ICT for Clean & Efficient Mobility
Final Report

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Brussels, November 2008

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Introduction

The Working Group on ICT for Clean and Efficient Mobility was established by the eSafety Forum in December 2006 with the purpose to identify and promote the potential benefits that ICT (information & communication technologies) and ITS (intelligent transport systems) applications & services can bring towards cleaner and more energy-efficient mobility for people and goods. These technologies as specifically applied for environmental ends are collectively referred to as “Green ITS”.

This report presents a review of the wide range of Green ITS already available or under development that can have a significant impact on road transport energy efficiency and emissions of pollutants and CO_2. It is a summary of the results of Working Group meetings and other inputs from the Working Group members.

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Summary of Conclusions

The Working Group (WG) is convinced that global warming and the need to preserve the environment in the face of growing demands for energy and mobility must be addressed and there is a need to act quickly.

The WG believes that the key to achieving sustainable energy savings and maintaining mobility for people and goods lies in the application of Information and Communication Technologies (ICT) in the form of "Green ITS" measures.

The WG believes that there is substantial untapped potential for a new generation of Green ITS technologies, applications and services whose primary purpose is to reduce environmental impacts or increase the energy efficiency of road transport. These measures lie within the triangle of an integrated approach that treats simultaneously the infrastructure, the vehicle and the driver.

he WG has identified seven types of Green ITS measure that seem to offer the greatest potential for environmental benefits. This potential has been supported by an assessment of a significant body of research and the presentation of specific case studies supplied by Working Group members:

- Eco-driving support
- Eco-traffic management

- Eco-information and guidance
- Eco-demand and access management
- Eco-mobility services
- Eco-freight and logistics management

- Eco-monitoring and modelling.

While the WG believes that within each of the above areas of Green ITS the measures identified in this report can deliver substantial benefits, it is not possible today to form a reliable and quantitative estimate of these impacts, either singly or if implemented together, as most of these measures are still in an early stage of development and few are deployed at a large scale.

Nevertheless, the Working Group believes that if all potential Green ITS measures would be implemented together and within a long-term concerted European programme supported by all key stakeholders, then an overall reduction of fuel consumption and CO_2 emissions in the order of 25% is achievable.

1. Introduction

The Working Group on ICT for Clean and Efficient Mobility was established by the eSafety Forum in December 2006 with the purpose to identify and promote the potential benefits that ICT (information & communication technologies) and ITS (intelligent transport systems) applications & services can bring towards cleaner and more energy-efficient mobility for people and goods. Hereafter in this report these technologies, applications and services will be collectively referred to as “Green ITS”.

The terms of reference of the Working Group (see Annex 1) include the following specific objectives:

- Identify and assess which ICT applications and services for mobility have the strongest potential to yield environmental benefits;
- Examine relevant measures that could complement and enhance the environmental compatibility and sustainability of mobility;
- Examine potential for educational and support tools and feedback to promote more environment-friendly driver behaviour;
- Undertake a cost-benefit assessment of measures to reduce environmental impact of mobility;
- Identify specific measures to promote and support deployment.

This report presents a review of the wide range of Green ITS already available or under development that can have a significant impact on road transport energy efficiency and emissions of pollutants and CO2. It is a summary of the results of Working Group meetings and other inputs from the Working Group members.

The report begins with this introduction, and a summary of the environmental challenges for a sustainable mobility. Then Section 2, comprising the body of the report, presents seven areas of ITS where the Working Group found a potential for significant impact on energy efficiency and the environment. Section 3 presents the conclusions and recommendations of the Working Group.

The report's Annexes contain various complementary information, including the Working Group's Terms of Reference (Annex 1); a summary of known projects and other studies relating to Green ITS (Annex 2); a matrix of known results concerning the impacts of Green ITS (Annex 3).

This report concentrates on ITS/ICT measures for road transport, intelligent road infrastructure and road users rather than aspects such as road construction, etc. Annex 4 discusses the contribution to clean and efficient mobility available from such non-ICT technologies and other measures.

1.2. The Environmental Challenge

1.2.1 Global warming

Global warming is now an accepted fact by the world's scientific community. The greatest influence appears to be the growth in emissions of CO_2, a powerful "greenhouse gas", that enters the atmosphere as a result of heating, industrial processes, electricity generation – and transport, principally from road, air and rail traffic.

CO2 emissions due to road transport are influenced by 1:

- Vehicle technology
- Fuel and how it is used
- Type of vehicle and how it is driven
- Efficiency of the road network and its management
- The traveller's choice of means of transport, e.g. comodality.

Transport sector emissions in OECD countries2 grew by 26% (820 million tonnes) between 1990 and 2003. This trend has continued and is expected to further increase in the future.

The challenge for Europe is plain: the European Council has adopted a decision to reduce greenhouse gas emissions by

1 Carl-Peter Forster, President GME, Fuel for Thought Event, Brussels, Nov. 21, 2007

2 ECMT: Cutting Transport CO2 emissions: What progress? ISBN 92-821-0382-X, 2007 (ECMT=European Conference of Ministers of Transport), page 5

20% by the year 2020. As road transport's share of CO_2 emissions is still growing, the task is to re-shape our transport system so that it can sustain a growth in mobility while drastically cutting greenhouse gas production.

1.2.2 Oil supply and security

The global demand for oil is expected to increase by 38% from 2008 to 2030. The IEA3 is warning of shrinking oil resources, oil capacity and slowing production, leading to further increases in petrol and diesel prices4. The prospect of unstable and uncertain future oil supplies in the future gives added reason for seeking to increase the overall fuel efficiency of today's mobility system.

1.2.3 Energy consumption

Currently our mobility is heavily dependent on fossil fuels, either petroleum products used in vehicle motors or to fuel power stations for generating electricity used in transport. The challenge is to reduce energy consumption per unit of mobility, and to redirect energy sources away from those that have a negative effect on the environment and sustainability.

In 2006 the European Commission adopted an Action Plan aimed at achieving by 2020 a 20% reduction in energy consumption as well as increasing renewables to a 20% share of total energy use. This Action Plan identifies that smart transport & logistics measures could reduce that sector's energy consumption by 26%.

The recently published "Smart 2020" report5 concludes that applying information and communication technologies (ICT) more widely in industry and infrastructure could help deliver significant energy efficiency gains and cut global greenhouse gas emissions by up to 15% p.a. by 2020.

The need is therefore urgent to find and use cleaner and

3 IEA Mid Term Oil Market report July 2007

4 FIA General Assembly Declaration: Make Cars Green, 26. October 2007

5 Global e-Sustainability Initiative (GSI) and the Climate Group: Smart 2020 Report "Enabling the low carbon economy in the information age", June 2008

less energy-consuming means of transport and apply intelligent mobility management. But to achieve wider take up also means a change in people's attitudes and the correct policies at local and national levels.

1.2.4 Air quality

EU air quality rules6 require Member States to limit the concentrations of pollutants such as benzene, carbon monoxide, nitrogen dioxide, particulates and sulphur dioxide in the ambient air, and to draw up action plans when the concentrations risk being exceeded. In 2005, some 70% of European towns and cities with 250,000 inhabitants or more have reported exceeding the PM10 limits in at least part of their area.

Recommended counter-measures include limiting or even suspending motor vehicle traffic. In practice, the risk of such air quality emergencies is highest in urban areas. A number of Member States and cities have already taken measures to restrict vehicle traffic on grounds of vehicle emissions or air pollution episodes. These are likely to grow in number as city traffic increases and as the stricter limits (e.g. for small particulates PM2.5) come into force.

Successive European legislation has imposed limits on the specific emission of new light and heavy vehicles. These have brought dramatic a reduction of emissions of particulates (PM10 and more recently PM2.5), NOx and volatile organic compounds. The latest standards require a reduction by more than 50% in each of the above pollutants from 2000 to 2020.

6 Directive 2008/50/EC of the European Parliament and the Council of 21 May 2008

2. Green ITS Measures and their Impact on Energy Efficiency and the Environment

2.1 An integrated approach to the challenge

The Working Group believes that an integrated approach towards clean and efficient mobility is necessary. This means both the involvement of a wide range of relevant stakeholders but most importantly to look for solutions not only from vehicle technology alone but also by complementary measures such as improving traffic management, adjusting infrastructure, increasing the use and availability of alternative fuels, changing driving behaviour and influencing consumer demand through taxation and enabling an integrated and seamless access of users to all modes of transport –both private and public.

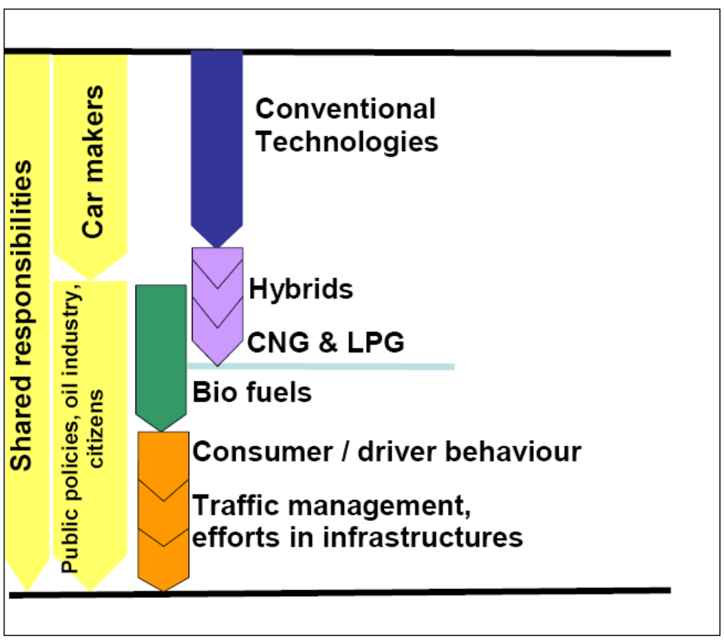


Figure 1: Integrated approach to reduce CO2 emissions

The Working Group has therefore pursued a balanced approach, considering the vehicle, the driver and the infrastructure in an integrated way.

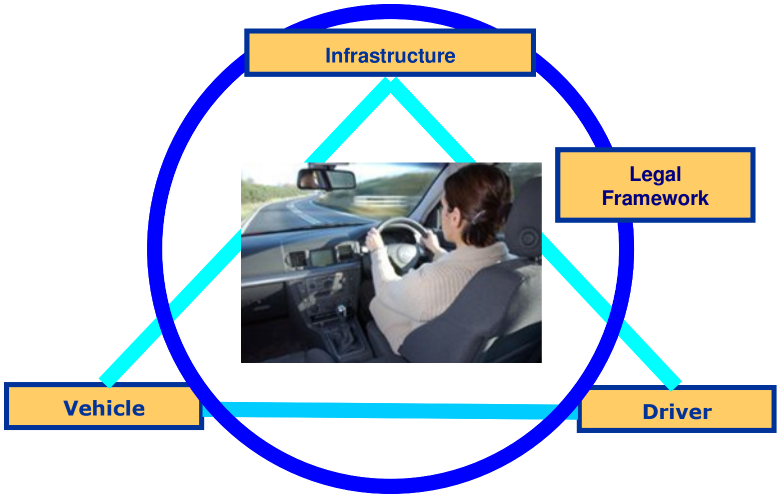


Figure 2: Working Group approach

Although the goal of the Working Group is to concentrate on those aspects either not treated adequately until now, or where there is a significant potential for eSafety technologies (ITS/ICT or "Green ITS" applications) to yield environmental benefits and productivity gains (traffic flow management, fleet management), it is recognised that many non-ICT related aspects may have a decisive influence on energy efficiency and the environment. These are discussed in detail in Annex 4.

2.2. Green ITS Measures

The Working Group approached its task by reviewing proposed ICT measures for clean and efficient mobility and reducing these to a limited core of seven areas thought likely to yield the most significant impacts on energy efficiency and environmental effects.

The seven types of "Green ITS" measure thought by the Working Group to hold greatest potential for environmental impact are as follows. They are presented below in the following order:

M.1 Eco-driving support
M.2 Eco-traffic management
M.3 Eco-information and guidance

M.4 Eco-demand & access management
M.5 Eco-mobility services
M.6 Eco-freight and logistics management.
M.7 Eco-monitoring and modelling

These are described in more detail below.

For each area the Working Group selected one or more case studies, and prepared a synthesis according to the following schema:

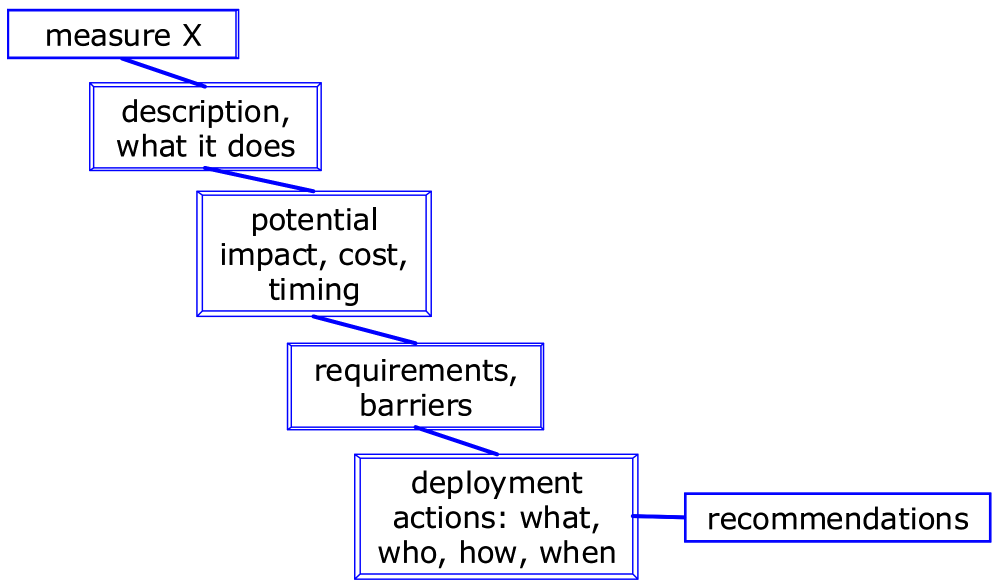


Figure 3: Assessment schema

M.1 Eco-driving support

One of the most significant measures for reducing fuel consumption and therefore also CO2 emissions is “eco-driving”, shorthand for a number of techniques to reduce fuel consumption through influencing human behaviour. The aim to change behaviour can be achieved through training, awareness, real-time information, incentives & penalties, for example. Green ITS technologies can also be applied to support the driver to adopt and then to maintain a more fuel-efficient driving style.

The “Golden Rules of Eco-Driving” include suggestions such as:

- Shift into a higher gear early; leave in gear when braking
- Maintain a steady speed at highest possible gear
- Look ahead and anticipate traffic flow
- Switch off engine at short stops
- Check and adjust tyre pressure regularly
- Make use of in-car fuel saving devices such as on-board computers and dynamic navigation to avoid traffic jams
- Remove surplus weight and unused roof racks.

Already certain of these techniques are becoming an integral feature of the vehicle itself, such as the display of fuel consumption, the stop-start assistant, eco-navigation system, gear-change indicator, advanced semi-automatic transmission and automatic tyre-pressure monitoring. Additional impacts can be expected from applications using enhanced vehicle and driver monitoring, adaptive cruise control, additional digital map content and vehicle-infrastructure communication.

As this report is related to ICT/ITS we focus on those eco-driving measures that make use of information and communication technologies, including:

- Eco-journey support – on-line and mobile information services to the traveller with advice on environmental conditions and on multi-modal choices, provided before and during the journey;
- Enhanced navigation using adapted algorithms for

dynamic route guidance, e.g. with historic data, least-fuel routing etc.

- Cooperative eco-driving – providing the driver with support, feedback and guidance on a more fuel-efficient driving behaviour (e.g. CO2 production or cost/saving in Euros)
- On-board monitoring and online coaching of "golden rules of eco-driving" for drivers.

Note that in deploying any driver support system it is important to ensure that environmental gains are not at the expense of safety, e.g. these systems should not overload drivers with information or actions, deflecting attention from the driving task or prolonging reaction times.

Case Study: Eco-drive coaching
Description of measure: Eco-driving is a way of driving that reduces fuel consumption, greenhouse gas emissions and accident rates. Eco-driving is about driving in a style suited to modern engine technology: smart, smooth and safe driving techniques that lead to average fuel savings of 5-10%. Eco-driving offers benefits for drivers of cars, vans, lorries and buses: cost savings and fewer accidents as well as reductions in emissions and noise levels. Several European countries have implemented successful eco-driving programmes. Background: education, training, policy etc. Fuel efficient driving can be supported by the use of in-car devices like cruise control or adaptive cruise control, tyre pressure monitoring systems, gear shift indicators and reactive accelerator pedal. ICT additions: - for commercial vehicles: need to improve HMI for drivers; may need new system development to support eco-driving for hybrid vehicles; - need real-time support (but safe HMI, no distraction) - on-board recorder, with post-trip feedback & analysis - online Internet service – benchmarking with own behaviour & peers - digital map support and location information - dynamic traffic adaptation (individual) - dynamic traffic adaptation, adaptive cruise control (cooperative system with wireless communication) References: • UK Project SENTIENCE –to optimise drivetrain control for hybrid vehicles • Nissan Carwings connected navigation system – with Internet feedback and coaching, comparison with performance of peers (drivers of the same car model).
Functioning:

• Data captured from vehicle CAN bus. • Data transfer to fleet owners/management by mobile communication, e.g. GPRS • Data analysis according to parameters relevant for Driver Coaching Direct information display in the cab to the driver (HMI) related to Eco-driving (e.g. speed, gear, rpm, idling, acceleration, tyre pressure, service etc.). Direct feedback is given to the driver concerning the actions to take in order to decrease fuel consumption, both instantaneously as well as averaged for the planned route. Fleet owner/management can extract and compile vehicle data that is relevant to Eco-driving. These data can be sorted according to a number of variables, e.g. individual drivers and vehicle; route; weight of vehicle and cargo; and can be displayed according to time (weekly, monthly etc.). The information from collected data could be used for an incentive scheme, for education/training, for optimising a logistics operation, for allocation of resources etc. The potential benefits for eco-driving from use of a gear-shift indicator has been discussed in an informal working group including the European Commission, car manufacturers and users. It is now proposed that gear-shift indicators become mandatory in all new cars.
Enabling factors: ▪ Driver training on eco-driving should be part of the learning package for new drivers and could also cover less experienced drivers; ▪ Driving schools and professional driving instructors promote eco-driving actively; ▪ Automobile clubs could offer their members training possibilities and share good practice; ▪ Improved driver HMI for clear, concise and easy to understand feedback on which actions to take while driving; ▪ Improved information presentation to fleet owner/manager in order to process data into meaningful information leading to actions to reduce fuel use; ▪ Incentives for fleet owners/management to invest in driver coaching systems and technologies i.e. proof of cost savings and investment pay-back; ▪ Model business case for investment in driver coaching; ▪ Incentive schemes for eco-driving measures, for drivers and for companies; ▪ Fiscal incentives to encourage reductions of CO_2 emissions; ▪ Insurance policy incentives to promote driver coaching; ▪ Enhancements to digital map data and other ICT technologies, e.g. real time traffic information.
Promising technologies: Gear-shift indicators (GSI): for vehicles with manual transmission, when the current gear is not optimum then the GSI displays to the driver which gear to select for maximum fuel efficiency. Tyre pressure monitoring systems (TPMS): TPMS alerts the driver when the vehicle's tyres are below their ideal pressure. A well-inflated tyre offers least rolling resistance and thereby increases fuel efficiency. Driving on tyres with air pressure at 50kPA (0.5kg/cm^2) below the recommended pressure decreases fuel efficiency by 2 per cent and 4 per cent in

urban and suburban areas respectively. Cruise control: Cruise control automatically maintains a vehicle's selected speed. The driver sets the speed and the system continually adjusts the throttle to maintain the set speed; this can lead to lower fuel consumption than that of an unassisted driver. Enhanced digital maps: both the in-built systems and the driver can operate more efficiently with additional information to help with choice of gear and speed. The most important data concern the current speed limit and the gradient of the road, e.g. to help decide when to change up or down a gear, or when to ease off the accelerator. Vehicle communications: vehicle-to-vehicle communication can enhance ACC to allow a vehicle to take account of movements of others further ahead in the traffic, thus reducing the need to change speed. Also, vehicle-to-infrastructure communication can transfer onboard driver and vehicle monitoring data to a service centre, or to the Internet where the driver can compare his performance over time, and against his peers.

Impacts and benefits:
 	
Eco-driving training leads to a reduction in fuel consumption of up to 20% after training, with a significant long-term effect of 7% under everyday driving conditions. In 2004 an "Ecodrive" programme in the Netherlands resulted in a reduction in CO_2 emission between 97,000 and 222,000 tonnes but it was felt that further driver training and promotion of the programme would be needed to maintain reduced fuel consumption. It was also suggested to integrate the principles of eco-driving in new driver tests[7]
 	
The European Climate Change Programme calculated that eco-driving could save 50 million tonnes of CO_2 emissions in Europe by 2010. The independent TNO research institute estimates cost savings to society of up to € 128 per tonne CO_2 saved.
 	
To show the dimension, with an average of 7% saving this is equivalent to approximate annual savings in EU-27 of 16bn litres of petrol/diesel (> 20bn Euro p.a.)[8]
 	
Another example of good practice is the European campaign to improve driving behaviour, energy efficiency and safety (ECODRIVEN initiative). This campaign runs across nine countries throughout 2007-2008 and aims to raise awareness for eco-driving and smart, smooth and safe driving techniques that lead to average fuel savings of 5-10%. The campaign wants to reach 2.5 million drivers and avoid 0.5 million tonnes of CO_2 in the period up to 2010[9]
 	
Eco-driving can have a number of positive benefits, including:
▪ Fleet owners/management: Cost saving due to
    ○ Decreased fuel consumption
    ○ Decreased costs for maintenance, service and repair
    ○ Possible reduction of insurance costs
    ○ Lower cost of taxes;
 	
▪ Driver:
    ○ Rewards according to green driving skills

7 EEA Technical report No.2/2008: Success stories within the transport sector on reducing greenhouse gas emissions and producing ancillary benefits

8 250 million Vehicles, 12.000 km p.a., 7.5l/100km, 7% sustainable saving, 1 liter= 1,30 €

9 see http://www.ecodrive.org and http://ec.europa.eu/energy/intelligent/projects/doc/factsheets/ecodriven.pdf

o Less stressful working conditions (due to lower speed) o Safer driving, fewer accidents. Long-term analysis shows that the promotion of efficient driving can increase overall fuel efficiency of passenger cars by five to ten percent, a non-negligible contribution to reducing greenhouse gases. While there is general agreement on the order of magnitude of the benefits of eco-driving support, more structured research is needed. For example, the detailed mechanisms linking drivers' actions with changes in instantaneous fuel consumption and CO_2 emissions are not well documented. The link to gear shift and accelerator behaviour is not reflected in today's micro-simulation models of vehicle behaviour or traffic; engine/drivetrain models also need to integrate driver behaviour. Research at University of Leeds, TNO, Imperial College.
Cost (vehicle, infrastructure, etc): Systems to monitor fuel economy and display the information to the driver have little added cost, as most data are already available on the CAN bus and existing displays can be re-programmed. The additional cost for a communication module can be shared with other systems such as pay-as-you-drive or eCall.
Deployment requirements: A proposal for a new regulation concerning type-approval requirements for the general safety of motor vehicles was published recently, addressing Low Rolling Resistance Tyres (LRRT) and Tyre Pressure Monitoring Systems (TPMS) in order to reduce CO2 emissions from cars. The Commission has also declared its intention to require all new cars to be equipped with a Gearshift Indicator. Data privacy and protection issues for data recorders, online monitoring. Although it has been shown that driver behaviour can be improved towards greater safety and lower fuel consumption simply by the fact that the driver is being monitored, it is important to ensure that the monitoring data are used with suitable protection in the case that the driver is an employee, or are anonymised in case the data are uploaded to the Internet.
Other comments: Traffic infrastructure, regulations and enforcement may need to be modified to support good eco-driving behaviour, and prevent poor behaviour .

Recommendations:

- Research to identify and validate the critical parameters for fuel efficiency and eco-driving. The parameters need to be weighted according to different scenarios and transport situations.
- HMI development based on user and customer needs and requirements in order to facilitate the deployment and outcome of driver coaching systems.
- Hybrid power train vehicles require specific eco-driving

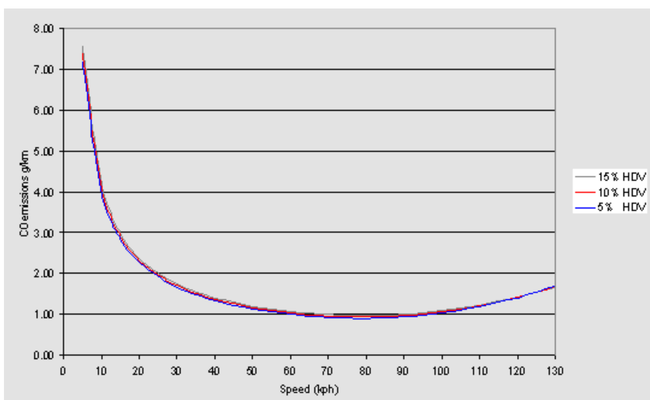
methods according to the type of hybrid technology, type of transportation, type of vehicle etc.

- Research is also needed to optimise hybrid eco-driving according to different variables, such as long-and short term optimisation of considering battery life cycles, the interaction between electric engines and combustion engines, instantaneous eco-driving actions, eco-driving for long-routes, the whole hybrid system's life cycle etc.
- EU to make low-resistance tyres, tyre pressure monitoring systems and gear shift indicators a (mandatory) option for all new cars
- Need to develop standards for system performance, data exchange, interfaces etc.

M.2 Eco-traffic management

It is estimated that traffic congestion costs about 2% of EU GDP. It also leads to extra fuel consumption and thus CO2 emissions. Optimised traffic flow management & control helps to improve road safety and also contributes to clean & efficient mobility as improving traffic flow leads to shorter journey times and lower average fuel consumption, while fewer stop-start cycles leads to lower fuel consumption and related emissions.

In urban areas, an increase in average speed dramatically reduces fuel consumption as shown in Figure 8.



Highways Agency

Figure 4: Specific vehicle CO2 emissions vs. speed

Another group of measures aims to give drivers information and guidance to help them reach their destination with least delay and lowest emissions, through collection of traffic monitoring data, and providing routing recommendations to avoid any congestion.

Where the volume of demand in the network does not permit such optimisation, then various tools for demand management are available. These aim to suppress part or all of vehicle-based trips and to encourage drivers to use more energy-efficient means of travel and transport.

Significant benefits can be achieved by the deployment of one of the latest generation of dynamic urban traffic control

(UTC) systems. These measure traffic flows and queue lengths and alter the traffic signal parameters dynamically to minimise total vehicle delay or another criterion. Installing such a system to replace fixed-plan traffic control can already bring significant benefits for the environment. However, there is potential to increase benefits further by optimising the traffic network management according to energy consumption or emissions.

Case study: Co-ordinated Dynamic Urban Traffic Control and Traffic Management
Description of measure: Dynamic traffic signal control relies on the detection of vehicles in real time and uses an embedded model to estimate a performance measure based on such traffic parameters as delay, stops and congestion. This performance measure may be optimised to maximise the traffic capacity across a signal control region, or to coordinate vehicle flows so as to minimise the number of stops. Performance measures may be converted to air pollutant emissions, fuel consumption or carbon emissions so that signal timings can be optimised to reduce environmental impact or minimise journey cost by reducing fuel used. Good traffic management becomes most important when the network reaches saturation. At this point queue location must be managed (to prevent blocking upstream junctions) and also speeds and flow levels (to reduce emissions or noise). This can be achieved through gating and metering of traffic by using the green splits and offsets, or with variable message signs (VMS) to advise speeds or alternative routes. When traffic problems recur at the same time and place then management measures can be implemented in specific areas of the network or at specific times of the day (or both). These measures can be tactical or strategic. One tactical measure could be the relocation of traffic congestion away from a narrow, residential street, with many pedestrians, to a more open space where natural ventilation can disperse any pollution. Strategic measures include park and ride schemes and bus priority lanes, giving pedestrians greater priority at traffic lights or green wave signal synchronisation through a series of junctions.
Functioning (how it works): The intelligence and flexibility of ITS provide the potential to manage networks across modes so that an integrated traffic control and management system has due consideration for the benefits achieved through public transport integration. Traffic management measures on motorways include variable speed limits through VMS, emergency stop lane/hard shoulder running and access control using ramp metering. Multi criteria traffic control can be achieved dynamically in time and space against different objectives, according to various high-level operational strategies. Even if a measure reduces the volume of stop-start traffic it may have second order effects that can encourage traffic demand to grow. In urban areas traffic management can try to balance the conflict between providing priority for public transport (red truncation, green

extension), pedestrians (short cycle times, scramble junctions) or vehicles. It is important to develop evaluation tools to assess the different trade-offs and the performance of various measures. This information can be presented to the operator and traffic manager to improve decision support, and also to the public to affect route and mode choice.
Enabling factors: • Reliability of data collection • Sensors for traffic, carbon emissions and air quality • New actuators • Standardised databases and statistical analysis to gain information and knowledge from the data collected • Accepted methodology(ies) for assessing the emissions and relating these to traffic system parameters • Communication network (low latency) between adjacent traffic signals • Standardised, user friendly and simple to understand information platform
Impacts and benefits: Evidence for the effectiveness of dynamic urban traffic control is strong and established over many years of experience. A pioneering system was the SCOOT (Split Cycle Offset Optimization Technique) UTC system developed by TRL as a tool for managing and controlling traffic signals in urban areas. It is an adaptive system that responds automatically to fluctuations in traffic flow through the use of on-street detectors embedded in the road. The effectiveness has been assessed by major trials in five cities (Glasgow, Coventry, Worcester, Southampton, London) where a reduction in journey travel time by 8% (cars) and 6% (buses) was measured, and a 20% reduction in delays[10]. On critical route sections improved traffic management can reduce traffic delay and congestion by up to 40%, with equivalent energy savings. A recent quantitative evaluation trial study[11] on the Tokyo Metropolitan Expressway and its new "Oji section" showed that the reduction of traffic congestion reduced annual CO_2 emissions in central Tokyo by between 22 and 31 million tonnes. In fuel conversion terms, this reduction corresponds to the annual gasoline consumption of approximately 10,000 passenger cars. A study in Southampton found that a Parking Guidance and Information System could reduce the average time spent searching for a parking space by 50%. If as is the case in some cities up to 30% of all vehicles in urban central areas are looking for a parking spot, overall saving on fuel and related emissions would be substantial. Traffic light synchronization has the potential to increase intersection throughput for private traffic by 15%. ACEA[12] estimated the yearly CO_2 reduction potential and costs of substituting 50% of current traffic lights with modern dynamic UTC, which generates an optimal traffic flow by adjusting to traffic conditions, and came to the result that 2.4 million tonnes of CO_2 p.a. could be saved across the EU. The UTOPIA (Urban Traffic Optimization by Integrated Automation) /SPOT (System for

10 SCOOT: http://www.scoot-utc.com/

11 JAMA documentation on CO2

12 ACEA Position Paper " Reducing CO2 emissions through infrastructure measures", May 2008

Priority and Optimization of Traffic) system developed by Fiat Research Center, ITAL TEL and MIZAR Automazione in Turin, Italy has been fully operational since 1985 on a network of about 40 signalized junctions in the central area of Torino and is now used in several cities in Italy, the Netherlands, USA, Norway, Finland and Denmark. The improvements attributed to UTOPIA (at 1985/86 traffic situations) were increase in private traffic speed of 15,9% on average, and of 35% in peak times. Public transport, which was given absolute priority, showed a speed increase of 19.9%.
Timing Intelligent transport systems are being delivered to a greater and lesser extent, across the whole of Europe mainly on trunk roads, motorways, towns and cities but also in rural and other networks. However the real challenge is for the control and management of traffic to be integrated across all systems (up to 3 years), networks (up to 5 years), and modes (10 years).
Deployment requirements & barriers: It is becoming increasingly important to have standardisation not just of the hardware but the database formats, software, information platforms. As ITS and other technologies are rolled out across Local Authority boundaries, across regions, nationally and across Europe consistency in all respects will have to be achieved. Barriers are political, organisational, technical and will require investment. Difficulties will arise if nationally managed motorways are not integrated with the urban road network to provide seamless management of traffic.
Deployment actions: These depend on the technology and the purpose for which it has been deployed. In urban areas demand responsive control would be implemented by traffic engineers when the traffic flows in a signal controlled region are continually varying through the day and from day to day by typically more than about 10%-15% resulting in congestion. The demand responsive technology would be a substantial investment made by the Local Authority and when installed, calibrated and fully commissioned will have justified its investment in typically 18 months. Maintenance and running costs of the system should be outweighed by benefits in terms of reduced delay shorter journey times, fewer accidents and less impact on the environment. An air quality action plan would be deployed when the weather conditions are such that at the expected level of traffic demand a pollution 'hot spot' is likely to occur. In this case when the combination of conditions occur a predefined signal plan will be implemented to, for example, relocate queues to an open space to enable the natural dispersion of tailpipe emissions. This strategy does not reduce emissions but simply spreads them around the network to avoid excessive levels at a particular junction. A complementary strategy would be to implement a park and ride scheme to reduce the traffic flows sufficiently to prevent the congested related emissions from occurring.

Variable message signs

Another measure in the Green ITS traffic management toolbox is the variable message sign (VMS). VMS can guide traffic away from problem areas, optimise section speed and capacity and lead to 10-30% less accidents with 2-8% less emissions. It can also provide traffic information and re-routing recommendations, that can influence drivers to change their behaviour and lead to congestion relief.

Cooperative systems

Intelligent Co-operative Systems13 are the next big challenge in automotive electronics and ITS. Cooperative systems allow communication between vehicles and infrastructure (vehicle-to-vehicle, vehicle-to-infrastructure and vice versa) and even with an equipment rate of only 20% (according to the German INVENT project) could lead to fewer traffic jams on selected highway sections due to smoother traffic flows. For example, the provision of personalised real time traffic information to drivers represents a promising service whose application will allow motorists to make informed route choices. It will also be possible in the future to book a parking space ahead of the trip.

Indeed intelligent co-operative systems increase the "time horizon", the quality and reliability of information available to drivers about their immediate environment, and about other vehicles and road users, enabling improved driving conditions leading to enhanced safety and efficiency of mobility.

Similarly, co-operative systems offer increased information about the vehicles, their location and the road conditions to the road operators and infrastructure, allowing optimized and safer use of the available road network, and better response to incidents and hazards.

Intelligent co-operative systems will build and expand on the functionality of autonomous and stand-alone in-vehicle and infrastructure-based systems, such as Intelligent Vehicle Safety Systems (eSafety systems), including Advanced Driver Assistance Systems (ADAS), traffic control and management systems, and motorway management systems.

13 http://www.cvisproject.org/en/about_cooperative_systems/introduction/

The benefits of intelligent co-operative systems stem from the increased information that is available of the vehicle and its environment. The same set of information can be used to extend the functionality of in-vehicle safety systems, and through vehicle-to-infrastructure communications for more efficient traffic control and management. The benefits include:

- Increased road network capacity
- Reduced congestion and pollution
- Shorter and more predictable journey times
- Improved traffic safety for all road users
- Lower vehicle operating costs
- More efficient logistics
- Improved management and control of the road network (both urban and inter-urban)
- Increased efficiency of the public transport systems
- Better and more efficient response to hazards, incidents and accidents.

One key project in this context is CVIS (Cooperative Vehicle Infrastructure Systems) whose objectives include:

- Create a unified technical solution allowing all vehicles and infrastructure elements to communicate with each other in a continuous and transparent way using a variety of media and with enhanced localization;
- Enable a wide range of potential cooperative services to run on an open application framework in the vehicle and roadside equipment;
- Define and validate an open architecture and system concept for a number of cooperative system applications, and develop common core components to support cooperation models in real-life applications and services for drivers, operators, industry and other key stakeholders;
- Address issues such as user acceptance, data privacy and security, system openness and interoperability, risk and liability, public policy needs, cost/benefit and business models, and roll-out plans for implementation.

The project deals with the following applications (listed according to customer preferences):

- Area routing and control
- Cooperative traveller assistance
- In-vehicle map update
- Obstacle warning
- Road status report
- Urban parking zones
- Flexible lane allocation
- Personalized route planning
- In-vehicle internet.

All of the applications are of environmental relevance but the project is still in progress and no results are currently available.

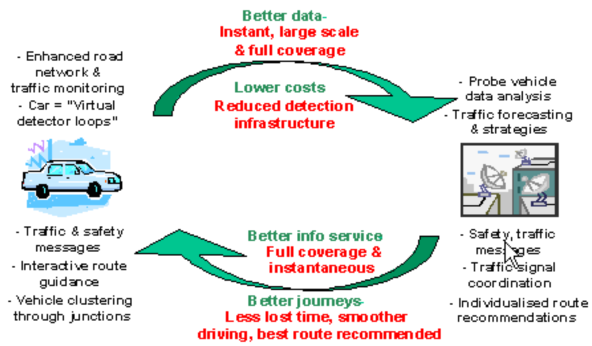


Figure 5: Better data – better information

This figure shows how cooperative systems can break the “vicious circle” of ever-worsening traffic problems by offering – for the first time – new ways for drivers and their vehicles to interact (and not just react) with a more intelligent infrastructure. And that new intelligence is due to new kinds of information that come, at least partly, from individual road users.

Urban traffic management and control centres cover a certain road traffic network of relevance. They are not applicable to other roads. E.g. traffic light synchronization is not relevant for rural roads. The innovation in CVIS is to link vehicles to the nearby roadside systems, allowing the traffic control system to interact with individual vehicles, e.g. to set up a local “green wave”, or to give a driver a recommended route to his destination that avoids known trouble-spots. Such a system could easily be optimised for least total fuel consumption rather than delay, that could further reduce emissions. In principle, with vehicle-infrastructure communication it would be possible to monitor each vehicle’s fuel consumption in real time and provide feedback to drivers as well as anonymous data to the traffic control system for signal optimisation.

Barriers to deployment:

- Technologies that are needed to create applications where vehicles and roadside infrastructure can talk to each other directly are not yet fully developed and validated
- Cost of investment in road construction, road safety improvements and for intelligent infrastructure
- Cost of traffic data collection
- High market fragmentation for roadside and in-vehicle equipment and related Telematics services
- Lack of technical standards
- No or poor information on alternative or complementary traffic modes/means including time and cost to reach a destination
- Low willingness of drivers to pay for traffic information
- Political priorities and limited budgets. Main entities involved are not yet persuaded of the utility and benefits of investing in cooperative system RTD, and the whole domain is as yet undeveloped.

Recommendations:

- Structured and organized exchange and political acceptance of best practices
- Gather and disseminate evidence for environmental benefits of advanced management & control systems
- Improve and organise collection of traffic information through floating car/phone/device data
- Initiate research & development of eco-optimised traffic management models including multi-modal traffic

planning and forecasting

- Investigate potential of cooperative systems with regards to safety and eco-efficiency
- Expand work on R&D for environmental monitoring & modelling, methods of impact assessment and impact analysis, development/adaptation of simulation models
- Improve incident detection and post-accident management
- Dissemination and application of onboard diagnostics to identify problems before they lead to breakdowns or accidents
- Give drivers on-line access to real-time traffic, travel and parking information
- After careful analysis public authorities/road operators should invest in state-of-the-art intelligent infrastructure, e.g. VMS, traffic control, speed management in respective areas
- National and local governments should cooperate and harmonise the approach to environment-friendly mobility in order to ensure interoperability, lower cost and greater impact

M.3 Eco-information & guidance

This group of measures includes two main themes:
- information and guidance for the driver, and
- information and guidance for the traveller.

As each comprises rather different types of system and information they are treated separately below.

Theme: Eco-information and guidance for the driver
Due to the explosive growth of portable navigation devices, a high proportion of drivers now use route guidance as an aide for finding their way and, increasingly, also for receiving traffic information and avoiding congestion. All navigation systems, including in-built and portable devices, depend on a digital map of the road network.

Most in-built systems and growing number of portable devices use TMC technology to receive and display information on traffic incidents and suggest alternative routes. Other key features are:
- Real-time data about free/full parking facilities;
- Pre-trip & on-trip multi-modal journey planning;
- Weather information, etc.
- Nearest public transport lines and fares.

Navigation systems can provide substantial benefits for fuel economy and environmental impacts. These include:
- Savings of driving time and fuel consumption, avoid traffic jams through real-time traffic information
- Reduction of mileage driven in unfamiliar areas by 16% (TNO study)
- Saving of up to 30% mileage searching for a parking place
- Less time caught in traffic jams, with lower energy consumption and emissions when supported by inter-modal information.

However, there are opportunities to enhance navigation and guidance even further with a view to energy efficiency and lower environmental impacts. For example, by adding additional information to a digital map such as gradient or environmental sensitivity it would be possible to use a routing algorithm that optimised a journey for fuel economy or least environmental impacts. Such “eco-guidance” features have already started to appear in some navigation systems, where as well as a choice of shortest or fastest route, or route with most or least motorway, a driver could be offered the route with least-CO2 emissions or with least nuisance.

In built-up areas such eco-information could extend to real-time guidance taking account of traffic signal optimisation or actual and historic traffic data, or where a routing server could distribute traffic over a number of alternative routes, thereby avoiding overloading any individual links.

Barriers to further market growth can be summarised as follows:

- Traffic data are often incomplete and inaccurate
- RTTI/TMC Traffic information is not always free of charge
- Lack of European-wide standards and interoperability
- Important safety features, environmental and alternative traffic mode information not yet integrated or available
- Lack of on-line information services for drivers e.g. parking information, urban road traffic information, environmental information
- Limited options for integration of mobile navigation systems in vehicles.

Recommendations include:

- Insist on safe and sustainable integration of mobile navigations systems in vehicles;
- Agree on certification process for nomadic devices to prove compliance with European guidelines;
- Expand take-up of vehicle based traffic data collection and integration with fixed systems;
- Explore potential for cooperative systems to improve data collection and exchange and agree on deployment roadmap
- Pursue traffic information interoperability by promoting traffic information service publishing according to Service-Oriented Architecture/Web Service standards

- Integrate more safety & environmental features for safer and eco-friendlier driving.

Theme: Eco information and guidance (traveller)
This theme comprises information services to the traveller, including info and services on the road network, environment, public transport, incident alerts, recommendations, etc, directed to individuals who may become drivers, passengers or pedestrians along the different stretches of their multi-modal journey. Types of information needed include:

- include on all available transport modes such as car, PT (bus, taxi, metro, train, flight, ferry), walking, bike (renting options)
- real-time information on timetable, service status, cost, availability, accessibility
- information on interchange requirements including Park & Ride
- information on environmental impacts
- information on various travel options with information on journey time, monetary cost, journey time reliability, environmental cost, health impact
- information on car-sharing (availability of car sharing) given as an option

Functioning:
Devices which are potable and owned by on individual or which are public and are embedded in a smart environment given access to information services. Access information and physical access to the different transport modes is enabled. The user can make well founded decisions – including environmental, time and cost criteria-both pre-trip and en-route. Decisions on modal changes are possible on trip.

- pre-trip information based on personal profile, journey purpose and preference, personal interests, etc.
- seamless travel experience (information support, booking and payment, en-route modal change)
- en-route information support through the journey based on the preference of the traveller and real-time information (traffic, weather, incident, etc)
- user-friendly collection of post trip feedback to validate

the traveller's experience

- system feedback for traveller on journey time, environmental impacts, compared with other travel options

Enabling factors

The challenge lies on the seamless access to and the integration of diverse systems and technologies, as well as on the timely update of information which must be sufficiently precise.

- personalised information provision (website including wireless access)
- location-based traveller information
- personalised mobile device
- supportive infrastructure: P&R

Impacts:

Private cars' energy consumption is between 6 and 30 times the energy used by public transport per passenger-km. This ratio is even bigger with respect to emissions. If by facilitating multimodality 30% of the passenger-km were shifted from private cars to public transport, this would lead to a reduction of at least 30% in energy consumption and much more in the emission of pollutants. By reducing traffic demand, the energy efficiency for other vehicles on road is improved at the same time.

Cost (vehicle, infrastructure, etc):

- information integration from all modes and multi-modal journey plan with environmental impact
- communication cost
- essential infrastructure such as car park, real-time information display/kiosk

Timing:

2 years for existing information providers to integrate environmental information with existing services

Deployment requirements and barriers

- cooperation between various transport operators (public transport operators, traffic operators)

- privacy
- data ownership

Deployment actions:

- small scale pilot demonstration is needed
- cost-benefit study to show benefits (short and long term) of such system on health, environment, energy consumption, etc.
- large scale demonstration in selected cities and regions
- policy or location authorities investments encourage such systems

Recommendations:

- EC needs to support such systems
- Research needs for such systems including data integration, real-time information management, HMI.
- Cooperation between various stakeholders with support of authorities at country/city/region level

M.4 Eco-demand and access management

Under the heading of "Eco-demand and access management" there are two related types of measure that can influence emissions and energy use: Demand Management and Access Management. Each has a different focus but are both used to better manage mobility by acting directly on demand for mobility, as opposed to Eco-traffic management that tries to optimise its supply.

Demand Management describes measures to influence the demand for transport and mobility. Mobility management tries to enable mobility while at the same time reducing the burden of increasing traffic.

Key principles are:

- Focus on mobility and accessibility, and not traffic
- Strive for sustainable, more efficient, socially acceptable and ecological mobility
- Base measures on information, communication, organisation and coordination
- Change choice of traffic means (modal split) in the direction of more environmentally friendly and more sustainable means of transportation (e.g. walking, bicycling, car sharing, public transport, railway & inland water transportation vs. truck, cars and planes)

Managing demand for mobility in an eco/energy-efficient way requires an integrated approach and involvement of all relevant stakeholders, provision of reliable, real-time and dynamic information on alternative means and schedules and information on how they connect to allow the private and commercial customer to go from A to B. Last but not least information must be provided on journey costs and travel time. Each customer needs full knowledge of the alternatives to choose according to his personal priorities (energy-efficiency, environmental friendliness, productivity (cost/time)).

This networking of alternatives is not yet deployed. Consequently environmental benefits are either not yet fully evaluated or are based on simulations under limited assumptions. Socio-economic aspects on how modal shift would impact employment, overall cost of mobility and disposable income have not been investigated neither.

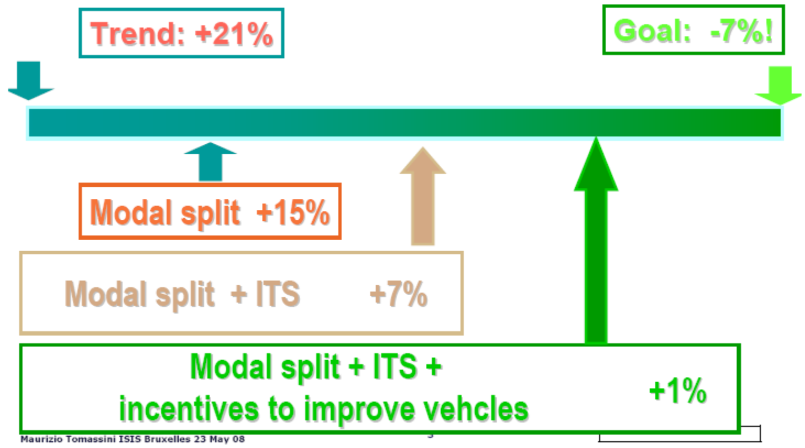


Figure 6: CO_2 reduction contributions by modal split

ISIS14 sees the potential for a 15% reduction in CO_2 through modal split alone, an additional 7% with the help of ITS and another 1% through incentives to further improve vehicles.

A variety of techniques may be used for demand management. Probably the most common is some form of charge relating to vehicle type or vehicle use. This can take the form of a specific tax or charge, or can be related to the distance travelled, to the location where the vehicle is used, or the time of day. A congestion charge, for example, may even vary directly according to the degree of congestion.

As a complement to demand management measures, it is important to raise awareness of modes of transport that are less energy-consuming than road transport, especially for moving goods long distances. Switching to rail transport or developing efficient short sea shipping can be particular effective when different modes of transport are effectively combined. Air transport still has a much greater environmental impact than other modes and is growing fast. Great efforts are needed to make necessary trips more energy-efficient without sacrificing productivity.

Access Management helps to achieve the necessary balance between traffic movement and accessibility by controlling access by vehicles to specific areas, with the aim to reduce congestion or improve air and environmental quality. The scheme may distinguish between different vehicle types or

14 Maurizio Tomassini, ISIS, Presentation Brussels 23 May 2008

characteristics such as emission class, may restrict access to residents of a zone, or may limit the number of trips. A number of ITS technologies may be used for vehicle detection and access management.

Traffic access to environment-critical areas can be controlled by intelligent access restrictions, intelligent infrastructure and charging schemes in order to

- Manage daily traffic load and flow
- Create a safer environment, less severe crashes
- Reduce inner-city congestion and pollution
- Increase fuel economy
- Improve inner urban living quality
- Charge according to polluter-pays principle

Case study: Access Management taking account of emission criteria
Description of measure: Road charging and Low Emissions Zones. Technologies that control the access of vehicles to a specific part or area of a city or urban area. This involves ways of observing number plates of vehicles entering, transiting and exiting from the 'controlled' zone. The measure can address policy objectives such as reducing congestion and/or emissions. Any pricing policy should reflect the objective, for example to influence congestion a charge relating to distance or to enter a zone would be the same for all vehicles. An emissions policy might lead to no charge for smaller, cleaner vehicles and heavy penalties for the higher emitters.
Functioning: Through the pricing policy the driver is faced with higher out of pocket costs for each trip requiring access to the controlled area. This makes the alternative modes less costly and may induce a modal shift.
Enabling factors: • Off-vehicle technologies are applied in London and other cities, where roadside monitoring is combined with automatic number plate recognition; comprehensive database and link with the national vehicle number plate database for enforcement; billing mechanism and exemption database. • Tolling gates can collect charges through automatic fare collection. • Access control through electronic vehicle identification (EVI); for example identifying whether the vehicle is private or commercial, fuel type, Euro standard whether or not a diesel vehicle has a filter etc. as in the Netherlands. • Air quality within a city varies by time of day; technologies with flexibility and a predictive mechanism needed to allow pre-trip warning of potential problems. • Development of a 'fair' system is essential. However, in the case of threats, to health, measures do not have to be fair, switching in mandatory measures when need. • Require mechanisms for dissemination to the users. • Potentially in the future, technologies on vehicles to provide information for billing and enforcement but will need incentives eg lower tax/rebate on fuels
Impacts: Main impacts include reduced congestion, lower fuel consumption and emissions. Evidence of impacts is still growing as these measures are applied more generally across

Europe. The London congestion charging zones have resulted in a 16,4% reduction in CO_2 emissions (2003 vs. 2002) and 12% lower emissions of NOx and PM10 from road traffic, based on a 30% reduction in traffic congestion. Similar schemes have been successfully implemented in Oslo and Trondheim, where they also led to an increase in revenue.

However, there are also critical voices. A Swedish newspaper[15] reports on the Stockholm congestion charging scheme that costs for the urban charging stations have doubled over the last 5 years compared with an initial estimate of around € 97 million, and that first benefits cannot be expected before 2011 at the earliest.

In the access control scheme in Milan, city centre PM emissions were down 30% and the number of cars by 10%, resulting into quicker public transport journeys.

There is a trend to introduce environmental zones in more European cities using different methods. The environmental zone in Prague has been successful in reducing emissions from heavy vehicles entering the city centre through application of weight restrictions. Estimated reduction of CO_2 from this measure was given as 1650 tons p.a.[16]

Barriers to introduction include:

- Lack of end-to-end travel planning and information systems including on-trip dynamic traveller support
- Integrated planning processes are hampered by organizational divisions between transport modes, government agencies and services
- Transport planning tends to be regarded as a technical task, quite often lacking adequate stakeholder participation and delivering only piecemeal measures17
- General poor acceptance by drivers who see higher journey costs and less freedom
- Public transport alternatives not always available, may be expensive & inconvenient for some travellers
- High cost of infrastructure based schemes
- Lack of interoperability across Europe
- Conflict of interest between travellers and residents of environmental zones

Recommendations:

- Devise technologies and organisational structures allowing the provision of end-to-end travel services including on-trip dynamic traveller support taking into account network disruptions, delay, etc.
- Develop and agree amongst European Commission and Member States for a European interoperable solution and/or framework: one device, one contract, one

15 Dagens Nyheter, 20.02.2008

16 EEA Technical report No. 2/2008: Success stories within the road transport sector on reducing greenhouse gas emissions and producing ancillary benefits

17 EU sponsored PILOT Project on “Sustainable Urban transport Planning” (SUTP), 2007

invoice principle

- Offer flexible access to areas of a city
- Apply intelligent systems with effective enforcement
- Set up Congestion Management Centres to measure air quality (online) in order to redirect and guide vehicles based on temporary speed limits displayed on variable message signs and/or on vehicle displays, opening/closing additional lanes (incl. hard shoulder), remote ramp metering, traffic light synchronization, etc.
- Expand Park & Ride offer and provide multi-modal alternatives in a transparent way
- Privilege environmentally friendly vehicles
- Exchange and learn from best practice.

M.5 Eco-mobility services

Under this heading we understand a wealth of applications using information and communication technologies that complement the principal means of travel and transport considered under “Intelligent Transport Systems”. These services (mainly intended for use by persons and not for goods) share the quality that their use implies a lesser impact on the environment than the use of individual road transport.

Although there are many examples we could include in this section, we concentrate here on three groups of service, that are described below:

- incentive schemes
- individual mobility
- collective mobility.

Incentive schemes

Under incentive schemes we include ideas such as “green bonus” or “earn-as-you-travel” and “pay-as-you-drive”. Beginning perhaps as a voluntary scheme where people try to live within a certain CO_2 budget, this could work by an application in a user’s GPS-enabled mobile device that could record sufficient journey information to allow an estimate of CO_2 emissions. The analysis could be made via an Internet service operated by a service provider or agency on the basis of uploaded data from each user.

The scheme would then reward or punish the user according to his/her CO_2 use compared to budget – awarding extra points for saving CO_2 and claiming back points when spending more than the allowance. Already there are a number of schemes in the marketplace for “pay-as-you-drive” insurance, where the cost of insurance is invoiced regularly on the basis of detailed exposure information (location, time, date) that is closely related to risk. These schemes are successful in both reducing the cost to users (who modify their driving to reduce costs) and reducing the risk to insurers (who receive more or less revenue when driving is more or less risky, respectively).

Individual mobility

Under individual mobility schemes we consider ideas that preserve many of the qualities of individual transport that today favour its continual growth in the face of ever-growing demand and consequent congestion. Thus, the "door-to-door" convenience of a private car or two-wheeler; the freedom to enjoy one's own infotainment content and climate control; the feeling of security; and the flexibility to set one's own timetable and route are benefits that must be approximated by any innovative service aspiring to attract drivers out of their vehicles.

However, pressure is growing to find more economical ways to travel, and with rising fuel prices and advantages such as those granted to "high-occupancy vehicles" where they may use a reserved highway lane, there is interest to find novel ways to increase vehicle occupancy. A combination of mobile phone with GNSS positioning, an Internet-based broker service and a kind of "Web 2.0" social community could offer a way that a vehicle driver could find compatible and trustworthy passengers to share a ride whilst offsetting some of his travel costs and perhaps even provide an agreeable travelling companion!

Such new mobility services could be stimulated by suitable tax or other incentives. A user could call up the ride-share service on the Internet or on his mobile device, and see on a map who was offering places to his destination, with the time of passing a number of potential pick-up points.

Case study: Car Sharing in Bremen
Description of measure: This scheme is designed for those who need the occasional use of a car in a city where they live, work or visit. A pool of cars is available for short-term hire, distributed at locations across the city. The user subscribes to the scheme (for a reasonable fee) and then pays per use, by time and/or distance.
Functioning: The system operates via Internet. The user can subscribe, check vehicle availability and book via the car-sharing website. Payment is electronic also. Once the car is booked the user gains access via his subscriber smartcard, that also serves as key for contactless unlocking and user registration.
Enabling factors: • Availability of shared-car parking spaces at busy city centre locations, e.g. rail stations; • Political support, often combined with willingness to subsidise the scheme; • Good coordination with other modes, e.g. railways, local public transport, car parks; and with major activity centres, e.g. employers, shops etc. • Public awareness campaign based on realised user benefits.
Impacts:

Operational since 2003, the Bremen “mobil.Punkte” car sharing stations now (03/2008) serve 4500 customers, with over 100 vehicles at some 34 stations.

- On average each shared car replaces between 4 and 8 individual cars, that reduces parking demand and traffic due to searching for a parking space;
- Car-share subscribers make a more rational use of transport and use their own cars less in the city, and use public transport more frequently;
- The car-share vehicles are certified as meeting the most stringent emission standards, thus on average they emit less than the average private car;
- Total private car use in Bremen has been reduced by over 6 million km annually, equivalent to over 1100 tonnes saving in CO2, and by the equivalent of 900 private cars.

Collective mobility

Collective transport services, ranging from taxis through mini- and midi-bus to full-scale bus services, could be configures to help reduce greenhouse gas and other emissions, and fuel consumption. Starting with taxis, these could become more responsive if a potential customer could see on his mobile device the availability of all taxis in the nearby area, and could call one up simply by “clicking on” the nearest one. The customer could also indicate his destination & departure time to an online Web-service, and the interested taxis could respond directly. This would make booking easier for both customer and taxi driver. It could also open the way to a more successful shared taxi service by helping taxis and passengers to meet up and match.

The smaller service buses could gain customers and improve revenue by adapting their routes and service timetable, by using communication with users’ mobile handsets to identify potential customers and to provide them with information on the next service to pass (location and time).

Similarly, even fixed-route large-vehicle services could benefit from knowing passengers’ intended destination, as this could help to adapt the timetable and the service volume offered. Departures could be programmed more flexibly for example to synchronise with feeder services or Park & Ride facilities. However, users need to know in advance and during the journey the timetable of each vehicle relevant to their journey. This information is needed before the driver sets off in his car, and during the journey if it is still possible to use multiple modes.

All these improvements could increase the attractiveness of collective transport and help persuade drivers to leave their vehicle at home or at a peripheral car park, thus providing direct environmental benefits. And these technologies could help make the service offering much better adapted to the changing demand, that would of course need to grow to compensate for those drivers changing from car to collective means.

M.6 Eco-freight and logistics management

The final application domain of Green ITS to be considered is that of freight and logistics, and fleet management.

A main concept in logistics management that is recently taking shape is the one of "Intelligent Cargo". Intelligent Cargo is intended to provide:

- Enhanced and widespread capability to monitor, trace and safely handle moving goods at the required level of detail, from full shipments to individual packages or items;
- Increased efficiency of transportation networks, by improving synchronization between logistic users, operators and control authorities.
- Improved sustainability of logistic systems, by reducing their impact on local communities in terms of traffic congestion and pollution.

To achieve these benefits, the Intelligent Cargo concept develops into a number of essential improvements on how moving goods are currently handled by ICT systems:

- Self-awareness means the ability of cargo to interact with the surrounding environment to actively notify its presence, identity and requirements. Despite recent developments in RFID technologies, moving goods are still perceived as passive entities that need to be tracked down by accessing some central system, fed by the back-office transactions of logistic services providers, carriers and consignees. An Intelligent Cargo item will be an active provider of information services, notifying to the interested users and systems its details, position and related events as they occur.
- Context-awareness means intelligent ad hoc combination of information from all the involved stakeholders (shippers, logistic services providers, infrastructures and authorities), based on the current cargo position and status. An Intelligent Cargo item will "understand" its context in terms of interacting entities (vehicle, user, infrastructure), related information services (e.g., shipment schedule, positioning, terminal availability) and available combinations of services to solve specific user needs (e.g., automated update of trans-shipment schedule based on proactive notification of arrival from the cargo itself).
- Connectivity of moving goods means their constant availability as service consumers or providers by

exploiting at need the mobile and fixed network infrastructures available along the route. Integration of Intelligent Cargo into service oriented architectures including mobile user and vehicle devices will make freight control virtually ubiquitous.

In such an overall framework, the currently predominant form of ITS today are fleet management systems and services. ITS for fleet management includes the management of cars, vans and trucks.

Fleet (vehicle) management functions can include vehicle maintenance and financing, vehicle and driver despatching, telematics services (such as floating-vehicle data collection, vehicle tracking and geo-fencing, cargo tracing, remote diagnostics and electronic fee collection), driver time and shift management, fuel monitoring and management, and health & safety management.

This requires an in-vehicle unit (original or after-market fit) for collecting certain monitoring data from the vehicle, driver and cargo, and sending these to a service centre. This is linked by two-way wireless communication (using either cellular or dedicated radio networks) with a service back-office that analyses the monitoring data and forwards it to the fleet owner, freight forwarder and/or cargo customer. The management or service centre can then contact the driver directly with advice or questions, and also the recipient of the goods at the destination of the journey, for example to confirm their expected arrival time.

ITS systems allow the collection of data for both real-time and "*a posteriori*" evaluation. It also helps the transport operator to develop strategies for better capacity utilization, select and optimise different transport modes (also from an environmental point of view) and to inform the customer on where his order currently is and when it will arrive. Professional planning and control avoids unnecessary trips and related emissions and helps to cut cost.

ITS also enters into the overall logistics chain, by linking in the movement of goods (using multiple modes if appropriate) with the production, handling and delivery processes. Such "smart logistics" can benefit from the use of mobile communications between vehicle and other actors in the chain, to better synchronise the transport process with all other processes that depend on the timely delivery of goods. Thus the use of traffic information, route guidance and electronic payment services can allow better coordination with the receiving end of a goods shipment – with adaptation in case of unforeseen problems – and a more efficient process if paperwork is replaced with online payment and administration services.

The Intelligent Cargo concept offers potential for substantial environmental benefits beyond those achievable by the services mentioned above. For example, one of the biggest sources of inefficiency is a low load-factor (ratio of the average load to total vehicle freight capacity) of many goods vehicles on the road. The proportion of truck journeys where the truck is empty (load-factor zero, or “empty hauling”) was 25% of total truck-km in Germany in 2000, and more than 40% in the Netherlands. There is also a tendency towards more frequent but smaller shipments as a result of the drive for greater logistics efficiency, that has a negative impact on load factors.

Web Services matching transport offer and demand can improve load factors, as can advances in packaging and loading systems that allow more flexible use of vectors’ capacity. Also operational improvements such as transhipment facilities with communication links to operators and their vehicles can increase load factors without adding excessively to journey or shipment times.

An area of potential improvement which may have a very large impact is the interaction of cargo with authority and infrastructure operators. For example, the process of authorizing goods transit at cross-border infrastructures is usually quite complex, integrating information from different authorities, the carrier and the cargo owner. Most of these information are still collected through paper-based processes, and partially through back-office integration. By means of Intelligent Cargo, operators will have the possibility to cross-reference relevant information on a cargo item directly in the field, automating the cargo certification process. For instance, tagged items in an intelligent truck can automatically certify that the truck actually carries what the papers declare, speeding up its transit.

According to market research from independent analyst Berg Insight, the number of fleet management units deployed in commercial fleets in Europe will exceed 1 million in 2008. Even though the overall penetration level is just a few percent, some segments such as road transport fleets may attain adoption rates above 30 percent.

Smart logistics & fleet management belong to an area where the market provides powerful incentives to take up Green ITS measures, and government interventions may not be needed. If investing in ICT provides economic and energy efficiency rewards to the investor, the market will develop itself. The main limitation of the market mechanisms is apparent when the costs of time are more valuable than the costs of transport, hence there is not a strong disincentive to running empty or lightly-loaded goods vehicles.

For the purpose of this report we have identified the following measures that can yield environmental benefits:

- An interoperability framework allowing the main actors on the field to expose and use Intelligent Cargo information services by linking these to their information systems
- A fixed and mobile Web Services framework for public and private stakeholders to access and use the information they need on a cargo item at any point along its route across European corridors, connecting the cargo with back-office and field staff.
- "on the fly" combination of services to address specific user/cargo/context interactions based on the concept of Service Oriented Architecture.
- Administration, planning, directing and control of vehicle fleets.

The key benefits are:

- Optimization of end-to-end flow of goods
- Coordination of road and inter-modal goods transport
- Significant productivity gains through optimized route planning and guidance
- Reduction of empty trips leading to less emissions
- Lower fuel consumption by maintaining an optimum vehicle speed
- Fewer thefts/follow up actions.

A recent study, the SMART 2020 Report18, argues that through a host of efficiencies in transport and storage, smart logistics in Europe could deliver fuel, electricity and heating savings of 225 Mt CO2 equivalent. The global emissions savings from smart logistics in 2020 would reach 1.5 Gt CO2 equivalent, with energy savings worth €280 billions. The implementation of efficient logistics levers enabled by ICT could result in an emissions reduction of approximately 27%, and road transport abatement opportunities represent 70% of the total abatement potential from energy efficiency measures in all sectors.

There are significant barriers to progress including:

- Fragmented, highly competitive market in Europe
- Many small companies with only few vehicles supplying a local/regional markets, low penetration of ITS technologies
- Perceived high investment costs for systems and high operating costs
- Lack of standards and need for open systems
- Insufficient interoperability between products
- Uncertainty and inconsistency on regulatory issues
- Lack of fiscal or operational incentives available from public sector

As solutions the following points are under discussion:

- Investigate possibilities of “green” logistics using the integrated approach brought by the Intelligent Cargo concept, focused on emission reduction and interaction of in-vehicle technology and systems with infrastructure and information
- Harmonization and interoperability of services to combat fragmentation of on-line service market by using Web Services and Service Oriented Architecture paradigm
- Develop/enhance truck specific navigation systems & maps
- Introduction of city logistics, special systems and facilities optimised for urban deliveries, e.g. favouring electric vehicles for downtown operation and transhipment facilities where goods can be transferred from large vehicles to city-friendly vehicles.

[18] SMART 2020: Enabling the low carbon economy in the Information age, The Climate Group, June 2008

M.7 Eco-monitoring and modelling

This last "Green ITS" area is horizontal in the sense that it is not an end service itself but can be an essential input to all the other services. Traffic monitoring techniques are rapidly becoming more accurate, with more complete road network coverage and with enhancements such as the integration of historical data. Floating-vehicle data collection is moving from a few "islands" of equipped fleets (e.g. taxis, trucks) in large cities to a more generalised monitoring of all drivers' mobile phone location, and now to full-network monitoring across the entire country by the newest generations of portable navigation devices with a cellular data connection.

Infrastructure-based monitoring is also expanding, with use of embedded cable loops or video/radar detectors at key locations. These may also be used for traffic control vehicle detection or automatic enforcement.

Environmental monitoring is still largely limited to the collection of air quality data at a limited number of locations in Europe's larger cities. These data are required for compliance with European legislation on permissible levels of the main airborne pollutants. However, they fall a long way short of the sort of complete coverage achieved for traffic monitoring for example.

Already a number of cities use vehicle-based air quality monitoring, and the UK MESSAGE project is investigating the potential of mobile monitoring combined with data management to relate air quality to vehicle emissions, weather, road design and driver behaviour.

The results of both traffic and air quality monitoring are needed as the basis of other Green ITS services. Thus, travellers need to know where there is unexpected traffic congestion in order to find the quickest route to their destination. But they may also wish to know where air quality is poor so as to avoid an ozone peak. Traffic managers also need these data in order to implement strategies for redirecting or reducing traffic in the locations and at the times when air pollution exceeds permitted standards.

For both traffic and environmental monitoring, data collection alone is not sufficient to guide remedial actions.

What is needed is forecasts of conditions in the future and at points of particular interest in the road network. This need can only be met by an integrated traffic and environmental model. The first generation of such dynamic forecasting models is now entering the market, such as the EnViVer integration between the Vissim dynamic microsimulation traffic model (PTV and Vialis) and the VERSIT emission model (TNO), but there still remains much development and validation to be done.

3. Conclusions and Recommendations

3.1 Conclusions

The Working Group (WG) is convinced that global warming and the need to preserve the environment in the face of growing demands for energy and mobility must be addressed and there is a need to act quickly.

The introduction of advanced ICT for transport safety will already bring secondary effects on environmental criteria and energy efficiency, even if these are not their primary purpose. So the WG supports the efforts to accelerate the deployment of ITS and ADAS promoted by the eSafety initiative.

The WG believes that the key to achieving sustainable energy savings and maintaining mobility for people and goods lies in the application of Information and Communication Technologies (ICT) in the form of "Green ITS" measures.

The WG believes that there is substantial untapped potential for a new generation of Green ITS technologies, applications and services whose primary purpose is to reduce environmental impacts or increase the energy efficiency of road transport. These measures lie within the triangle of an integrated approach that treats simultaneously the infrastructure, the vehicle and the driver.

The WG concludes that to achieve sustainable mobility non-ICT measures should take their place alongside the new "intelligent" techniques. The success of Green ITS will nevertheless depend on the quality of the underlying infrastructure. Therefore it is necessary to bring Europe's road, traffic management and transport system infrastructure up to the current state-of-the-art before full benefits can be obtained from ITS deployment.

The WG has identified seven types of Green ITS measure that seem to offer the greatest potential for environmental benefits. This potential has been supported by an assessment of a significant body of research and the presentation of specific case studies supplied by Working Group members:

- Eco-driving support
- Eco-traffic management

- Eco-information and guidance
- Eco-demand and access management
- Eco-mobility services
- Eco-freight and logistics management

- Eco-monitoring and modelling.

While the WG believes that within each of the above areas of Green ITS the measures identified in this report can deliver substantial benefits, it is not possible today to form a reliable and quantitative estimate of these impacts, either singly or if implemented together, as most of these measures are still in an early stage of development and few are deployed at a large scale.

Nevertheless, the Working Group believes that if all potential Green ITS measures would be implemented together and within a long-term concerted European programme supported by all key stakeholders, then an overall reduction of fuel consumption and CO_2 emissions in the order of 25% is achievable.

3.2 Recommendations

This final section suggests a number of recommendations reflecting the views of members of the Working Group, directed at different actors:

General recommendations

The WG recommends that a pan-European and multi-sector initiative be established to promote the development and rapid deployment of Green ITS.

The WG recommends to investigate further the mechanisms by which impacts of Green ITS are generated, and how the effects and potential benefits of integrated and interdependent systems can be assessed.

Formalised collection and exchange of best practice is needed to support Green ITS deployment.

A European roadmap and action plan involving all relevant stakeholders is needed to promote the implementation of Green ITS.

Governments should explore possibilities to promote more efficient driver behaviour through targeted measures such as fiscal or other incentives, as well as the adoption of "clean mobility" objectives within transport, energy and environment policy.

Standardisation bodies should identify the need for European and global standards for Green ITS technologies, and promote a corresponding standardisation road-map and action plan in order to ensure interoperability and successful market development.

Recommendations for priority Green ITS measures

Eco-driving support

Research is needed into how the "golden rules of eco-driving" might be automated within onboard and off-board services;

To create awareness and acceptance for eco-driving measures multi-media campaigns should be launched in a coordinated way;

Automotive manufacturers should explore the potential for additional optional eco-driving support functions such as eco-driving feedback display, reporting and analysis, on-line coaching etc.;

On-line services should be promoted that support eco-driving behaviour through comparison with the performance of a driver's peers, through competitions and incentives, etc.

Eco-traffic management

Research and development is needed into a new generation of urban traffic control systems that can be optimised according to environmental criteria, such as least overall fuel consumption, or that minimise CO2 or pollutant emissions;

Those cities where there is not a modern adaptive urban traffic and parking management system should be encouraged and helped to invest accordingly;

A guidebook should be compiled featuring best practice on energy-efficient traffic management strategies and measures, and distributed widely to urban traffic managers;

New public-private partnership models for cooperative system deployment should be explored.

Eco-information and guidance

Digital maps should be enhanced to include additional environmental attributes such as road gradient (slope), speed limits, truck-specific restrictions, road charging/ controlled access zone data, accident risk, historic traffic data etc.;

Public authorities that own such data should offer them to digital map providers;

Real-time traffic information (RTTI) service providers should offer enhanced information including critical weather conditions and multi-modal journey alternatives;

To improve the quality and coverage of RTTI services, floating car/device data collection, processing and delivery needs to be promoted in a joint stakeholder effort.

Eco-mobility services

Research is needed into the public acceptance of eco-mobility services and how to promote a shift towards eco-friendly modes;

Research is needed on the potential environmental benefits and fuel savings of ride-sharing, car-sharing and multi-modality concepts and end-to-end traveller support services;

Deployment support and large scale demonstrations are needed to build stakeholder acceptance of technologies and standards.

Eco-demand and access management

Technologies and the operational framework for demand and access management should be harmonised across Europe, around a core of European standards.

Eco-freight and logistics management

Research is needed into potential ICT solutions leading to fewer empty haul journeys and higher load factors, and towards innovative "Intelligent Cargo" technologies and services;

Research is needed to develop a standards-based open platform offering commercial vehicle fleet operators a range of services to improve fuel economy and reduce environmental impacts;

Support actions are needed for the demonstration and deployment of Intelligent Cargo concepts;

A multi-sector forum is needed to agree a common European approach to city logistics.

Eco-monitoring and modelling

For better decision making, new integrated tools for assessment and modelling of air quality, energy efficiency, CO2 emissions and traffic need to be developed and tested in a real life environment.

Annex 1: Terms of reference

Working Group - ICT for Clean & Efficient Mobility

Terms of reference

Co-chair ACEA, ERTICO

Aim

Identify and promote the potential benefits ITS applications & services can bring towards cleaner and more energy-efficient mobility for people and goods.

Background

The environmental effects of steadily increasing demand for mobility of people and goods present challenges that need to be addressed in the interest of long-term sustainability and public concern. The European economy and the prosperity of its citizens depend on a high level and quality of mobility of people and goods, while there is less and less opportunity to create new transport infrastructure.

Information and communication technologies (ICT) are the basis of intelligent transport systems, applications and services (ITS). ITS can be applied in support of "cleaner and efficient mobility" by improving communication and the collection and flow of information amongst vehicles and infrastructure in order to manage a smoother, more flexible traffic flow of people and goods and in the most cost-efficient way.

ITS applications for traffic efficiency can produce as side effects positive environmental benefits, for example traffic management systems that reduce vehicles' delay leading to less fuel consumption and lower emissions. However, there are relatively few ITS systems and services that specifically address environmental objectives.

The *e*Safety Forum is looking towards the environment as a potential area for future ITS development and deployment exploiting the architectures and technologies under development for safety applications. This new Working Group is intended to take the first steps to mobilise the various sectors that need to cooperate to work towards identifying possible new solutions.

Work areas

Examples of the technical and non-technical work areas could include:-

- Environmental traffic management strategies & operations, e.g. environment-optimised traffic light synchronisation, automatic traffic incident detection and management, congestion management, parking management, urban goods delivery management, air pollution crisis management etc.;

- Integrated traffic/mobility management systems, traveller information and guidance services;
- Infrastructural measures reducing the negative environmental impact of mobility;
- Cooperative vehicle-infrastructure systems, e.g. optimisation of vehicle-traffic management in order to avoid congestion, with accompanying environmental benefits;
- On-line environmental information services for drivers, travellers and operators;
- Systems, tools and incentives to support and educate drivers in environmentally-friendly driving;
- Innovative business and organisational models to deliver environmental ITS;
- Cost-benefit analysis of environmental ITS policies and options
- Measures to promote and support the deployment of ITS for Clean and Efficient Mobility.

Objectives

The *e*Safety Forum brings together a wide range of stakeholders in each work area to identify priorities for action to promote deployment of ITS and advanced safety systems and services. The area of ICT for Clean and Efficient Mobility is relatively new, and there is a need for an early assessment of the scope for action. Certainly there is a need for R&D in basic and applied eSafety technologies, but much progress can be made by better application and organisation of existing techniques. Also there is probably scope to apply in the ITS domain results coming from other domains.

The role of this Working Group should therefore focus on the identification of priority actions in R&D and deployment support.

The following objectives are proposed as first steps in this new work area:

- Identify and assess which ICT applications and services for mobility have the strongest potential to yield environmental benefits;
- Examine relevant measures that could complement and enhance the environmental compatibility and sustainability of mobility;
- Examine potential for educational and support tools and feedback to promote more environment-friendly driver behaviour;
- Undertake a cost-benefit assessment of measures to reduce environmental impact of mobility;
- Identify specific measures to promote and support deployment.

Participants

Representatives of key stakeholders: users, public authorities, infrastructure and telecom operators, automotive industry, transport & environment industries, NGOs, integrated traffic management specialists, energy industries, R&D institutes etc.

Annex 2: ICT for Clean & Efficient Mobility – Current activities

This Annex presents a summary of known projects, products and other activities in the domain of Green ITS, or “ICT for clean and efficient mobility”. These are presented separately for activities for mobility of people and for mobility of goods.

	ICT for People	ICT for Goods
Education/instruction based systems	Eco-Driving behaviour instructions, simulation, training	iManage (GE fleet) includes the ability to look at drivers performance in terms of spend, maintenance costs and CO2 profiles
	85,2% of accidents are caused by pure human error	Economical driving training for truck, bus and coach drivers
Internet/ Telecommunication/Sensor based systems	Online environmental information/ eco-information for journey planning	Online environmental information (e.g. temperature, smog alarm)
	Personalized information systems	ITSWAP (transport services via wireless applications)
	AMBIESENSE (information system for mobile users)	ROLLING STOCK (internet monitoring of cargo for time of arrival)
	DIAMOND (ITS application through Multimedia DAB)	TROP (virtual enterprise for forwarders)
	APNEE/APNEE-TU (Combine environmental data with travel information)	GIFT (Global freight information system)
	MESSAGE (use busses and pedestrians to act as mobile sensors, collecting vital real time air quality data	MOSCA (DSS for door to door delivery)
	PEPTRAN (Pedestrian + public transport navigator)	Ad-hoc journey & load sharing management
Vehicle based systems	Driver information feedback systems	Driver information feedback systems
	Vehicle crash prevention systems	Vehicle crash prevention systems
	Navigation systems	Navigation systems
	Energy efficiency of safety related applications like ADAS/ACC systems	Energy efficiency of safety related applications like ADAS/ACC systems
	Enhanced engine & drive train management/control and feedback	Enhanced engine & drive train management/control and feedback
Infrastructure based systems	5,1% of accidents are related to infrastructure issues	Adaptive network management & control using real data

		Online quality control
	Inter-modal support (TRASCOM, TRANS-3)	Tracking and Tracing (PARCELCALL, MOCONT-II
	Synchronization of traffic lights	Route & Load optimization
	Incident detection and management	Delivery optimization
	Network supported route & parking guidance	
	Map related projects: NextMap, ACTMAP, MAPS&ADAS, FEEDMAP	
Cooperative systems	CVIS project (www.cvisproject.org); SAFESPOT project (www.safespot-eu.org) COOPERS project (www.coopers-ip.eu)	

Annex 3: Impact Matrix (based on research results)

Below are compiled a number of results of the impact of vehicle and/or infrastructure measures to reduce environmental impact. Note that some are expressed as a reduction of fuel consumption, others as reduction of emissions; these are of course closely associated.

	Impact indicator	**Emission reduction**
Eco-Driving	20-25% decrease after driver training and 10% less fuel consumption as sustainable training effect on driving behaviour	A 10% decrease in consumption would translate into 40 billion litres of fuel and 100 mega-tones carbon dioxide (CO2) emissions
Gearshift Indicator (GSI)	GSI as driver assistance measure will reduce fuel consumption by some 3%	Related reducing effects on CO2 and other emissions
	GERICO on-board system design (driver to adopt best driving behaviour, smooth speed and good gear management by visual and vocal messages (optimization algorithm) leading to up to 15% consumption reduction (80 tests)	ECODRIVEN project (European-wide eco-driving campaign) with 500.000 car drivers to reach 0.5 Mton of CO2 emission reduction until 2010
Adaptive Cruise Control (ACC)	0.4-3.6% in normal traffic (field data)	
	Simulation: 10% ACC vehicles 28%	Up to 60% less pollution in specific situations
	Intelligent vehicles with ACC/LDW cut accidents by 8% (Dutch Field test) and saved 3% of fuel	Emissions decreased by up to 10% when driving with ACC and LDW (Dutch Field test)
Traffic Management	Smart NETS: new software + real-time traffic data in urban traffic control centres: considerable energy savings	Up to 40% in traffic standstill and congestion
	Free flowing traffic along the motorways consume on average 60% less fuel than when travelling on the local urban network (Greece)	By penalizing left-hand turns in route planning (trucks) the ROADNET software generates savings on fuel and emissions
Floating Vehicle Data for Traffic Management and		Congestion information from highways and interurban and urban roads

incident data to vehicle systems		
Traffic Light Synchronisation	Utopia (Italy) dynamic urban traffic control system increased intersection throughput for private traffic by 15%	
Transport Demand Management Strategies (TDMS)		HEAVEN DSS (2003): Decision Support System to evaluate the environmental effect (air/noise quality) of TDMS. Driven by 6 European cities
		CITEAIR (based on HEAVEN experience) 11-18 European cities are developing efficient means to collect, present and compare air quality data across a multitude of sites and provide input to the air quality reporting and action planning.
Predictive cruise control	CC linked to intelligent map information + GNSS position + maps: up to 2% of fuel economy	
Navigation systems	Linked to real-time traffic information: reduced driving time and fuel consumption	
Cooperative systems	PReVENT: equipment rate of only 20% of vehicles could avoid traffic jams on selected highway sections with subsequent energy savings	
Public Transport and Intermodality	Linked to the provision of ICT based infomobility services promoting seamless intermodal travels. Public transport trips involve up to 66% less greenhouse emissions per passenger kilometre than private cars. *(source: 'Public Transport role in reducing greenhouse emissions' Commissioner for Environmental Sustainability, Melbourne, Victoria State, Australia, July 2008)*	Up to 66% reduction CO2 reduction in purely public transport trips, a substantial figure –above 35%- in multimodal trips.

Annex 4: Autonomous Vehicle Technologies with Impact on the Environment

A4.1 Vehicle, Fuel & Tyre Technologies

In February 2007, the European Commission presented a strategy paper calling for the introduction of improved vehicle technology in order to reduce the CO_2 emissions of new cars in Europe to an average of 130 grams per kilometre by 2012. A further reduction of 10 grams was to be achieved through additional measures such as improving the efficiency of vehicle components (e.g. tires) and a step-by-step transition to fuels containing less carbon[19].

Vehicle & fuel technologies are thoroughly treated in other fora, and are therefore not the subject of this Working Group on ICT for Clean & Efficient Mobility.

Since 1995 European vehicle makers have introduced more then 50 CO_2-cutting technologies into their vehicles. Some of the key developments include[20]:

- Engine efficiency: direct injection diesel and petrol engines, second & third common rail injection, variable valve lift, downsizing, twin-charge turbo engines, start & stop systems, hybrid technology…
- Optimised transmission: automated manual transmission, 6th, 7th and 8th gear, continuously variable transmission, low friction transmission, computer controlled manual transmission, …
- Cleaner exhaust: particulate matter filter, catalytic converter, selective catalytic reduction, …
- Alternative low emission fuels: ethanol or gas (liquefied or compressed natural gas or liquefied petroleum gas), “flex fuel” (85% ethanol and 15% conventional petrol) are available, second generation bio fuels are on the way
- Technologies under development include hydrogen cars, fuel cell technology, electric vehicles, storage and use of heat, energy-efficient LED lights, …
- Other fuel-efficient technologies are related to vehicle design, ultra lightweight materials to reduce vehicle weight and new tyre technologies to reduce rolling resistance. According to estimates, maintaining correct tyre pressure can reduce fuel consumption by up to 5%. Introducing tyre pressure monitoring systems on all new vehicles would, therefore, help reduce wasted energy.

[19] Daimler 360 Facts: Sustainability Report 2008, pages 28ff
[20] ACEA: Cars, Trucks & the Environment, July 2008

A4.2 Vehicle Safety Technologies and Related Applications

Driver support systems, often based on information and communication technologies, with a primary objective of safety – even if they provide a secondary impact on fuel consumption and related emissions – are discussed in this Annex where significant environmental benefits can be demonstrated. A good example in this respect is adaptive cruise control (ACC), e.g. including "start & stop assistant", which although intended to maintain a safe headway to the vehicle in front could also help to reduce fuel consumption.

The earliest advanced safety systems now entering the marketplace include functions such as:

- ESC (Electronic Stability Control)
- Seatbelt reminders and head restraint systems
- Emergency braking systems (Brake Assist and Adaptive Brake Lights)
- Lane departure warning, lane keeping assist, blind spot monitoring, obstacle warning systems
- Traffic sign recognition
- Adaptive cruise control (ACC)
- Electronic brake assist, including automatic emergency braking
- Adaptive front lighting
- Night vision systems (infrared, radar)
- Intersection warning
- Speed alert
- Driver impairment (alcohol, drugs, tiredness detection) monitoring

The direct impact of these systems on the environment is generally limited and difficult to assess. A study has been launched by the European Commission to get further evidence for the environmental benefits of such systems as well as those enhanced with communication technologies.

In the future autonomous systems will be further linked and together with an intelligent and responsive infrastructure will form a new cooperative safety network with additional potential benefits for the environment. Examples of future applications and services include:

- Extended environmental information
- High quality congestion/ traffic information/ RTTI (Real Time Travel and Traffic Information)
- Infrastructure-based warning systems/local danger warning
- Inter-vehicle hazard warning

- Cooperative ACC for automatic regulation of inter-vehicle separation
- Infrastructure based speed alert
- Dynamic traffic management (VMS)
- eCall – Pan-European emergency call service

The limited extent of deployment of such integrated systems means that there is little hard evidence related to potential environmental benefits.

Indeed, the growth of passive and active safety systems implies has contributed to an increase of the average weight of passenger cars by about 300 kg based on customer demand for safer vehicles. Future advanced ICT-based safety systems are likely to have less impact on vehicle weight, as far as they comprise (weightless) software, and benefit from miniaturisation and integration of several independent systems and functions into one platform.

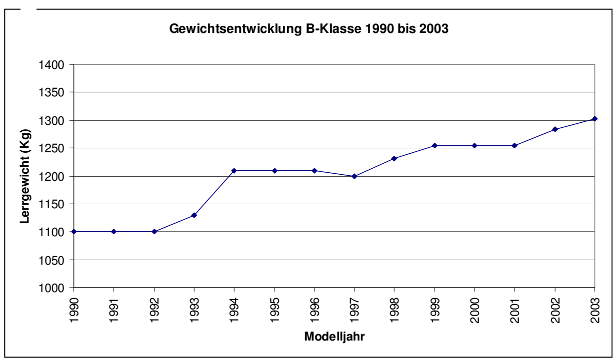


Figure 7: Weight increase 2003 vs. 1990 of selected vehicles

The EC's approach to co-funding collaborative R&D projects has had a very positive role in advancing ADAS technologies to increase road safety and reduce road deaths in support of the eSafety initiative. However, there is a widening gap between EC-funded R&D activities and actual market adoption of ADAS systems.

To overcome the low (less than 1%) market penetration of ADAS systems (except for camera and parking assistance systems, now at around 20% penetration) and to unlock the related safety and other secondary benefits, growth strategies are required including a number of marketing strategies to drive the safety technologies into the mass market in the future. Any proposal should take into account the current imbalance between technological advancement and real-world implementation issues and should suggest how this could be improved to ensure that ADAS delivers its true safety – and secondary environmental – benefits to society[21].

[21] Abhishek Visveswaran - Telematics & ITS Technical Analyst

How much each of the ADAS groups of applications contributes to CO_2 emission reduction is extremely difficult to calculate, especially as many systems are still in pre-mature status or have just achieve a less than 1% market penetration.

A4.3 Non-ICT Infrastructure Measures[22]

Also non-ICT infrastructure measures have strong potential to reduce CO_2 emissions. It has been calculated that, simply through a more efficient planning and management of roundabouts, CO_2 emissions could be reduced by up to 20%[23]. Better road design and more investment in road infrastructure may also help to remove bottlenecks, to divert more traffic around city centres and to complete missing links in the network, which together cost billions of Euros each year in lost fuel and contribute avoidably to the sector's total emissions.

Better roads in terms of better alignment and sufficient width and capacity, can lead to smoother traffic flow and thus to lower emissions from car traffic and should be regarded as positive contribution to a sustainable environment.

Road construction itself has an environmental impact, this can be minimized by a mix of sound environmental road design and management, and a combination of processes and techniques including optimised route planning, environmental impact analyses or use of recycled and environment-friendly construction material.

Significant impact on fuel consumption can be realised through use of improved road surface materials and construction. This can achieve reductions in tyre rolling resistance of up to 40%, corresponding to a saving of approximately 5% of CO_2 emissions.

These arguments are supported by a number of studies. A Norwegian study released in 2007[24] found conclusive evidence that road improvements and realignments reduce car emissions. Taking three baseline scenarios, the emissions of CO_2were reduced by 38% while local pollutants also fell. The same study indicated that in a majority of cases, the changes did not generate new car trips.

Initiatives in the field of road infrastructures currently represent an under-exploited opportunity for energy efficiency gains, which should receive substantially more attention by EU authorities. There is an urgent need to identify and investigate the cost

[22] ACEA comments on "Reducing CO_2 emissions through infrastructure measures, May 2008
[23] VUB-TNO study for AMINAL project 2002
[24] "Environmental consequences of better roads", SINTEF, 2007

effectiveness of potential measures to reduce vehicle CO_2 emissions with infrastructure related measures.

Possible future actions to enhance the effectiveness of such infrastructure measures include:

- CO_2 audits of road network
- EU action plan on CO_2 savings from infrastructure
- Consideration of infrastructure measures as part of EU Sustainable Consumption and Production action plan
- Commission to study and implement Japanese measures for saving CO_2 through infrastructure adjustments
- Spend fuel taxes on CO_2 saving infrastructure improvements ("ear-marking"
- CO_2 saving targets through infrastructure measures as part of the Integrated Approach.

A4.4 Enforcement

With the introduction of a European driver's licence (March 2006), harmonisation of traffic rules and cross-border enforcement of traffic law violations in the area of speeding, drink driving, failure to wear a seatbelt, not stopping at red lights (adopted proposal March 2008) as well as increased control (incl. speed cameras) of potential offenders could be further improved. For example, France achieved notable success through the deployment of large numbers of speed cameras some years ago and increased enforcement: this has led to some 30% reduction of fatal accidents. As accidents are very often linked to a slowdown of the surrounding traffic if not traffic jams, a reduction in their number has immediately a positive impact on the environment.

A4.5 CO_2 Related Taxation

On July 8, 2008 the European Commission presented its "greening transport" package aimed at making the European transport sector more sustainable.

The package is composed of:

(1) A Communication entitled "Greening Transport", which sets out EC initiatives until 2009 in the field of transport that have an impact on climate change, noise, pollution, congestion and accidents.
(2) An inventory of measures already in place at EU level to "green transport"
(3) A communication entitled "strategy of the internalisation of external costs" accompanied by an impact assessment and a technical annex on how to estimate

external costs. The intention is that transport prices better reflect the indirect costs that transport causes to society.

(4) A proposal to amend Directive 1999/62 (Eurovignette).

This last proposal would revise the Eurovignette Directive so as to promote deployment of road charging systems obliging trucks to pay their costs of pollution, noise and road congestion (internalisation of external costs). The amount of this charge would vary in terms of vehicle environmental quality (EURO class) and time of day.

All these combined measures target the CO_2 challenge currently under discussion for 2012.