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INTELLIGENT TRANSPORT

Intelligent transport systems (ITS) combine information technology and communications for transport applications. By allowing communication to, from and between vehicles, ITS could address a number of the aims of the Government's integrated transport policy, such as reducing congestion and accident rates and improving network management. ITS can also enable electronic fee collection in road charging schemes. This briefing describes current and future applications of ITS in road transport. It goes on to discuss questions such as financing, management and safety which need attention if such schemes are to be implemented successfully.

Applications of ITS

Recent advances in technology, and in particular developments in satellite navigation and wireless communication, provide new ways to track and communicate with vehicles. A vehicle can use the GPS satellite navigation system (see box opposite) to identify its location. Mobile communications allow this and other information, such as data from in-vehicle sensors or driver requests, to be relayed from the vehicle. Traffic or routing information, or information about road use charges, can be sent directly to roadside signs or to the vehicle. The box opposite describes in more detail the main technologies of ITS (also known as transport telematics) applications.

Reducing congestion

Road charging

Automated charging of moving vehicles can be carried out several ways. Roadside beacons can be used to communicate with an in-vehicle unit to check that the vehicle has an appropriate pass or to deduct a charge. Vehicles without a unit are detected by photographing their number plates; a bill or violation notice can then be dispatched to the registered user. Such systems are in operation at a number of toll roads worldwide, but the complexity of urban road networks makes their use in urban areas rare (see box overleaf for details of London's proposed scheme).

Technologies for ITS

Location

Use of the GPS (global positioning system) satellites enables vehicles equipped with a GPS receiver to establish their location to within approximately 10 m anywhere in the world. The GPS satellites do not themselves locate objects; the GPS receiver enables the vehicle to locate itself by interpreting the satellite signals. This location information is unknown to others until communicated by the vehicle.

Communications

Several means of communicating with a vehicle exist:

- **Mobile communications** - The Global System for Mobile communications (GSM) standard used for mobile telephony can equally be used for communicating with a vehicle. Alternatively, the General Packet Radio Service (GPRS) can be used to send higher data rates over the GSM network. Although GSM is currently popular in ITS applications, disadvantages include the lack of universal coverage and high charges for international use of the network.
- **Roadside beacons** - Transmitters located at the roadside can communicate over short distances by microwave or infrared with vehicles fitted with suitable on-board equipment. Such systems can be used for electronic fee collection in road charging schemes**.**
- **RDS TMC** - The Radio Data System Traffic Message Channel sends coded messages about traffic conditions to an in-vehicle radio. The signals are decoded by onboard units.
- **Satellite communications** - Satellite communications enable pan-European coverage but are currently expensive compared with GSM.

As well as communicating driving-related information, such systems can provide additional services such as in-vehicle mobile telephony and internet access.

Alternatively, a vehicle could itself determine if it were in a charging zone and calculate costs by comparison with an in- or ex-vehicle database of charges. Charges could be billed retrospectively or debited from an in-vehicle "smart card". This system could be used in a distance-based charging scheme. The Commission for Integrated Transport recently investigated the effect of replacing vehicle excise duty with a charging scheme based on actual road use. They concluded that a fiscally neutral scheme focussing charges on the heaviest used roads at the busiest times could reduce congestion by up to 44%[1]. Trucks in Switzerland are already charged according to distance travelled, with Germany due to follow suit by October 2003. A distance-based truck charging scheme is targeted for introduction in the UK around 2006 or 2007.

The London Congestion Charging scheme
From February 2003, a £5 daily charge will be levied for driving in central London between 7am and 6.30pm on weekdays. The scheme aims to reduce congestion by 10 - 15%, as well as raising money for public transport projects. London's scheme will not use electronic toll collection (Transport for London were concerned about complexity and the lack of common electronic charging standards across the UK - see issues section), but will be able to adopt ETC in future if desired. Instead, drivers must purchase a pass (yearly, monthly, weekly or daily), by the end of the day in which they use the charging zone. Vehicles entering the zone will be photographed and automatic number plate recognition (ANPR) used to identify the registration number. This will be checked against a database of pass holders' vehicles and exempt vehicles (such as taxis and emergency vehicles). If no match is found, a penalty charge notice will be dispatched to the registered owner of the vehicle.

Inter-urban network management
Using information on current traffic conditions to manage traffic flows may reduce congestion (and the accompanying accidents and pollutant emissions), and assist drivers in journey planning. Worldwide, traffic management schemes have typically demonstrated increases of around 5% in capacity and average speed, together with smaller reductions in accident rates.[2] Analysis of the effect of varying speed limits on the UK's M25 has, however, been inconclusive so far.

Traffic information for such schemes is gathered from roadside sensors, CCTV, police reports or from fleets of vehicles using the road network. This is processed to determine appropriate speed limits or diversion routes, or to control traffic joining motorways. The resulting traffic signals are sent to drivers through variable message signs at the roadside, while information on traffic conditions can be distributed by a variety of media including telephone, local radio and the internet.

Services are also available which combine in-vehicle navigation systems and traffic information to provide dynamic route guidance i.e. guidance on the optimum route dependent on the actual traffic conditions. Fleet management systems use similar services to devise optimal routings for each vehicle in a fleet.

Public transport applications
ITS has a number of potential applications in public transport:
- Traffic signals can be programmed to give priority to public transport. Results of the EU QUARTET PLUS programme in Gothenburg and Turin demonstrated public transport travel time reductions of 10 - 15% on implementation of public transport priority, without appreciable delays to private transport.[3] Several UK cities, including London and Cardiff, have implemented such systems.
- Bus location data can be used to provide real time public transport information to bus stops or travel information services.
- ITS can enable 'demand responsive systems' e.g. users can reserve parking spaces on approach to a city, or book journeys on a door to door bus service.

Although all the above applications have been either demonstrated or adopted in cities worldwide, take-up in the UK is patchy.

Safety and security applications
Intelligent speed adaptation
Vehicles equipped for intelligent speed adaptation (ISA) warn or prevent the driver from exceeding the local speed limit. Speed limits are obtained either by comparing vehicle location to an in-vehicle speed limits database or by transmission of speed limits to the vehicle by roadside beacons. Recent trials of ISA in Sweden concluded that its universal use could cut deaths and serious injuries by up to 20%, without increasing journey times. The resulting recommendations to the Swedish Government included making ISA standard for new vehicles in Sweden by 2005. UK research sponsored by the Department for Transport (DfT) has concluded that an ISA system which prevents drivers from exceeding the speed limit could reduce fatal accidents by 59%. However, the Government has no plans to require the introduction of ISA in the UK in the foreseeable future.

Automatic emergency vehicle call-out
An EU research programme, E-MERGE, is currently developing a standard for automatic emergency service call-out following an accident. A crash would trigger the vehicle to send a message identifying its location to the emergency services. Such a system has the potential to save lives by ensuring emergency services are aware of and know the exact location of accidents, hence reducing the time for emergency vehicles to reach the crash scene. Similar services are already available commercially in the US and Australia.

In-vehicle systems
In-vehicle systems such as adaptive cruise control (ACC), lane keeping and collision warning can potentially increase safety. Future developments to ACC include adapting vehicle speed to road conditions, for example in response to movements of neighbouring vehicles on a motorway or to move a car forward in traffic queues. It could also be combined with real time traffic information or navigation data to adjust vehicle speed in response to slow moving traffic or hazards caused by road layout.

Electronic vehicle identification
Electronic vehicle identification (EVI) enables a vehicle to send its unique ID to roadside infrastructure or hand-held equipment, for example to aid in combating car crime. The facility could also be used in road charging systems, but has civil liberties and security implications. The DfT is currently exploring the feasibility of EVI in the UK.

Issues

The examples above demonstrate that ITS has many potential benefits for the road network. This section discusses possible barriers to ITS deployment in the UK.

Financing and management

Are ITS systems worth it?

Quantifying the monetary value of reduced congestion, accident rates, or pollution, or of social benefits such as reduced traveller stress or improved general health, presents a challenge. Existing ITS schemes can at best provide a rough guide to the impact of similar systems in different locations. Moreover, since many ITS applications rely on the existence of physical or virtual infrastructure which is common to a number of applications (such as roadside traffic monitoring or communication equipment, a digital map of the UK's road system, or a database of traffic information), quantifying the infrastructure costs for individual applications is difficult. Hence evaluation of the costs and benefits of any given project can be challenging. The DfT commissioned research in this area in the mid 1990s, and plans to extend this.[4] Decision-makers may be reluctant to deploy ITS systems without quantitative data on costs and benefits.

ITS infrastructure and institutional issues

One of the challenges for Government in ITS deployment is how and whether it facilitates development of the supporting infrastructure. Revenue from a single ITS application will often be insufficient to justify infrastructure investment. Moreover, private sector operators may be concerned that public sector developments could make their services redundant. For example, publicly available sources of traffic information already compete with the commercial Trafficmaster system. The current lack of common standards for many aspects of ITS may also discourage investors (see the further discussion of standards below). Hence much ITS infrastructure development may depend on public-private ventures (although alternative funding options such as surcharges on in-vehicle equipment or service subscriptions exist). Public-private arrangements inevitably raise complex questions of responsibility for maintenance, repair and upgrading of the system, revenue sharing arrangements, reliability and ownership of the system, use of data, and liability in the event of failure. Resolving these questions may prove more difficult than the technical aspects of any given project.

The Highways Agency's Traffic Control Centre project provides an example of public private partnership for ITS infrastructure development, here the virtual infrastructure of a traffic information database. Basic information will be distributed for free while more detailed information is used by the private sector in value-added services.

Lack of the necessary skills to understand the potential of and to implement ITS may also discourage deployment, particularly at a local level. The Government's ITS Assist programme aims to overcome these barriers and encourage the take-up of ITS by local authorities.

System interoperability

Developments in ITS are rapid and often technology driven. As a result many systems have evolved ahead of standards. With the potential introduction of a multitude of ITS systems there is a need to try to integrate these services and provide common means of payment, communication, vehicle location and information delivery. Without these, public transport users could be put off ITS applications by the need to learn to use several new systems. Operators of bus or truck fleets could require different in-vehicle equipment to interact with charging or vehicle location systems in different areas. For example, the truck-charging schemes currently under development in a number of EU countries use a variety of different technological approaches. A lack of common standards and system interoperability could act as a barrier to private investment in ITS, and to commercial and public sector use of such systems.

A particular challenge in this area may be the inter-operability of in-vehicle systems, typically designed by vehicle manufacturers to rapid timetables, with road infrastructure, typically provided by public authorities to longer timescales. For example, in-vehicle dynamic route guidance systems may currently receive up-to-date traffic information from a private sector operator but might be unable to take advantage of any future publicly available in-vehicle traffic information service.

Although some in the industry have argued that Government-imposed standards would provide a rapid stimulus to industry, others believe that industry self-regulation would be more effective. The Government maintains that it recognises the value of development of common standards, both at national and EU level.

Data processing

By their nature, many ITS applications involve large amounts of data. Developing the IT systems necessary to process and use this information effectively may be a greater challenge than development of the roadside technology. For example, the benefits of any automated emergency call system could be lost unless systems were put in place to ensure that messages were forwarded rapidly to the local emergency service.

Data processing in road charging

Many electronic road tolling schemes rely on accurate linking of vehicle licence plates to vehicle owners for billing or enforcement purposes. Toll roads in Ontario and Melbourne using automated numberplate recognition (ANPR) to identify vehicles suffered from considerable teething troubles. Inaccuracies in processing registration plates and in the database of registered keepers led to false bills or penalties being issued. Staffing levels were inadequate to deal with the complaints, exacerbating the problems. Road user groups such as the AA have expressed concern that the scale of London's scheme, which will also use ANPR technology, could lead to similar problems (although unlike Melbourne's system, the London scheme requires a manual check before penalty notices are issued). Transport for London (TfL) are confident that they can avoid such difficulties and point out that their contractual arrangements with the scheme operator, Capita, are based on a required service level rather than particular staffing or resource levels.

The AA is also concerned that since ANPR systems can fail to read dirty or non-standard registration plates, some motorists may evade payment. TfL plans to develop a database of such offenders and search for their vehicles manually. The credibility of this enforcement method may be crucial to effective operation of the scheme.

Driver distraction

Many of the systems described above have the potential to add to driver distraction, either through physical and visual distraction (using manual controls or reading screen-based information) or through mental distraction (processing information or conversing with an operator). Exploiting the communications links used in ITS applications for non-driving related purposes such as provision of information on local facilities, mobile telephony or internet access may increase this distraction risk. Although ITS providers are developing voice-activated systems with the aim of reducing driver distraction, it is not clear that these do reduce distraction significantly. Research on mobile phone use while driving suggests that distraction from hands-free sets is not substantially less that that from hand-held sets[5].

Driver distraction can be reduced by altering either driver behaviour or system design. The Government has recommended guidelines for design of in-vehicle information systems. These are used as part of the safety assessment for dynamic route guidance systems, which require a licence from the Department for Transport (non-driving related services such as in-vehicle internet, currently extremely rare, do not require a DfT licence). Drivers can also be prosecuted for not having "full control of their vehicle at all times". However, the need for specific legislation against drink driving, and the current consultation on legislating against use of hand-held mobile phones while driving, suggest that existing legislation may not be sufficient to ensure safe driving. Moreover, drivers may be unaware of the risks of mental distraction and view a voice-activated system as safe.

Privacy

Concerns over the privacy implications of recording driver movements have contributed to difficulties in introduction of a number of ITS schemes to date, such as a proposed road charging scheme in Hong Kong. The potential use of ITS by commercial fleet operators to monitor employees' use of company vehicles, including details such as driving style and length of breaks taken, also raises privacy concerns. Successful implementation of distance-based road charging, with the possibility that bills could record all journeys, is likely to depend on addressing privacy issues.

Technical solutions are available to maintain driver anonymity. Electronic toll collection schemes can allow drivers a choice between retrospective billing or anonymous pre-pay schemes. Location based services such as Intelligent Speed Adaptation or distance charging may be able to avoid the need to communicate vehicle location by use of an in-vehicle database of speeds or charges (although the need for regular updating of this database could pose different challenges).

Security

Although the ability to track, identify and even stop vehicles remotely has security benefits, it could enable vehicles to be tracked by unscrupulous individuals. Use of encryption could overcome this to a certain extent.

Liability

The recent EU RESPONSE project examined liability implications of developments in ITS. If a driver suffers a collision while relying on automated driving, the study concluded that the manufacturer is unlikely to be found liable (unless the driver could not have intervened to prevent the accident). However, for infrastructure based incidents (for example one caused by incorrect speed limit information in an ISA system), the infrastructure operator could be liable. Public authorities are not generally held liable currently for accidents arising from poor maintenance of physical highway infrastructure. Any liability arising from provision of ITS infrastructure would therefore represent a significant departure. Concerns about such a shift in liability could influence a public authority's approach to ITS deployment.

Overview

ITS systems have the potential to lead to improvements in many aspects of our road transport system. Although concerted effort to overcome institutional, organisational and interoperability barriers could accelerate ITS use in the UK, issues of driver distraction, privacy and security will also be important for successful deployment.

Endnotes

1 *Paying for Road Use*, Commission for Integrated Transport, February 2002.
2 The COMPASS system on 42 km of Toronto's Highway 401 increased average speeds by between 7 and 19% while preventing around 200 crashes per year. The EU's TABASCO project demonstrated a 5% increase in motorway capacity. A scheme in Kentucky reduced road fatalities by approximately 3% at morning and evening peak times.
3 The Turin trials demonstrated that reductions in journey times for private transport parallel to public transport routes outweighed delays to private traffic crossing public transport routes.
4 *Review of the potential benefits of Road Transport Telematics*: TRL report 220, 1996.
5 See e.g. the Independent Expert Group on Mobile Phones, *Mobile Phones and Health*, April 2000 or *The Risk of Using a Mobile Phone While Driving*, ROSPA, www.rospa.com/pdfs/road/mobiles/report.pdf.

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