ITS RADAR INTERNATIONAL

Identifying ITS Opportunities for the HA

Meeting Sustainability Objectives – the Contribution of ITS

Fact Sheet

Summary

The UK Government has committed to reducing carbon emissions from all sources and the Department for Transport has published the policy 'Low Carbon Transport: A Greener Future' to help reduce emissions from transport.

This fact sheet presents a discussion on the role of technology in reducing emissions from road based transport, with a particular focus on those measures relevant to the Highways Agency and the Strategic Road Network. Initiatives and technologies are presented along with results from a range of examples around the world. Mechanisms to improve the sustainability of ITS are also considered. Finally, views on the future of transport technology in regard to sustainability are presented.

Key Words

Congestion, Environment, Policy, Project, Traffic Management, Traffic Operations

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Introduction

UK Policy on Sustainability

The imperative to address climate change is clear, with the Stern and Eddington reports in particular signalling the way forward for Transport. Stern has suggested that global warming could shrink the global economy by 20%, whereas taking action now would cost just 1% of global gross domestic product. In terms of specific actions, Eddington concluded that making better use of existing networks, planning for the long term and targeting investment in the key inter-urban corridors and international gateways are priorities. The Government has responded to this need by setting challenging targets to reduce CO_2 emissions.

In July 2009, the Department for Transport published 'Low Carbon Transport: A Greener Future', setting out a carbon reduction strategy for transport; the objective is to give people and business more low carbon choices about when, where and how to travel or to transport goods. The aim is to reduce domestic emissions by around 14 percent on today's levels by 2020; saving an additional 85 million tonnes of CO_2 in the period 2018-2022.

The Highways Agency is taking positive action to assist the Government in meeting its targets to reduce greenhouse gas emissions. The Highways Agency has direct control over the construction, maintenance and operation of the strategic road network and is also taking opportunities to influence the users of its network, so they can reduce the greenhouse gas emissions from their journey choices.

In order to meet target reductions for CO_2 emissions and ensure the long-term sustainability of transport, new transport strategies are being developed. These strategies will plan, influence, manage and deliver travel and transport in ways that optimise environmental outcomes, but without compromising economic and social objectives. This requires more flexible solutions to transport problems that are able to respond to an evolving sustainable transport agenda.

The Role of ITS

Investment in appropriate technologies can provide the mechanism to put flexible, 'policy responsive' strategies into place, with Intelligent Transport Systems (ITS) at the forefront of improving transport sustainability.

ITS can help:

- in making the most of existing infrastructure and future investment by locking in the capacity provided e.g. by maximising the capacity of existing roads it reduces the need to widen them or build new roads
- by facilitating both supply side and demand side measures
- by supporting best use policy aspirations
- by encouraging a shift away from car usage
- by reducing congestion
- by using technology to help vehicles be driven more efficiently
- in proactively managing all forms of travel.

By providing the travelling public with a wider array of choices and real-time information, including potentially their carbon footprint for travel by different modes, transport technology allows informed decisions to be made on when and how to travel.

In the longer term, major switches to low carbon vehicles and fuels and intelligent integration between vehicles and the highway infrastructure could have a major impact in reducing transport emissions. In the short term, the greatest benefits are likely to come from traveller information persuading travellers to use public transport or to postpone their trip until congestion has cleared, and smarter use of co-ordinated control and management measures to smooth traffic flow and improve the overall efficiency of transport operations.

Critical to the choice of which particular applications to pursue and determining their role in reducing transport emissions is an appreciation of their possible application and likely impacts. This Fact Sheet, therefore, presents an overview of those technology systems which are likely to play an increasingly important role in reducing transport emissions, with an indication of their potential impacts on transport emissions. It covers systems deployed on or adjacent to the highway and within vehicles.

Intelligent Transportation Systems (ITS) Applications

The following ITS applications can be used to improve overall transport efficiency, with consequential beneficial impacts on fuel usage and, hence, transport emissions. The source of the information on each of these applications can be found in the bibliography.

Ramp Metering is one of several ITS technologies designed to manage traffic flow. The goal of ramp metering is to regulate vehicles merging onto a highway, smoothing out traffic flows, while minimising speed disruptions to traffic on the mainline. Fuel consumption and emissions impacts depend on the exact nature of the site and traffic characteristics and the balance that can be struck between stop-start traffic flows on slip roads with smoother vehicle flow on the mainline. Journey times past the junction are typically improved by around 10%. Dutch studies, reported in the EasyWay project (the ITS deployment programme within Europe) indicate delay reductions of around 15% which in turn would lead to a reduction in emissions.

Automated Speed Enforcement particularly when used in association with **Mandatory Variable Speed Limits** reduces vehicle accidents, reducing also consequential disruption and delays to traffic and improves overall traffic flow, particularly stop-start traffic. When employed as part of an Active Traffic Management system, also including the use of the hard shoulder during periods of congestion, emissions saving of up to 10% have been identified. Speed Control alone has been shown elsewhere (as reported in the EasyWay project) to reduce emissions in 'targeted' areas by around 15%. Potentially Mandatory Variable Speed Limits could be used to reduce emissions during periods of low air quality, although in practice this would only be relevant in urban areas.

Dynamic Lane Management with the selection of appropriate operational regimes relying on ITS to determine when and how to open and close appropriate lanes on the carriageway, has been shown to deliver significant operational and environmental benefits. The EasyWay project reports that Hard Shoulder Running has been shown to increase the observed capacity on Motorways by between 7% and 9%, with a commensurate reduction in fuel consumption and CO_2 emissions (4% savings in CO_2 are not untypical where this application has been used).

The innovative Active Traffic Management scheme on the M42, which allows motorists to drive on the hard shoulder during peak periods, has won an award for its contribution to the environment. This is in recognition of the fact that the scheme, which is deployed between junctions 3A and 7 of the M42, was shown to have reduced vehicle emissions by between 4% and 10% in its first six months of operation.

Research has been conducted into the carbon impact of a change in policy from conventional widening when compared to hard shoulder running. The research suggests that a change in policy from widening to managed motorways is likely to result in a saving of approximately 850,000 tonnes of CO_2, the equivalent of the emissions of 155,000 UK households. Carbon emissions as a result of conventional widening are predicted to be nearly four times more than those related to the design and construction of managed motorways. This would contribute to the UK's greenhouse gas emissions reduction targets (Holt, Conquest 2009).

ITS contributions to **incident management** include improved surveillance, verification, and dispatch of personnel to manage an incident, which reduce incident duration. ITS can also provide early notification for upstream drivers, which reduces incident-related congestion, as drivers have more time to select an alternative route. It has been estimated in studies undertaken within the EasyWay project that for every minute saved in detecting an incident, normal network operations are restored four minutes sooner than would otherwise be the case.

Improved incident management has the potential to decrease fuel consumption and hence emissions by reducing the delay and congestion associated with blocked traffic. A twelve month study undertaken during 2003-4 showed that the use of the Georgia Department of Transport's incident management system, known as NaviGAtor, which covers 140 freeway miles in the Atlanta metropolitan area, reduced annual gasoline consumption by over 5.17 million gallons and decreased diesel consumption by nearly 1.66 million gallons per year. Carbon monoxide (CO) emissions fell by 2,457 tons, hydrocarbon (HC) emissions declined by 186 tons, and nitrous oxide (NO_x) emissions decreased by 262 tons.

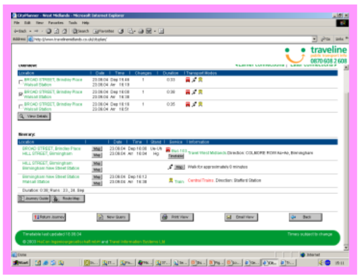
Traffic Signal Control improves traffic flow and provides priority for public transport or high occupancy vehicles. Signals can be used to manage traffic speeds, vehicle merging and corridor crossings, as well as interactions between vehicles and low-speed or non-motorised modes, encouraging walking and cycling.

Impacts vary, but 20% savings in vehicle delays, with consequential savings in emissions of around 5% are not uncommon.

A calculation of CO_2 saving as a part of the unpublished business case for enhanced traffic signal control on the Olympic Route Network, including the extensive use of SCOOT UTC to control signal timings to deliver target journey times for the Olympic Family, indicates a likely annual saving of 422,000 tonnes of CO_2. This results from smoother travel, with fewer stops and an overall reduction in congestion.

ITS-based **traveller information** technologies support the collection, processing, and dissemination of real-time information about travel modes, conditions and optimal routes, either pre-trip via web-sites and other media, or en-route via in-vehicle, at the roadside or at the transit station systems.

The actual impact of traveller information on fuel consumption and CO_2 emissions depends on a number of factors including familiarity with the area and available alternative routes / modes. Benefits might result from modal shift (e.g. from a single occupancy vehicle to public transport or bicycle) and fuel savings proportional to travel time reductions achieved by taking an alternative route to avoid congestion. The EasyWay project reports CO_2 savings of up to 3% for on-board and roadside information (with savings up to 1% for pre-trip and travel time information). Co-modal information, similar to that available through Transport Direct, for example, has also been assessed to result in CO_2 savings up to 3%.



There are also several examples of how technology has been applied to reduce transport emissions, by improving driver behaviour, encouraging the use of non-car modes and in some cases, removing the need to travel:

The DfT's Freight Best Practice behaviour change programme has, for example, been found to have saved around 120,000 tonnes of CO_2 per year. This has been achieved through improved operations and consequential reductions in fuel usage, facilitated by improved driver and fleet operator information and enhanced aid-to decision tools.

The use of teleconferencing enabled British Telecom to reduce the CO_2 impact of its business-related travel by around 100,000 tonnes a year both within the United Kingdom and internationally. Although it will not replace all business travel within the company and may not be suitable for other businesses where face-to-face meetings are a necessity, more sustainable transport modes are to be used instead

Technology can also play an important role within the vehicle to reduce fuel consumption and hence transport emissions. **Vehicle control technologies** such as intelligent cruise control, speed alert, collision avoidance and anti-lock brakes aim to improve vehicle safety, efficiency, and driver 'comfort'. By smoothing acceleration/deceleration and anticipating changes in terrain, in-vehicle electronics could also reduce fuel consumption. Simulations undertaken for the DfT CVHS Project indicate that intelligent cruise control seemingly has the potential to reduce fuel consumption by up to 25%, if fitted to at least 10% of vehicles in the traffic stream.

Broadly speaking vehicle-based technologies can be categorised according to their role in the driving cycle:

- **Before driving** – choosing the most emissions efficient route

  Navigation systems can be programmed to calculate an emissions optimal route to the destination. This route is the ideal combination of fast and short routes, with the least overall fuel consumption and hence minimum emissions. Recent studies have shown the use of a sat-nav has a potential to improve fuel efficiency by 12% and potentially more, if dynamic routing algorithms using traffic information are applied.

- **Whilst driving** – Advanced Driver ASsistance (ADAS) or Eco-driving systems

  ADAS systems such as adaptive cruise control and intelligent speed adaption can help in keeping the vehicle within a zone where fuel economy is at its maximum and emissions are reduced to a minimum. Examples include Audi's Travolution and Nissan's EcoPedal systems.

- **After driving** – remote analysis

  Telematics systems, such as Nissan's CarWing system available in Japan, have the potential to record driving patterns in real time and to later analyse these data to provide driver-specific tips to reduce fuel consumption.

Several of these types of function are now being combined within a single package. The Sentience project has developed a system to 'see' beyond the horizon through the use of internet-enabled mobile phone communications, GPS and advanced mapping data. By integrating these modules with the car's own control system, the partners in the Sentience project have demonstrated that fuel savings of between 5 and 24 per cent are possible at very modest cost.

Conceptually, such savings would be further enhanced if vehicles were to communicate amongst themselves and / or the highway infrastructure.

The concept behind **automated highways** is to employ technologies that facilitate vehicle-to-vehicle and vehicle-to-roadside communication to improve safety and system efficiency. Appropriately equipped vehicles will be able to anonymously send information that includes travel time and environmental conditions. In automated highways, vehicles will be able to operate in very close proximity to each other, with simulations indicating up to a 15% reduction in fuel consumption due to aerodynamic effects (CVHS Unpublished Report).

Improving the Sustainability of ITS Services

Recognising the high energy consumption associated with many technology applications, there are a number of measures and initiatives which might be considered to improve the sustainability of ITS services themselves.

Lighting - there are several possible methods of reducing energy consumption and the environmental impact of lighting, including that used for the illumination of signs, as well as general road lighting.

> As part of the Highways Agency's Sustainable Development Action Plan, it is carrying out a midnight to 5am switch-off of road lighting at six motorway sites in Southern England. It is estimated that this will provide a reduction in consumption of energy and carbon output of up to 40% at each site.

Short of switching off lighting, there are several measures that can be considered to reduce energy consumption, including that associated with the lighting of road signs:

- Using white light sources which may allow a reduced lighting level and therefore lower wattages
- Using modern lamps which have reduced wattages and low circuit losses
- Where ever possible using electronic control gear
- Ensuring all illuminated signs are Photo Electric Control Unit (PECU) controlled
- Incorporate new energy efficient technology such as LED.

Traffic Signs and Signals - traffic signs and signals are also significant consumers of energy. Extra Low Voltage controllers, Solar Panels and LED lighting can be used to reduce energy used. For example, Southampton City Council recently investigated the use of LED signals and estimated that implementing LED signals throughout Southampton could save 280 tonnes of carbon and approximately £60,000 per year. These technologies should be considered on a site by site basis when replacing existing equipment.

Switching off ITS with high power consumption - equipment such as CCTV or Variable Message Signs often consume large amounts of power and is often left switched on at all times of the day. Low powered wireless devices could allow these devices to be switched on and off as required. Low powered wireless communications using either Wi-Fi or GPRS could be used, ensuring that constant communications can be maintained with devices "powered up" only when required.

Alternative power sources such as wind power and solar cells may provide the potential to power ITS equipment; however, due to the small amount of power generated and power variability due to weather conditions, this may only be suitable for low-power equipment. Alternative power sources do offer other advantages such as ensuring an independent power supply for equipment plus their use in remote locations can reduce the need for power supply cables to be installed to link to other power sources.

A further consideration is the **materials used** in producing and installing equipment. For instance, light-weight gantries uses less materials and potentially recyclable materials.

The Future For Transport Technology?

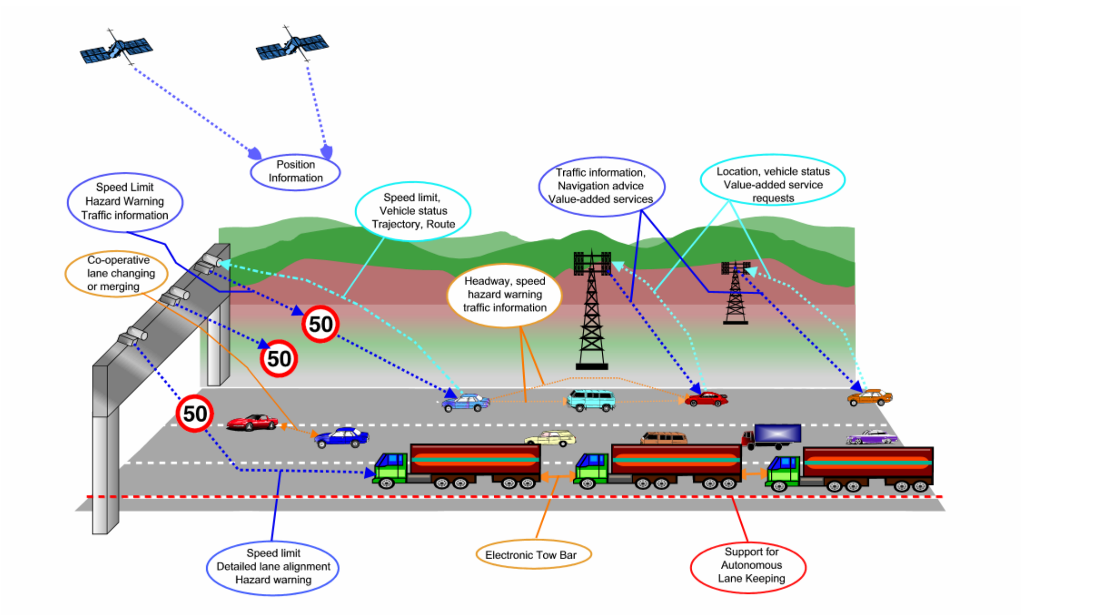
Whilst ITS applications become more widely deployed, delivering tangible benefits in improved transport operations, there is a limit to the operational efficiencies that can be gained. However, the freedom offered by private vehicles means that the public are reluctant to switch to other modes. Therefore, attention will increasingly turn towards new vehicle technologies, including advanced power train technology and the search for alternative fuels to further reduce transport emissions.

The use of renewable low carbon fuels, or alternative zero carbon fuels will offer significant green house gas reduction potential. However, a large scale shift to such fuels is currently not feasible, and an incremental approach to the successive optimisation of existing vehicle technologies is more likely to happen over the foreseeable future.

Taken either individually or in combination, the motor industry is actively developing solutions for:

- **Future fuels** – covering blended bio-fuels, synthetic tailored fuels through to carbon neutral / carbon free alternatives such as Hydrogen. Initiatives take a whole-life environmental approach, given the need to either uniquely process a fuel prior to its delivery at the roadside, or for the vehicle to carry additional weight to support the requirements for the new system (for example, hydrogen or CNG safety cages).
- **Advanced conventional power train technology** – combining both light weight materials and the successive optimisation of designs and also an array of hybrid technologies provide a means for an internal combustion engine to operate at it's optimal efficiency, with additional electric propulsion available "on demand" to cover transient (and therefore polluting) driving situations. Anticipated fuel savings range from 5 to 15%, although they are heavily dependent on actual driving conditions.
- **Alternative power train technology –** including fuel cell designs with their potential for near zero life time emissions.

> The EUCAR project, amongst others, was established to foster strategic cooperation in research and technological development activities across the European automotive industry, with energy, environment and resources identified as a key area for collaboration. The objective is to enable the industry as a whole to progressively deliver technologies across a common supportable roadmap, especially where a supporting infrastructure is required, whilst maintaining individual competitive advantage.



Beyond developing the vehicle itself, attention is also being given to achieving intelligent co-operation between vehicles and the highway infrastructure. Such **'Cooperative Vehicle and Highway Systems'** (CVHS) would increase significantly the returns possible from investment in ITS and new vehicle technologies, if otherwise pursued in isolation.

CVHS are a combination of information services, traffic management and traffic control applications that link computer systems in separate vehicles to each other and to computer systems that are part of the infrastructure.

These systems offer the capability to improve safety through extending the "event horizon" over which advance warnings of hazards can be provided beyond those of on-board sensors, providing greater awareness between vehicles and by taking some degree of control in extreme situations, for example, through emergency braking or the steering of a vehicle within lane boundaries.

CVHS also offers the capability to share the balance of control between infrastructure, vehicle and driver such that the density of vehicles can be increased without compromising safety. This is achieved by allowing 'platoons' of vehicles with headways lower than those that can be sustained by drivers who have sole control of the vehicle and by enhanced lateral control allowing reduced lane widths, thereby providing more traffic lanes for a given land take.

By smoothing traffic flows, there is an immediate benefit to the environment in that both steady state and transient emissions can be reduced. For example, by maintaining headway with the vehicle in front, aerodynamic drag is reduced, especially with trucks. It is estimated that vehicles running in a closely running platoon will collectively burn significantly less fuel, estimated at around 15% less.

Further details on CVHS can be found in the ITS Radar International CVHS Factsheet.

Intelligent Speed Adaptation is a related technology, with a vehicle's maximum speed being set by prevailing road regulations and, potentially, in response to prevailing traffic congestion (where mandatory variable speed limits are in operation). Whilst seen primarily as a safety aid, there are clear secondary environmental benefits in smoothing traffic flow as a whole.

Intelligent traffic signals also have the potential for reducing emissions, by considering the mix of vehicle types on each arm and offering "green waves" to HGVs, which will cause the most emissions when stopped.

A workshop was recently held by the European EasyWay programme entitled "Traffic Management based on Environmental Criteria". This presented the latest thinking from eight different European perspectives.

The European Commission's ICT work programme for 2010 includes energy efficient cooperative transport management, covering many of the technologies mentioned in this Fact Sheet: eco-traffic management and control systems, eco-demand and access systems, eco-navigation and travel information systems, driver behaviour change and eco-driving - see the February 2010 European Commission call "ICT for a Low Carbon Economy and Smart Mobility: 2010" for details. Thus, the issue of energy efficiency is likely to be an increasingly a focus of activities in ITS in the immediate future.

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Acknowledgements

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Glossary

ADAS	Advanced Driver Assistance
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CVHS	Cooperative Vehicle and Highway Systems
GPRS	General Packet Radio Service (Mobile based communications)
ICT	Information and Communication Technologies
ITS	Intelligent Transport System
LED	Light Emitting Diode
PECU	Photo Electric Control Unit
SCOOT	Split Cycle Offset Optimisation Technique
UTC	Urban Traffic Control
Wi-fi	Wireless Local Area Network