

**TECHNOLOGICAL ADVANCEMENTS IN TRANSPORT  
- THE ROLE AND IMPACTS OF INTELLIGENT  
TRANSPORT SYSTEMS IN THE PROCESS OF  
TRANSPORT REFORM**

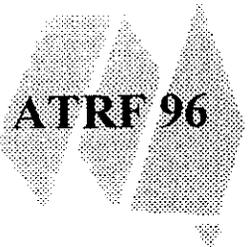
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**ABSTRACT**

This paper examines the impact of Intelligent Transport Systems (ITS) technologies on the Australian road system in terms of the future characteristics of road networks and the implications for road users and the community. In particular, it focuses on technologies that relate to the efficient use and management of the road system plus vehicle design and non-transport related technologies that indirectly affect the road system through their impact on society. It also considers community impacts and the many social, political, legal, regulatory and institutional issues that arise from major technological change.

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The logo for ATRF 96, featuring a stylized map of Australia with the text 'ATRF 96' overlaid.

**ATRF 96**

## **Introduction**

Technology is changing the world around us and having an impact on many aspects of daily life. The road systems of Australasia are not immune to these changes. Technology is changing the characteristics of the vehicles and roadways and the way that we use the roads. The impetus to apply advanced technology to the road system is largely a reaction to competing demands. On the one hand, there is increasing demand for travel while on the other, there are community demands for reduced congestion, greater safety and reduced environmental impacts of road traffic. There is also community opposition to major road construction and an imperative to make better use of existing infrastructure. Technology can offer some assistance in balancing these demands. Overall, the aim of using emerging technologies is to improve the links between the road, the vehicles and users to make individual components and the road system as a whole work more efficiently and effectively. The range of potential benefits of advanced technology include:

- better utilisation of infrastructure
- improved traffic flow
- better service from public transport
- enhanced safety
- lower cost freight transport
- reduced environmental impact

In addition, technology is changing the nature of work and having an impact on the locations of homes and workplaces, on the pattern of trips made on the road network and ultimately on the need to travel. As travel habits change, there are direct implications for the role of the road system and the way that it should evolve to best serve community needs.

This paper examines the impact of emerging technologies on the Australian road system in terms of the future characteristics of road networks and the implications for road users and the community. It focuses on technologies that relate to the efficient use and management of the road system plus vehicle design and non-transport related technologies that indirectly affect the road system through their impact on society. It also considers community impacts and the many social, political, legal, regulatory and institutional issues that arise from major technological change.

## **The technologies**

The road system will be affected by advances in almost any area of technology but there are several technologies that are strongly influencing current developments, as follows.

### **Stored value cards and 'smart cards'**

These are plastic cards like credit cards but with a small inbuilt computer that allows the card to perform a variety of financial transactions. In one form the card can be used as an electronic purse that is loaded with money at an ATM or EFTPOS machine. It can then be used for small transactions such as bus fares and road tolls. Each time the card is used, its cash balance is reduced by the value of the transaction. When all the money has been spent, more money is loaded in the card and the process is repeated. Over time, smart

cards are likely to replace the magnetic stripe cards currently being used for public transport ticketing and some toll systems.

### **Vehicle tracking systems**

The movement of vehicles in the traffic stream can be tracked using a satellite-based system such as GPS (Global Positioning System) or a ground-based system based on electronic sign posts located at strategic points on the road network, such as RTA-NSW's ANTTTS system (Automatic Network Travel Time System). Using these technologies, the location of vehicles such as buses and emergency vehicles can be continually monitored.

### **Vehicle identification systems**

Vehicles can be fitted with customised electronic tags. These tags can then be read by detectors installed in the road system to register the arrival of that vehicle at a particular location. The tags can be installed in buses and emergency vehicles to trigger traffic lights, or can be used to monitor vehicle fleets, or collect road charges.

### **Advanced sensors**

Sensor technology is being applied in many aspects of the road system. Sensors installed in the road range from simple vehicle detectors at traffic lights through to sensors that weigh trucks as they drive over the sensor at normal highway speed. Other sensors are fitted in vehicles to trigger safety devices such as ABS brakes and airbags.

### **Variable message signs**

We are all accustomed to road signs that display a single fixed message. New technology signs allow messages that change according to the current traffic conditions and provide up-to-date information and advice to road users.

### **Digital video imaging**

Digital video cameras can be used to capture images of the traffic stream or of individual number plates. These images can then be processed by computer to provide automatic monitoring of traffic conditions and incidents, or to identify particular vehicles.

### **High speed, affordable computers**

The power of computers has increased and their price decreased to a point that it is now feasible to collect and process the vast amounts of data that is generated by the road system. What is more, the data can be processed in realtime and up to the minute information can be available for road system managers and users.

### **Data and voice communications**

The 'information superhighway' has already come to the road network. Traffic lights, vehicle detectors, control centres and variable message signs are already connected using high speed data communications. The fixed elements of the road system are connected by cables but it is also possible to transfer digital information to and from vehicles using radio communications. In future, the same technology will connect to homes and provide information on locations of congestion, road works, accidents, and so on. The 'information superhighway' will also have an impact on the road system through the variety of services that it offers. Users will be able to shop and work from home and pay-

television and related entertainment services may reduce travel demand, or at least change the pattern of trips that people make. Mobile phones are another communications medium that is having an impact on the road system. The phones can be used to report and receive information about traffic conditions and sometimes can provide an alternative to travel.

## **The applications**

The technologies described above are all proven and currently available. What is new is the way that they are being applied to the road system. In general, the technologies are not used individually but are combined to create new applications to solve specific problems. Applications involving advanced information and telecommunications technologies applied to the operation and management of transport infrastructure and services are known collectively as Intelligent Transport Systems (ITS). ITS is currently the focus of a worldwide research and development effort and will have a major role to play in the future of the Australian road system. ITS applications may be grouped into the following categories.

### **Advanced Traffic Control (ATC)**

These are systems designed to control and facilitate the movement of traffic and pedestrians using coordinated traffic signal technology. An important input is real time information about traffic flows and speeds collected using sensors and vehicle identification systems. ATC also includes systems for priority at signalised intersections to transit and emergency vehicles. The coordinated traffic signal systems installed in most Australian cities are one form of ATC.

### **Route Guidance (ROG)**

Imagine an electronic street directory that keeps track of the location of the vehicle and can provide route guidance to the driver through an electronic map display or synthesised voice instructions. The category also includes computerised street maps and similar systems for assisting with route finding and planning. Cars equipped with route guidance systems are already on sale in Japan and Europe.

### **Driver Information Systems (DIS)**

DIS provides drivers with information pertinent to their journey, either prior to their departure or during the journey. Information on delays (due to congestion, fog, flooding, accidents, etc), road works, parking guidance and alternative routes allow drivers to make informed decisions about their journey. The information can be conveyed by broad cast media, telephone, or computer networks. It can also be displayed on variable message roadside signs, or can be transmitted direct to the vehicle for in-vehicle displays. The aim is to provide timely and accurate information to allow travellers to make better decisions about their route and time of travel.

### **Incident Management (INM)**

A high proportion of congestion on major roads is caused by incidents such as breakdowns, accidents and road works. INM systems are designed to assist in the rapid detection of incidents and in rapid response so that the incident can be cleared as soon as possible.

### **Electronic Toll Collection (ETC)**

These systems are designed for automatic payment of tolls on roads and bridges without the need to slow down. Vehicles are equipped with a 'smart card' or are electronically tagged so that as the vehicle passes the toll point, the toll charge is deducted from the card or account. This category encompasses technologies for a wide range of charging mechanisms which may be imposed for the use of roads. Trial systems are in operation in some cities (e.g. Stuttgart, see Hug, Mock-Hecker and Würtenberger (1995), and Singapore - as part of an electronic road pricing system (e.g. see Tan, 1994)) and are mooted for others, e.g. Melbourne, for the City Link project.

### **Automatic Vehicle Control (AVC)**

Cruise control currently installed in many cars is a simple example of this type of system. The next step is 'smart' cruise control which uses radar or radio-based technology to detect vehicles ahead and adjusts speed accordingly. There are proposals to extend the idea to fully automated highways on which steering and speed are controlled by a combination of computers and sensors installed in the vehicle and roadway.

### **Public Transport Information (PTI)**

PTI systems are designed to provide travellers with information about the availability of public transport. This information can be provided before the trip (about timetables and fares, transfers, etc) or during the trip (waiting time until the next bus, availability of seats, estimated time of arrival at destination, etc). The information can be displayed at bus stops or be distributed by phone, or computer network. By linking timetables with vehicle tracking systems and information about current traffic conditions, the information can be up to date and accurate. The aim is to provide timely and accurate information to allow travellers to better plan their trip in terms of mode and time of travel. A prototype system is being developed in Adelaide (Seaman, 1995).

### **Public Transport Management (PTM)**

PTM includes systems that enhance the efficiency and safety of public transport vehicles, such as computerised timetabling, dispatch and rostering, fleet monitoring systems and intelligent control systems. Technology is allowing public transport to more cost effective and more responsive to the needs of travellers. The computerised vehicle dispatch systems currently installed in taxis provide a familiar example of this technology.

### **Road Safety Enhancement (RSE)**

RSE systems that help the driver avoid an accident and provide better protection if a crash occurs. Australian vehicles are already fitted with a range of safety devices but in future they will be supplemented with systems that aid the driver and respond more quickly and intelligently to accident situations. Using sensors that respond to imminent collisions, seat belts can be tightened and airbags deployed in an optimal way to minimise injury. Other emerging technologies include head-up displays, vision enhancement systems for driving in conditions of reduced visibility (night, fog), and proximity, speed, and hazard alarms that warn of potential danger ahead. Systems are also being developed that diagnose the roadworthiness of the vehicle and driver. By storing data on driving characteristics of the vehicle and driver, an onboard computer can detect unusual behaviour, e.g. driver fatigue

or impending mechanical failure. The driver can then be warned of the reduced levels of safety. Similar systems can act like an aircraft's 'black box' recorder and provide information about the circumstances of crashes.

### **Freight Management Systems (FMS)**

FMS involve a range of technologies aimed at increasing the reliability, service quality and efficiency of freight transport. The basic idea is increase the efficiency of freight operations through greater control of fleet operations by monitoring movements of the vehicles and freight using vehicle tracking and identification systems, and providing two-way communications between freight vehicles and control centre. New technologies are also being used to monitor compliance with government regulations. Sensors can be used to identify individual vehicles and measure their weight and dimensions without the need for the vehicle to stop. This category also includes Electronic Data Interchange (EDI) systems that facilitate smooth movements of freight through the logistics chain.

### **Environment and Pollution Monitoring (EPM)**

Pollution monitoring devices and warning systems are already installed in vulnerable locations such as the Sydney Harbour Tunnel. It is already possible to monitor and process measurements from a large number of pollution sensors scattered across a region so it is likely that environment and pollution monitoring systems will become more widespread. Warnings can then be broadcast and traffic control strategies implemented to reduce the problem. The legislative requirements for 'zero emission' vehicles being introduced in the USA are spurring technological developments with both electric vehicles and 'smog eating' add-ons (e.g. chemical coatings for vehicle radiators that absorb air pollutants from the atmosphere, effectively producing 'negative emission' vehicles).

### **Telecommunication Applications (TEL)**

In addition to the technologies that have a direct influence on the road system, there are technology related trends in society that are having an indirect impact on the road system. In particular, information and communications technologies are changing the type of work that we do and the way that we do it. Mobile phones, faxes, computers and the information superhighway are making telecommuting and teleworking increasingly available as alternative modes of working. Technology is also providing alternatives to travel for other purposes, such as shopping, entertainment and education. This has long term implications for land use and the structure of cities and for the pattern of demand for the road network. In future it is likely that fewer people will be commuting long distances to work and that the daily commuter trips are replaced by local trips to schools, shops and other services. This may reduce the length of trips but possibly increase their number? It will also change the spatial distribution of trips and when they occur.

## **Interactions**

It is clear that there is a complex array of technologies being applied to the road system. How will it affect the way that we use the road system and the way that the road system is managed? A common feature of many of the emerging technologies is the growing reliance on communications and information. The biggest impending change is in the amount of communication and the flow of information between the components of the

road system. At present the components largely work in isolation but in future there will be much more interaction between them. Three broad components may be identified:

1. *Roads* - all the fixed infrastructure and organisations supporting the road network. This includes the road pavement, road signs and vehicle detectors, and the authorities that build and manage the road network, and any commercial operators that sell road-related services.
2. *Vehicles* - all the cars, motorcycles, trucks, buses and bicycles driven on the roads
3. *Users* - all the people who use the roads

New interactions and flows of information arise from ITS technologies.

### **Road-vehicle interactions**

These interactions require the flow of information between the infrastructure and the vehicle with no direct intervention by the users. At present, this flow does not exist for the vast majority of road users. However this is a basic element of applications such as vehicle tracking and identification systems (PTM, PTI, FMS, SES), automatic toll collection (ATC), and ultimately automated highways (AVC).

### **Road-user interactions**

Technologies that involve communication between the road infrastructure and the user will increase in importance and sophistication. Current information is static and directed equally to all road users. In future the information will be dynamic and personalised. Information about the current status of roadways and traffic (DIS, INM, FMS), public transport (PTI) or environmental conditions (EPM) will be collected and synthesised by relevant authorities and passed on to road system users.

### **Vehicle-user interactions**

The level of information provided to the user by the vehicle will change rapidly. Currently the only information we receive from the vehicle relates to its own performance (speed, engine temperature, etc). Sensors and computer systems can be built into the vehicle to provide route guidance information to driver (ROG) and provide safety warnings (RSE).

### **Road-vehicle-user interactions**

Technologies that involve communication from the roadway to the vehicle then to the user provide another layer in the road operating system. The technologies include vehicle navigation systems that include realtime information (ROG), vehicle dispatch systems (FMS, PTM) and driver and public transport information systems installed in vehicles, at bus stops or computer kiosks, or available through computer networks (DIS, PTI).

### **Other interactions**

The new technologies will also enable each of the system components to collect and process more and richer information. By using a wider range of sensors and exploiting high speed communications and computing, road authorities will have access to much more information about current traffic conditions. This information can then be used to react to incidents more quickly (INM) and adjust traffic lights to ease congestion (ATC) and reduce pollution (EPM). Vehicles will also become 'smarter'. Sensors and onboard computers will monitor the condition of the vehicle, the roadway and the driver to optimise vehicle performance (EST, PTM) and help to protect the driver (RSE).

## Benefits

So far, we have examined the emerging ITS technologies, their applications and the way that the relationships between the road system components will change. But what will the technologies deliver in terms of benefits? Six types of benefits were identified in the introduction. These benefits will be delivered by combinations of technologies working together towards the overall aim of making the road system better serve the community. Improved traffic control, better information about traffic conditions and transport options, better vehicles and improved public transport will work together to make it easier and more efficient to use the road network. ITS will also improve the utilisation of existing infrastructure and reduce the need to provide more roads and road transport services. In addition, reduced environmental impact can result from more efficient usage of the road network by more environmentally friendly vehicles.

It is difficult to quantify the individual benefits that ITS technologies will deliver. Many of the benefits are effectively intangible (reduced environmental impacts, better service quality, etc) and the overall benefits will depend on the characteristics of each city or region and the combination of technologies that are in use. In addition, many of the technologies are complementary and their full benefits will only be delivered when they are all in place. Rather than attempt to assign dollar values, each technology may be assessed in terms of the type of benefits that it will deliver. Table 1 summarises the likely benefits from each of the technology categories.

**Table 1: Potential benefits from emerging technologies**

Technology	Better Utilisation of Infrastructure	Improved Traffic Flow	Better Public Transport	Enhanced Safety	Lower Freight Costs	Reduced Environmental Impact
ATC	✓	✓	✓	✓	✓	✓
ROG	✓	✓	✓	✓	✓	✓
DIS	✓	✓	✓	✓	✓	✓
INM	✓	✓	✓	✓	✓	✓
ETC	✓	✓	✓			✓
AVC	✓	✓		✓		✓
PPI			✓			✓
PTM			✓			✓
RSE				✓		
FMS					✓	
EPM						✓
TEL	✓	✓				✓

## Developments in Australia

Australia has been quick to take advantage of emerging technologies where there is a demonstrable benefit. Table 2 lists some examples of major applications of ITS

**Table 2: Some applications of emerging ITS technology in Australia**

NSW	<ul style="list-style-type: none"> <li>• Sydney is a leader in coordinated traffic signal technology (ATC). The SCATS system is now in use in many cities in Australia and overseas. SCATS has been enhanced to include a vehicle tracking system using automatic vehicle identification technology. This system, known as ANTTTS, detects the passage of specially equipped vehicles (mostly taxis, buses and government vehicles) through more than 200 intersections in Sydney. The information can then be used to estimate travel time and identify congested areas.</li> <li>• An incident management system (INM) is currently installed on the Sydney Harbour Bridge and a more advanced system is planned for the M4 freeway.</li> <li>• The F6 freeway connecting Sydney and Wollongong is subject to severe fog. A system of visibility detectors and variable message signs (DIS) has been installed to increase safety (RSE) on the freeway. The system also provides messages to individual vehicles about their current speed.</li> <li>• The NSW government is equipping its truck checking stations with sensors that will check the weight and dimensions of trucks (FMS) as they drive through the station. In future some stations may become fully automated.</li> </ul>
Victoria	<ul style="list-style-type: none"> <li>• A freeway information system (DIS) has recently been installed on Melbourne's South Eastern Freeway. The system provides realtime information to motorists on current traffic conditions and estimated travel times on the freeway. The system makes extensive use of variable message signs and also broadcasts the information using computer, fax, teletext and telephone.</li> <li>• Incident detection systems (INM) have been installed on four Melbourne freeways. The system uses sensors built into the road to measure traffic flow and automatically detect incidents. An incident management plan can then be initiated to clear the problem and get the traffic flowing normally.</li> <li>• The Public Transport Corporation of Victoria is using radio beacons located at key sites in the network to track and monitor its tram fleet (PTM). This information is being used to develop a system to predict tram arrival times (PTI). The system is being trialed at the Elizabeth St Terminal.</li> <li>• The Victorian government recently announced the construction of the Melbourne City Link project. Vehicles will pay a toll to use the road and all toll collection will occur automatically (ATC) using automatic vehicle identification technology.</li> </ul>
Queensland	<ul style="list-style-type: none"> <li>• Variable message signs (DIS) and an incident management system (INM) are installed on Brisbane's South East Freeway, its entry ramps, and on the surrounding surface streets.</li> <li>• Automatic toll collection (ATC) is being trialed on the Gateway Bridge.</li> <li>• An ITS System Architecture has been developed for the TRAC traffic control system employing modern international computing standards and protocols to integrate all ITS applications in modular manner. This permits the transparent sharing of information and communications.</li> <li>• Electronic tagging of buses to establish priority at traffic signals is continuing, and a trial is under way to tag emergency vehicles.</li> <li>• An 'over mass' container authorisation system has been installed on the access road from the Port of Brisbane. This facility combines electronic tagging and weigh in motion technologies. A tagged truck is automatically provided with a permit to carry the overmass container for a limited distance, with the appropriate fee charged as an electronic transaction.</li> </ul>
SA	<ul style="list-style-type: none"> <li>• Adelaide is a leader in the application of technology to public transport (PTI, PTM), including electronic ticketing, computerised planning (PTM), an interactive passenger information system and vehicle technology such as the guided busway (EST).</li> <li>• Variable message signs (DIS) and an incident management system (INM) have been installed on Mount Barker Road, on the western slopes of the Adelaide Hills.</li> </ul>

developments in the Australian road system. The table is not comprehensive but gives an indication of systems already in operation and developments currently under way. A more comprehensive review has been undertaken as part of the National Transport Policy Framework process (ATC, 1995).

Thus Australia has been quick to take up some of the opportunities available from applying ITS technologies to the road system. But what of the future? In 1994 a survey was undertaken by ARRB (Miller, 1994) to gauge the relative importance of various technologies and applications as the basis for developing a national research strategy. The survey included representatives of manufacturing industry, motoring associations, road authorities and research agencies. The survey identified seven areas as being of top priority. These areas are shown in Figure 1.

**Figure 1: ITS research priorities (after Miller, 1994)**

<i>Australian Research Priorities for ITS</i>	
1	<i>Incident detection and management</i>
2	<i>Market research</i>
3	<i>Collection of real time traffic data</i>
4	<i>Assessment and adaptation of overseas research</i>
5	<i>Establishment of standards and protocols</i>
6	<i>Adaptive traffic control systems</i>
7	<i>Legal implications</i>

The priorities reflect the fact that despite the examples listed above, the penetration of advanced technologies into the operation of the Australian road system is still in its early stages. There is concern for setting the scene for implementation through market research and monitoring overseas developments, plus sorting out standards, protocols and legal implications. The only applications included in the list are aspects of the core function of traffic control. This suggests that priorities for the immediate future involve an emphasis on building on Australia's existing strength in advanced traffic control systems while creating an environment that is conducive to the implementation of technologies being developed elsewhere in the world.

### **International perspective**

The European Union, United States and Japan have large scale research programs aimed at developing and trialing ITS applications. The current total budget is some A\$1B per annum. In large measure this is a response to acute traffic congestion coupled with environmental problems and resistance to building more and more roads. The programs cover the full range of applications listed above. The strength of overseas R&D programs and rapid implementation in overseas markets has implications for Australia in two major areas:

- (1) *standards*: the development of uniform standards and protocols is an extremely important issue. There is a strong push, particularly from Europe, to create and

enforce appropriate standards. Common standards will allow the various technologies to be connected and work together and will allow vehicles to make use of local facilities as they move from one region to another. Without standards we may end up with compatibility problems and the need duplicate hardware either on the roadway or in the vehicle or both. Most work in this area is being undertaken by technical committees of the International Standards Organisation (ISO). Australian industry and governments are actively participating in these committees, and

- (2) *access to technology*: Australia cannot match the R&D budgets available in Europe, US and Japan and the Australian market is too small to support development in many areas. However Australia is in a position to adopt and customise technology being developed overseas. It may be possible to legislate in the ADR's for a suitable 'platform' for technology development and the implementation of a wide range of applications in new vehicles in Australia.

If international standards are adopted throughout Australia then it will be possible for overseas technology to be quickly adapted to Australian conditions and integrated into existing systems. It also means that it is conceivable that in the future, a traveller will be able to use the same 'smart card' to pay for travel by public transport or to pay tolls in any city throughout Australia.

## Community issues

*The introduction of any new technology for any purpose has an effect on society. It may cause behaviour to change, it may alter the costs associated with different kinds of behaviour, it may be socially redistributive, it may alter the relative balance of power between the state and its citizens. These effects and people's expectations about them generate arguments about the relative merits of the technology, arguments that may effectively decide whether the technology is introduced.*

(Daniel, Webber and Wigan, 1990)

The application of advanced technologies has the potential to deliver significant benefits to road users and road system administrators. However the technology and its benefits cannot be considered in isolation from community context. Inherent in any major technological change, there are range of social, legal, regulatory and institutional issues. In terms of the impacts of ITS, these include: privacy; information ownership; legal liability; equity; uniform standards, and legislation and regulation.

These issues cannot be fully explored or resolved here but there is an opportunity to introduce the circumstances under which they arise, to look at how they will affect individuals and the community as a whole, and to raise some important questions that should be addressed by the community. Many of the community issues, especially those affecting individuals, will arise because ITS allows components of the road system to interact in new ways and information to flow between the components

Current road transport technology is largely impersonal and operates on the basis of averages and totals. Each car, each driver and bus passenger is treated equally and the

way that the system is presented and responds is the same for every user. In future this is likely to change. ITS will allow roads and vehicles to recognise individuals and to communicate and respond on a personalised basis. In some circumstances this interaction will occur automatically. There is also the capability to collect, integrate and disseminate information collected over a wider region to provide an overview for strategic decision making. The impact of emerging technologies as noticed by individual members of the community will be to change their perception of the system as follows

{Impersonal, Manual, Local} ⇒ {Personalised, Automatic, Wide Area}

Most current road system technologies are impersonal, and manual to the extent that interaction between the user and the road system is largely under the user's conscious control. Current technologies also appear to operate on a small local area (single vehicle or intersection), even if this perception is incorrect. For example, a red light is perceived to apply to that particular intersection, whether or not it is part of a coordinated traffic control area spanning a large area. Emerging technologies are allowing road, vehicle and user interactions that relate to specific individuals and occur automatically, perhaps without the user being aware that it is happening.

### **Privacy and information issues**

The first group of community issues arises because ITS can personalise the road system to such an extent that it is possible to automatically identify and capture information about the activities of particular road users. For instance, automatic vehicle identification allows individual vehicles to be identified and tracked. If the technology is used on public vehicles (such as buses, ambulances, police) or commercial vehicles then monitoring can be justified on the basis of control and operational efficiency. However when private vehicles are identified and their movements traced then there are immediately issues of privacy and ownership of information. The issues include:

- who owns the information ?
- who has access to the information ?
- what purposes can the information be used for ?
- can road users retain their anonymity ?

The last question highlights that options exist for using emerging technologies to implement systems that are specific to individuals yet allow them to remain anonymous. An example is electronic toll collection (ETC). There are at least two different ways in which the application can be implemented. One system involves identifying each vehicle as it passes the tolling point and then passing the information to a billing system. An alternative is the use of a 'smart card' that can be prepaid and automatically debited. This provides positive identification for the purposes of charging and is associated with the individual but there is no link between the vehicle and the particular event. In this way the individual remains anonymous. So in some cases there are alternative ways of implementing the technology and it will be up to the community to decide if and how the technology is adopted.

The issue of user rights, particularly those relating to privacy and information, have been the focus of considerable community debate in the USA. Figure 2 indicates the sort of guidelines currently being developed there to ensure that individual's rights are preserved.

## Legal issues

The ability to identify individuals can also be used as a mechanism for enforcement of regulations. This immediately leads to issues of legal liability. Identifying the vehicle and identifying the driver are two entirely different processes. Most technology is linked to the vehicle but vehicles can have many different drivers. Under current legal regimes in Australia, the vehicle owner is responsible for the vehicle and liable for any offences committed by the vehicle. The onus is on the owner to identify the driver. This issue of the vehicle versus the driver will become more important as automatic vehicle identification technologies become more widespread.

Figure 2: Draft US guidelines - user rights and privacy in ITS applications

<b>DRAFT Fair Information and Privacy Principles (ITS America, 1995)</b>	
1.	<i>Individual Centred</i> Recognise and respect the individual's interests in privacy and the use of information
2.	<i>Visible</i> Systems will be built in a manner 'visible' to users
3.	<i>Comply</i> Comply with laws governing privacy and information use
4.	<i>Secure</i> Make use of data security technology and audit procedures appropriate to the sensitivity of the information
5.	<i>Law Enforcement</i> Information identifying individuals will not be disclosed to law enforcement and systems should not be used as surveillance for enforcing traffic laws
6.	<i>Relevant</i> Only collect relevant personal information
7.	<i>Secondary Use</i> Information may be used for non-ITS applications if coupled with appropriate individual privacy protection
8.	<i>Freedom of Information</i> Relevant freedom of information laws and procedures should apply

Similar issues of responsibility and legal liability also arise where there is information flowing from the roadway to the driver or between the roadway and vehicle. Driver information systems and automatic vehicle control are examples. Who will be liable for an accident on an automated highway or for problems that arise if a driver follows directions provided by a driver information system? The current principle is that the driver is in control of the vehicle and cannot transfer any liability. This may need re-examination.

## Equity

Concerns have also been raised that the effects of ITS will be felt differently across the community. Not all members of the community have equal access to the technology or to the information and related services that it can provide. Will the greatest benefits accrue to

those in the community with the greatest ability to pay? Similarly, not all members of the community are equally comfortable using information based technologies. As with all new technologies, the rate of acceptance and ability to utilise the technology will vary within the population. This means that ITS technologies should be introduced in ways that are easy to use and accessible for the majority.

ITS may also produce changes in accessibility, travel behaviour and the pattern of traffic flows. For instance, driver information systems (DIS) may encourage drivers to change their routes and patterns of trips. This has implications for the distribution of economic activity in the city. It will benefit some areas but equally will disadvantage others.

There are already many examples of the use of ITS on Australian roads and the pace of adoption of technological solutions to road system problems is sure to quicken. However most applications of advanced transport technology are aimed at areas where road system usage is high, in terms of traffic congestion, heavily used public transport and lots of trucks. This means that the technologies will be felt first and most extensively in the largest cities where road systems problems are most acute. So far, the focus of applying technology has been in Sydney and Melbourne and is rapidly gaining pace in Brisbane. Systems are being planned or are under consideration in Adelaide and Perth but are largely restricted to basic traffic control and public transport management. In smaller cities, including Hobart, Darwin and Canberra, the need for advanced technology to help alleviate road transport problems is not as urgent. It follows that each State and city is likely to select those parts of the technology that appropriate to their own problems. The take-up rate of the technologies is likely to vary considerably across the country.

### **Standards and institutions**

Standards and institutional change relate to the creation of an environment in which the technologies can deliver maximum benefits with minimal negative impact on the community. The need for standards has already been established since without them there is a danger of having a hodge-podge of incompatible technologies. This has immediate implications for the community in terms of ease of use and cost. It is inconvenient and costly to swap between different systems and to have more than one piece of equipment to do the same job. Likewise it is important that laws, regulations and institutional structures keep pace with changes in technology. The community issues associated with the various technology applications are summarised in Table 3.

There are also important issues relating to public acceptance and implementation. Many of the proposed technologies involve significant changes to the way that road users interact with the road environment. The success of these and other technologies largely depends on the level of public acceptance and willingness to utilise them. There is a danger that potentially beneficial technologies may not be adopted because they become associated with negative issues such as enforcement and invasion of privacy. There are also problems associated with managing the implementation of technological solutions. For many proposed systems, the full benefits will not be realised until a large percentage of the vehicle fleet is fitted with the required instrumentation or a large proportion of the road network is equipped with advanced instrumentation and signage. As a result, initial

benefits may be small and there will be significant challenges associated with managing the transition period until full benefits are realised.

**Table 3: Potential community issues from emerging technologies**

Technology	Issue	Privacy	Information Ownership & Access	Legal & Enforcement	Social & Equity	Standards	Legislative & Organisational
ATC		✓		✓			✓
ROG		✓	✓			✓	
DIS		✓	✓	✓		✓	✓
INM			✓	✓			✓
ETC		✓	✓	✓	✓	✓	✓
AVC		✓		✓	✓	✓	✓
PTI		✓	✓		✓	✓	✓
PTM							✓
RSE		✓	✓	✓	✓	✓	✓
FMS		✓	✓	✓		✓	✓
EPM			✓		✓	✓	✓
TEL		✓	✓		✓	✓	✓

It is clear that ITS has direct implications for the community and community institutions. However there are choices in terms of when and how the technology is introduced. This suggests that social impact analysis and community consultation should be integral components of the process of introducing ITS into the road system.

## Commercialisation

ITS will open up unprecedented opportunities for private sector participation in the overall road system and for greater commercialisation. This will include the development of both the fixed infrastructure by partnerships of government and industry and of the supporting services and facilities. An obvious market is the production and sale of the gadgetry that will support the technology. Another is in software and the sale of information services. The increased availability and use of information about the road system plus communications will create opportunities for companies to collect and process data and then sell it back to road users in a value-added form. For instance, one company might sell realtime traffic information, while another sells electronic maps for route guidance systems, while yet another sells advertising space on the back of 'smart cards'.

Australia could be well placed to take advantage of some of the commercial opportunities arising from emerging technologies. As mentioned above, Australia cannot compete with the budgets for transport technology R&D in Europe, US and Japan, but there are certain areas, such as coordinated traffic signal control, where Australia is a world leader. By building on this lead and targeting niche markets there is considerable potential for

Australia to expand its role as an exporter of advanced technology for road transport operations. In particular, Australian industry can play a role in using advanced technologies to alleviate the traffic problems of Asian cities.

## Conclusions - the future

ITS has an important role to play in the future of the Australian transport system. The need to make better use of existing road transport infrastructure and to improve the efficiency of road transport operations suggests that advanced technologies will be increasingly used in planning, managing and operating the Australian road system. Better practice in Australia may come by providing an environment to facilitate the application of ITS technologies which

- improve the efficiency of business
- increase fuel efficiency and reduce and monitor noise and emissions
- improve road safety
- improve accessibility (demand responsive transport and transport information systems)
- improve travel data collection and monitoring systems.

This is creating exciting opportunities but as we move to take advantage of these opportunities, we must not lose sight of the impact on the community and the broader legal and institutional issues. Further, there is a clear need to adopt a national approach to ensure that uniform standards and regulations are developed and adopted.

The technologies and applications described here are not 'science fiction'. They are available now and it is up to the community to decide how and where to use them.

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