active safety systems are Electronic Stability Control (ESC) for passenger vehicles and Electronic Vehicle Stability Control (EVSC) for heavy-duty vehicles. The implementation of crash avoidance systems may be the next big step.

(b) *Passive safety* (i.e. systems to enhance crashworthiness): systems and devices to prevent or reduce the severity of injuries when a crash is imminent or actually happening. Much research is carried out using anthropomorphic crash test dummies. Most of these systems are restraint systems (safety belts, air bags, pretensioners etc.), although crumple zones also fall into this category. Crumple zones are structural features designed to compact during an accident to absorb energy from the impact. Typically, crumple zones are located in the front part of the vehicle in order to absorb the impact of a head-on collision, though they may be found on other parts of the vehicle as well.

Other important safety aspects include attempts to promote concentration and comfort for drivers, and any other methods that support drivers and keep them informed of running conditions and potential hazards. Another emerging concept concerns the possibility that drivers could provide emergency services with accurate and reliable information on the location and nature of accidents to enhance response times. This function can be facilitated through capabilities that communicate between vehicles and systems, as well as between vehicles and infrastructure, thanks to positioning devices based on satellite navigation technology.

Safety devices or systems that are now widely used in new car designs include:
- ABS (Anti-lock Braking System).
- ESC (Electronic Stability Control), EVSC (Electronic Vehicle Stability Control).
- DBC (Dynamic Brake Control).
- TCS (Traction Control System).
- EBD (Electronic Brake Distribution).
- BAS (Brake Assist Systems).
- AEBS (Automatic Emergency Braking Systems).

There are other active safety systems that are less

(33) Technical standards relevant to structural design and motor vehicle equipment

well known or still in the testing stage. These include:

- Anti-collision systems such as Forward Collision Warning Systems (FCWS).
- Systems that communicate the existence of hazards and obstacles.
- Lane Departure Warning Systems (LDWS).
- Systems that detect the condition of the driver or perform the automatic correction of driving errors.

It is indisputable that a significant number of road accidents involving casualties occur in poor visibility, normally at night or to a lesser extent in foggy conditions. Different types of sensors are - or can be - used to obtain information about objects in the vicinity of the vehicle. The most frequently used technologies in the automotive industry that serve this purpose are:

- Ultrasound sensors.
- Infrared sensors.
- Radar.
- LiDAR (Light Detection And Ranging - an optical remote-sensing technology that measures the properties of scattered light to find range and/or other information about a distant target).
- Artificial vision.

Every type of sensor operates in a different range of frequencies in the electro-magnetic spectrum (apart from ultra-sound sensors). Every sensor supplies information on the space around a vehicle and a combination of different sensors and technologies might provide better results than using each technology indipendently.

To be widely deployed, these on-board devices - as well as other ITS technologies - must be beneficial investments that meet user needs. For this reason, a concept that needs to be considered is Cost-Benefit Analysis (CBA/BCA) to provide an analysis of the return on investment for on-board safety systems for the motory industry. Cost-Benefit Analysis can define and quantify key financial metrics, such as returns on investments and payback periods. For these analysis, the potential benefits in terms of cost avoidance in relation to crashes can be measured against the purchase installation and operational costs of the technology.

Other industry stakeholders such as insurance companies, vendors and risk managers can equally apply the calculations to their own internal assessments and programs.

Public bodies can also perform their own CBA. If the analysis shows that the assessed equipment is potentially increases safety levels or results in any other public benefits, legal instruments can be activated that overshoot the results of any sectoral cost-benefit analyses.

Cost-Benefit Analysis can define and quantify key financial metrics such as returns on investments and payback periods. For these analyses, the potential benefits, in terms of cost avoidance in relation to crashes, can be measured against the purchase, installation and operational costs of the technology.

Other than being used to estimate the average annual numbers of preventable crashes, crash data can be the basis for estimating the costs of the different types of crashes involving Property Damage Only (PDO), injuries and/or fatalities.

Primary data for calculating benefits and crash costs can be garnered from information provided by insurance companies, motor carriers and legal experts.

Crash costs include[34]:

- Labour costs.
- Worker's compensation costs.
- Operational costs.
- Property damage and auto-liability costs.
- Environmental costs.
- Legal costs.

A measure of crash cost avoidance can be calculated using the number of incidents that each technology is estimated to prevent annually per Vehicle Miles Travelled (VMT).

16

Some brief descriptions of certain ITS applications are listed below:

Digital tachograph

The tachograph is a device that combines the functions of a clock and a speedometer. Fitted into a motor vehicle, a tachograph records the time frame of a vehicle's use, i.e. the vehicle's speed and whether it is moving or stationary.

European Economic Community (EEC) regulation 3821/85 from 20 December 1985 made the tachograph mandatory throughout the EEC. A "*European Agreement concerning the Work of Crews of*

(34) Technical brief of Federal Motor Carrier Safety Administration (available from **www.fmcsa.dot.gov/facts-research/research-technology/tech/09-023-TB-Onboard-Safety-Systems-508.pdf**)

17. Digital Tachograph[36]

18. Stability control intervention for understeer and oversteer[37]

19. Concept of warning thresholds and warning threshold placement zones[39]

20. Example of warning systems for blind spot detection[40]

Vehicles engaged in International Road Transport" (AETR) was signed in Geneva on 1 July 1970. The current version was updated in 2006[35].
European directive 22/2006/EC sets out new rules for regulating the hours of drivers engaged in the transportation of goods and passengers. It provides common methods for undertaking roadside checks, as well as checks at the premises of transport operators. Moreover, it promotes mechanisms of cooperation between member States authorities in charge of road transport enforcement. Regulation 561/2006/EC of the European Union adopted on 11 April 2007 specified driving and rest times for professional drivers. These time periods can be checked by the employers, police and other authorities with the help of the tachograph.
The digital tachograph is a new, advanced piece of recording equipment, consisting of a digital vehicle unit and a personal driver card. This new equipment has been designed in such a way that the digital tachograph itself can be considered to be the "memory" of the vehicle in which it is fitted, whilst the driver card can be considered the "memory" of the activities performed by the driver.
The introduction - in all newly registered vehicles (trucks weighing more than 3.5 tonnes and buses capable of carrying more than nine people) - of the digital tachograph has the sole aim of improving the comfort and working conditions of the driver and enhancing road safety through better enforcement. This prevents any discrimination in transport across the whole AETR region, thus representing a positive development for all Contracting Parties and road transport companies.
The use of the digital tachograph requires the implementation of sophisticated infrastructure, specific interoperable databases and complex security policies at national level. Well-developed communication interfaces between AETR countries also need to be established. These are necessary to allow the efficient, harmonised and secure functioning of the digital tachograph system.

17

Tachograph Card

Data encrypted on the chipset

Location-based information

Location-based information services allow the driver to find the nearest business of a certain type, like the next fuelling station, Automated Teller Machine, accommodation or restaurants available in the immediate vicinity. The driver might also have the option of receiving certain types of location-based information such as traffic updates, local points of interest or localised advertisements. To prevent the potential misuse of the system, the secure authentication and authorization of all incoming messages is needed. Outgoing transmissions also require adequate protection to ensure the driver's privacy.

Electronic Stability Control (ESC) and Electronic Vehicle Stability Control (EVSC)

Although various systems for vehicle stability control are currently available from many different companies, their functions and performances are all similar. These systems use a computer to control the braking of individual wheels to help the driver maintain control of the vehicle during extreme manoeuvres. Using these systems, it is possible to keep the vehicle headed in the direction in which the driver is steering even when the vehicle reaches the limits of its road traction abilities.
A stability control system maintains "yaw" (or heading) control by comparing the driver's intended heading with the vehicle's actual response, and automatically turning the vehicle if its response does not match the driver's intention. However, with a stability control system, turning is accomplished by applying counter torques from the braking system rather than from steering input. Speed and steering angle are used to determine the driver's intended heading.
The vehicle's response is determined in terms of lateral acceleration and yaw rate by onboard sensors. If the vehicle is responding in a manner corresponding to driver input, the yaw rate will be in balance with the speed and lateral acceleration[38].

(35) The consolidated text, version 2006, document ECE/TRANS/SC.1/2006/2 is available on www.unece.org/trans/main/sc1/sc1aetr.html
(36) Images from www.unece.org/trans/doc/2006/sc1aetr/Pres3Kelly.pdf
(37) www.unece.org/trans/doc/2008/wp29/ECE-TRANS-WP29-2008-69e.doc
(38) Other information can be found from the work of UNECE Working Party on Brakes and Running Gear (GRRF) on www.unece.org/trans/doc/2008/wp29/ECE-TRANS-WP29-2008-69e.doc

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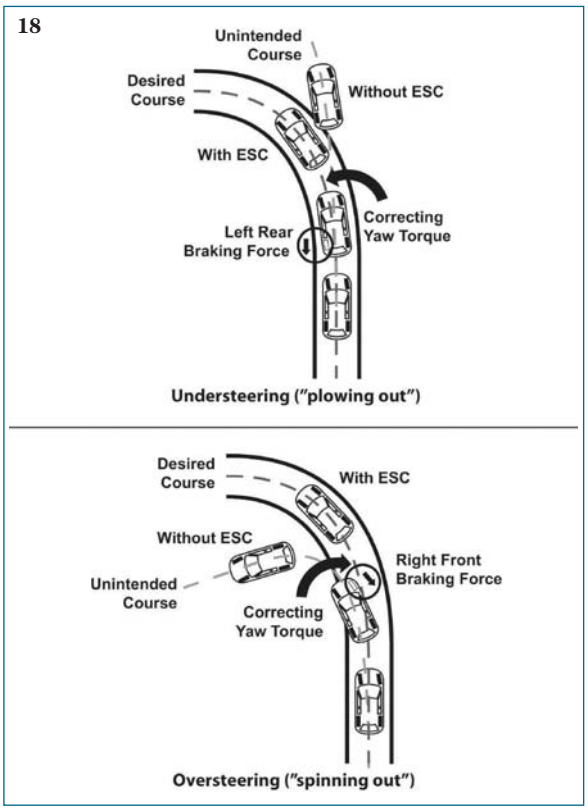

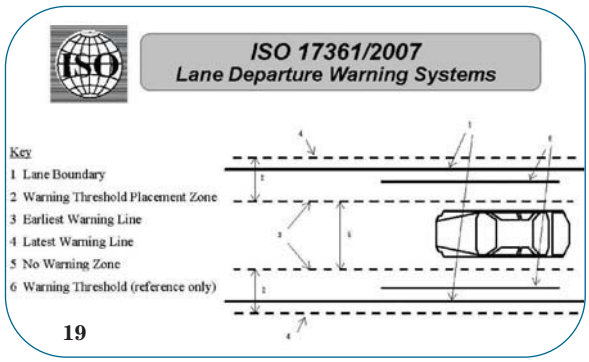

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Advanced Driver Assistance Systems (ADAS)

Advanced Driver Assistance Systems represent a wide range of systems designed to help the driver, making the driving process safer and more efficient. When designed with a safe Human-Machine Interface (HMI) they should improve car safety and road safety in general. Examples of such systems include: adaptive cruise control; adaptive light control; automatic parking; blind spot detection; collision avoidance system (pre-crash system); driver drowsiness detection; intelligent speed adaptation or intelligent speed advice; in-vehicle navigation systems (typically GPS and TMC for providing up-to-date traffic information); lane change assistance; lane departure warning systems; night vision; pedestrian protection systems; traffic sign recognition etc.

The first application from the above list is a system used for the automatic control of speed. Using a distance gauge, either radar or laser, the vehicle is able to perceive the presence of another vehicle immediately ahead of it in the same lane.

If the other vehicle is moving at a slower rate, the on-board system aids deceleration, adapting to the speed of the vehicle in front. This function is called Adaptive Cruise Control (ACC).

In the lateral control of the vehicle, sensor systems based on cameras may help the driver to stay in lane. An acoustic or tactile signal (i.e. vibration of the steering wheel) is generated when the system detects that the vehicle is about to divert from the lane. Research is also being conducted into systems that provide automatic steering control (lane keeping). In any case, car manufacturers are very cautious of this function, as it could be interpreted not as a support system, but as the actual automated driving of a vehicle, which in turn could produce unintended driver carelessness.

Other examples of driving support functions available on the market or at an advanced stage of development are:

- Night vision: infra-red cameras enable the driver to have better perception in conditions of low visibility, such as at night and in fog.
- Blind spot detection: rear-view mirrors are affected by the blind angle a side area the driver cannot see unless they turn their head. A camera and an electronic image processing unit could serve as a vital warning system to alert drivers to a vehicle overtaking them.
- Parking manoeuvre support: parking sensors are already widespread on many vehicles. Furthermore, some vehicles have recently been equipped with a function that detects the space between two vehicles and - if sufficient - aids manoeuvring by guiding the steering wheel.

In ADAS, both warnings and controls play an important role in safety enhancement. Effective warnings have the potential to compensate for

20

(39) www.unece.org/trans/doc/2008/wp29grrf/ECE-TRANS-WP29-GRRF-S08-inf09e.ppt
(40) Image from www.unece.org/trans/doc/2007/wp29/ITS-15-05e.pdf

21. Example of road sign repetition on vehicle instrument panel through visual recognition of the sign at the edge of the road[42]

22. VMS for traffic control and communicating information to road users (A22 del Brennero)

23. On-board instrument panel, displaying maximum allowed speed, alert messages and information relayed by cooperative systems

driver limitations, helping to prevent road accidents. When dealing with humans, warnings and control measures need to be carefully assessed in terms of frequency and priority. High-priority warning signals are communicated via human interface systems to promote awareness and timely, appropriate driver action in situations that present potential or immediate danger.

There are typically three levels of warning priority[41]:

1. Low-level: driver should take action within the timeframe of 10 seconds to 2 minutes; may escalate to a higher level if not acted upon.
2. Mid-level: requires action within the timeframe of 2 to 10 seconds; may escalate to high-level warning if not acted upon.
3. High-level: warning requires the driver to take immediate action within 2 seconds to avoid a potential crash.

These principles apply to "driver-in-the-loop" systems that warn or provide drivers with support for avoiding crashes. This means that these principles do not apply to fully automated systems (i.e. ABS, ESC) or in-vehicle information and communication systems (i.e. navigation systems). They apply to systems that require drivers to initiate one or more of the following responses:

- Immediate braking for crash evasion.
- Immediate steering manoeuvre for crash evasion.
- Immediate termination of initiated action.
- Seek awareness of situation and perform one of the above responses.
- Immediate decision to retake driver control.

ADAS with high-priority warnings are: Forward Collision Warning (FCW) systems, Lane Departure Warning systems (LDW), Blind-Spot Warning (BSW) systems and back-up warning systems.

Intelligent Speed Adaptation (ISA)

Another example of ADAS is Intelligent Speed Adaptation (ISA), a system which uses information and communication technology to provide speed limit information on a vehicle's dashboard. The typical means of doing this is a through a digital road map; when the map is combined with current position information from a GPS receiver, the ISA can display the speed limit and a warning for the driver. The same information can be linked to the vehicle's engine management system to provide an intervening ISA (voluntary - may be overridden by driver; mandatory - without the option to override). This kind of system could also be combined with traffic sign recognition systems.

3.4.3 Cooperative technologies

The idea of cooperative systems is to have vehicles connected via continuous wireless communication with the road infrastructure on motorways (and possibly other roads), and to "exchange data and information relevant for the specific road segment to increase overall road safety and enable cooperative traffic management"[43].

The basic innovation of cooperative systems is that intelligent transport tools, both in infrastructure and on vehicles, are active and "cooperate" in order to perform a common service. Consequently, in cooperative systems, communication can be Vehicle to Vehicle (V2V) or Vehicle to Infrastructure (V2I).

(a) Vehicle to Vehicle communication: can be defined as the cooperative exchange of data between vehicles through wireless technology in a range that varies between a few meters to a few hundred meters, with the aim of improving road safety, mobility, efficiency and improving the use of road capacity.

(b) Vehicle to Infrastructure communication: can be defined as wireless cooperative interaction, between vehicles and infrastructure, based on systems that can improve safety and performance on roads.

(41) www.unece.org/trans/doc/2008/wp29/ITS-16-03e.pdf
(42) Image from http://w1.siemens.com/press/en/pp_cc/2007/02_feb/sosep200702_27_(mt_special_mobility)_1434304.htm
(43) www.coopers-ip.eu

Vehicle to Infrastructure communication requires that vehicles are equipped with the technology necessary to transmit relevant data to the TCC of surrounding infrastructure where it is assessed and integrated with other information and then sent back to the different vehicles in the nearby vicinity as useful and "more valuable" information.
Taking this into consideration, it is evident that "intelligent infrastructure" and the "intelligent vehicle" are preconditions for the development of cooperative systems. Intelligent infrastructure is manned and equipped by technical and technological systems and the overall measures adopted make it able to collect information, perform Infrastructure to Infrastructure (I2I) communication and deliver advanced services to users.
Cooperative systems are expected to make use of state-of-the-art communication facilities to allow the driver access to all road and traffic information (i.e. information currently diffused through VMS) directly from the vehicle's instrument panel.
Some of the targets of cooperative systems, along with relevant examples, are as follows:

(a) Comfort: cooperative systems improve passenger comfort and the efficiency of traffic. Examples of this include: traffic information systems, delivery of weather forecasts and interactive communication such as access to internet services.
(b) Safety: passenger safety is improved through cooperative systems by enabling vehicles to receive information transferred from the TCC (Infrastructure to Vehicle [I2V]) and exchange it through V2V systems. The information can be supplied directly to the driver or it can trigger an active on-board safety system. Examples of this are: crossroad coordination, warnings for drivers breaching road regulations and information on road conditions. Some of these applications could call for direct V2V communication due to the very local relevance of the information and the need to minimize delays.
(c) Efficiency: the use of cooperative systems could help re-route traffic when events are disrupting traffic flow, optimizing the capacity of the road network and promoting efficiency network. Cooperative systems also enable Electronic Toll Collection (ETC) systems, which prevent queuing at toll barriers.
(d) Capacity: cooperative systems promote the better use of road capacity by transmitting information through V2V or V2I technology and ensuring compliance with the minimum safety distance between vehicles. Vehicle-to-Vehicle applications have so far only been proposed and not tested in real conditions. It has yet to be established whether or not they will be viable in the future, but at the moment they appear to be promising. In order to operate in real time, the delays detected must be minimal and the communication systems used must be highly reliable. In comparison, some V2I services already exist (i.e. ETC systems).


22

23

Some services can have an impact on multiple objectives: for instance, ETC is a cooperative service that provides better comfort, better use of capacity, as well as enhanced safety (avoiding queues on toll plazas). ETC systems are the only cooperative systems with bi-directional communication that have so far reached an significant level of penetration in several regional markets, with several million "On-Board Units"[44] (OBU) in circulation. ETC systems make use of a V2I data exchange in order to perform toll collection transactions without vehicles having to stop.
The most pressing issue in this field is the future availability of multipurpose on-board units for cars that are able to integrate toll collection services

(44) About 15 million On-Board Units in the European region (year 2008) - source ASECAP

24. Lanes dedicated to vehicles with On-Board Units for ETC on Torino-Milan Motorway

25. Penetration of ETC On-Board Units in national markets[46]

together with services for safety and user information in a single platform.
Another example of V2I is the Yellow Signal Warning System (YSWS). This system is aimed at reducing accidents by helping drivers avoid hazardous situations at crossroads controlled by traffic lights. The purpose of the system is to inform the driver when their vehicle is approaching a crossroads with a speed in excess of the official limit. The system therefore contributes to the avoidance of traffic violations at crossroads and helps to mitigate the effects of unavoidable collisions.

Automatic emergency call system

Once an accident occurs, the timely transmission of information related to the event to the appropriate services assumes vital importance. Thanks to GPS navigation devices and mobile communication services it is possible to install a specific electronic safety system in cars that automatically contacts emergency services in the event of an accident.
Information is transmitted to the TCC of the localised infrastructure or to any other pertinent Public Safety Answering Point (PSAP), in order to arrange a speedy response from the necessary services (i.e. towing operators, traffic police, emergency medical units, fire brigade). Even if the driver is unconscious, the system can use its on-board transmitters to inform rescue services of the vehicle's exact whereabouts, reducing the overall reaction time of the emergency services. In case of an emergency, the on-board automatic emergency call system can establish a voice connection directly to a call centre initiated either manually by vehicle occupants or automatically via activation of in-vehicle sensors (i.e. synchronous with the activation of airbags). At the same time, actual location, available information on the event, or specific medical data will be sent to the same PSAP operator receiving the voice call.
The in-vehicle unit needs to be suitably protected and provided with an autonomous power supply. Examples of this service are already in place through private rescue stations and for specific groups of users with particular requirements - for instance, for the transportation of valuables. To spread this service, all requisite standards will need to be fully defined and several national agencies and operators will need to be committed to the effort.
Initiatives already exist in this direction (i.e. at EU level)[45]. In particular, the confluence of all the emergency calls onto a single emergency number handling service (112 or 911) is being investigated and technical and organizational solutions need to be found in order to properly organise the service, integrating it into existing procedures. It is of critical importance that all actors involved in the emergency response are immediately and simultaneously activated (i.e. the medical services for the pertinent emergency, in additon to the operator in charge of the road section, the traffic police in charge of the area's traffic management, etc.).

Electronic Toll Collection (ETC)

Electronic Toll Collection, which allows the electronic payment of toll fees on motorways or the imposition of specific road pricing in particular urban areas, was one of the first cooperative ITS services and today is considered a mature technology. This kind of technology cuts queues and delays at toll stations and consequently avoids the pollution that comes from "stop-and-go" traffic. ETC systems take advantage of V2I communication technologies to perform an electronic monetary transaction between a vehicle/user that is passing through a toll station and the road operator or toll agency. Until now, this procedure most commonly used Dedicated Short Range Communication (DSRC). More recently, GPS/GSM/DSRC technology was adopted in Germany.
The roadside equipment checks all vehicles and detects whether or not the cars that pass are equipped with on-board units. If vehicles are found not to be equipped with the necessary on-board unit, then enforcement procedures are put into action (see point 4 below). Vehicles that have a valid on-board unit are charged the appropriate amount (through the bank account of the contract owner) without the vehicle having to stop.
Electronic Toll Collection systems require onboard units and rely on four major components:

(a) Automated vehicle identification: the process of determining the identity of a vehicular entity


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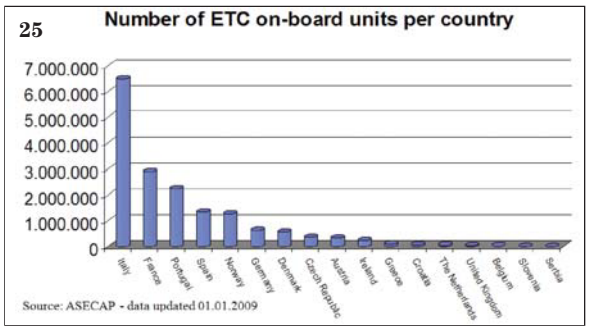
(45) See eCall initiative http://ec.europa.eu/information_society/index_en.htm
(46) www.asecap.com/english/documents/ASECAP_ENCHIFFRE_000.pdf



subject to the toll. The majority of current toll systems detect and record the passage of vehicles through a limited number of toll gates.

(b) Automated vehicle classification: most toll facilities charge different rates for different classes of vehicle, making it necessary to detect the class of vehicle passing through the toll facility.

(c) Transaction processing: deals with maintaining customer accounts, processing toll transactions and customer payments to the right accounts and handling customer inquiries.

(d) Violation enforcement: useful in reducing the number of unpaid tolls - several methods, devices and patrol actions can be used to deter toll violators.

Electronic Toll Collection has several benefits:

- Increased toll plaza capacity.
- Reduction in waiting times.
- Reduction in fuel consumption and pollutant emissions by reducing or eliminating stop-and-go traffic.
- Reduction in toll collection costs and enhancement of audit control by centralizing user accounts.
- Possibility to implement congestion pricing by breaking technical barriers: non-intrusive toll collection requires much less infrastructure, automatic vehicle counting and classification and automated accounting systems.
- Digital license plate recognition devices can accurately and efficiently identify toll violators.

Electronic Toll Collection also has its costs:

- Installation and maintenance of V2I communication technologies, On-Board Units, vehicle detection and classification as well as enforcement technologies.
- Standardisation and technical interoperability of systems impose costs.
- Staff and resources devoted to enforcement.
- Marketing and stakeholder involvement efforts.

Many countries operate ETC systems. While many of them use similar technologies, few of them are compatible at present. This leads to inefficiencies for drivers who frequently travel on international itineraries.

Directive 2004/52/EC on ETC

To address such issues in Europe, the European Commission has already published a directive on ETC, which emphasizes the need for the interoperability of systems. Directive (2004/52/EC) proposes the introduction of the European Electronic Toll Service (EETS) that makes it mandatory for fee collection systems to use one or more of the following technologies:

- Satellite positioning.
- Mobile communications using GSM and GPRS standards.
- 5.8 GHz microwave technologies, or Dedicated Short Range Communications (DSRC).

Furthermore, such systems should be interoperable and based on open and public standards, available on a non-discriminatory basis to all system suppliers.

Fleet management

Vehicles can be tracked from a TCC using GPS navigation devices together with communication facilities and digital cartography. Traffic Control Centre agents also have fast access to staff and resources that can be activated when it becomes necessary to handle an event. The same applies to the central control room of the traffic police and other emergency services. It's not only the emergency services that need to monitor fleets. Fleet owners can also supervise their own vehicles. In addition to vehicle tracking, modern fleet management systems enable advanced functions such as centrally managed routing and efficient dispatch, driver authentication, remote diagnosis while gathering details on current drivers' status, mileage, fuel consumption or container status data.

Integration of Traffic Message Channel (TMC) into navigation devices

While mentioning V2I systems, particular attention should be given to the Traffic Message Channel (TMC). Through a digital radio channel, information related to traffic (concerning motorways and main highways) and road conditions (such as queues, accidents, fog and similar events) is continuously broadcast. TMC information can be integrated with GPS navigation devices able to both capture the broadcast information and convey it

26. Traffic Message Channel

27. Classification of the communication process

28. Future communication systems

29. ITS in urban transport[48]

in a visual or acoustic manner. Once a destination has been established, the GPS navigation device can integrate TMC information and check whether some critical roads are included in the route. If this is the case, a warning can be delivered to the driver and the GPS device can suggest a new route avoiding the critical area. However, this application can present problematic issues: a new route automatically computed or suggested by an independent service provider could clash with different rerouting strategies designated by competent authorities or road operators, creating an inefficient traffic management scenario.

26

3.4.4 ICT infrastructure and communication networks

Every ITS service depends on the availability of an Information and Communication Technology (ICT) backbone and enabling systems that constitute the core of ICT infrastructure, laying the foundation for all services. For instance, no real-time video system can exist in the absence of suitable communications technology (i.e. fibre optics). Communication equipment underpins practically every ITS service. The success rate of implementing ITS is closely related to the availability of ICT infrastructure. The capability to deliver ITS services does not grow in a linear fashion with the augmentation of available technology. For most ITS services a minimum critical mass is needed in order to perform a wide number of tasks. For example, real-time traffic monitoring is essential to traffic management services. This monitoring can be performed by video cameras, although other devices are capable of performing this task. The same footage collected from these cameras can be used for other services - it can be published on the internet for pre-trip information or can be used for automatic incident detection.

As we all know, the cost a service usually rises in proportion to its quality. The quality of a service can be continuously upgraded but a minimum base level needs to be initially guaranteed in order to avoid generalised public mistrust towards the service.

The cost of ICT infrastructure is relatively small when compared to the cost of road infrastructure as a whole. This presents an opportunity for developing countries that are currently building roads: when building new infrastructure they can opt directly for state-of-the-art ICT equipment.

Information systems are based on the exchange of information between vehicles and roads, vehicles and other vehicles, and vehicles and roads with people. ITS depend heavily on telecommunication technologies and communications structures in order to provide useful services.

Wireless communication technologies such as GSM and DSRC are used for extra-vehicular communi-

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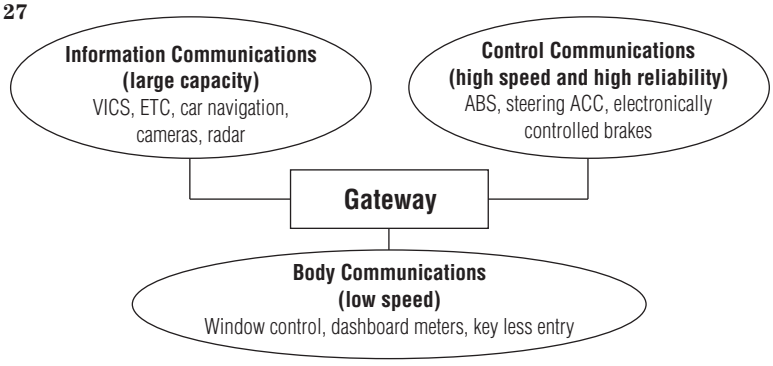

Source: Prepared by the Development: Bank of Japan from various materials.

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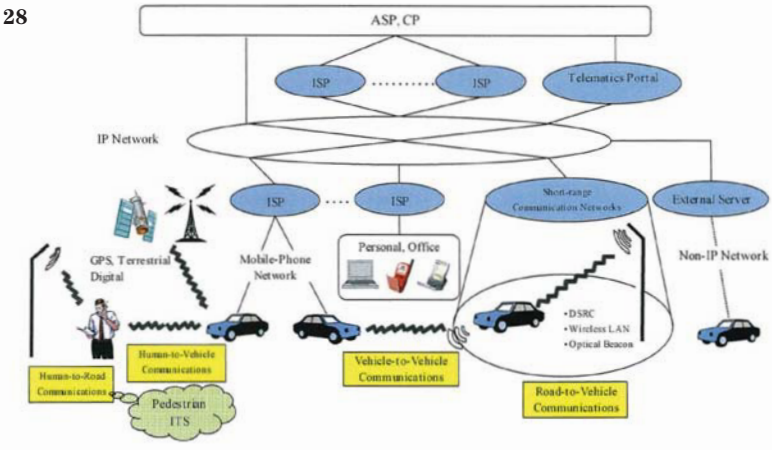

Note: ISP: Internet Service Provider, ASP: Application Service Provider, CP: Content Provider.
Source: Prepared by the Development Bank of Japan from Internet Council materials and other sources.

cations. For communications that link on-board components within a vehicle, cable harnesses are used. To minimize the number of wires, multiplexed communications are frequently employed. These networks types are classed as body, operation or information according to the purpose of the communications.

The requirements for each type are different and each year in-vehicle communication becomes more complex. Regarding V2V communication, consortiums have already been established in Europe and the United States, and now Japan is setting up its own body to hasten the development of advantageous standards.

3.4.5 ITS in urban transport[47]

ITS applications can play an important role in transport, especially in more urban areas.
In particular, they help in:

(a) Improving traffic flow:
- Signalised junction controls can improve traffic flow and reduce air pollution.
- Urban traffic management and control can enable police, local authorities and public transport operators to share information and help develop a truly integrated and more efficient transport system.

(b) Improving road safety:
- Enforcement cameras deter speeding and discourage traffic violations at traffic lights;
- Intelligent traffic signals can increase the time available for people crossing roads, where and when this is needed.

(c) Improving security and reducing crime:
- Closed circuit television can deter crime and improve response time to incidents;
- Traffic information services can improve the quality of information available to travellers.
- VMS can provide information on current travel conditions, the availability of parking spaces or real-time public transport information.

(d) Improving public transport:
- Operators can improve their services by having accurate information on the location and progress of vehicles.
- Travellers can get up-to-date information from the appropriate websites.

(e) Improving freight efficiency:
- Improved traffic flow and more accurate positioning information will result in faster and more reliable movement of goods.

(f) Lessening environmental impact:
- Reduced congestion, a more efficient transport network together with better-informed travellers and more sustainable transport choices can help tackle climate change and reduce air pollution.

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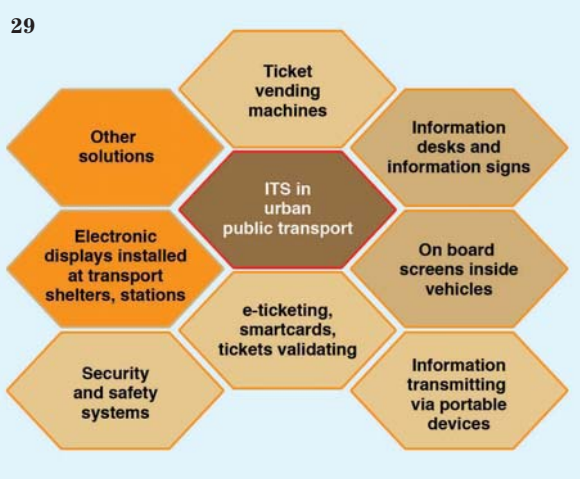


Receiving the right information at the right time and in the right place is critical for successful urban public transport, especially in a multimodal transport system. It is hard to imagine the existence of flexible and high-quality urban public transport without the deployment of ITS. The following usage of ITS in urban public transport is critical for improving standards:

- Information prior to or during the journey on urban public transport (WAP, SMS etc.).
- Electronic displays showing the remaining time before arrival should be installed in bus, train and tram stops and at stations.
- Electronic information desks for the retrieval of information on routes, ticket prices, timetables, announcements on traffic conditions etc.
- On-board screens in urban public transport vehicles (vocally announcing stops, showing teletext and other information).
- Ticket Vending Machines (TVMs).
- Electronic tickets, e-ticketing etc.
- Security systems (security cameras etc.).
- Electronic information signs such as illuminated arrows, numbers, pictograms etc.
- Other passenger information services (displaying vehicle location, walking distances between stops, parking information etc.).

(47) *"ITS in urban transport: the challenges for the UNECE Transport Division"*, Molnar, Alexopoulos (**www.unece.org/trans/news/eurotransport2008-05.pdf**)
(48) **www.unece.org/trans/news/eurotransport2008-05.pdf**

3.5 Applications for the transport of dangerous goods (safety and security)

30. Visual identification systems for security in port areas: reading and automatic processing of container codes (based on fibre-optic technology, RFID etc.)

31. Operational checks and inspection of both goods and vehicles in port areas: examples of X/gamma ray systems used to detect smuggled materials, explosives etc. These systems are also used for customs clearance purposes

32. Fire on a vehicle carrying dangerous goods

Most of the considerations mentioned thus far relate to the field of safety. It should also be noted that security is a primary concern in ITS. A matter of particular relevance is the transport of dangerous goods, a case that goes beyond companies' private management efforts since it involves the safety of both traffic and the general public.

In the international context, the committee of experts appointed by the United Nations Secretary General at the request of the Economic and Social Council periodically draft the *"Recommendations on the Transport of Dangerous Goods"*, which is to be applied to all modes of transport. These recommendations are then incorporated into international regulations in compliance with the following schemes:

- European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterway (ADN), for inland navigation transport.
- European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), for road transport.
- Regulations concerning the International Carriage of Dangerous Goods by Rail (RID), for railway transport.
- International Maritime Dangerous Goods Code (IMDG), managed by the International Maritime Organization (IMO), for sea transport.
- Annex 18 to the Chicago Convention of the International Civil Aviation Organization (ICAO) or Annex A to resolutions 618 and 619 of the International Air Transport Association (IATA), for air transport.

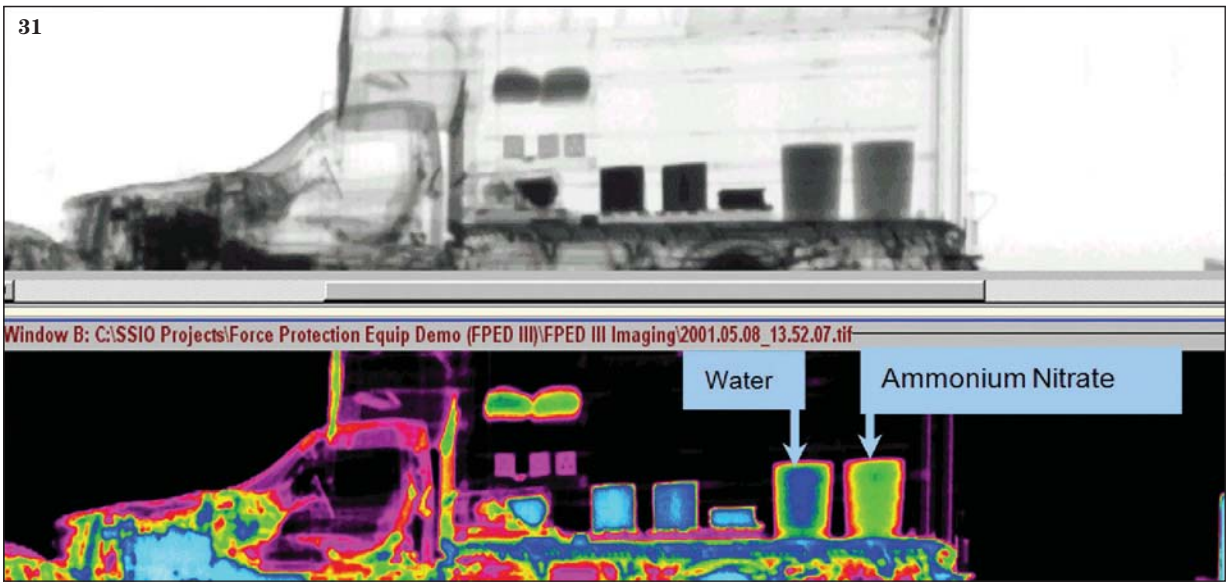
It should also be noted that through directive 2008/68/EC, the regulations stipulated by the ADR, RID and ADN are mandatory for domestic traffic in EU countries and are also applicable to domestic traffic in many other countries (i.e. the United States, Canada, China, Australia, Japan etc.).

It is evident that the overall actions of the UN in the field of dangerous goods transport aim to promote a high level of safety, creating an overall level of common understanding and a common approach to the safety of drivers, road users and citizens living along roads and highways. This is fostered through the following key elements:

- Provisions for drivers (requirements for vehicle crews, consignment procedures etc.).
- Criteria of circulation (listing and coding dangerous goods in a unified way, provisions related to quantities etc.).
- Provisions for vehicles (packing and tanker provisions, periodical overhauling and replacement of sub-standard tankers etc.).

We need to remember that the safety of road transport depends on continuous supervision by stakeholders and authorities of every single detail of the process - there can be no common safety standard if drivers do not adopt safety procedures or if authorities have a lax approach to enforcement or to the monitoring of vehicles and tankers through the inspection of expired or invalid certification documents or relevant vehicle parts. It should also be highlighted, particularly in relation to road transport, that the European Council has acknowledged the growth of ICT systems and places a high premium on their operational utility.

The arrival of ADR 2005 introduced the concept



of security and protection for vehicles and goods while as also taking steps toward tackling accidents resulting from fraudulent acts. Besides helping to ensure safe driving and people's safety, it is the duty of the Dangerous Goods Safety Adviser (DGSA) to set up a plan that oversees the safety and security of high-risk goods and sets out operational measures (i.e. drawing up the itinerary). Another milestone for safety is the applicative provisions laid out by EU regulations on the digital tachograph for vehicles, which have been mandatory since May 2006.

It also appears clear that the need to monitor the transportation of dangerous goods is becoming an absolute priority because of issues connected with mobility and the safeguarding of the environment, but mainly because of the growing stature of international terrorism. The United States, which often anticipates the application of provisions that are currently subject to negotiations at international level, has already undertaken a series of unilateral measures.

Finally we should mention the US Maritime Transportation Security Act and the Container Security

Initiative (CSI) which involves the preventive inspection of containers before they leave for the United States. The CSI uses the following procedures: technological means to inspect high-risk containers, introduction of protected containers that allow intelligent monitoring and sending alerts to harbours warning of a ship's arrival 24 hours in advance.

4. Outlook of UNECE action in the field of ITS and current provisions

4.1 The UNECE Transport Division's approach to ITS

Whilst pursuing their own institutional activities, the UNECE Transport Division and the other bodies of the UNECE promote ITS through facilitating coordination activities and preparatory studies for legal instruments aimed at the application and deployment of ITS.

The UNECE Transport Division was established after the end of World War II in response to an urgent need for an overall coordinator and facilitator of the international movement of people and cargo by road, rail and inland waterways, i.e. international transport.

Nowadays, the Division's main challenge is to listen, understand and respond to new transport issues and in parallel continue its task of promoting the implementation of existing conventions and agreements by all of its member countries.

The UNECE's strategy is to approach transport in an integrated way, concentrating not only on innovative new ways of doing things but also on ways to merge traditional, well-functioning legal instruments with new technology. Intelligent Transport Systems are part of this holistic vision for the transport system.

Through cooperation with member Governments, other international organizations and non-governmental organizations, the UNECE Transport Division works to reduce the frequency and gravity of road accidents.

To this end, it promotes the development of internationally accepted legal instruments as well as recommendations and resolutions.

The Transport Division is composed of a number of different sections and units that specialise in various transport areas, including inland waterway transport, road transport, road traffic safety, vehicle regulations, rail transport, tunnel safety and the transportation of dangerous goods and sensitive cargoes.

Several groups deal with ITS-related matters. Recognising the importance of ITS, a focal point has been nominated.

33. The "Palais des Nations" in Geneva

34. Transport on the UNECE website

A perspective vision: ITS - an area to be strengthened in the transport sector

Intelligent Transport Systems offer non-traditional solutions in an effective way. The UNECE's main focus on ITS regulations has so far been overseen by the World Forum for Harmonization of Vehicle Regulations (WP.29). Technical specifications for Advanced Emergency Braking Systems (AEBS) and Lane Departure Warning Systems (LDWS) are just two examples of standards implemented by WP.29.


33

Significant improvements in vehicle-related safety and the reduction of pollution from traffic have been achieved at global level through the work of WP.29. However, greater improvements in the safety and environmental performance of vehicles may be achieved if ITS applications are streamlined further into the output of WP.29.

Motor vehicles are today - and most likely will be in the future - much safer thanks to the use of ITS. The technological upgrade of vehicles and related services for drivers and road users is currently being explored, and a benchmarking process is being performed by the ITS Informal Group operating inside WP.29.

The applications made available by ITS are already helping to enhance the performance of vehicles through the use of technologies such as lane-keeping support systems, automatic braking systems, doze alert systems and rear lateral/lateral collision avoidance systems. It is essential that infrastructure takes a path of continuous development in order to arrive at the "intelligent road" stage, enabling the transport system to deliver safer and more efficient solutions for the mobility of people and goods.

The traffic management of specific vehicles carrying dangerous goods, the tracing of vehicles themselves and the possibility of rerouting them in the case of an emergency or critical situation are all issues that the UNECE Working Party on the Transport of Dangerous Goods (WP.15) considers to be of paramount importance. Moreover, catering for requirements related to the transport of dangerous goods and their passage through specific locations (i.e. places with a high concentration of people) is beneficial for road safety and gives additional advantages in terms of security.

Logistical and procedural issues relating to transport management are addressed by the Working Party on Intermodal Transport and Logistics (WP.24). The Working Party deals with the issues and requirements of industries and transport policymakers in areas such as pan-European networks; service standards for combined transport (European Agreement on Important International Combined Transport Lines and Related Installations [AGTC]); efficient chain management and logistics in intermodal transport; and interregional Euro-Asian land transport links.

The Trans-European North-South Motorway (TEM) is one of the projects where UNECE is acting as the executing agency. The TEM is a project through which Governments and stakeholders decided to cooperate to promote a corridor for cross-border road traffic in Europe between the countries belonging to Western, Eastern, Central and South Eastern Europe.

The project's core aim is to give assistance in the integration process of Europe's transport infrastructure systems, thus promoting overall development in the region. This can be seen as a special opportunity for establishing a system of high-capacity roads that will ensure a high quality of service for traffic as a result of the application of adopted standards, good practices and technology.

Taking the development of TEM and the Trans-European Networks (TEN) into consideration, it is of utmost importance to realise an overall traffic management service that can be implemented with new operating criteria and state-of-the-art technology.

If we consider this programme in synergy with other programmes such as Trans-European Transport Networks (TEN-T) and the European Commission project "EasyWay", we can envisage a new Europe-wide scenario; a new operating ground through which the demands of long-distance and international traffic can be satisfied alongside technological development and/or upgrade. It would be an important achievement and a winning step to embrace the potential added value of ITS in this new vision and to foster commitment to the Amsterdam declaration.

In order to build bridges and create links between transport, health, environment and between the countries of Europe - including Eastern Europe - the Caucasus, Central Asia and South East Europe, a decision has been made to strengthen the *"Transport, Health and Environment pan-European Programme"* (THE PEP). To this end, efforts are being made on the pan-European platform to bring countries together to cooperate for efficient, healthy and environmentally friendly transport facilities.

4.2 Working Parties and groups of UNECE: generalities, activities and aims

35. UN meeting room, Geneva

36. UNECE Working Parties on vehicle regulations within WP.29

37. UN conference room, Geneva

In the framework of the vehicle regulations activities of the UNECE in Geneva, WP.29 is administering the following two agreements:

1. The 1958 Agreement concerning the adoption of uniform technical prescriptions for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the basis of these prescriptions. The 1958 agreement includes the 130 UN regulations annexed to the agreement as well as the complete status information of the agreement, listing the Contracting Parties (CP) applying the UNECE regulations[49].
2. The 1998 Agreement concerning the establishment of the global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles.


35

The 1998 agreement includes the Global Registry, which is the repository of nine Global Technical Regulations (GTR), the compendium of candidates for participation in the harmonization or adoption of global technical regulations as well as the complete status information of the agreement[50].

The categories of wheeled vehicles established by UNECE regulations can be found in the following acts:

(a) The definitions of the different categories of vehicles established within the 1958 Agreement can be found in the Consolidated Resolution on the Construction of Vehicles (R.E.3) available in TRANS/WP.29/78/Rev.1 and its amendments[51].

(b) The definitions of the different categories of vehicles established within the 1998 Agreement can be found in Special Resolution No. 1 (S.R.1) available in TRANS/WP.29/1045 and Amend.1[52].

A blue book on the activities, and how to join WP.29, contains the guidelines and main fields of operation[53].

The activities are structured as illustrated below in figure 36.

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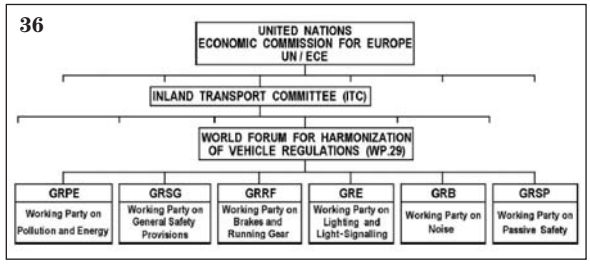


Reports of sessions, references to working documents and other resources are all available on the UNECE website.

The following working parties are involved in activities relating to safety and matters that are potentially ITS-related: Working Party on Lighting and Light-Signalling (GRE), Working Party on Brakes and Running Gear (GRRF), Working Party on Passive Safety (GRSP) and Working Party on General Safety Provisions (GRSG).

The subsidiary body of WP.29 responsible for updating the existing requirements with regard to general safety provisions is the Working Party on General Safety Provisions (GRSG)[54]. The subsidiary body of WP.29 responsible for updating the existing requirements with regard to Passive Safety Provisions, is the Working Party on Passive Safety (GRSP)[55]. The subsidiary bodies of WP.29 responsible for updating the existing requirements with regard to Active Safety, are the Working Party on Brakes and Running Gear (GRRF)[56] and the Working Party on Lighting and Light-Signalling (GRE)[57].

The following are the main legal instruments relating to road traffic safety and road infrastructure:

(a) Convention on Road Traffic of 1968 and European Agreement Supplementing the Convention - 2006 consolidated versions.

(b) Convention on Road Signs and Signals of 1968,

(49) www.unece.org/trans/main/welcwp29.htm
(50) www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29glob.html
(51) www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29re3.html
(52) www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29sr.html
(53) www.unece.org/trans/main/wp29/wp29wgs/wp29gen/wp29pub.html - www.unece.org/trans/doc/2004/itc/itcrt/Overview.ppt#16

European Agreement Supplementing the Convention and Protocol on Road Markings Additional to the European Agreement - 2006 consolidated versions.

(c) European Agreement on Main International Traffic Arteries (AGR) of 15 November 1975.


37

Within the general mandate of the United Nations, the Working Party on Road Traffic Safety (WP.1) initiates and pursues actions aimed at reinforcing and improving road safety. More specifically, the WP.1 works for the elaboration and continous updating of the 1968 conventions on road traffic and on road signs and signals, as well as the European agreements supplementing them, in addition to the unique set of road safety best practices contained in the Consolidated Resolution on Road Traffic (R.E.1) and the Consolidated Resolution on Road Signs and Signals (R.E.2[58]).

The Working Party supervises the collection of data published by Governments concerning existing national road traffic legislation and road traffic statistics (accidents and casualties) from Europe and North America. According to the latest United Nations resolutions on road safety (United Nations General Assembly resolutions 58/9 of 5 November 2003 on the global road safety crisis, 58/289 of 11 May 2004, 60/5 of 1 December 2005 and 62/244 of 31 March 2008 on improving global road safety and the most recent United Nations Road Safety Resolution 64/255 of 2 March 2010) WP.1 and the UNECE have coordinated several road safety projects, such as the latest UNDA project on *"Improving Global Road Safety: Setting Regional and National Road Traffic Casualty Reduction Targets"*. The objective of which is to assist Governments in low and middle income countries to develop regional and national road safety targets and to exchange experiences on good practices for achieving these targets by 2015.

In order to adapt the existing conventions and sets of rules to the dynamics of road safety, thematic *ad hoc* working groups have been given special mandate on specific issues, including ITS (such as the creation of an expert group on VMS), as well as the creation of joint working groups on matters that have an impact on road safety (i.e. joint work on road safety and infrastructure with the Working Party on Road Transport [SC.1]).

4.3 Activities performed by UNECE bodies in the field of ITS

The UNECE Transport Division aims to promote the application of ITS in order to achieve its policy goals.

Intelligent Transport Systems were discussed and made the object of specific legal instruments thanks to the work of several UNECE bodies[59], including: the World Forum for Harmonization of Vehicle Regulations (WP.29); the Working Party on Road Safety (WP.1); the Multidisciplinary Group of Experts on Road Safety in Tunnels (AC.7); the Working Party on Inter-modal Transport and Logistics (WP.24); the Working Party on Customs Questions affecting Transport (WP.30) and the Working Party on the Transport of Dangerous Goods (WP.15). All these bodies have expressed their wish that UNECE Transport Division, being their secretary, provides strategic guidance and administrative support to them with regard to ITS, focussing on the following four areas:

1. Mitigating traffic congestion.
2. Improving road traffic safety.
3. Reducing pollution and noise.
4. Improving fuel efficiency.

The following pages include some highlights of ITS-related actions that have already been implemented or are in progress within UNECE official bodies. The list is not exhaustive.

(54) www.unece.org/trans/main/wp29/wp29wgs/wp29grsg/grsgage.html
(55) www.unece.org/trans/main/wp29/wp29wgs/wp29grsp/grspage.html
(56) www.unece.org/trans/main/wp29/wp29wgs/wp29grrf/grrfage.html
(57) www.unece.org/trans/main/wp29/wp29wgs/wp29gre/greage.html
(58) www.unece.org/trans/roadsafe/wp1fdoc.html
(59) www.unece.org/trans/theme_its.html

4.3.1 Informal Group on ITS under WP.29 for in-vehicle ITS

38. Effect of on-board ITS on human behaviour[61]

As a result of efforts to equip motor vehicles with artificial intelligence and information systems, some advanced Intelligent Vehicle Systems (IVS) technologies were introduced into the automotive market. The acceleration of the widespread use of these technologies was considered desirable not only because they contribute to the comfort and safety of equipped vehicles, but they also contribute to enhanced safety for road traffic as a whole.

It is possible that in-vehicle ITS technologies may be rejected by the market before they become fully developed if people are not aware of their ability to enhance safety and their overall contribution to efficiency. It was therefore necessary to bring about a common understanding of possible regulations and certification procedures in stakeholder countries. Rising expectations made WP.29 take the initiative in building such a consensus.

As a response, WP.29 established an ITS Informal Group in June 2002, to began preparation for the Inland Transport Committee (ITC) roundtable meeting and deepen its understanding of in-vehicle ITS issues. At the ITC roundtable of 18 February 2004, WP.29 members and organizations reconfirmed the importance of discussing in-vehicle ITS issues in WP.29 and agreed to continue the activities of the ITS Informal Group.

The ITS Informal Group assumed the role of a "strategic group", which works to expand knowledge of new technologies designed to enhance safety, including developing a common understanding of these technologies. The Informal Group also discusses now to handle these technologies in the regulatory framework, if necessary, and reports the discussion results to the WP.29.

The Informal Group aims to accelerate the development, deployment and use of intelligent integrated safety systems that use Information and Communication Technologies (ICT) in solutions for improving road safety, reducing the number of accidents on Europe's roads and making road traffic both greener and smarter. The technologies discussed by the WP.29/ITS Informal Group are in-vehicle ITS (on-board safety systems that utilize information received from direct sensing and/or telecommunications via road infrastructure or other sources).

The Informal Group has issued the following statement concerning on-board ITS:

- It is important to emphasize that certain ITS applications use advanced technologies to provide in-vehicle support for reducing the number of crashes and attendant injuries and deaths. Other ITS applications provide in-vehicle information for purposes other than improved safety. Whatever the primary function is, both types of ITS applications can have important unintentional influences on safety (positive and negative).

In addition, since there are strong expectations for the contributions of ITS to the enhancement of vehicle and traffic safety, it was determined that the following understanding is also necessary:

- Certain areas of systems are expected to be discussed primarily for enhancing the safety of vehicles. They include systems that use advanced technologies for enhancing safety, and that advise/warn, and/or assist the driver with the purpose of vehicle functions and performance in driving.

Looking at the function of in-vehicle ITS for safety enhancement, the extent of the system's assistance to drivers' control is an important issue to be deliberated, including how far the "assist" can be extended and how closely it is related to "substitution". This discussion can be based on certain current in-vehicle ITS solutions.

In-vehicle ITS technologies can be divided into three categories:

1. Assistance by information presentation and control under normal driving conditions.
2. Assistance by warning under critical conditions.
3. Assistance by control under pre-crash conditions.

In June 2011, the World Forum (WP.29) adopted guidelines on establishing requirements for high-priority warning signals (ECE/TRANS8WP.29/2011/90). They were transmitted by the Informal Group on ITS and contain the Statement of Principles on the Design of High-Priority Warning Signals for Advanced Driver Assistance Systems (ADAS).

Intelligent Vehicle Systems

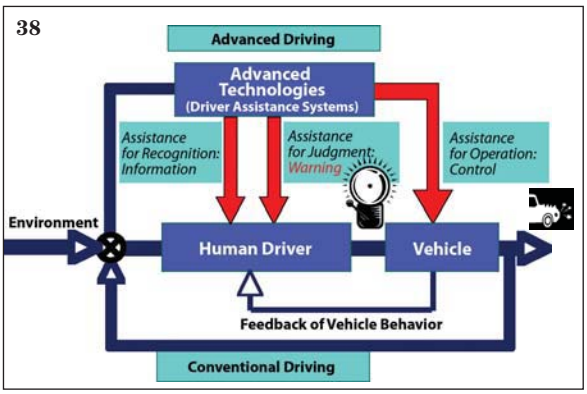
In regard to vehicle construction, UNECE has provided strategic direction to improve safety and reduce pollution created by vehicles at a global level through WP.29, which also tackles the issue of ITS implementation in transport. Several ITS technologies are currently in operation, such as the Anti-lock Braking System (ABS) - one of the first example of ITS to be used in motor vehicles - and the Electronic Stability Control (ESC) system. The Tyre Pressure Monitoring Sys-

tem (TPMS) and Brake Assist Systems (BAS) are two of the most recent representative examples introduced by legal instruments under the responsibility of WP.29. The TPMS improves vehicle safety, providing real-time tyre pressure monitoring while also helping to reduce CO_2 emissions. The aim of the BAS is to improve brake efficiency - a development not only good for passengers, but for pedestrians too. In 2009, provisions regarding TPMS were adopted and incorporated into regulations for passenger vehicles. The development of provisions for other vehicle-based systems such as Lane Departure Warning Systems (LDWS) and Brake Assist Systems (BAS) are in the final stage and should be completed by 2011/2012. In addition to systems that are confined to vehicles, there are a number of other systems that interact between the road side/infrastructure and the vehicle.

Safety regulations are based on performance requirements, not on specific technologies, to prevent design restrictions[60]. The future development of road safety will be improved by accident avoidance much more than by injury mitigation.

The future appears promising for driver assistance systems. Very soon it will be possible to send incremental map and information updates to in-vehicle systems. In conventional driving, the driver observes their surroundings and the running condition of their vehicle, making judgments on appropriate actions and consequently directly operating the steering wheel, pedal and brake.

38



The driving system illustrated in figure 6 may be supported by a separate "driving assistance system" designed to assist the driver's recognition, decision-making and control abilities by utilizing advanced technologies.

The concept of driving assistance, including assistance for control, should be separated from "complete substitution", which means taking over of all of the driver's functions and responsibilities. Various research institutes are currently engaged in studies on the form, extent, timing and other appropriate elements of possible driver assistance. While some types of driver assistance systems are already in practical use on vehicles, as a whole they are still in their developmental stage. This offers a timely opportunity for countries and the transport sector in general to seek a deeper understanding of the technologies available for driver assistance.

4.3.2 Informal working group on telematics - Working Party on the Transport of Dangerous Goods (WP.15)

In order to promote the use of ITS, the RID/ADR/ADN Joint Meeting put in place an informal working group on telematics to consider what type of data can be provided by ICT systems to enhance the safety and security of dangerous goods transport and related facilities. In particular, it will consider who might benefit from the delivery of information and in what way.

These parties may include consignors, transport operators, emergency response teams, law enforcement officials or motorway regulators (see terms of reference ECE/TRANS/WP.15/AC.1/108/Add.3). Moreover, the group will analyse the costs/benefits of utilising ITS tools for the previously mentioned purposes and will consider what procedures/responsibilities might be necessary in the monitoring of the information received. A decision also needs to be reached on how access to data should be controlled.

In the UNECE framework of actions and references, attention was also paid to the European Commission's action plan on the development of ITS, which should be pan-European. It could be an advantageous asset to have a shared view on a consistent ITS system for all transport modes.

In this respect, it is interesting to note that the European transmission protocol DATEX II - which defines the data transmission protocol between traffic management and traffic information centres in Europe - has the potential to cover these multimodal aspects and the consequent operations on roads.

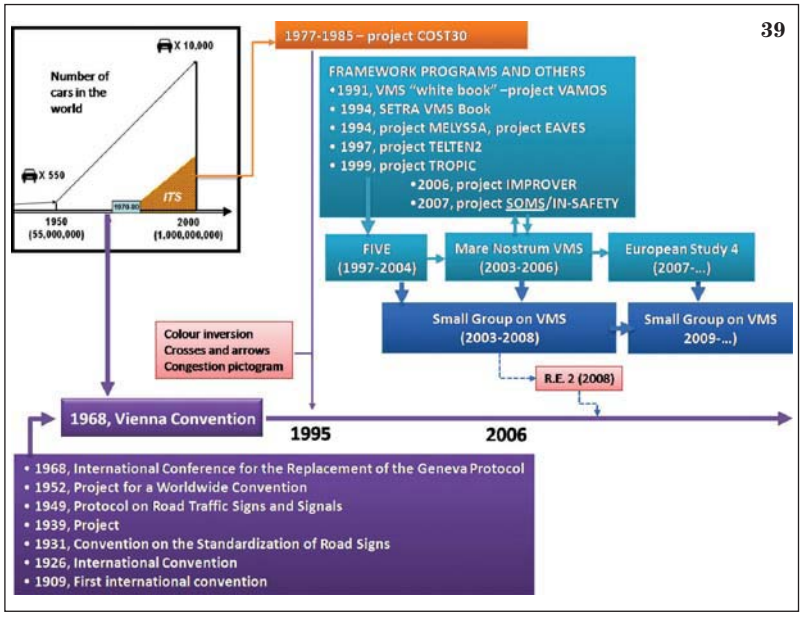
(60) For instance, UNECE Regulation on Frontal collision (regulation No. 94) does not mandate the installation of air-bags for occupant protection but sets biomechanical injury criteria and limits (measured through test dummies) to be complied with during testing. Accordingly, the vehicle shall perform occupant protection allowing the manufacturer to devise the best design for achieving it

(61) www.unece.org/trans/doc/2009/wp29/ITS-17-02e.ppt

4.3.3 UNECE Road Safety Forum (WP.1) - Informal working group for harmonization of VMS pictograms[62]

Variable Message Signs (VMS) are one of the better known ITS devices. This kind of technology is mainly, but not entirely, used for information purposes. In order to harmonize these types of signs, the UNECE launched a devoted working group[63] within the institutional framework of the Working Party on Road Traffic Safety (WP.1). With the same objective regarding harmonization since the mid-1990s, the European Commission Directorate General for Transport and Energy's (DG TREN) Multi-annual Indicative Programmes (MIP) for ITS implementation has developed a network of Euro-regional projects[64] dealing with many ITS-related issues, including VMS. Perhaps an interesting trend that best demonstrates this effort in Europe can be seen in projects that incorporate a range of areas; from applied science (framework programmes) through to scientific implementation (Euro-regional projects).
The project Substituting/Optimizing (variable) Message Signs for the Trans-European Road Network (SOMS/IN-SAFETY) operated in that manner between 2005 and 2007. Similarly, MIP-2 MARE NOSTRUM VMS (2003-2006) adopted empirical procedures in order to solve the old problems of sign innovation and standardisation. The outcome of both projects was the formation of the UNECE's WP.1 Small Group on VMS, a group made up of functionaries from France, the Netherlands, Spain (all personnel coming from Mare Nostrum VMS) and Germany.
This method of progress found its place within the EC EasyWay programme. Continuing with the vision of the Mare Nostrum VMS Long Distance Corridor (2003-2006), EasyWay's 4th European Study (ES4 2007-2013) - coherently called Mare Nostrum - retains and expands on this approach for dealing with the innovation and standardisation of VMS. The ES-4 group complements the work carried out by other bodies such as the European Committee for Standardization (CEN) - which is focused on the harmonisation of technical display parameters - or the work of the Conference of European Directors of Roads (CEDR). The Conference of European Directors of Roads' Framework for the Harmonised Implementation of VMS in Europe (FIVE), for example, recommends general design principles for VMS but does not analyze in detail the specific informative elements that are missing on each of the road/traffic situations that require harmonisation.
The goal is to avoid scenarios where the European driver may not be able to understand information concerning their safety, route diversions and all the other potential improvements that can be made to their journey, due to language problems. A complete harmonisation of VMS will improve safety and increase the efficiency of the road network, especially for long-distance transport. The identification and development of specific informative elements (pictograms, alphanumeric codes) and message structures that are totally independent of local languages is also envisaged.
EasyWay ES-4 has already realised historic milestones through the delivery of important documents (notably the so-called "Working Book" and the ES-4 Guidelines, which deal specifically with up to 47 road/traffic situations and acknowledge already-existing VMS types and specific road situations).
Back in the 1900s, danger warning signs were basically the only immediately available resource for overcoming the sudden and pronounced changes to the road environment that came with the advent of motor vehicles. It is easy to understand that on roads the difference between 16 km/h (horse-drawn carriages) and 80 km/h (that was soon available to most motorcars) is enormous. Motorization made the road network into a more dangerous place in just a few years and road signs were the most pragmatic and feasible way of easing that problem.
Motorized nations quickly had to identify road or

39. Evolution of road sign harmonisation in Europe (1909-2009)



(62) Most material is from *"The VMS Unit: a proposal"*, Arbaiza, Lucas
(63) Papers produced in 2008 are available on **http://www.unece.org/trans/roadsafe/wp12008.html**
(64) ARTS, CENTRICO, CONNECT, CORVETTE, ITHACA, SERTI, STREETWISE, VIKING

traffic situations that could be managed via road signs. In the 1970s, a technological revolution named the "third telematic wave" brought an additional parameter into play: the enlargement of VMS visualization devices. In two decades, devices progressed from fixed-post to fixed-variable and to mobile, in-car displays; from painted bulbs to LED surfaces; from restricted displays to full matrix. In fact, a new vision of road transport and traffic was developing in the 1980s - the key words here are high-speed and real-time traffic information - while the catalogue of international road signs still largely looked like it was from the 1950s. The lack of activity in road signs at global level correlated directly with the state of innovation at national level.

In the early 1990s, new information technologies made it evident that road signs hadn't been updated since the catalogue from the 1968 Convention on Road Signs and Signals. Encouraged by industrial dispositions and management needs, national road administrations (particularly in Europe) were faster in generating and adopting new road signs than UNECE's WP.1 was in standardizing them. The result was a lack of road sign harmonisation within the new and expanding domain of temporary, variable and real-time road signing.

Modern signs (both roadside VMS and in-car displays) may refer to practically all traffic circumstances: visibility, congestion, re-routing, ghost drivers, grip or capacity issues, speed control, polluted areas, black spots or sections, and so on. This gives way to tactical or strategic management; the core signing functions - regulatory, warning of danger, or informative messages - can now be displayed at any time according to road, traffic and enforcement parameters.

Variable Message Signs have spread widely because of their flexibility: they supply drivers with up-to-date information regarding road and travel conditions. A common use of VMS is to display a Tactical Incident Message (TIM) - a specific message warning of a particular impending hazard.

Variable Message Signs can also distribute more general advice on good driving habits by transmitting safety campaign messages. Behavioural studies[(65)] helped WP.1 to focus on the essential requirements of messages and on the need to broaden the scope of existing ones.

In these studies, drivers were tested in order to find out the effectiveness of alert messages and how their use affected their behaviour as drivers. Variable Message Signs carrying repeated safety messages were shown to have a positive impact on driver alertness in tests using eye-tracking devices.

The response and concurrent influence on driving performances and journey re-planning have been factors of relevant consideration for experts and for WP. 1.

The real time information provided by VMS is in itself considered to be vital in several scenarios. Traffic operators, mobility management teams and police officers need VMS in order to transmit messages to drivers in the quickest possible way. To be effective the message must be brief and convey information that a driver can react to and put to use in a prompt and effective manner. Messages can be generated by road operators from a pre-existing library or customized for the situation to not only inform drivers of delays, but also bring general information (such as the availability of park and ride options) or to target and influence driver behaviour and safety (i.e. safety belt reminders, speed limits).

It has been proven that credibility and clarity are of utmost importance if VMS are to have an effect on driver behaviour. Incorrect or vague information could lead to risky behaviour, whereas messages that instruct drivers on what action to take ('prescriptive' signs) are very effective and more likely to cause drivers to change their behaviour than messages that simply describe the situation. It has also been demonstrated that drivers respond strongly to the selection of words, their sequence and format, and to the location and spacing of signs.

A recent update of the Consolidated Resolution on Road Signs and Signals (RE2)[(66)], which was used to convey updated references in the Vienna Convention on Road Signs and Signals - set an innovative definition on the use of pictograms and on the main information provided by them. The update also set the general deployment rules used to facilitate the harmonization of VMS in all UNECE regions. Particular emphasis was placed on fostering their use in international traffic corridors.

Because the aim is to facilitate the use of VMS in an effective way, in cross-border traffic management, it is recommended that only well-known, international abbreviations (i.e. 'km' for kilometre, 'min' for minute, etc.) should be used. In addition, general, shared terms of reference should be established to keep messages clear and effective with the minimum number of words and symbols.

(65) Performed mainly by the University of Valencia and by SINA in cooperation with the University of Roma 3
(66) See **http://www.unece.org/trans/doc/2008/wp1/ECE-TRANS-WP1-2005-06r4e.pdf**

4.3.4 Expert group for safety in road tunnels

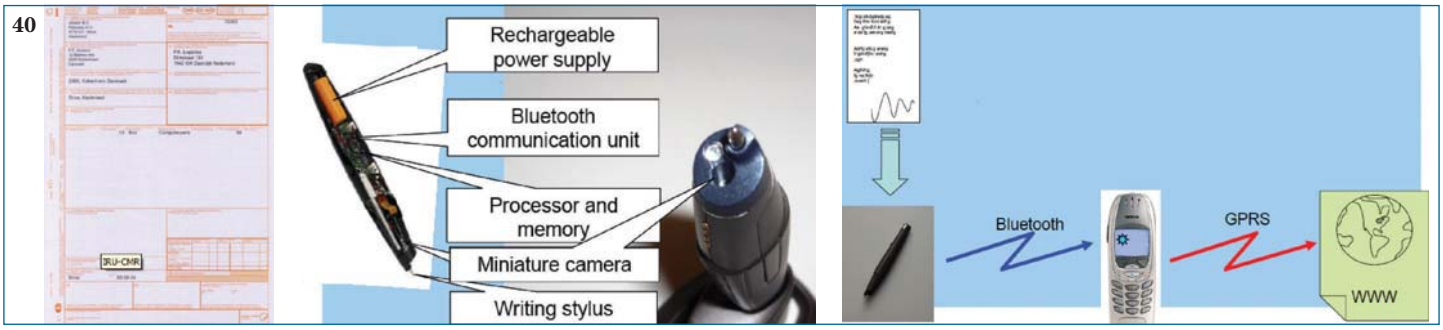
The three major tunnel accidents that struck four European countries between 1999 and 2001 (Mont Blanc, Tauern and St. Gotthard) served to remind international authorities of the need to find ways to prevent such incidents and mitigate their consequences. This target can be achieved through the provision of safe design criteria for new tunnels, effective management and possible upgrade of tunnels that are in service, and improved communication of important information to tunnel users. The likelihood of fatalities can be greatly reduced through the efficient organization of operational and emergency services (harmonized, safer and more efficient emergency procedures, chiefly for cross-border operations) hiring more skilled personnel, implementing more effective safety systems and promoting better awareness among road users of how to behave in emergency situations.
UNECE reacted to this need by establishing a multidisciplinary group of experts on road tunnel safety with the official participation of the World Road Association (PIARC). In December 2001 the group published the *"Recommendations of the Group of Experts on Safety in Road Tunnels: Final Report"*. This report includes recommendations on all aspects related to road tunnel safety - users, operation, infrastructure and vehicles. The report was approved by all member countries.
The paper includes several proposals for ITS. These include: on-board video systems for load monitoring (see measure C.4.1); Variable Message Signs (see measure 3.09 and annex 1); traffic monitoring (see measures 3.04 and 3.11); radio communications (see measure 3.04); traffic management (see measure 2.12); traffic management plans (see measure 2.13); lane management (see measure 2.08); and the x-ray analysis of heavy goods vehicles and GPS tracking (see measure 1.04).
In line with the goal to improving tunnel safety, the EC drafted a directive on the minimum safety requirements for tunnels in the Trans-European Road Network (TERN). This legislative document was approved by the European Parliament and European Council and entered into force in April 2004. It was then transposed into the national legislation of EU countries (directive 2004/54/EC, 11888/03, 29 April 2004). Recital No. 14 of directive 2004/54/EC recalls the background work performed by the UNECE.

4.3.5 E-CMR

The UNECE Convention on the Contract for the International Carriage of Goods by Road (CMR) is a UN convention signed in Geneva on 19 May 1956. It deals with various legal issues concerning cargo transportation (predominantly by lorries) on roads. Based on the CMR, the International Road Union (IRU) developed the currently used standard CMR waybill. In 2008, an e-CMR Protocol[67] was agreed upon, which aims to ease international road freight and further improve good governance in road transport by allowing the use of electronic consignment notes.

This new Protocol is an Additional Protocol to the CMR. It sets out the legal framework and standards for using electronic means to record and store consignment note data, making information transfer faster and more efficient in comparison to paper-based systems. Less paperwork means time saved and reduces margins for error.
As well as saving time and money, transport operators will benefit from streamlined procedures and secure data exchange. In particular, the so-called e-CMR will reduce the room for errors in dealing with identification and the authentication of signatures.
Current practices, which still use paper, struggle

40. Digital CMR - an example[68]



(67) www.unece.org/trans/main/sc1/sc1cmr.html
(68) Images from http://www.unece.org/trans/doc/2008/sc1/ECE-TRANS-SC1-103-pres02e.pdf

with lengthy procedures and goods are often delivered before the documents arrive. By implementing the e-CMR Protocol, the countries involved have ensured that their road transport is up to speed with other transport modes that already make use of the electronic consignment note or will shortly do so.
Some of the advantages of the e-CMR are efficiency, real-time notification and freight invoicing on the day of delivery. The disadvantages include the possibility that the consignee may not be in line with UNECE regulations and be connected to the digital CMR, so an in-cabin paper CMR waybill will continue to be required. It can therefore be said that the paper CMR waybill will remain common, at least for the time being.

4.3.6 Rail transport

Improving rail infrastructure

The interoperability of telecommunications in railway operations is important for all countries in the pan-European region. It aims to improve rail infrastructure efficiency by ensuring that the rail sector contributes to sustainable transport in an environment competitive with all other modes. Some of the necessary harmonization (interoperability) efforts that have taken place in the EU and European Free Trade Association (EFTA) countries are briefly described below.
The EU selected GSM-R as the transmission technology defined in the EU directive on the interoperability of high speed trains and other EU directives for railways (including the European directive on the interoperability of conventional lines). GSM-R uses GSM technology that has been adapted to specialized requirements for harmonized railway operations, in particular for high-speed trains and container trains. Within the EU and EFTA area, GSM-R is now being combined with the General Packet Radio Service (GPRS) to form the basis of an ITS tool that would give railways the means to improve efficiency and offer new services providing that the market, while opening to competition, can progress in a workable manner. The European Rail Traffic Management System (ERTMS) combines the European Train Control System (ETCS) with GSM-R. ERTMS should eventually achieve interoperability across the EU rail network. At present, ERTMS compatible high-speed lines operate in Belgium, France, Germany, Italy, the Netherlands, Spain and Switzerland. In the area of intermodal transport, ERTMS has been successfully introduced on the border-crossing trains of the four participating countries (the Netherlands, Germany, Switzerland and Italy) on the Rotterdam-Genoa corridor. The use of multi-current ERTMS locomotives that can cross national borders has contributed significantly to the quality of service along this corridor.
There is a need to hasten interoperability in the rail sector beyond the EU - i.e. in the wider Europe area and Central Asia - in order to improve sustainability. However, there is a trade-off between speed and efficiency. The ITS tools adopted by the EU and EFTA countries are not interoperable in the Economic Commission for Europe (ECE) region as a whole. In other words, the ITS standards for rail operations in (Eastern Europe and Central Asia) are not necessarily compatible with ERTMS. The fragmentation of technical standards increases the cost of business because potential economies of scale in the manufacturing of rail vehicles and rail operations cannot be fully captured. Although, in principle, SC.2 could play an active role in the process of harmonization of ITS standards across the ECE region, it has to be emphasized that there are no resources available for this task at present.

Improving rail security

Recent research activity has demonstrated that ITS capabilities can be used to considerably enhance the security of rail transport. This is significant given the likelihood of terrorist attacks against “soft” targets, including railway infrastructure (stations, rolling stock, track and inter-modal terminals). In the area of container transport, various reports have emphasized that security tends to be uneven from one mode to the next. While security measures are usually well-developed and integrated in ports, hinterland connections (rail, road and inland waterways) on the outer edges of the supply chain are often less protected against security breaches. In the area of passenger transport, railway stations and trains are not as well protected as airports and airplanes.
Two interesting ITS applications in the rail sector include the integrated security system for critical railway and energy infrastructure developed recently by Ferrovie Dello Stato in Italy, and the rail IT model for interdependent integration developed by the Altstom corporation. Both applications will be considered by the recently established Task Force on Rail Security and most likely recommended to the Governments of UNECE member States.

Developing international intermodal networks

Geographic Information System (GIS) technology has been used extensively for a number of years in three projects supported by the UNECE: Trans-European Motorway (TEM) network, Trans-European Railways (TER) network and Euro-Asian Transport Links (EATL). The TEM/TER and EATL networks are intermodal and include important inland and maritime transport links. The great challenge for further UNECE work in this area is to collect accurate traffic data to be analysed using GIS technology to improve the understanding of intra-regional and inter-regional container transport flows. This type of work is policy-relevant and is included in the draft work plan of the UNECE Expert Group on Euro-Asian Transport Links. Actual implementation is subject to the availability of resources.

Improving accessibility for passengers in rail systems

The Working Party on Rail Transport (SC.2) decided to address this topic as it is likely to be important for the future of passenger transport by rail. Demographic projections show that the number of people over the age of 65 is certain to increase rapidly in most countries of the ECE region in the not too distant future. In parts of the ECE region, this 65+ population will have a reasonably high life expectancy and considerable disposable income. If rail operators could accommodate for the travel needs of the aged, demand for rail passenger services (including international services) would almost certainly rise. Intelligent Transport Systems applications are capable of efficiently addressing many older passengers' needs (user-friendly ticketing, appropriate signage, etc.).

4.3.7 Inland Water Transport

Inland navigation has also put ITS to good use. The latest information technology systems have provided a basis for the development of harmonized information services such as the so-called River Information Services (RIS), which support traffic and transport management while also interfacing with other transport modes. The goal is to contribute to a safe and efficient transport process and to use the available waterways (rivers, canals, lakes) and their infrastructure to their fullest potential.

River Information Services are in operation in many countries of the UNECE region, ranging from incipient systems to fully-fledged services and comprehensive Vessel Traffic Services (VTS).

Taking into account the variety of available technological solutions (VHF radio, mobile data communication services, Global Navigation Satellite Systems [GNSS], internet, etc.), the emphasis of RIS is more toward services that facilitate information exchange between parties in inland navigation and less on technology-dependent solutions. River Information Services include a wide range of services, such as fairway information services, traffic information services, traffic management, calamity abatement reports, information for transport logistics and information for law enforcement[69].

Given the international and intermodal aspects of inland shipping, it is crucial to establish internationally harmonized standards on the general RIS framework and specific RIS tools, such as the Inland Electronic Charts Display and Information System (Inland ECDIS), electronic ship reporting, electronic data transmission to skippers and inland Automatic Identification (AIS) systems. To the greatest possible extent, these standards are built in line with maritime navigation standards developed by an international group of experts supported by countries and competent international organizations such as the UNECE and the River Commissions and International Navigation Association (PIANC). In EU Member States, directive 2005/44/EC from 7 September 2005 deals with harmonised RIS on inland waterways. The multi-annual action programme on Navigation and Inland Waterway Action and Development in Europe (NAIADES) includes an important component on RIS implementation.

The UNECE Working Party on Inland Water Transport (SC.3) has issued several resolutions on RIS-related issues, including the Recommendation on Electronic Chart Display and Information System for Inland Navigation (resolution No. 48); Guidelines and Recommendations for River Information Services (resolution No. 57); Guidelines and Criteria for Vessel Traffic Services on Inland Waterways (resolution No. 58); International Standards for Notices to Skippers and for Electronic Ship Reporting in Inland Navigation (resolution No. 60) and the International Standard for Tracking and Tracing on Inland Waterways (resolution No. 63). Discussion related to RIS implementation regularly appears on the SC.3's agenda.

41. VMS for dynamic use of emergency lane (A22 del Brennero)

(69) http://www.unece.org/trans/doc/finaldocs/sc3/TRANS-SC3-165e.pdf

5. Summary of benefits and challenges in the promotion of ITS

5.1 Benefits

Concerning the benefits and costs of ITS, the Research and Innovative Technology Administration (RITA) of the United States has published a very large database of case studies[70] on the internet. To be pragmatic, we can look at a key set of assets, generally deemed valid for ITS, but specifically deemed valid for emerging economies (see also the aforementioned "*ITS Technical Note For Developing Countries*[71]", published by the World Bank). Hereinafter are some examples of benefits.

Asset 1. *Fatalities and injuries*
Roadside and on-board technologies will help drivers to detect and avoid potentially dangerous driving situations. Other technologies will identify drivers impaired as a result of alcohol, drugs or fatigue, and address reckless driving. The role of ITS is important for improving enforcement on roads and highways. Intelligent Transport Systems are helping to shift the safety focus from minimising the consequences of crashes (through the use of seat belts, head rests, impact absorbing front ends, etc.) to the use of technology that makes crashes less severe and can prevent them altogether.

Asset 2. *Mobility*
People need travel options to be convenient, reliable and affordable. Mobility is of key importance to people with special needs, including the elderly, the poor, people with disabilities and people who live in remote areas. Better mobility improves quality of life and boosts the ability of individuals and organisations to contribute to the growth of the economy. Intelligent Transport Systems include many methods for enhancing the mobility of people and freight in all transportation modes. For instance, travel information helps travellers avoid congestion, promoting a better use of existing road capacity and subsequently improving traffic conditions. Traffic management (i.e. the more effective timing of traffic signals) can help increase traffic efficiency. Demand management, (i.e. road and access pricing) can help relieve heavily congested urban areas. Commercial vehicle management helps to improve security and efficiency, not only for carriers but also for related public agencies.

Asset 3. *Environment*
Intelligent Transport Systems will help to reduce the wasted time and energy by optimising trips, reducing congestion, improving vehicle and driver performance and fostering better the management of the transportation system as a whole. The optimisation of the transport system will result in energy savings, lower pollution levels and reduced environmental impact.

Asset 4. *Faster emergency response and increased efficiency of road operators*
The availability of new communication systems and organisational means will enhance the abilities of road operators and the emergency services. Intelligent Transport Systems will be able to pinpoint an accident, help determine the extent of injuries sustained, direct emergency vehicles to the accident site more quickly and find the best route to hospitals, allowing the flow of traffic to return to normal conditions more quickly.

41

(70) www.benefitcost.its.dot.gov
(71) http://siteresources.worldbank.org/INTTRANSPORT/214578-1097078718496/20281380/ITSper cent20Noteper cent201.pdf

42. Queuing at toll gates can be reduced thanks to ETC systems[72]

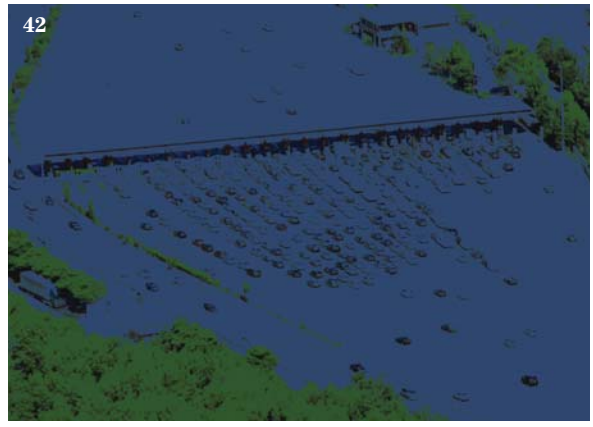
Asset 5. *Reducing travel uncertainty*
The transportation system will guide travellers in real-time, helping them on a daily basis to avoid congestion or react to accidents and other incidents such as strikes, seasonal peaks or adverse weather conditions. Intelligent Transport Systems can help to reduce travel uncertainty by smoothing traffic flow (and therefore reducing fluctuations in travel times). Intelligent Transport Systems can also provide improved real-time and predictive information that allows travellers to plan trips in a more effective way. In-vehicle navigation systems can incorporate real-time traffic information to dynamically adjust driving routes, optimising trips based on the received information.

Asset 6. *Increasing security*
Intelligent Transport Systems provide technology that permits users to address security concerns through the use of GPS (or other positioning technology), wired and wireless communications and improved sensors and information systems. Intelligent Transport Systems can monitor the contents and locations of containers, monitor the cargo and routes taken by trucks, track the location and status of public transport vehicles, and generally support, simplify, and increase the visibility of transport logistics. This is an area in which increased security can facilitate efficiency and productivity by standardising and integrating processes for managing the transport of people and cargoes.

Asset 7. *Increasing comfort for road users*
Intelligent Transport Systems also help travellers to have more comfortable and efficient trips. For example, Electronic Toll Collection (ETC) systems have advantages for individual drivers as well as for the overall road system. The immediate advantage to the individual driver is that with ETC it is no longer necessary to stop at toll barriers - the toll can be paid while vehicles are still in motion. The indirect advantage is an overall decrease in delays at toll barriers for all vehicles, even those that are not using ETC devices. In this way overall pollution is reduced as a result of reducing the level of stop-and-go traffic.

Asset 8. *Public Private Partnership (PPP) and industrial development*
Private companies will team up with public agencies to provide products and services to consumers, Governments and other businesses. Governments will provide provisions and incentives to consumers that encourage the use of technologies that underpin a public benefit.
In many cases, it is more economical for developing countries to import technology from developed countries than to develop the technology domestically. However, there are some cases in which the demand for IT-related equipment, including ITS equipment, can help foster new domestic industries for manufacturing this equipment. This works best in developing countries that already have at least some base IT industry in place.
In addition, ITS equipment and systems require maintenance and renovation throughout their life cycle, some of which can often be provided by domestic resources. This can also help build the IT base in developing countries. Plans for developing these industries can be made during the introduction of ITS.

Asset 9. *A step towards co-modality*
The availability of efficient information and the possibility of a smart road transport system allows for the promotion of a pro-active exchange of information and services with other modes of transport, promoting an integration of the capabilities of the different modes.



(72) Image from http://www.unece.org/trans/doc/reviews/UNECE-Transport-Review-2.pdf

5.2 Challenges

The assets derived from ITS deployment are more numerous and better defined than the potential difficulties that could arise. However, the objectives of administrators and road traffic designers face variables such as human factors and technological and cultural limits that could hamper the effectiveness of ITS. Technical progress in road transport will produce positive effects as long as stakeholders are aware of the possible backlash. Below is a description of issues that could arise with the deployment of ITS.

Issue 1. *Interoperability is essential*

For historical reasons it's actually quite difficult to move rail rolling stock across national borders: the lack of interoperability remains a major obstacle to rail network development. However, similar interoperability problems should not hinder ITS deployment across Europe and beyond. This is an area where the UNECE could make a major contribution. By focusing on effective interoperability, vehicles should be able to easily travel across borders, despite the fact that infrastructures are managed locally. In this istance, technology can be an asset rather than a hindrance, on the condition that their use and operability is harmonized. For example consider electronic road pricing or toll charges. If you needed a different device for each country visited you could very well end up with no room left for the driver in the car. By striving to achive full interoperability between intelligent transport devices we avoid the risk of creating barriers to the seamless flow of people and goods. This is a crucial objective, not just for UNECE countries, but for the world as whole.

Many efforts were made by the EU and other organizations to develop interoperable ITS. These efforts include directive 2004/52/CE on the Interoperability of Electronic Fee Collection Systems in Europe and the DATEX standard developed for information exchange between traffic management centres. Thanks to increasingly powerful transport systems and new political and legal frameworks, physical barriers are collapsing rapidly along with administrative barriers in certain geographical and economical spheres. It is necessary to avoid the occurrence of new interoperability problems. The world of transport is currently not free from problems relating to interoperability. This is a field where the multinational nature of the UNECE could be useful when combined with the actions already undertaken by the EC and national Governments. Gaps need to be identified and the UNECE, through its bodies and legal instruments, could be proactive when it comes to filling in the missing links.

Issue 2. *Fraud and violations in the use of ITS*

If ITS require automated charging for a service (i.e. in the case of ETC) several events may prevent the correct functioning of this proceedure. These include incidents brought about by the user or those caused by the simple malfunctioning of the system, or parts of it. Depending on the case, the incident can either be classified as an error in the proper functioning of the system, or as fraud. Fraud results from any act that avoids the electronic collection of due fees through means prohibited by the rules or laws applicable to the road network concerned, and is considered an offence. Systems need to be rendered fraud resistant through technical means and legal instruments and provisions. A sufficient level of enforcement services should also be put in place. If a system is not sufficiently fraud resistant, cases of inappropriate use may rise, threatening the system's proper functioning. If an international level of interoperability is required, then a higher level of cooperation is needed from different Governments. Enforcement proceedures against those who violate standard proceedures should also be possible at an international level.

Issue 3. *Possible penetration in consumer markets*

Building a business case for ITS is not always straightforward as it is not an easy task to quantify potential benefits. Benefits are known from previous cases - some of them are summarized in this report - but the task of promoting ITS benefits becomes even more difficult if the effectiveness of an application is not only subject to policy making and/or decisions from public bodies and road operators alone, but also to penetration into the consumer market (i.e. in the case of cooperative systems or on-board systems that are not mandatory).

Issue 4. *Regional differences*

Intelligent Transport Systems are reasonably common in developed countries but still rare on the roads of emerging economies. This represents an

unfavourable trend in relation to the smoothing of regional differences in the development of an international transport system. The UNECE will play a role in trying to adress this imbalance.

Issue 5. *Security and privacy*

New ITS tools need to be mindful of privacy issues and require a reasonable minimum level of security in exchanges of data, transactions etc.

Issue 6. *Human factor*

Almost all deaths and injuries that result from road traffic accidents are preventable and in most cases are caused by the reckless conduct and impaired judgment of the driver. If a person drives a vehicle at a speed appropriate for current road conditions, wears a safety-belt and uses properly-fitted child restraints, the number of deaths and injuries resulting from road traffic accidents can be significantly reduced.

The introduction of new technologies - and ultimately the deployment of ITS in road traffic - is aimed at reducing the human factor (when negative) and accordingly human error. One such human factor is the "rubber-necking" phenomena, or when people who are looking at an accident lose concentration and have an accident themselves. Intelligent Transport Systems can help in the avoidance of such accidents.

The objective of the design rationales of vehicles and roads has been to remove as many unpredictable factors as possible. Vehicles and roads are therefore becoming highly predictable environments in which a driver is unlikely to encounter any unexpected events without receiving prior notification. As a result, drivers are increasingly operating on lower states of alert and can be unprepared for dealing with any unexpected situation or distraction that may arise. In any case, even the most advanced technological road environment cannot completely rule out unpredictable situations.

It is clear that drivers introduce a certain "risk factor" to the road environment when they perceive a situation to be "safe". When vehicles or roads are made "safer", drivers will travel more recklessly. They will accept the same amount of risk but change their driving approach in reaction to the increased safety level brought about by the new technical and technological environment. Technical progress has its limits in coping with the risk factors that human error introduces.

Moreover, technology is not harmonized in all traffic situations. Users that drive recklessly in a predictable environment because they feel assisted by technology (such as on a high-tech motorway) might behave in the same way in a less predictable environment such as on residential streets where children may cross roads (D. Engwicht, "Intrigue and uncertainty", p.6).

Issue 7. *Technology factor*

There are numerous research initiatives currently underway aimed at determining how physical infrastructure improvements with a limited introduction of new technology can also improve safety. Crashes can be reduced through engineering techniques that incorporate better geometric design, more durable road markings, roadside signs with higher visability and road surfaces with increased skid resistance. One of the measures to help prevent road crashes caused by drivers unintentially departing from the inside and outside lanes is the installation of rumble strips that create noise and vibration when a driver drifts off the road onto the hard shoulder. A study conducted by the Federal Highway Administration (FHWA) of the United States on the installation of rumble strips has demonstrated that rumble strips reduced fixed-object crashes and crashes in the opposite direction, both of which are very severe and likely to result in injuries or death. The Lane Departure Warning (LDW) systems that are installed on most recent vehicles do not lead to any benefits on roads where the corresponding strips are missing. Therefore, the bad maintenance of road strips (or the total lack of road strips) could be fatal for drivers who rely on this new device, which is ineffective in these cases. Similar concerns are linked to braking devices. ABS, AEBS, ESC or BAS can be more effective if skid-resistant road surfaces are deployed ubiquitously. Other downsides are linked to the vehicle's environment, namely to those Intelligent Vehicle Systems (IVS) that are aimed at protecting vehicle occupants. The less occupants are informed about the proper use of their vehicle's systems, the more they might constitute a threat rather than a protective measure. The increasing number of on-board warning signals will eventually clash with drivers' limited abilities to perceive and prioritise these warnings. The WP.29 Informal Group on ITS conducted discussions on the correct standardisation of key aspects of ITS that will allow them to be effective while avoiding the stifling of the development process or creating obstacles to innovation and technical development. So-called "out-of-position" drivers and passengers (those seated in an unconventional manner) are

also a major source of potential road injury statistics. Frontal or lateral impact protection has been optimized by the presence of airbags. However, these pieces of equipment were tested and developed on the basis of dummies in standardized positions. In order to receive the best performance from these protective devices the occupants should be seated in an arrangement similar to that of the tested dummies. When, for instance, a driver has their forearm across the centre of the steering wheel or the passenger on the driver's side has their head or other body parts too close to the panel where the air-bag is located, a serious injury, or even death, can result from air-bag deployment. Consequently, there is a downside to the strategy of trying to improve safety by making an environment totally predictable. Whenever humans are involved, it is impossible to deliver the promise of total predictability. Administrators and politicians should take this into account when conceptualising and designing the future road environment. A holistic strategy on ITS deployment should therefore involve educational programs directed at acclimatising road users to the vehicle and road environment of the future.

Some examples and best practices

This section contains the index of some examples of best practices, that are available in the CD ROM attached to this document. The editorial team believed that a sufficient number of best practices is able to give a practical view of ITS, thus providing a suitable base from which the Road Map can grow. It was decided that the collection of best practices should not be limited to those that the editorial team could collect. This section has therefore been specifically opened up to the suggestions of different stakeholders (authorities, road operators, or industry) or from other operators and experts, which are now - after the public consultation - included in the CD ROM.

Index

List of acronyms

ABS	Anti-lock Braking System
ACC	Adaptive Cruise Control
ADAS	Advanced Driver Assistance Systems
ADN	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways
ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
AEB	Automatic Emergency Braking Systems
AEI	Automatic Equipment Identification
AETR	European Agreement concerning the Work of Crews of Vehicles engaged in International Road Transport
AGR	European Agreement on Main International Traffic Arteries
AGTC	European Agreement on Important International Combined Transport Lines and Related Installations
AID	Automatic Incident Detection
AIS	Automatic Identification Systems
APC	Automatic Passenger Counters
ASECAP	European Association of Tolled Motorways, Bridges and Tunnels
ASTM	Autostrada Torino-Milano SpA
AVI	Automatic Vehicle Identification
AVLS	Automatic Vehicle Locating System
BAS	Brake Assist Systems
BCA	Benefit-Cost Analysis
CP	Contracting Parties
CALM	Continuous Air interface for Long and Medium distance
CCISS	Centro Coordinamento Informazioni sulla Sicurezza Stradale
CCTV	Closed Circuit Television
CEDR	Conference of European Directors of Roads
CEN	European Committee for Standardization
CMBS	Collision-Mitigation Braking systems
CMR	Contract for the International Carriage of Goods by Road
CSI	Container Security Initiative
DAB	Digital Audio Broadcasting
DATEX	Standard for information exchange between traffic control centres
DBC	Dynamic Brake Control
DG	Directorate General
DGSA	Dangerous Goods Safety Adviser
DG TREN	EC Directorate General for Energy and Transport
DOT	Department of Transportation
DSRC	Dedicated Short Range Communications
DVB	Digital Video Broadcasting
EasyWay	European Program for ITS Deployment on TERN
EATL	Euro-Asian Transport Links
EBD	Electronic Brake Distribution
EC	European Commission
ECA	Economic Commission for Africa
ECDIS	Electronic Charts Display and Information System
ECE	Economic Commission for Europe
ECLAC	Economic Commission for Latin America and the Caribbean
EDI	Electronic Data Interchange
EEC	European Economic Community
EETS	European Electronic Toll Service
EFTA	European Fair Trade Association
ERTMS	EU Rail Traffic Management System
ES	European Study
ESC	Electronic Stability Control
ESCAP	Economic and Social Commission for Asia and the Pacific
ESCWA	Economic and Social Commission for Western Asia
ETC	Electronic Toll Collection
EU	European Union
EVSC	Electronic Vehicle Stability Control
FCW	Forward Collision Warning
FCWS	Forward Collision Warning Systems
GDP	Gross Domestic Product
GHG	Green House Gases
GIS	Geographic Information System
GNSS	Global Navigation Satellite Systems
GPRS	General Packet Radio Service
GPS	Global Positioning System
GRE	Working Party on Lighting and Light-Signalling
GRPE	Working Party on Pollution and Energy
GRRF	Working Party on Brakes and Running Gear
GRSG	Working Party on General Safety Provisions
GRSP	Working Party on Passive Safety
GSM	Global System for Mobile
GSM-R	Global Positioning System-Railway
GTRS	Global Technical Regulations
HMI	Human-Machine Interface
I2I	Infrastructure to Infrastructure
I2V	Infrastructure to Vehicle

IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICT	Information and Communication Technologies
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ILO	International Labour Organization
IMDG	International Maritime Dangerous Goods
IMO	International Maritime Organization
IRTAD	International Road Traffic and Accident Database
IRU	International Road Union
ISA	Intelligent speed adaptation or intelligent speed advice
ISO	International Organization for Standardization
ITF	International Transport Forum
ITS	Intelligent Transport Systems
IVS	Intelligent Vehicle Systems
LDW	Lane Departure Warning
LDWS	Lane Departure Warning Systems
LED	Light Emitting Diode
LiDAR	Light Detection And Ranging
NAIADES	Navigation and Inland Waterway Action and Development in Europe
OBU	On-Board Unit
OECD	Organisation for Economic Co-operation and Development
OECD/RTR	OECD Road Transport and Intermodal Linkages Research Programme Reports
OICA	International Organization of Motor Vehicle Manufacturers
PDO	Property Damage Only
PIANC	Permanent International Association of Navigation Congresses
PIARC	World Road Association
PM	Particulate matters
PPP	Public Private Partnership
PSAP	Public Safety Answering Point
RBDS	Radio Broadcast Data System
RD&D	Research, Development and Deployment
RDS	Radio Data System
RE	Resolution
RFID	Radio Frequency Identification
RID	Regulations Concerning the International Carriage of Dangerous Goods by Rail
RIS	River Information Services
RITA	Research and Innovative Technology Administration
RSU	Road-Side Unit
SALT	Società Autostrada Ligure Toscana
SC.1	Working Party on Road Transport
SC.2	Working Party on Rail Transport
SIAS	Società Iniziative Autostradali e Servizi
SINA	Società Iniziative Nazionali Autostradali
SMS	Short Message Service
TC	Technical Committee
TCC	Traffic Control Centre
TCCs	Traffic Control Centres
TCS	Traction Control System
TEM	Trans-European North-South Motorway
TEN	Trans-European Network
TER	Trans-European Railways
TERN	Trans-European Road Network
THE PEP	Pan-European Programme on Transport, Health and Environment
TIC	Traffic Information Centres
TIM	Tactical Incident Message
TIR	Customs Convention on the International Transport of Goods under cover of TIR Carnets
TLC	Telecommunications Networks
TMC	Traffic Message Channel
TVMs	Ticket Vending Machines
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UNRSC	United Nations Global Road Safety Collaboration
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
VHF	Very High Frequency
VMS	Variable Message Signs
VMT	Vehicle Miles Travelled
VRS	Variable Reluctance Sensor
VTS	Vessel Traffic Service
WAP	Wireless Application Protocol
WAVE	Wireless Access in Vehicular Environments
WG	Working Group
WHO	World Health Organization
WIM	Weigh in Motion
WLAN	Wireless Local Area Network
WP	Working Party
YSWS	Yellow Signal Warning System

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