Parliamentary Office of Science and Technology

postnote

January 2009 Number 322

INTELLIGENT TRANSPORT SYSTEMS

Information and communication technologies may be widely used on the roads in future in so-called 'Intelligent Transport Systems' (ITS). Systems that warn of upcoming hazards or intervene to avoid them could prevent accidents. ITS could also enable road charging and the better provision of information to drivers, which may help to reduce congestion. This POSTnote outlines current and future applications of ITS in road transport, as well as technical, behavioural and economic limitations to their deployment.

Background

The Role of ITS

Intelligent Transport Systems address the problems of road safety and congestion. Improving safety has long been a primary objective of government transport policy.[1] Other policies have been formulated largely in response to the Stern and Eddington[2] reports. Reducing congestion addresses many of these other objectives, such as the promotion of economic competitiveness. Congestion reduction also leads to environmental benefits such as improved air quality and reduced CO_2 emissions.[3]

Individual systems generally address either safety or congestion issues, but these cannot be wholly separated. Road accidents, for example, can lead to severe congestion, while findings from a recent scheme on the M42 to improve traffic flow also show safety benefits.

The Technologies behind ITS

The underlying technologies required for ITS are now well-established (Box 1). Satellite location is already used in navigation systems, and could permit a range of further applications. Often, a communications system is also required. For information provision, mobile telephony is usually most suitable, but wireless networks are needed for some safety applications.

Box 1. Key Underlying Technologies for ITS

- **Satellite location**: A small receiver uses the signals from several different satellites to calculate its position. This requires line-of-sight to the satellites. Usually locations can be determined to within about 10 m. The only operational system is the American Global Positioning System (GPS), although the EU plans to build its Galileo system by 2013 and Russia is restoring its own system. These are likely to complement one another.
- **Mobile telephony**: Advantages include its wide availability in towns and along major roads. However, additional network capacity may be required if vehicles are fitted with this technology, and network operators would need to cover these costs. Mobile telephony is not suitable for some safety-critical applications since communication can take too long.[4]
- **Wireless networks**: Similar to technology commonly used for wireless internet access, these allow rapid communications between vehicles and to the roadside, but have a range of only a few hundred metres. This can be extended by each successive vehicle or roadside node passing on the information to the next. Wireless communication systems are also used for road charging.

Improving Road Safety

Current Situation

Europe-wide, the cost of road accidents is estimated to be around 1% of GDP.[5] In the UK alone, 2,946 people were killed and 245,000 injured in road accidents in 2007. In 2000, the government set a target to reduce the numbers of those killed or seriously injured in road accidents by 40% by 2010 compared with the mid-1990s. This target has already been nearly achieved. However, the House of Commons Transport Committee has recently questioned the reliability of these statistics.[6] It asserted that the reduction may be significantly less than that claimed, because of under-reporting of serious injuries. The government plans to consult in early 2009 on road safety strategy for the period beyond 2010.

New Safety Technologies

ITS could allow big improvements in road safety. Many systems are already technically feasible, but have been held back by questions about implementation, cost, effectiveness, and public acceptability.

eCall

eCall is a European Commission scheme to equip all new vehicles with mobile connectivity and GPS so they can automatically alert the emergency services following an accident, and provide them with the location. Drivers may also be able to use the device to call breakdown services. The Commission hopes to roll out eCall from 2010, but while 14 EU countries have signed up, the UK government remains uncommitted.

The Commission claims that eCall could save up to 2,500 lives each year in Europe.[5] However, many experts believe the evidence for this is slim. The main study looked at accidents in Finland to estimate the reduction in casualties, which largely occur on isolated roads with no witnesses. By contrast, almost all accidents in the UK are quickly reported to the emergency services. A report commissioned by the Department for Transport concluded that the benefits for the UK are outweighed by the costs, which are estimated at £2.2 billion between 2010 and 2020.[7] As this is mostly due to the cost of the eCall devices themselves, costs would be much reduced if eCall could be integrated into an existing device (such as one for road charging).

Intelligent Speed Adaptation (ISA)

The aim of ISA is to assist drivers in keeping within the speed limit. This may be achieved either by giving a warning to the driver if the limit is exceeded, or by automatic intervention (overridable by the driver or otherwise) to slow the vehicle. A recent field trial showed that ISA is technically feasible and effective at reducing speeds.[8] The findings suggested that fatal accidents may be reduced by 42% if all vehicles were fitted with non-overridable intervening ISA. However, public acceptance of ISA is uncertain. The government currently has no plans to mandate its introduction. One pre-requisite for ISA is a means for vehicles to identify the prevailing speed limit (Box 2).

Box 2. Digital Speed Limit Maps

The usual implementation of Intelligent Speed Adaptation (ISA) involves the vehicle obtaining its location via GPS and comparing it with an on-board digital map of speed limits. Such a map exists for London, but progress on creating a national one has been slow, with little commercial interest. The Department for Transport (DfT) is now developing the framework to create a suitable map. The costs of keeping the map up-to-date could be considerable, with over 50,000 changes a year to London roads alone.

In a significant proportion of accidents, vehicles are found to be within the speed limit, but driving too fast for the road or weather conditions. More sophisticated forms of ISA could take account of these local road conditions, although the work by the DfT on a digital map will not initially do so.

In-vehicle Driver Assistance and Warning Technologies

A variety of systems has been developed that warn of hazards or take over tasks from the driver. Many of these have begun appearing in higher-end vehicles in recent years. The technologies include:

- Lane Departure Warning, to prevent a vehicle drifting out of its lane;
- Adaptive Cruise Control, which varies the speed to maintain separation from the vehicle in front;
- Blindspot Warning, which assists in changing lanes;
- Electronic Stability Control, which prevents skids induced by sharp steering and excess speed.

Cooperative Safety Systems

Wireless networks (Box 1) could allow vehicles to send and receive safety-related information. One application might be to warn following drivers when emergency braking is applied. Another use might be to warn of approaching vehicles at an intersection. Such information could be provided directly from one vehicle to another (V-V), and/or from a roadside sensor to the vehicle (R-V).

Such systems have been demonstrated successfully, but their deployment is hindered by the need for different stakeholders to cooperate, and is likely to be some years away. R-V systems have the advantage of allowing central coordination of the road network, and may work over longer ranges than V-V communications. However, implementation of R-V requires roadside equipment and other infrastructure that must be planned and paid for by the government, local authorities or third parties.

Adoption of these technologies is hindered by a 'chicken-and-egg' situation. Initial users will get little benefit from the system as there is neither the roadside infrastructure for R-V systems nor other equipped vehicles for V-V systems. However, the government is reluctant to invest in a costly infrastructure that cannot yet be used and for which the long-term specification is not agreed.

Issues with Safety Technologies

The impact of new systems may be reduced by giving the driver too much or too little to do. Moreover, the rate of introduction of new systems is likely to be slow.

Behavioural Limitations

Too many different information and warning systems could overload the driver and distract attention away from the road. On the other hand, driver assistance technologies could leave drivers with too little to do ('underloaded') under normal driving conditions. The driver may then not respond quickly enough in an emergency that the automatic system cannot handle. The extent of overload or underload can vary significantly with factors such as driver age, experience, stress, and the time of day. Consideration during the design process of the flow of information from systems to the driver could help to mitigate these problems. Some also claim that new technologies could cause drivers to reduce safety margins. For example, anti-lock brakes may be treated by some drivers as a performance enhancement that allows them to drive faster.

Lack of understanding of how to use new systems and of their limitations could also be a problem. These problems might be exacerbated when driving an unfamiliar vehicle, or with a system designed only for emergency situations which a driver has not yet experienced. Some experts believe that training should be provided either when learning to drive or when purchasing a new vehicle.

Implementation
Manufacturers want to be certain of a technology's success before including it in vehicle designs, while subsequent production occurs over several years. Moreover, cars in the UK are on average scrapped only every 14 years. For cheaper cars, competition on price is intense, and so extra features are minimised. This slow adoption rate contrasts with that for the development of many computing- and communications-based technologies. Vehicles may therefore be driven for many years after the technology in them is outdated, unless systems are able to be upgraded after purchase.

To speed up adoption, new systems could be mandated. However, if they are expensive, drivers may delay replacement of older vehicles, which also lack other safety features. Regulation often also needs to be agreed internationally, and may not be able to keep pace with technology. One alternative is a voluntary rating scheme to inform consumers of safety performance. An existing European scheme which covers crash-worthiness (but not ITS) is considered a success.

Retrofitting systems into existing vehicles could also speed adoption. This is possible for some information or warning systems such as Lane Departure Warning and satellite navigation. To retrofit technologies that intervene, however, would require major and expensive alterations to a vehicle's existing systems.

Legal Liability
There is concern regarding legal liability for accidents if intelligent systems are fitted. However, the conclusion of a study sponsored by the European Commission was that the driver retained responsibility unless a system's intervention could not be overridden.

Congestion Reduction

Current Situation

Total traffic in the UK is over 500 billion vehicle km per year. This is 80% higher than in 1980,[1] in-line with the rise in GDP. 8% of UK road traffic is now subject to very congested conditions, which causes costs due to delays and unreliability. If unchecked, congestion is forecast to increase by 30% by 2025 in England alone, costing a further £22 billion a year.[2] Moreover, slow-moving and stationary traffic emits increased amounts of CO_2 and other pollutants.[3] The transport sector already contributes around a quarter of the UK's CO_2 emissions, of which 93% is from road transport.[1]

Road Charging

Charging for road use is increasingly being used to reduce congestion. In London, there is a flat-rate fee to drive within a central zone on weekdays. When introduced, there was a reduction in congestion within the zone of 20-30%, although the impact has since lessened.[9]

Many experts favour replacing current vehicle taxes with charges based on the cost of congestion, and on the external costs of driving such as maintenance, accidents, and pollution. By charging more at congested times, traffic levels could be evened out or reduced. Similarly, insurance could be charged on a distance basis, with higher charges at riskier times such as at night.

National road pricing is technically feasible (Box 3), but public acceptance may be an issue. In 2007, an online petition against national road charging gathered 1.8 million signatures. Having cancelled a national scheme for lorries due to its cost and complexity, the government's policy is instead to encourage urban congestion charging.[1] A referendum in Greater Manchester recently rejected such a scheme.

Box 3. Technology for Road Charging
Technological options for automated road charging include:

- roadside camera detection;
- in-vehicle tags communicating with roadside beacons;
- satellite-based location finding.

Camera- or tag-based schemes are appropriate only for zone-based charges (as in London), or for charging for specific roads (such as the M6 Toll). This is due to the very large cost of the necessary roadside equipment.

For a scheme covering all roads, a GPS-based on-board unit in every vehicle is necessary. This requires less roadside infrastructure. The position obtained by GPS is compared with a digital road map. Each road is assigned a cost per mile, which can vary according to the category or location of the road, the time of day, and the characteristics of the vehicle such as its CO_2 emissions. Details of trips can be sent by mobile telephony to a central facility to calculate charges, or they can be calculated by the on-board unit with only summary information sent to a central facility for billing.

Some other countries are continuing to pursue national schemes. The Netherlands plans to charge all roads for lorries by 2011 and for cars by 2016.[10] Germany has already implemented distance-based road pricing for lorries on motorways, but with no congestion component. A key question is the cost of such schemes. The Dutch aim to keep operating costs below 5% of revenue. Some consider this target unrealistic. For the UK, the DfT has estimated operating costs of £2-5 billion,[11] together with set-up costs of at least £10 billion. By comparison, the collection costs of current road taxes are far lower.

Issues with GPS-based Pricing Systems
A GPS-based system could be vulnerable to fraud. GPS signals up to a kilometre away can be jammed by a simple device. Covering the GPS antenna could prevent it receiving signals, and there are anecdotal reports of this occurring in the German scheme. Some compliance checking may be necessary, using roadside equipment (static or mobile) to communicate with the on-board unit.

Since GPS requires line-of-sight to several satellites, it may not be sufficiently accurate in urban areas when surrounded by tall buildings. Additional systems such as an accelerometer or a connection to the vehicle's odometer (mileage counter) may be able to overcome this, but would add to the cost.

Personal privacy could be affected if vehicle movements are monitored. Calculating charges on the on-board unit could overcome this as only summary information would be sent to a central facility, but would increase costs.

Information Provision

The government's Foresight Programme envisages improvements to the efficiency of transport through much better provision of information.[12] In-vehicle satellite navigation systems ('sat-navs') have already become commonplace, providing recommended routes to destinations. Many road haulage companies use such systems to track their vehicles, and to optimise routes to save time and fuel. However, off-the-shelf sat-navs do not currently hold information on roads unsuitable for lorries, which can cause inappropriate routeing.

Applying Information to Reduce Congestion

For some years, sat-navs have been able to change dynamically the recommended route to avoid traffic jams. This requires real-time traffic information, which is provided in the UK by several companies. Widespread take-up of this technology could allow traffic to use roads more efficiently and thus reduce congestion. Most benefits may arise when only specific routes are suffering delays (for example, due to an accident), rather than during the rush hour when there are few uncongested alternatives. Within the next two years, it is likely that mobile phones with in-built GPS devices will become common, potentially offering similar functionality.

One major source of congestion in urban areas is vehicles looking for parking. It would be technically feasible to integrate real-time parking availability for car parks into sat-navs or roadside signs. However, this would require local authorities and others to provide this information on a widespread basis, which is currently not the case.

Management of the Road Network

Coordinated control of the road network can increase capacity. On the M25 and M42, speed limits are varied with congestion levels to increase capacity and to improve journey time reliability, since separation between vehicles can be smaller and traffic flow can be smoother. Urban congestion, meanwhile, is reduced by the coordination of traffic signals.

In future, cooperative systems, similar to those for safety applications discussed above, could lead to further improvements. They could, for example, allow coordination between vehicles where two motorways merge. Variable speed limits could be more widely implemented by replacing expensive electronic roadside signs with in-vehicle information, which could also link in to an Intelligent Speed Adaptation system (see above).

System Integration

Although developed separately, many different systems are likely to be implemented together. If sub-systems were shared, costs could be reduced significantly. For example, eCall could be implemented at low cost if integrated into an existing road charging unit.[7] The same device could also provide for distance-based insurance and satellite navigation. However, a business case for such a combination of systems can be hard to develop since many of them are not certain to be implemented. Another advantage of system integration includes a reduction in driver overload. However, integrating retrofitted systems with existing ones may be hard.

Integrated systems will need to be standardised technically. In particular, cooperative systems will have to be able to communicate with one another. There has been some progress recently at a European level towards such standardisation, for example by the allocation of a specific radio frequency for cooperative systems. However, more work is still required, and manufacturers feel that worldwide standards would be needed.

Overview

- Intelligent Transport Systems aim to tackle the problems of road safety and congestion. Most proposed systems are already technically feasible.
- Various safety systems exist that warn of hazards or that automatically intervene to assist the driver.
- Safety systems need to be carefully implemented to avoid giving the driver too much or too little to do.
- Congestion could be reduced by road charging, and by better network management and information provision.
- Road charges could reflect the costs of congestion and pollution. However, such a system could be expensive.
- Integrating different systems could reduce costs.

Endnotes

1 *Delivering a Sustainable Transport System*, DfT, 2008
2 *The Eddington Transport Study*, DfT, 2006
3 *Advanced Motorway Signalling and Traffic Management Feasibility Study*, DfT, 2008
4 *Tomorrow's Wireless World*, Ofcom, 2008
5 *First Intelligent Car Report*, EC, 2007
6 *Ending the Scandal of Complacency: Road Safety beyond 2010*, Transport Select Committee, 2008
7 *eCall – The Case for Deployment in the UK*, SBD/DfT, 2006
8 *ISA-UK Intelligent Speed Adaptation Final Report*, DfT, 2008
9 *Central London Congestion Charging: Impacts Monitoring, Sixth Annual Report*, Transport for London, 2008
10 *Implementation of Road Pricing System*, Ministry of Transport, Public Works and Water Management, The Netherlands, 2008
11 *Feasibility of Road Pricing in the UK*, DfT, 2004
12 *Intelligent Infrastructure Futures*, Foresight, 2006

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