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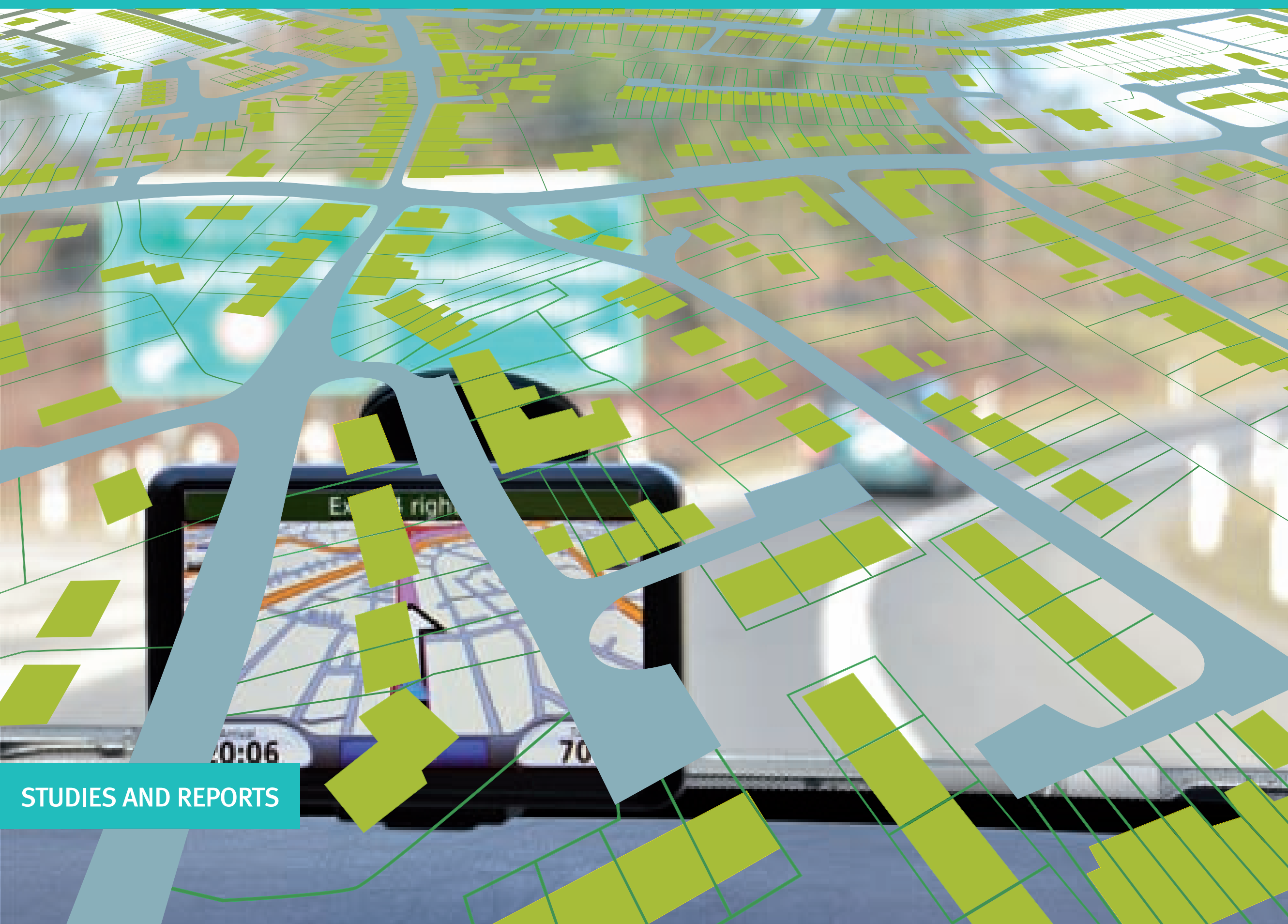
Intelligent transport systems

EU-funded research for efficient, clean and safe road transport



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Contact: Patrick Mercier – Handisyde

European Commission
Office CDMA 04/188
B-1049 Brussels

Tel. (32-2) 29-68329
E-mail: Patrick.Mercier-Handisyde@ec.europa.eu

EUROPEAN COMMISSION

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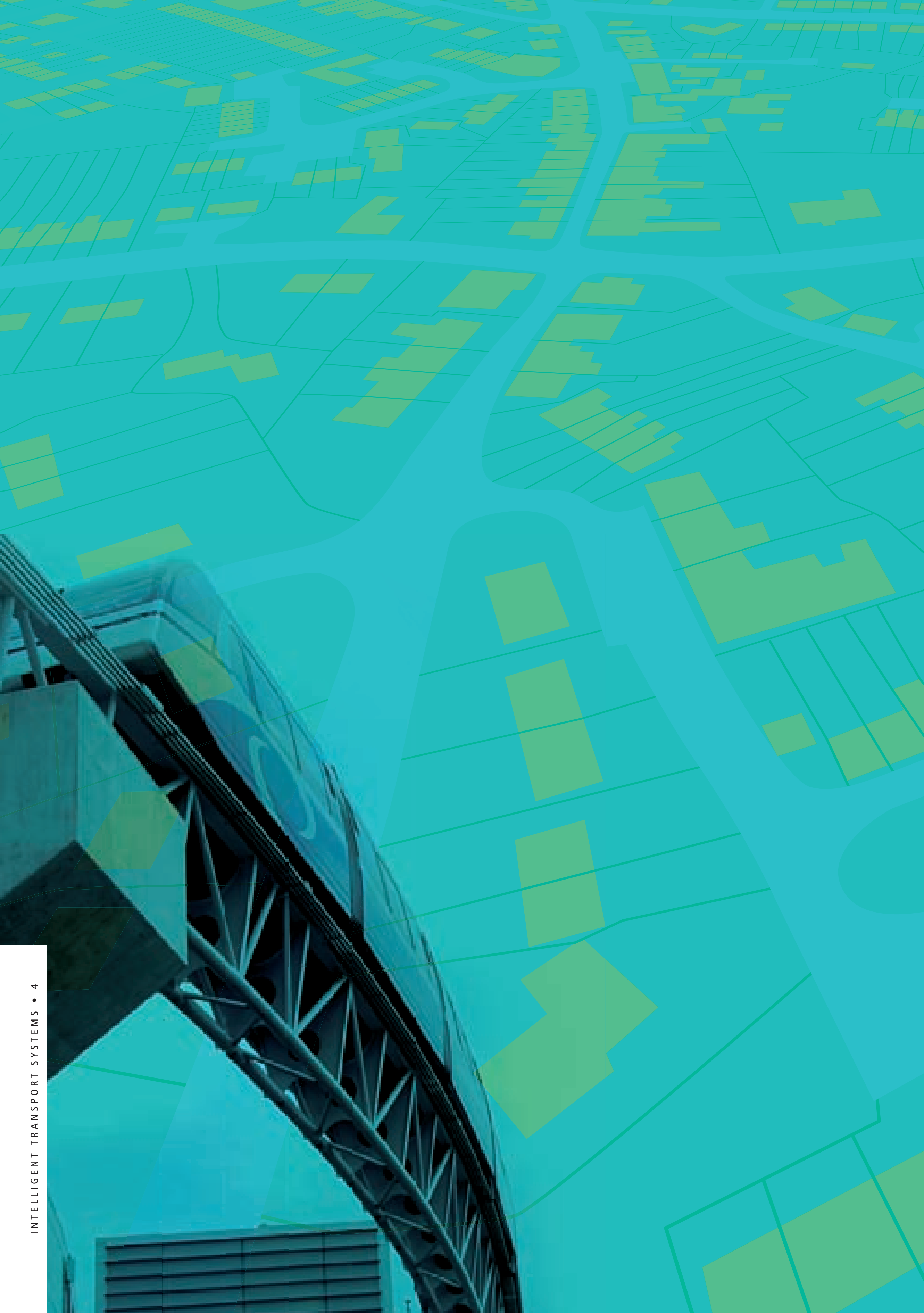


CHAPTER 1

Research promotes integration for Europe-wide intelligent transport

Intelligent Transport Systems and Services (ITS) refers to the integration of information and communication technologies with transport infrastructure to improve economic performance, safety, mobility and environmental sustainability for the benefit of all European citizens.

Affordable and accessible transport is clearly fundamental to sustainable wealth and prosperity in Europe. It underpins employment, economic growth and global exports, while providing citizens with resources and mobility that are essential to the quality of life.

The ability of transport systems to respond to mobility needs of citizens and goods is hampered by a continuous increase in traffic demand as a result of higher levels of motorisation, urbanisation, population growth and changes in population density. The resulting traffic congestion reduces the efficiency of mobility systems, increasing travel times, air pollution and fuel consumption.

Addressing traffic congestion was one of the initial motivations to look at intelligent transport systems solutions for a better utilisation of transport capacity through the exchange of real-time information on infrastructure and traffic conditions. Since then, new transport applications based on information and communications technologies (ICT) have emerged and continue to emerge, ranging from basic traffic management systems (e.g. navigation, traffic control) to management of containers; from monitoring applications such as closed-circuit television (CCTV) security systems to more advanced applications integrating live data and feedback from a variety of information sources (e.g. parking guidance, weather information).

At the September 2009 ITS World Congress in Stockholm, András Siegler, Director of Transport for the European Commission's DG Research, estimated that widespread introduction of intelligent systems and services could reduce congestion by up to 15 %, CO_2 emissions by 20 %, and road fatalities by up to 15 %.

Some of the major technological constituents of ITS are:

- Various forms of wireless communication for both short-range and long-range data exchange (UHF, VHF, WiMAX, GSM, etc.);
- Computational technologies – the present trend is towards fewer and more costly microprocessors, allowing for more sophisticated applications such as model-based process control and artificial intelligence;
- Sensing technology – employing sensors to feed control systems with both vehicle-based data (from devices such as radar, RFID readers, infrared- and visible-band cameras) and infrastructure-based data (from similar devices, as well as inductive or pressure sensors installed or embedded in and around the road).

To meet the challenges of achieving virtually accident-free, clean and efficient mobility through ITS, it is crucial that all elements of transport systems are able to communicate and cooperate in exchanging real-time information. Bi-directional communication is needed from vehicle to vehicle (V2V) and vehicle to infrastructure (V2I). This requires the development of a communication architecture that provides a common frame for cooperative systems to work together. Examples of applications based on cooperative systems that are currently under development are: traffic control and management, intersection collision warning, weather and road conditions warning, and route guidance to avoid traffic congestion.

Several services of the European Commission contribute to the development and deployment of ITS in Europe: DG Mobility and Transport is responsible for the ITS policy framework. R&D, projects dealing with the enabling technologies – ICT, intelligent sensors, electronic devices, cooperative systems, etc. – are funded primarily via DG Information Society and Media. Information on the research relating to these wide-ranging aspects can be found in a number of publications issued by the European Commission (see website: http://www.ec.europa.eu/information_society/activities/esafety/index_en.htm). However, the specific purpose of this brochure is to present the impact of initiatives underpinning the integration of generic ITS technologies in innovative road transport, as pursued by DG Research under the 'Sustainable Surface Transport' (SST) programme since the start of FP5 in 1998.

Road predominates

Tackling road-related issues alone does not provide a complete answer to the needs of the transport sector, but road clearly plays a predominant role in the EU-27 countries. In 2006, passenger cars, motorcycles, buses and coaches together accounted for 83 % of total passenger/kilometres. Road also carried 46 % of freighted goods, with intra-EU sea transport in second place at 37 % (Eurostat Panorama of Transport 2009).

These benefits nevertheless come at considerable cost in terms of societal impacts. Road transport is responsible for 72 % of the EU's transport-related CO_2 emissions; congestion accounts for economic losses of 1 % of the EU's GDP – an annual bill of roughly EUR 112 billion – while road accidents caused almost 39 000 deaths in 2008, despite a 28.2 % improvement since 2001.

Integrated effort essential

Because transport is inherently transnational in nature, research efforts to solve its problems must also transcend the scope and scale of purely national efforts. The resultant innovations should be applicable across the whole of Europe, and even beyond. Geographical continuity, standardisation and interoperability of services are essential, in order to avoid the emergence of a patchwork of ITS applications and services.

It is increasingly evident that technological improvements involving individual vehicles or infrastructure components and sub-systems are insufficient. Solutions must be found at the level of the interactions between the various constituents of transport systems, including users, and their optimal combination.

Even with relatively small investments, the integration of existing technologies could create new services bringing more reliable, real-time traffic information and better routing. This would make more effective use of the available infrastructure and avoid delays caused by traffic jams, as well as reducing the need for new investments in additional roads. Continuing progress in ICT and sensing devices will open the door to even more radical advances. And, while environmental benefit may not be the prime purpose of many ITS developments, more efficient road usage automatically leads to energy savings and reduced emissions.

Integration is needed at three levels:

- between vehicles, infrastructures and users – against an appropriate background of legislation to promote deployment across Europe;
- between different transport modes, permitting efficient and cost-effective door-to-door trips for both passengers and freight; and
- multi-criteria optimisation, taking into account performance indicators related to safety, congestion, environmental impact, cost and comfort.

The main contribution of the Sustainable Surface Transport programme to ITS is its support for an integrated systemic approach to transport research. In this respect, its principal role is to implement generic ITS technologies in innovative transport applications.

Plan for action

ITS has been on the agenda of the Commission transport policy for quite some time. R&D, funding and standardisation efforts are supported under various political initiatives, such as the 2001 White Paper, its 2006 Mid-Term review and the Greening of Transport package. These have not only been applied to road transport, but to all transport modes – leading to the development of various applications such as ERTMS for rail transport (European Railway Traffic Management System), SESAR for air transport (Single European Sky ATM Research Programme), RIS for inland waterways (River Information System) and VTMIS for maritime transport (Vessel Traffic Management Information System). Yet, while there is considerable harmonisation of strategic road transport research through initiatives such as those developed by the Technology Platform ERTRAC (European Road Transport Research Advisory Council) and ERTICO – ITS Europe (representing the interests and expertise of European multi-sector stakeholders involved in providing ITS), no 'umbrella' structure for the advance from research to realisation in the field of ITS has yet been established.

To remedy this situation, the European Commission introduced an **'Action Plan for the Deployment of Intelligent Transport Systems (ITS) in Europe'**, which was adopted in December 2008, together with a proposal for a Directive laying down the framework for its implementation (approved in July 2010).

The Action Plan acknowledged that much of the activity in this field since the 1980s had been relatively fragmented, focusing on specific topics such as CO_2 abatement, safety or traffic management. The aim of the Plan is to ensure the compatibility and interoperability of systems, to facilitate the continuity of ITS services, and to do so through a coordinated and concerted action at EU level. It therefore includes 24 targeted actions in six priority areas:

- optimal use of road, traffic and travel data;
- continuity of traffic and freight management ITS services in European transport corridors and conurbations;
- road safety and security;
- integration of the vehicle into the transport infrastructure;
- data security and protection, and liability issues;
- European ITS cooperation and coordination.

The ITS Directive is a seven-year legal framework for a coordinated deployment of ITS, intended to harmonise the specifications that will be used whenever ITS services or applications are adopted in the Member States. To increase its efficiency, the European Parliament and the Council have focused the activity by specifying the six priority actions on which the Commission will start its work:

- EU-wide multimodal travel information services;
- EU-wide real-time traffic information services;
- road safety-related minimum universal traffic information free of charge to users;
- interoperable EU-wide eCall (for emergency calls using a single dial-up number);
- information services on safe and secure parking places for trucks and commercial vehicles;
- reservation services for safe and secure parking of trucks and commercial vehicles.

For more information on the ITS Action Plan and Directive, see:
http://ec.europa.eu/transport/its/road/action_planen.htm

CHAPTER 2
Evolving approach to safety

Safety was a major focus of automotive research in the latter half of the 20th century, aiming to reduce road accident fatalities and injuries through improved vehicle design based primarily on the incorporation of passive devices – seatbelts, head restraints, appropriately strengthened structures, air bags and anti-lock braking. This continued to be supported under FP5 (1998-2002) by DG Research, in initiatives such as ADVANCE, CHILD, IMPACT, ROLLOVER, VITES and WHIPLASH II. It also extended into FP6, when projects such as APROSYS, in parallel with DG Information Society and Media-supported PREVENT, continued to seek improvements in integrated safety (these projects, and the underlying philosophy, are described in more detail in another brochure in this series dealing with road safety).

From passive to active systems

Even in FP5, however, increasing emphasis was being placed on the investigation of more active and preventive safety solutions, in order to lower the risk of collision by continuously monitoring driver behaviour and driving conditions – and, when collision is unavoidable, to minimise the effects of impacts on all road users. At this stage, however, some of the essential elements were not yet in place:

'A problem for the early developers was that they were obliged to plan for future technologies that were still some years away from realisation,' recalls Alan Thomas (Jaguar Cars), coordinator of the ROADSENSE project. 'For instance, I drove Lund University's intelligent speed adaptation Volvo demonstrator in about 1998-9, but it used a CD to simulate detailed GPS navigation and road/traffic data, including local roadworks. The in-vehicle technologies needed 3G telecommunications for the accuracy and speed of delivery to make services usable and useful – and that only really became possible a decade on.'

A strong impetus to progress was given by establishment of the eSafety Forum early in 2003, following consultation between the Commission, ERTICO – ITS Europe, industry and public-sector stakeholders. The general objective of this joint platform is to promote and monitor the implementation of recommendations identified by the eSafety Working Groups, and to support the development, deployment and use of a range of intelligent integrated safety systems.

ROADSENSE
Road awareness for driving via a strategy that evaluates numerous systems.

ROADSENSE aimed to provide the European automotive industry with a framework for studying human-vehicle interactions, and to construct a simulation environment for the evaluation of new technologies. A general-purpose driver behaviour interface test equipment (D-BITE) was produced, but comparison of laboratory trials with drivers' on-road reactions showed that further development of the then-available simulator system would be needed to achieve greater reliability. Several project partners have continued to build on these initial outcomes to further improve HMIs.

Coordinator: Jaguar Cars (UK)
Total budget | EUR 4.41 million
EU funding | EUR 2.80 million
Start/end | 01/02/2001 – 30/06/2004
Website | www.cvisproject.org/download/roadsense.pdf

EUCLIDE

Enhanced human machine interface for on vehicle integrated driving support systems.

An integrated driver assistance system designed in the EUCLIDE project combined far infrared and microwave radar sensors, together with an enhanced multifunctional user interface, to warn drivers of potentially dangerous situations by monitoring the road ahead. This is particularly useful in conditions of reduced visibility – at night or during bad weather. Following analysis of warning strategies to determine an optimal balance between the level of support and the risks of distraction, systems were implemented in two vehicles and road-tested in real traffic situations.

Coordinator: CRF – Fiat Research Centre (Italy)

Total budget | EUR 3.85 million

EU funding | EUR 2.35 million

Start/end | 01/03/2001 – 31/05/2004

Website | http://www.transport-research.info/web/projects/

Otherwise collectively described as **Advanced Driver Assistance Systems (ADAS)**, these typically employ on-board sensors, together with digital maps and other computerised data, to enable vehicles to 'understand' the environment around them. They facilitate control, accident avoidance and journey planning – either by providing the driver with information, or by taking automatic action in the event of a detected hazard.

Examples of ADAS now becoming increasingly commonplace in the latest vehicles include:

- Electronic stability control (ESC) – automatically braking individual wheels when a control unit monitoring steering wheel angle and vehicle rotation detects a departure from the intended trajectory.
- Adaptive headlights – swiveling the beams in response to steering wheel angle, to provide better illumination on cornering.
- Adaptive cruise control (ACC) – modifying the pre-set speed in order to maintain a safe distance from detected traffic ahead.
- Blind-spot monitoring – warning the driver when there are vehicles in the blind spots of the wing mirrors.
- Speed alert – using satellite navigation data to signal that a vehicle is travelling too quickly when approaching a limited-speed road section.
- Forward collision and lane departure warning – indicating convergence with a slower vehicle ahead, or deviation from a traffic lane.

ITS for safety also embraces the protection of other vulnerable road users, with the development of detection systems to warn drivers of the presence of pedestrians, cyclists or street maintenance workers.

Some 37 % of serious accidents involving such persons occur in conditions of darkness or fog. The FP5 EUCLIDE project therefore explored the use of heat-sensing technology derived from military applications to display images of these potential 'obstacles' on an in-car screen before they are within the visible range of a vehicle's headlights.

As coordinator Luisa Andreone (CRF – Fiat Research Centre) notes, 'Our work led directly to the night vision systems introduced in Europe around one year later. But manufacturers opted for different aspects of the technology, each with particular performance advantages and manufacturing consequences. Whereas some vehicles were equipped with a far-infrared system, as previously used by the military, others used a near-infrared camera – which has a somewhat shorter vision range and sensitivity to weather conditions, although with better resolution. Because this is less costly to produce, it could facilitate deployment in a wider range of models.'

Improved human-machine interface

It became apparent from an early stage that, given the large and growing range of available data sources and types, the impact of potential information overload on the primary task of safe vehicle operation could become a matter of serious concern. Also, in improving the performance of a particular sub-task, it is important to ensure that there are no negative impacts on other aspects of the overall driving experience.

As well as developing the systems themselves, research thus needs to address the selection and prioritisation of information, the mode of its presentation and reaction required from a driver – i.e the **human-machine interface (HMI)**. Further essential topics are to identify common reasons for drivers' errors, and to define the most dangerous situations needing to be dealt with.

Over 95 % of automotive accidents are estimated to involve a degree of human misjudgement or malfunction, due to factors such as excessive speed, fatigue, distraction (mobile phones, passengers, 'rubbernecking', etc.), aggression, reduced mental acuity (drink, drugs), or physical decline. The elderly are particularly prone to problems of deteriorating vision, lack of flexibility, impaired distance perception, etc.

By influencing the behaviour of drivers and actively modifying that of the vehicles themselves, ADAS can not only help to prevent accidents, but also to make journeys less stressful and more economical.

VERTEC
Vehicle, road, tyre and electronic control systems interaction: increasing vehicle active safety by means of a fully integrated model for behaviour prediction in potentially dangerous situations.

VERTEC developed and validated an integrated model to predict vehicle behaviour in hazardous conditions such as ice, rain and snow. Running on a PC, the model can be used to simulate different road, track, driver and tyre combinations, together with the effects of dynamic control systems such as ABS (automatic braking system), as a basis for the design of safer new products. Guidelines on improved active vehicle safety were proposed for passenger cars, heavy goods vehicles, control systems and road hazard warning systems.

Coordinator: Pirelli (Italy)
Total budget I EUR 5.35 million
EU funding I EUR 3.00 million
Start/end I 01/12/2001 – 30/11/2005
Website I http://www.transport-research.info/web/projects/

CHAPTER 3

New approaches to traffic management and intelligent infrastructures

Another major trend in FP6 was the drive to make vehicles more 'open', both with respect to other vehicles and with the transport infrastructure. More and more ITS technologies, as well as services such as journey planning and dynamic in-vehicle navigation, could thus interact and be networked with each other across whole transport systems.

Initiatives funded under Sustainable Surface Transport again focused on their application and integration. As part of this process, they also began to address active safety applications in the wider context of their cost, environmental impact and effect on traffic congestion, rather than simply in isolation.

Technologies available today can be used to reconcile the interests of authorities, transport operators and drivers by adding intelligence to the roads themselves. They can also contribute to more reactive traffic management, by replacing fixed-plan control with **optimised dynamic signalling** based on performance objectives such as total vehicle delay, length of queues, etc.

Centralised processing of data on the natural and infrastructure conditions of a road network makes it possible to generate alerts, indicate speed and make route recommendations for a vehicle based on its location at any given time.

'Road owners face growing challenges in keeping the network fit for purpose in the face of the damaging effects of increasing traffic and a changing climate,' observes Steve Phillips, Secretary General of FEHRL (Forum of European National Highway Research Laboratories). 'Work in INTRO and related FP6 projects has contributed to a better understanding of the ways in which the growing 'soft' aspects of infrastructure can complement research in the traditional 'hard' areas. For example, introducing technologies to make bridges stronger with new materials can also present opportunities to make them smarter, by adding facilities for self-monitoring and the communication of conditions to passing vehicles.'

Interviews conducted as part of the INTRO project confirmed that some road operators are waiting for evaluation of existing solutions and equipment from research in order to guide their decisions on ITS deployment. Others had already installed significant ITS infrastructure, but were waiting for innovative solutions to help them make improvements.

'Clearly it will take some time to bring about the full benefits of such systems, but examples of successful implementation already show the way these projects will help roads, bridges and tunnels to last longer by informing maintenance and encouraging appropriate driving choices,' says Phillips. 'The vision of road networks that stay 'open for business', bringing safer and more efficient traffic movement under all conditions, could become a reality.'

INTRO
Intelligent roads.

INTRO demonstrated how innovative use of new and existing sensor technologies in pavements and bridges can be combined with data from moving vehicles to provide operators, maintenance authorities and road users with rapid warning of emerging problems. Simulator studies and trials with probe-equipped cars were used to explore factors such as the effects of slippery roads and reduced visibility on drivers' behaviour, and to assess their reactions to safety warnings. More tests investigated in-situ sensing to monitor the bearing capacity of roads under different weather conditions.

Coordinator: VTI – Swedish Road and Transport Research Institute (Sweden)

Total budget | EUR 3.50 million
EU funding | EUR 2.00 million
Start/end | 01/03/2005 – 29/02/2008
Website | http://intro.fehrl.org

REACT
Realizing enhanced safety and efficiency in European road transport.

The REACT system, demonstrated in Munich in September 2006, senses natural and infrastructure conditions within and in the vicinity of suitably-equipped vehicles, and transmits real-time data to a central server, where it can be analysed by sophisticated prediction and decision-making models. It generates safety alerts, speed and route recommendations to individual drivers, plus relevant information for road and law enforcement authorities. By using mobile vehicle sensors, REACT is able to cover roads beyond the reach of conventional traffic management systems.

Coordinator: Motorola (Israel)

Total budget | EUR 3.70 million
EU funding | EUR 2.00 million
Start/end | 01/01/2005 – 31/12/2006
Website | https://www.eurtd.org/quickplace/project-react

MISS
Monitor Integrated Safety Systems.

The objective of MISS was to enhance the safety and efficiency of transport operations through dynamic sensing and prediction of natural and infrastructure conditions. Its innovative platform comprises a Unified Operative Centre equipped with fixed and mobile devices, and linked via a TETRA terrestrial trunked radio network with 'black box' sensing and communication units installed in a fleet of vehicles. Extensive field tests were conducted under operational conditions in Bologna, Italy, together with smaller demonstrations in other European cities.

Coordinator: Province of Bologna (Italy)

Total budget | EUR 3.00 million
EU funding | EUR 1.50 million
Start/end | 01/12/2004 – 31/03/2007
Website | http://www.transport-research.info/web/projects/

CHAPTER 4

Towards holistic solutions

With the advent of FP7, the objectives of research have advanced even further along the road of integrating the various components of ITS to deliver more holistic solutions to Europe's transport needs.

The major challenge is the merging of information from different sources into a comprehensive system able to communicate with all interested users. This must take account of many considerations relating to the vehicles, transport infrastructures, drivers' behaviour and legislation – a complex scenario that can only be addressed by systemic research.

Communication systems benefit increasingly from the multi-channel wireless connectivity offered by mobile telecommunications, low cost satellite technology, dedicated short range communication (DSRC) and mobile wireless local area networks (WLAN). In conjunction with satellite positioning, this will support personalised applications such as emergency calls and messages, traffic alerts, accident warning, speed alerts and eco-driving guidance.

Much can be accomplished using mobile communications alone, without incurring the cost of extensive infrastructural investment and complex in-car equipment, but this has some limitations. For example, issuing a black ice warning to all vehicles approaching a particular stretch of road is helpful, but telecoms are unlikely to provide the split-second speed to react if a vehicle immediately ahead suddenly swerves or brakes. In such circumstances, a more comprehensive interactive capability is highly desirable. Research is therefore turning towards the development of so-called 'Cooperative ITS'.

What is Cooperative ITS?

Whereas the first active driver aids to achieve major market penetration were autonomous or **infrastructure-to-vehicle** (I2V) systems, Cooperative ITS will also incorporate **vehicle to infrastructure** (V2I) and **vehicle to vehicle** (V2V) **interaction**.

'Closing the loop by using the vehicles themselves to send data back to traffic control centres will bring great improvements in the efficiency of management and the safety of road users, while also allowing much fuller coverage of the road systems than is possible today,' says Vincent Blervaque, Director of Development and Deployment at ERTICO – ITS Europe. 'Many of the underlying technologies are sufficiently mature. The need now is for standardisation, large-scale testing and demonstration, backed by hard facts to show the authorities and the general public precisely how they will benefit.'

National highways in most European countries are already equipped for some degree of dynamic traffic management and control, with surveillance cameras, sensors and electronic message signs that aim to regulate flows by informing drivers about expected travel times to various destinations, displaying congestion or accident warnings and proposing recommended alternative routes.

High investment in fixed equipment for this purpose is justifiable in urban areas, where most congestion occurs, and on the TEN-T network linking the regions and Member States of the

EU (for which a deployment roadmap has been set out under the DG Mobility and Transport project EASYWAY). For interurban networks and secondary roads, greater reliance on in-car systems to provide 'floating car data', in conjunction with smaller amounts of roadside hardware, would allow coverage to be extended at much lower cost in terms of installation and maintenance.

The basic idea is that vehicles be equipped with on-board units, routers and antennae, so that they can exchange data with roadside infrastructure, display information to the drivers (or passengers on public transport) and communicate wirelessly with other vehicles and the infrastructure.

New generation

Three large Integrated Projects funded by DG Information Society and Media – CVIS, COOPERS and SAFESPOT – have already made great strides in addressing the ICT and infrastructural aspects. What will be novel in the **next generation of cooperative systems** is that they will allow two-way communication over an open platform, permitting many different services and applications to be added with ease by any vendor. Whereas existing wireless communications technologies use different systems to tackle specific requirements, the new cooperative systems will provide a single, universal solution to many problems.

The increased availability of information from each vehicle fitted with the technology, and the coordinated manner in which the data can be managed, will greatly increase the quality and reliability of personalised information available to drivers about their immediate environment and impending situations.

They would be able to receive more complete and up-to-date information about traffic hazards and congestion – from road signs, variable message panels and traffic light status – displayed in their vehicles. New V2V interfaces would also enable them to exchange requests and recommendations, while 'always-on' communication would allow safer interaction with home and office, as well as access to information and entertainment content delivered via the Internet.

SAFETRIP

Satellite application for emergency handling, traffic alerts, road safety and incident prevention.

S-band technology, supported by a new satellite launched in April 2009, will permit content delivery to vehicles and two-way communications via on-board units interoperable with Galileo and UMTS systems. Under the SAFETRIP project, low cost receivers installed in vehicles will provide a range of personalised services, including emergency calls and messages, traffic alerts, incident/accident warning, speed alerts, vehicle tracking and tracing, and driver behaviour monitoring. Applications will be field-tested in France and Spain.

Coordinator: SANEF (France)

Total budget	EUR 11.25 million
EU funding	EUR 7.89 million
Start/end	01/10/2009 – 30/09/2012
Website	www.safetrip.eu

SARTRE

Road awareness for driving via a strategy that evaluates numerous systems.

SARTRE is developing a concept that will enable suitably equipped cars and trucks to join road trains (platoons), each with a professional lead driver assuming wireless remote control of the string of vehicles. The ability to run in very close formation will reduce air drag, bringing energy saving in the region of 20 %, while also making more efficient use of road capacity. As well as allowing the following drivers to relax or deal with business during their journey, this has the potential to improve traffic flow, and to reduce accidents and environmental impact.

Coordinator: Ricardo (UK)

Total budget	EUR 6.41 million
EU funding	EUR 3.84 million
Start/end	01/09/2009 – 31/08/2012
Website	www.sartre-project.eu

CITYMOBIL
Towards advanced road transport for the urban environment.

The CITYMOBIL project builds on the results of recent European and national projects to create a complete automated city transport system with vehicles ranging from advanced city cars (with ADAS), and driverless track- guided PRT carrying up to four passengers, to mid-sized shuttles (cybercars) and hybrid buses/tramways combining automatic guidance with manual control. Large-scale public demonstrations are already well advanced at project sites in Heathrow Airport (PRT), London, Rome's new exhibition centre (cybercars) and Castellón, Spain (advance buses). First European test track trials could begin as soon as 2011. These will be followed by limited open-road testing – after which, Europe-wide roll-out could be possible by 2018.

Showcase activities launched under CITYMOBIL are being continued in the follow-up CITYNETMOBIL project, which hosted events in Formello, Italy, and Clermont Ferrand, France, during 2009.

Coordinator: TNO – Netherlands organisation for applied scientific research (The Netherlands)

Total budget	EUR 42 million
EU funding	EUR 11 million
Start/end	01/05/2006 – 30/04/2011
Website	www.citymobil-project.eu

Following eventual take-up on a sufficient scale, traffic management systems will for the first time have the ability to communicate with individual vehicles, and to optimise network efficiency with knowledge of every vehicle's position and trajectory, and even its desired destination. This opens the door to personalised routing guidance using real-time traffic information, safety alerts to vehicles in hazardous areas and speed recommendations to groups of vehicles. It will increase total network capacity and reduce localised congestion, thus also reducing the number of accidents. Traffic flowing more smoothly and with fewer stops will limit pollution and improve air quality. Special priority could be given to classes of vehicles involved in emergency or public transport services – or even to goods vehicles, where appropriate.

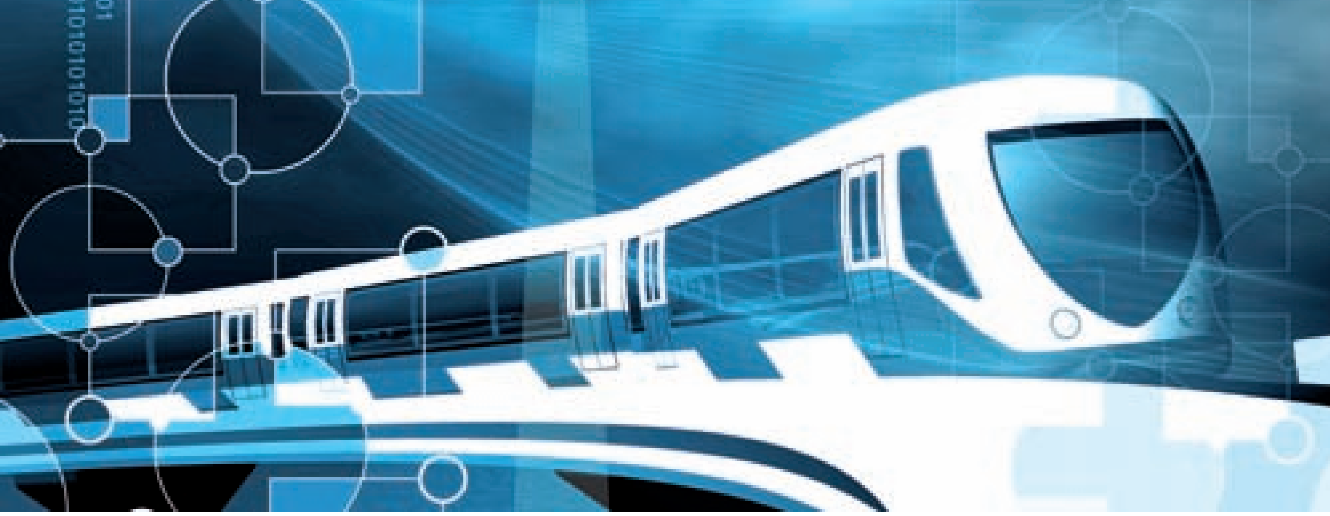
The same data can also be used to extend the functionality of in-vehicle safety systems – for example, by constructing integrated architectures to facilitate the exchange of information between road and vehicles regarding dangerous situations and driver behaviour. As well as giving drivers advance warning of problems and alerting authorities to irregularities, collated inputs from roadside and on-board sensors could be used to trigger automatic intervention by active driver aids to prevent accidents.

A problem to be faced is that equipping new vehicles alone for V2V and V2I will not achieve the level of deployment required to deliver significant benefits within a reasonable timeframe. Government intervention – such as tax incentives – will be necessary both to oblige automakers to act and to persuade existing car owners to retrofit.

ICT for energy efficiency

As well as guiding and modifying driver behaviour, another important task for ITS in the context of green cars is to optimise the energy-efficiency of the vehicles themselves. Electronic components currently account for some 20-30 % of total production costs for all car categories, and reports suggest this figure could reach 40 % or more by 2015.

In conventional petrol- or diesel-powered vehicles, electronics improves fuel economy by managing the fuel injection, thermal systems and battery charge/discharge cycles. Moreover, hybrid vehicles, with their regenerative braking



and start-stop systems, have a substantially higher semiconductor content than regular passenger cars.

Fully electric vehicles also rely heavily on computerised systems to extend their autonomy and prolong battery life by monitoring and managing the complex packs of lithium-ion cells. Here, especially, the growing variety of functionality seen as essential to comfort and safety presents the problem of added power train compromising an already limited driving range.

The 'X-by-wire' concept, whereby hydraulic or mechanical power transmission systems are replaced by electrical/electronic systems utilising sensors and motors, will further accelerate the trend towards more comprehensive computerisation. In the interests of energy conservation, new intelligent systems will be needed for integrated control of the many sub-systems involved.

'Hands-off' driving

Although the idea of relinquishing control of a moving vehicle may be a daunting prospect, interactive X-by-wire technology already allows vehicles to be operated without any input from the person behind the wheel. This can be compared to the techniques used in aircraft, where automated systems routinely manage the flight controls, with the pilot acting as a supervisor/controller able to intervene or modify settings as necessary.

Automated metros, trains and airport shuttles have been in service for a number of years. New kinds of **automated transport systems** (ATS) are now being developed by researchers in the EU and throughout the world.

Since the late 1990s, there has been a strong resurgence of interest in the idea of **Personal Rapid Transit** (PRT): a form of demand-responsive ATS that was strongly promoted during the 1960s and '70s, but foundered due to the lack of maturity of the technologies at that time. PRT uses small driverless electric vehicles – often called 'pods' – typically able to carry two to four passengers along dedicated rails or guideways.

In contrast to tramways and light rail systems, the principle is that users can summon a pod or join it at a convenient pick-up station, and instruct it to carry them in an unbroken journey to their selected destination. At the time of writing, a world premier public demonstration of the ULTra PRT system developed in cooperation with the CITYMOBIL project series is undergoing extensive testing at Heathrow airport, London. It is currently scheduled to commence commercial operation in autumn 2010.

In the late 1990, several projects supported by the European Commission developed a new concept which tries to fuse the principle of car-sharing with PRT: automated electric public vehicles known as '**cybercars**', which can run on demand on existing urban infrastructures that also accommodate pedestrians, cyclists and even a limited numbers of cars. The latter can be restricted in terms of ownership (i.e. residents and public services) and/or speed.

The first such system operated in a long-stay parking lot at Schiphol airport, the Netherlands, with four automated electric vans from Frog Navigation. These ran for several years from December 1997. Under the CITYMOBIL project, a new installation in Rome, Italy, will serve the city's large exhibition centre.

So far, these cybercar systems have been located in fairly confined areas, far from the city centres. Now, La Rochelle, France, has decided to experiment with the new type of public transport in a central pedestrian zone. Its decision follows a demonstration that took place during CITYMOBIL and at the end of the CYBERCARS-2 project, featuring cybercars and advanced car-sharing vehicles capable of some automated manoeuvres such as parking and 'platooning'.

Theoretically, driverless cars could be integrated fully on public thoroughfares – although this is not permissible under present law. Some of the future scenarios that could be foreseen include:

1. Town centre: dual-mode vehicles equipped for both human and automated control, able to circulate in historic town centres;
2. E-lanes: high-speed dedicated lanes where vehicles operate in automatic mode;
3. Inner city centre: fully automated low-speed vehicles in pedestrian areas;
4. Shared traffic: dedicated lanes for automated and classical buses.

One potential solution now being studied is the formation of automated transport convoys ('**platoons**') of dual-mode vehicles. This would allow groups of cars, trucks or buses to be electronically linked, with a single professional lead driver taking sole charge of acceleration, braking and steering for the duration of a trip. By drawing the vehicles into a closely spaced formation, separated by distances in the order of one metre, fuel-wasting aerodynamic drag is reduced and road occupancy minimised. For this to be accepted, numerous technical and safety-related questions remain to be answered by research:

- Can system benefits be made to outweigh the driver workload?
- How will prolonged reliance on automation affect drivers' behaviour and awareness of surrounding traffic?
- What will be the optimal methods to warn of system failure or transitions from automatic to manual mode?
- How can individual vehicles safely enter/exit platoons?
- How can other road users be made aware that they are in the vicinity of a platoon?

The vision of motorway commuters joining a platoon and watching a DVD or working on office matters until it is time for them to leave at a predetermined exit may be a long-term prospect. However, an early application could be the overnight redistribution of car hire fleets – e.g. between city centres and airports or peripheral parking sites – ready for pick-up by customers the following day.

Making the most of multimodality

Trip advisors

Another important direction for ITS research is the promotion of **multimodal door-to-door journeys**, which combine different forms of transport, taking into account traffic congestion, environmental impact, cost, time, comfort and accessibility, based on data provided via RTTI services. For passenger transport, the envisaged systems embrace all types of mobility available to users – buses, taxis, train, metro, walking, cycling, etc. Equally vital is optimisation of the movement of freight, both within the EU and in transactions with Europe's international trading partners.

A significant impediment to multimodal travel is the fragmentation of information about the various resources, their costs and the ease of **interconnectivity**. With increasing demand, especially in urban areas, it becomes more and more crucial to have ready access to accurate real-time data for pre-trip planning and on-the spot response to changing needs or conditions.

Reliable cross-mode timetables and seamless ticketing are essential to maximise consumer acceptance of public transport as a viable alternative to personal vehicle ownership.

Integrated travel planners could even extend to the provision of information about **demand-responsive transport** (DRT), now being developed in many cities and regions, DRT employs small/medium-sized vehicles operating flexibly in shared-ride mode between pick-up and drop-off points of passengers' choice. With the aid of cooperative systems, journey planners could ultimately provide real-time schedule data for individual bus stops or rail stations, so that DRT could be fully coordinated with the fixed line services – which would be of great value to **people with reduced mobility**.

Tools for decision makers

New technologies developed in research projects are also supporting decision makers with the development of guidelines and policy recommendations: to promote passengers to use all transport modes including public transport with a particular focus on vulnerable users (ACCESS 2 ALL); also to help city authorities to implement ITS applications (CONDUITS).

i-TRAVEL
Service platform for the connected traveller.

i-TRAVEL is laying the foundation for a virtual 'e-Marketplace' connecting travel information providers to service providers and to users' mobile or handheld devices. Using real-time and context-specific data, trusted travel assistants will be able to plan each journey and guide travellers throughout their itineraries with timely advice and problem warnings. Publishing the content on a standardised platform will bring closer the vision of end-to-end travel services extending from pre-trip preparation to on-trip support and post-trip evaluation. This project is part of a larger cluster of research projects on multimodal trip advisors, supported by DG Research, DG Mobility and Transport and DG Information Society and Media. It builds upon results of previous projects and shares results with others, supporting the European Commission ITS Action Plan, for the 'promotion of multimodal journey planners' (Action 1.5).

Coordinator: ERTICO – ITS Europe (Belgium)
Total budget | EUR 2.20 million
EU funding | EUR 1.40 million
Start/end | 01/01/2008 – 30/06/2009
Website | www.i-travelproject.com

WISETRIP

Wide scale network of e-systems for multimodal journey planning and delivery of trip intelligent personalised data.

Existing systems for journey planning and route guidance tend to be limited to single forms of transport or even single providers, and are restricted in scale of coverage. Consequently, they do not respond to the need for multimodal travel. WISETRIP is therefore creating a 'Wide-Scale Journey Planner' as a one-stop shop able to answer complex questions by connecting inputs from various journey planners. Real-time personalised information will be accessible by travellers through mobile or fixed devices before and during their journeys.

Coordinator: Hellenic Telecommunications and Telematics Applications Company (Greece)

Total budget | EUR 2.12 million

EU funding | EUR 1.44 million

Start/end | 01/02/2008 – 31/07/2010

Website | www.wisetrip-eu.org

ACCESS 2 ALL

Mobility schemes ensuring accessibility of public transport for all users.

Through the coordination of current research efforts, production of common research roadmaps, identification of best practice models and the appropriate use of ICT tools, ACCESS 2 ALL is defining guidelines and policy recommendations intended to ensure accessibility of public transport to all users, including those with impaired mobility. Its goal is to encourage transport operators to adopt new technologies and schemes appropriate to the special needs of passengers such as the elderly, disabled, ICT-uneducated, dyslexic and illiterate.

Coordinator: ERT – Europe Recherche Transport (France)

Total budget | EUR 0.80 million

EU funding | EUR 0.80 million

Start/end | 01/12/2008 – 30/11/2010

Website | www.access-to-all.eu

CONDUITS

Coordination of network descriptors for urban intelligent transport systems.

To promote Europe-wide adoption of ITS, CONDUITS is developing a number of tools to assist local authorities in making informed investment decisions. Key Performance Indicators (KPI) will enable the impact of ITS to be measured from efficiency, environmental, energy, safety and spatial perspectives. Building up an understanding of the ITS plans of European cities will permit comparison with worldwide practices and facilitate the exchange of good practices. The research will identify markets for specific applications and indicate barriers to implementation. The KPI system will be tested through case studies in Paris, Barcelona and Rome. A 'City Club' on ITS will also be set-up. CONDUITS directly supports the Action 6.4 'Urban ITS Platform' of the EC's ITS Action Plan.

Coordinator: ISIS – Institute of Studies for the Integration of Systems (Italy)

Total budget | EUR 0.95 million

EU funding | EUR 0.95 million

Start/end | 01/05/2009 – 30/04/2011

Website | www.conduits.eu

CHAPTER 6

Framework for freight logistics

CITYLOG

Sustainability and efficiency of city logistics.

To improve the sustainability and the efficiency of urban goods delivery, the CITYLOG project is conducting research in three related areas: logistics-oriented telematics for optimised routing and mission management; driver support systems for safer, more flexible operation of vans and trucks; and innovative load units enabling vehicle interiors to be reconfigured for maximum versatility. The intention is to decrease the numbers of vehicles required, reduce travel distances and fuel consumption, and minimise unsuccessful deliveries.

Coordinator: CRF – Fiat Research Centre (Italy)

Total budget | EUR 6.00 million

EU funding | EUR 3.60 million

Start/end | 01/01/2010 – 31/12/2012

Website | www.city-log.eu

Intelligent freight distribution

Optimisation of the movement of freight, both within the EU and in transactions with international trading partners, is vital to Europe's future competitiveness in the global marketplace.

Within the 2008 Logistics Action Plan, the EU aimed to establish a framework for developing ITS applications for freight transport, including digital mapping, the monitoring of dangerous goods and live animals, and interoperability of electronic fee collection for trucks. The EC Marco Polo programme is also funding projects that aim to shift freight from road to sea, rail and inland waterways, again combating congestion and pollution by reducing vehicle numbers.

A key logistical concept to streamline the transport of goods is that of '**intelligent cargoes**', equipped with sensors to make them self-aware, context-aware and connected through global telecommunication networks that support a wide range of information services for transport operators, industrial users and public authorities. In this way, the freight itself will permit synchronisation of its transportation with other processes that depend on the timely delivery of goods. As well as allowing an optimal combination of transport modes, it could aid the maximisation of load-factor rates (ratio of the average load to total vehicle freight capacity), which in European countries may now vary between 25 % and 40 %.

'In urban spaces, goods delivery produces up to 30 % of motorised trips and involves more than 10 % of the circulating vehicles, 66 % of which park irregularly,' says CITYLOG project coordinator Saverio Zuccotti from Fiat Research Centre. 'By adapting existing technologies for **vehicle routing and fleet management**, new logistic models are possible, reducing the impact of freight distribution on the city environment.'

One more approach to reducing the number of circulating vehicles, especially applicable in crowded urban environments, is the introduction of multi-purpose vehicles that can be adapted for different functions according to demand at any given time.

HEAVYROUTE
Intelligent route guidance of heavy vehicles.

Building on inputs from several earlier EU-funded projects, HEAVYROUTE derived a prototype satellite-based mapping system for pre-trip route planning that takes account of specific truck characteristics and the identification of preferred networks for heavy vehicles. Driving simulator studies were carried out to determine the type of HMI offering the greatest potential to improve safety. A further aspect was to devise management strategies for issuing instructions when approaching vulnerable bridges equipped with 'weigh-in-motion' (WIM) sensors.

Coordinator: VTI – Swedish Road and Transport Research Institute (Sweden)

Total budget | EUR 3.30 million
EU funding | EUR 1.70 million
Start/end | 01/09/2006 – 30/06/2009
Website | http://heavyroute.fehrl.org

Damage limitation

The high weight of long range trucks poses some threats to the surrounding environment, and it is important to help drivers in minimising them. Some studies are therefore seeking to reduce the impact of essential journeys on the infrastructure and other road users. By harnessing **weigh-in-motion technology** (sensors embedded in the road surface, which are able to capture and record truck axle weights and gross vehicle weights without requiring them to stop), it is possible to encourage responsible behaviour by advising heavy goods drivers how to proceed safely when approaching load-sensitive bridges. By adapting satellite mapping to plan routes that take account of the actual size and weight of individual heavy vehicles, much driver frustration can be avoided, while removing a common reason for road blockages and delivery delays.

CHAPTER 7

International cooperation

Research cooperation with countries beyond the EU itself – in ITS, as in many other fields – is a central element of Commission policy. 'The global challenges we face cannot be addressed if we simply confine our action to Europe,' explains DG Research Project Officer Patrick Mercier-Handisyde., 'This is why we are opening our research funding to emerging economies. Supporting interesting and innovative research projects in the field of transport is a great way to start. At the same time, promoting development in third countries enhances European industrial competitiveness via transfer of technologies, and will have positive knock-on effects that will benefit the world economy.'

New instruments

Three such projects have been launched under FP7, taking advantage of the SICA (Specific International Cooperation Actions) mechanism, which allows the EU to collaborate in addressing specific needs of mutual interest to itself and targeted International Co-operation Partner Countries (ICPC) or regions.

Coordination with BRIC countries and South-Africa

'This has been particularly useful in enabling us to build strong links with the so-called BRIC countries (**Brazil, Russia, India, China**) and **South-Africa**,' says Vincent Blervaque of ERTICO – ITS, which coordinates two of the projects and is a member of all three consortia (SIMBA II, VIAJEO and STADIUM). 'STADIUM will provide a particularly high-profile showcase for ITS as applied to the control of traffic and public transport during major events that place unusually heavy demands on the host cities' infrastructures. Demonstrations are planned at three of the world's most popular sporting gatherings.'

SIMBA II

Strengthening road transport research cooperation between Europe and emerging international markets.

SIMBA II aimed to broaden road transport research cooperation between Europe and the emerging markets of Brazil, China, India, Russia and South-Africa by establishing a collaboration network that brings together key stakeholders in the fields of ITS, urban mobility and road infrastructures development. The project examined how the EU and its partner countries could jointly increase road safety, mobility and efficiency, through sustainable urban transport planning, while at the same time cutting levels of transport-related pollution.

Coordinator: ERTICO-ITS Europe (Belgium)

Total budget | EUR 0.50 million

EU funding | EUR 0.50 million

Start/end | 01/05/2008 – 30/04/2010

Website | www.simbaproject.org

VIAJEO

International demonstrations of an open platform for transport planning and travel information.

Cities face ever increasing demands on their transportation systems, especially in developing regions with growing car ownership and rapid urban migration. Even more than heavy infrastructure investment, strategic mobility management is becoming the most important tool for meeting this demand. The VIAJEO project will design, demonstrate and validate an open platform which will facilitate data sharing and exchange from different sources and provide data processing and management to support a variety of services. The project will integrate the open platform with local components and demonstrate its applications in Europe (Athens), Brazil (São Paulo), and China (Beijing and Shanghai).

Coordinator: ERTICO-ITS Europe (Belgium)

Total budget | EUR 5.9 million

EU funding | EUR 3.6 million

Start/end | 01/09/2009 – 31/08/2012

Website | www.viajeo.eu

STADIUM

Smart transport applications designed for large events with impacts on urban mobility.

To improve the performance of transport systems operating during large events hosted by major cities, the STADIUM project is developing a set of management support guidelines and tools based on experiences gathered during past sporting events. These take account of the mobility requirements of visitors, employees, participants and VIPs, within the framework of general event logistics. Applications will be demonstrated at the South-Africa World Cup (2010), the India Commonwealth Games (2010) and the London Olympics (2012).

Coordinator: ISIS – Institute of Studies for the Integration of Systems (Italy)

Total budget | EUR 5.75 million

EU funding | EUR 3.6 million

Start/end | 01/05/2009 – 30/04/2013

Website | www.stadium-project.eu/site

CHAPTER 8

Conclusions and the way forward

Transport scenarios

To summarise the foregoing pages, ITS will play a prominent part in securing the future of sustainable mobility against a background of mounting economic, environmental and societal pressures.

Cities will be obliged to apply ever-stricter air quality legislation, and to reduce transport-related CO_2 emissions in line with increasingly stringent European and global targets.

Greater priority will be placed on policies for the prevention and avoidance of congestion, which will inevitably include measures such as access control and road charging to manage the level of demand. Incentives and sanctions will favour low-impact collective and individual modes of passenger transport, while special attention will be paid to goods delivery, with new provisions for truck routing, loading, parking and the associated logistics services.

On the positive side, ITS will enable connected vehicle-infrastructure communication systems to deliver real-time and context-sensitive information to enhance safety, improve the efficiency of road usage and reduce environmental impact. New generations of traffic management systems will integrate data from vehicles, to provide dynamic, predictive and adaptive control of traffic flows.

The evolution of mobile communication networks to 4G and beyond will deliver continuous connectivity to vehicles and travellers, giving access to on-line services via mobile Internet links. Multimodal traffic and travel information services will grow in quality and quantity – with mobile handsets becoming increasingly powerful personal mobility terminals. Travel guidance, on-line booking and payment facilities will be combined with location-based Web 2.0 applications to facilitate ride-sharing, data collection and information exchange via mushrooming social networking websites.

Research recommendations

Experience gained with existing ITS deployments and current developments shows that they can provide concrete solutions to many of the mobility needs for people and goods. However, to realise their full potential, a number of research areas merit continued attention and effort, notably:

- development and validation of the 'connected traveller' concept, through pilot and demonstration projects;
- construction of an e-marketplace in traveller services (predictive traffic management, real-time multimodal traveller information, demand and access management...), based on open platforms to collect, aggregate and exchange traffic and transport data from various sources, with an emphasis on quality, standardisation and cost-efficiency;
- creation of seamless and ubiquitous connected services (simple, upgradable and scalable) via low-cost universal devices;
- development of demand-driven, easy-to-use and affordable services for all users, learning from the success of portable navigation systems and Web 2.0 social networks;
- enhanced geo-localisation and guidance, also able to function in indoor/underground areas where satellite positioning is not available;
- management of recurring or temporary peaks in demand, e.g. for peak-hour commuter travel and large-scale events;
- pursuit of behavioural studies to understand and improve user acceptance and response to the potentially complex offerings of new mobility services, combining multimodal traveller information with options such as demand-responsive transport and car sharing or pooling;
- exploration of the possibilities offered by new-generation fully electric vehicles, especially in cities, to support more sustainable mobility behaviour;
- boosting infrastructure capacity by reorganising and up-scaling transport flows, to increase load factors by up to 80 %;
- establishment of green corridors and supply chain management methods to create a solid European e-logistics framework based on ICT applications.

Glossary

ABS	Automatic braking system
ACC	Active cruise control
ADAS	Advanced driver assistant system
ATM	Air traffic management
BRIC	Brazil, Russia, India and China
CCTV	Closed circuit television
DG	Directorate-General
DRT	Demand-responsive transport
DSRC	Dedicated short range communication
EGCI	European Green Cars Initiative
ERTMS	European Railway Traffic Management System
ERTRAC	European Road Transport Research Advisory Council
ESC	Electronic stability control
EU	European Union
GSM	Global system for mobile communications
HMI	Human-machine interface
I2V	Infrastructure to vehicle
ICPC	International cooperation partner countries
ICT	Information and communication technologies
ITS	Intelligent transport systems
PRT	Personal rapid transit
RFID	Radio frequency identification device
RIS	River information system
RTTI	Real-time traffic information
SESAR	Single European Sky air traffic management research program
SICA	Specific international cooperation action
SST	Sustainable surface transport
TEN-T	Trans-European network for transport
TETRA	Terrestrial trunked radio
UHF	Ultra-high frequency
UMTS	Universal Mobile Telecommunications System
V2I	Vehicle to infrastructure
V2V	Vehicle to vehicle
VHF	Very high frequency
VTMIS	Vessel traffic management information system
WIM	Weigh in motion
WIMAX	Worldwide interoperability for microwave access
WLAN	Wireless local area network

European Commission

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Intelligent Transport Systems (ITS) are under continuous development to reduce congestion and to ensure the sustainable mobility of citizens and goods in response to increase in traffic demand, resulting from higher levels of motorisation, urbanisation, population growth and demographic change.

This brochure reviews the contribution made over 15 years of EU-funded research in the field of ITS by the Sustainable Surface Transport programme. Its main contribution is the support for an integrated systemic approach to transport research. This evolution is described through the presentation of research projects including: road safety, traffic management and intelligent infrastructures, holistic solutions, multimodality, freight logistics and international cooperation.

Many of the projects are still ongoing; this brochure gives an exciting insight into the state of the art of ITS research and provides a glimpse of ITS technologies and systems we can expect to see on our roads in the near future.

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