



Intelligent Transport Systems

Module 4e

Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities

OVERVIEW OF THE SOURCEBOOK

Sustainable Transport:

A Sourcebook for Policy-Makers in Developing Cities

What is the Sourcebook?

This *Sourcebook* on Sustainable Urban Transport addresses the key areas of a sustainable transport policy framework for a developing city. The *Sourcebook* consists of more than 26 modules mentioned on the following pages. It is also complemented by a series of training documents and other material available from <http://www.sutp.org> (and <http://www.sutp.cn> for Chinese users).

Who is it for?

The *Sourcebook* is intended for policy-makers in developing cities, and their advisors. This target audience is reflected in the content, which provides policy tools appropriate for application in a range of developing cities. The academic sector (*e.g.* universities) has also benefited from this material.

How is it supposed to be used?

The *Sourcebook* can be used in a number of ways. If printed, it should be kept in one location, and the different modules provided to officials involved in urban transport. The *Sourcebook* can be easily adapted to fit a formal short course training event, or can serve as a guide for developing a curriculum or other training program in the area of urban transport. GTZ has and is still further elaborating training packages for selected modules, all available since October 2004 from <http://www.sutp.org> or <http://www.sutp.cn>.

What are some of the key features?

The key features of the *Sourcebook* include:

- A practical orientation, focusing on best practices in planning and regulation and, where possible, successful experiences in developing cities.
- Contributors are leading experts in their fields.
- An attractive and easy-to-read, colour layout.
- Non-technical language (to the extent possible), with technical terms explained.
- Updates via the Internet.

How do I get a copy?

Electronic versions (pdf) of the modules are available at <http://www.sutp.org> or <http://www.sutp.cn>. Due to the updating of all modules print versions of the English language edition are no longer available. A print version of the first 20 modules in Chinese language is sold throughout China by Communication Press and a compilation of selected modules will be sold by McMillan, India, in South Asia from June 2009. Any questions regarding the use of the modules can be directed to sutp@sutp.org or transport@gtz.de.

Comments or feedback?

We would welcome any of your comments or suggestions, on any aspect of the *Sourcebook*, by e-mail to sutp@sutp.org and transport@gtz.de, or by surface mail to:

Manfred Breithaupt
GTZ, Division 44
P. O. Box 5180
65726 Eschborn, Germany

Further modules and resources

Further modules are under preparation in the areas of *Financing Urban Transport* (November 2009), *Transport and Health* (December 2009), and *Parking Management* (November 2009), and *Social Change and Urban Transport* (October 2009). Additional resources are being developed, and Urban Transport Photo CD-ROMs and DVD are available (some photos have been uploaded in <http://www.sutp.org> – photo section). You will also find relevant links, bibliographical references and more than 400 documents and presentations under <http://www.sutp.org> (<http://www.sutp.cn> for Chinese users).

Modules and contributors

- (i) *Sourcebook Overview and Cross-cutting Issues of Urban Transport* (GTZ)

Institutional and policy orientation

- 1a. *The Role of Transport in Urban Development Policy* (Enrique Peñalosa)
1b. *Urban Transport Institutions* (Richard Meakin)
1c. *Private Sector Participation in Urban Transport Infrastructure Provision* (Christopher Zegras, MIT)
1d. *Economic Instruments* (Manfred Breithaupt, GTZ)
1e. *Raising Public Awareness about Sustainable Urban Transport* (Karl Fjellstrom, Carlos F. Pardo, GTZ)

Land use planning and demand management

- 2a. *Land Use Planning and Urban Transport* (Rudolf Petersen, Wuppertal Institute)
2b. *Mobility Management* (Todd Litman, VTPI)

Transit, walking, and cycling

- 3a. *Mass Transit Options* (Lloyd Wright, ITDP; Karl Fjellstrom, GTZ)
3b. *Bus Rapid Transit* (Lloyd Wright, ITDP)
3c. *Bus Regulation & Planning* (Richard Meakin)
3d. *Preserving and Expanding the Role of Non-motorised Transport* (Walter Hook, ITDP)
3e. *Car-Free Development* (Lloyd Wright, ITDP)

Vehicles and fuels

- 4a. *Cleaner Fuels and Vehicle Technologies* (Michael Walsh; Reinhard Kolke, Umweltbundesamt – UBA)
4b. *Inspection & Maintenance and Roadworthiness* (Reinhard Kolke, UBA)
4c. *Two- and Three-Wheelers* (Jitendra Shah, World Bank; N.V. Iyer, Bajaj Auto)
4d. *Natural Gas Vehicles* (MVV InnoTec)
4e. *Intelligent Transport Systems* (Phil Sayeg, TRA; Phil Charles, University of Queensland)
4f. *EcoDriving* (VTL; Manfred Breithaupt, Oliver Eberz, GTZ)

Environmental and health impacts

- 5a. *Air Quality Management* (Dietrich Schwela, World Health Organization)
5b. *Urban Road Safety* (Jacqueline Lacroix, DVR; David Silcock, GRSP)
5c. *Noise and its Abatement* (Civic Exchange Hong Kong; GTZ; UBA)
5d. *The CDM in the Transport Sector* (Jürg M. Grütter)
5e. *Transport and Climate Change* (Holger Dalkmann; Charlotte Brannigan, C4S)

Resources

6. *Resources for Policy-makers* (GTZ)

Social and cross-cutting issues on urban transport

- 7a. *Gender and Urban Transport: Smart and Affordable* (Mika Kunieda; Aimée Gauthier)
7b. *Social Change and Urban Transport* (Marie Thynell, SGS-UG)

About the authors

Phil Sayeg has specialised in transport planning and related management for 30 years since graduation. Clients have included all levels of government in Australia, foreign governments, international organisations and private companies. As a former director of a large Australian consulting company, he managed their Thailand operations for three years after which he established his own firm in Bangkok and subsequently in Brisbane, Australia. He maintains close connections with his Asian colleagues, works part-time with the World Bank as a staff consultant in several Asian countries, and works with numerous other international clients.

For a number of years, Phil Sayeg has specialised in Asia's urban and regional commercial fleet operations, Intelligent Transportation Systems, environmental issues related to transport, and the impact of Asia's development and socio-economic change on the future demand for transport.

Professor **Phil Charles** is the Director, Centre for Transport Strategy, The University of Queensland, Brisbane, Australia. He has over 30 years of experience in transport strategy roles and has been responsible for transport strategy and policy initiatives within Australia and internationally. He has expertise and experience in

transport strategy development, including infrastructure development and management, intelligent transport systems and road safety, traffic and incident management, strategic analysis and futures scanning, institutional strengthening, professional capability development and business planning, including market assessment for new transport technologies. He has undertaken these roles in Western Australia and New South Wales' road authorities, as chief executive of a national association, as a management consultant with Booz Allen and Hamilton and as part of a University research centre. Professor Charles has graduate and postgraduate qualifications in engineering, and public and business management.

Phil Sayeg and Professor Phil Charles wrote ITS Australia's Intelligent Transport Systems Handbook that was published in 2003 and edit their quarterly Members' Information Pack. They are currently contributing to the development of the first ITS Strategy for Bangkok, Thailand.

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Intelligent Transport Systems

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Authors: Phil Sayeg
(Transport Roundtable Australasia)
Professor Phil Charles
(Centre for Transport Strategy,
The University of Queensland)

Editor: Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH
P. O. Box 5180
D - 65726 Eschborn, Germany
<http://www.gtz.de>

Division 44, Environment and Infrastructure
Sector Project "Transport Policy Advisory Services"

On behalf of
Bundesministerium für wirtschaftliche
Zusammenarbeit und Entwicklung (BMZ)
Friedrich-Ebert-Allee 40
D - 53113 Bonn, Germany
<http://www.bmz.de>

Manager: Manfred Breithaupt

Editing: Manfred Breithaupt, Armin Wagner

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1. Introduction

The application of advanced technologies to assist in the management of traffic flow has been common for over 70 years with the first crude attempts at traffic signal control of intersections and railway crossings in the USA and Europe.

Vehicle manufacturers have been developing advanced technologies to make vehicles safer, driving less stressful, and more comfortable. Many of these same technologies can be found in buses and trains. Advanced technologies are increasingly applied to the management of large public transport networks, and for disseminating information on train and bus arrivals to passengers.

Within the freight transport sector a wide variety of technologies are applied to facilitate efficient movement of vehicles and associated commercial transactions as part of the supply chain.

Collectively, the various technologies are now known as *intelligent transport systems* (ITS). When carefully applied, ITS can make the transport system safer and more secure, more efficient and reduce environmental impact.

The purpose of this module is to assist decision makers and their advisers in developing cities understand what to consider to be able to make best use of ITS, what opportunities and challenges ITS may present, and how best to address the challenges and take advantage of the opportunities.

The focus of this module on ITS in the Source Book is on ITS applications that support the concept of sustainable transport by encouraging the following desirable outcomes which can be expected to find general acceptance:

- Equitable access and improved mobility and including reduced demand for motorised private transport; and improve the modal split in favour of walking, transit, and cycling;
- Improved transport efficiency and productivity;
- Improved safety and security; and
- Reduced environmental impact and improved 'livability', especially in congested city centres.



Figure 1

Managing urban traffic flows is a key challenge of the 21st century.

Jan Schwaab, Mexico-City 2002
GTZ Urban Transport Photo CD

The emphasis here is on urban road based transport, as rail is a more mature technology, and the biggest opportunity can be made in improvements in road-based transport and interfaces with other modes.

ITS is not a panacea for urban and regional transport problems. ITS cannot replace the need for sound transport policy and the provision of competent institutions and adequate infrastructure.

The challenge for developing and developed cities is to understand how ITS can assist with the management of their transport system, to lay the basis for progressive and coordinated development of ITS, and to develop actual experience and competence with ITS, as a purchaser of ITS technologies, and also as a manager of a transport system that employs some ITS applications.

There has been a reliance on looking to developed country experience in planning and implementing ITS in many developing cities. However, there is scope for many developing cities to develop their own approaches that take advantage of, or respond more appropriately

to, their own unique characteristics, as they are in the unique position to be able to learn from the experiences elsewhere and leapfrog developments to more cost-effective deployments.

Since the first edition of this module was published in early 2005 the adoption of ITS and related technologies to benefit common place transport applications has been striking. Navigation technologies for cars, pedestrians, sports persons sometimes on mobile phones or dedicated GPS devices are ubiquitous and now consumer products. Mobile phones are used widely throughout the developing world in transport, even by autorickshaw drivers in India to maintain contact with their families and to enhance their incomes. Smart card applications are increasingly common for facilitating use of public transport systems in developed and developing cities and for payment mechanisms in car and bicycle sharing schemes in developed cities.

2. Description of ITS technologies and applications

2.1 What is ITS?

ITS is essentially the merger of developments in computing, information technology and telecommunications coupled to automotive and transportation sector expertise. The key emerging ITS technologies are being drawn from mainstream developments in these sectors. ITS can therefore be defined as the application of **computing, information and communications** technologies to the real-time management of vehicles and networks involving the movement of people and goods.

2.2 Description of ITS user services

Transport, and therefore associated ITS, involves three components:

- Infrastructure – both from the surface down and above the surface (*e.g.* traffic signals, communications, computers, toll gates, sensors);
- Vehicles – types of vehicles, their safety features, their degree of use of advanced electronics and computing;
- People – human behaviour, preferences and use of transport modes, regulation and enforcement.

A generally accepted way of describing the range of potential ITS applications, or ITS user services, which involve infrastructure, vehicles and people is shown in Table 1. This list of 44 user services within 11 user service bundles is as defined by the International Organisation for Standardisation (ISO). Users include individuals, fleet owners and transport infrastructure owners. Most of these user services or applications would not usually be implemented separately due to the synergies and interdependencies between them (Chen & Miles 2004).

An ITS architecture is a framework for development, planning, deployment and operation of integrated ITS. The US National ITS Logical Architecture defines the activities and functions required for ITS user services as nine functional process trees (Figure 2). They encompass all the functionality of: traffic management, commercial vehicle management, vehicle monitoring and control, transit management, emergency

services, driver and traveller services, electronic payment services, data archiving, and maintenance and construction management.

As an example of the extent to which these ITS user services are deployed in two countries at different stages of development, Table 2

illustrates the situation in a vast developing country like China, with 34 cities of more than 1M, and where there are numerous large, relatively wealthy cities such as Beijing, Shanghai and Guangzhou. It also illustrates the deployment of ITS in Singapore which has been classified as an “advanced developing country” by the

Table 1: ITS user services

User service bundle	User service
Traveller information Services	<ul style="list-style-type: none"> ■ Pre-trip Information ■ On-trip Information ■ Travel Services Information ■ Route Guidance and Navigation – Pre-trip ■ Route Guidance and Navigation – On-trip ■ Trip Planning Support
Traffic Management and Operations Services	<ul style="list-style-type: none"> ■ Traffic Management and Control ■ Transport Related Incident Management ■ Demand Management ■ Transport Infrastructure Maintenance Management ■ Policing/Enforcement
Vehicle Services	<ul style="list-style-type: none"> ■ Vision Enhancement ■ Automated Vehicle Operation ■ Collision Avoidance ■ Safety Readiness ■ Pre-crash Restraint
Freight Transport Services	<ul style="list-style-type: none"> ■ Commercial Vehicle Pre-clearance ■ Commercial Vehicle Administrative Processes ■ Automated Roadside Safety Inspection ■ Commercial Vehicle On-board Safety Monitoring ■ Freight Transport Fleet Management ■ Intermodal Information Management ■ Management and Control of Intermodal Centres ■ Management of Dangerous Freight
Public Transport Services	<ul style="list-style-type: none"> ■ Public Transport Management ■ Demand Responsive and Shared Transport
Emergency Services	<ul style="list-style-type: none"> ■ Transport Related Emergency Notification and Personal Security ■ After Theft Vehicle Recovery ■ Emergency Vehicle Management ■ Hazardous Materials and Incident Notification
Transport-related Electronic Payment Services	<ul style="list-style-type: none"> ■ Transport-related Electronic Financial Transactions ■ Integration of Transport Related Electronic Payment Services
Road Transport Related Personal Safety	<ul style="list-style-type: none"> ■ Public Travel Security ■ Safety Enhancements for Vulnerable Road Users ■ Safety Enhancements for Disabled Road Users ■ Safety Provisions for Pedestrians Using Intelligent Junctions and Links
Weather and Environmental Conditions Monitoring Services	<ul style="list-style-type: none"> ■ Weather Monitoring ■ Environmental Conditions Monitoring
Disaster Response Management and Coordination Services	<ul style="list-style-type: none"> ■ Disaster Data Management ■ Disaster Response Management ■ Coordination With Emergency Agencies
National Security Services	<ul style="list-style-type: none"> ■ National Security Services ■ Monitoring and Control of Suspicious Vehicles ■ Utility, Structures and Pipeline Monitoring

Organisation for Economic Cooperation and Development (OECD) since 1995.

The difference is that Singapore is small and has very advanced, generally integrated ITS within its borders while ITS deployment in China is

unevenly distributed among its cities and with ITS applications deployed in cities usually on a non-integrated basis. However, China's largest cities are planning to develop ITS facilities similar to that in Singapore.

Table 2: Current ITS deployment, China and Singapore (I)

User service bundle	China	Singapore
Traveller information Services	<ul style="list-style-type: none"> ■ Common traffic and transport information programs being promoted in all major cities as a priority. ■ Bus passenger VMS displays in Shanghai and some other cities. Integrated passenger information systems now being planned. ■ Development of embryonic Location-based services (LBS) using mobile phones also being developed with EU support in Beijing. 	<ul style="list-style-type: none"> ■ I-Transport – integrated transport information system: Provides information on real time conditions when completed. ■ TrafficScan – uses probe vehicles (mainly taxis) to collect real time information on traffic conditions. ■ TransitLink web site http://www.transitlink.com.sg – comprehensive portal of timetabled bus and rail schedules. ■ Some embryonic Location-based services (LBS) using mobile phones.
Traffic Management and Operations Services	<ul style="list-style-type: none"> ■ Number of larger cities with advanced UTC systems and CCTV increasing; smaller cities CCTV only. ■ Speed and red light cameras common in cities. ■ Expressway incident management systems. ■ Previous examples of Cordon Pricing (e.g. Guangzhou) – now disbanded. Demand management now being considered in other cities. ■ LED use in traffic signals increasing. 	<ul style="list-style-type: none"> ■ Green Light (GLIDE) intelligent traffic signal system covering 1,850 junctions are under GLIDE control incorporating bus priority pre-emption of signals. ■ Expressway Monitoring and Advisory (EMAS) system. ■ J-eyes – intelligent cameras at some intersections (ie AID). ■ LED used in traffic signals ■ Building on the traffic restraint scheme that commenced in 1975, in 1998, Singapore introduced electronic road pricing (ERP).
Vehicle Services	<ul style="list-style-type: none"> ■ Minor examples in research agencies such as at National ITS Centre. ■ Automotive manufacturers can be expected to introduce in vehicle navigation systems as digital, navigable mapping is developed, e.g. Beijing, where prototype maps are being produced with EU assistance. 	<ul style="list-style-type: none"> ■ Advanced vehicle systems available dependent on market requirements as Singapore imports all vehicles. ■ Car manufacturers are offering in-vehicle navigation systems. ■ Navigable, digital mapping of Singapore and Johor Bahru completed in 2002.
Freight transport Services	<ul style="list-style-type: none"> ■ Taxi (Shanghai) and truck (private companies) fleet management common. ■ Major freight forwarders and international courier companies such as UPS, Fedex using bar coding of consignments and EDI for fast clearance of cargo at major international airports. 	<ul style="list-style-type: none"> ■ All taxis companies now have fleet dispatch/management systems. ■ Limited use of these systems in truck fleets. ■ EDI used at port and airport.

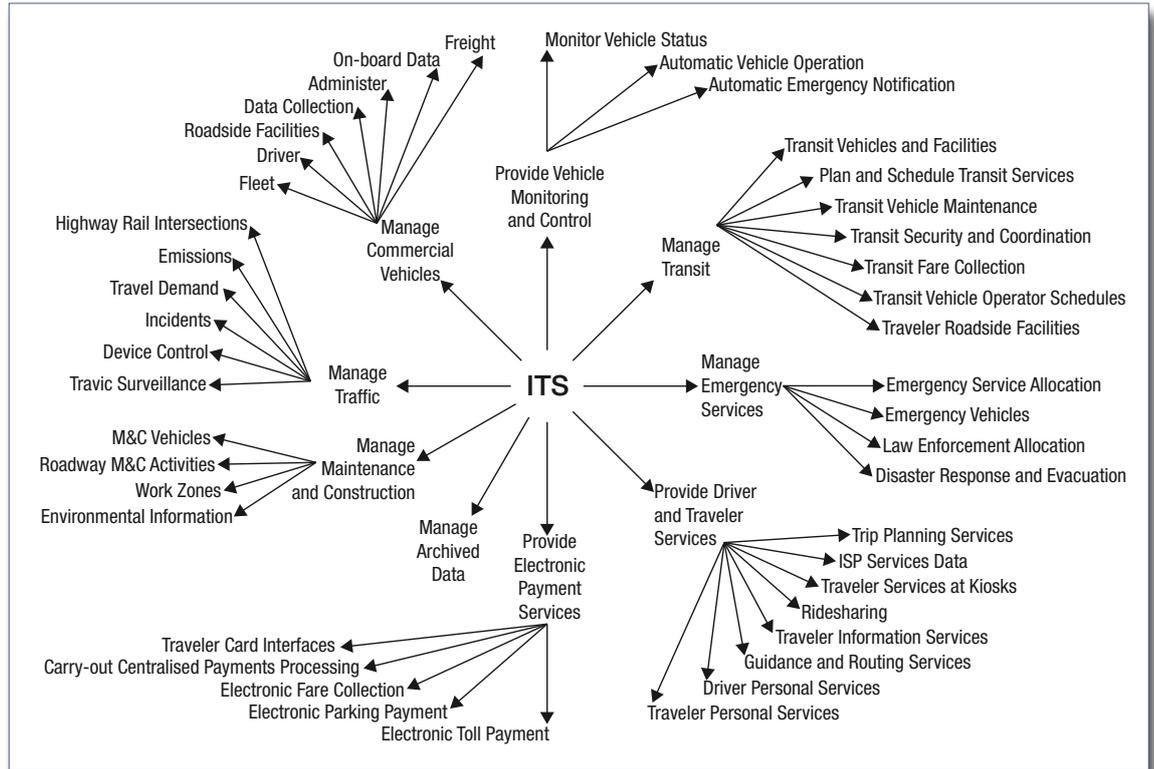
Table 2: Current ITS deployment, China and Singapore (II)

User service bundle	China	Singapore
Public transport Services	<ul style="list-style-type: none"> ■ Bus fleet management using GPS for automatic vehicle location beginning in some cities on large scale, e.g. Shanghai and Beijing. 	<ul style="list-style-type: none"> ■ All buses are fitted with GPS—all bus companies now have fleet management systems.
Emergency Services	<ul style="list-style-type: none"> ■ Police car fleet management GPS systems and on-line infringement system applications in major cities ■ In bus, mayday systems, e.g. mainly inter-city bus. 	<ul style="list-style-type: none"> ■ Advanced emergency services partly coordinated by Singapore's GLIDE and EMAS control centres.
Transport-related Electronic Payment Services	<ul style="list-style-type: none"> ■ Automatic fare collection systems introduced for rail and bus in numerous cities, e.g. Beijing, Shanghai. ■ Electronic Toll Collection (ETC) widespread. China's has directed significant efforts at standardisation for ETC. 	<ul style="list-style-type: none"> ■ Electronic payment part of ERP scheme. ■ Ez-Link smart card system for Singapore public transport and payment of other small purchases including parking.
Road Transport Related Personal Safety	<ul style="list-style-type: none"> ■ CCTV at transit stations and in cities. ■ Help kiosks at transit stations ■ Emergency call telephone numbers. 	<ul style="list-style-type: none"> ■ CCTV at transit stations and in cities. ■ Help kiosks at transit stations ■ Emergency call telephone numbers.
Weather and Environmental Conditions Monitoring Services	<ul style="list-style-type: none"> ■ Weather monitoring stations, control centres and ITS to facilitate emergency response common as part of ITS used in expressways and highways. 	<ul style="list-style-type: none"> ■ Weather monitoring stations, control centres and ITS to facilitate emergency response.
Disaster Response Management and Coordination Services	<ul style="list-style-type: none"> ■ Disaster response coordination plans. 	<ul style="list-style-type: none"> ■ Disaster response coordination plans.
National Security Services	<ul style="list-style-type: none"> ■ CCTV at transit stations and in cities. 	<ul style="list-style-type: none"> ■ CCTV at transit stations and in cities.
Other	<ul style="list-style-type: none"> ■ Smart card driver licences—many provinces have such systems and there are also proposed identity card projects. ■ Bidding system for right to own a private vehicle in Shanghai similar to Singapore's Certificate of Entitlement (COE) scheme. 	<ul style="list-style-type: none"> ■ Certificate of Entitlement (COE) scheme using on line bidding for the rights to purchase a vehicle.

Figure 2

ITS Functions

Source: Fan et. al., 2007



2.3 Priority ITS user services

In keeping with the focus of the Source Book on developing sustainable transport solutions, several priority ITS user service bundles (*i.e.* there is a range of types of services and applications within each bundle) for developing cities have been identified, and they support:

- Traveller information to assist travellers to make better travel decisions prior to their trip for their own convenience and that of their fellow commuters, and to provide more precise information on expected vehicle arrival times and sources of delay while making their journey;
- Traffic (and transport) management to reduce the demand for motorised travel and to give priority to buses, non motorised vehicles (NMVs) and pedestrians;
- Freight transport management to increase the efficiency of freight transport and to reduce the impact of freight vehicles on the community;
- Public transport management in a multi modal sense to ensure compliance with schedules, to minimise the impact of congestion on operations and to achieve efficient allocation of staff and resources;
- Electronic payment for multi-modal transport ticketing (*e.g.* integrated ticketing using

smart cards) and tolling, bicycle and car sharing schemes but also including congestion charging applications to improve efficiency and convenience; and

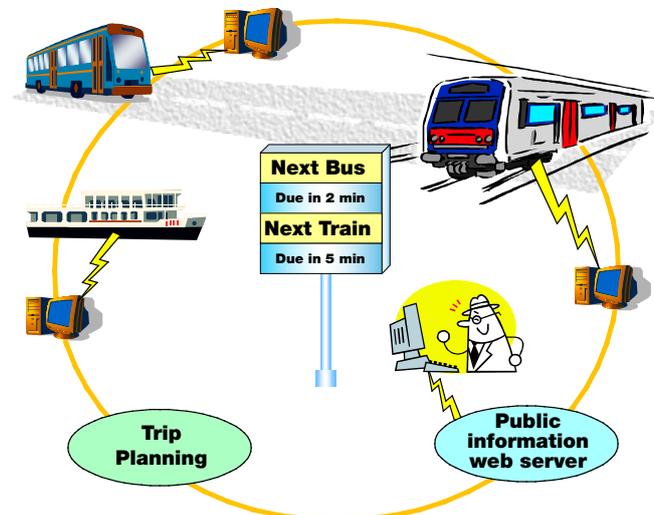
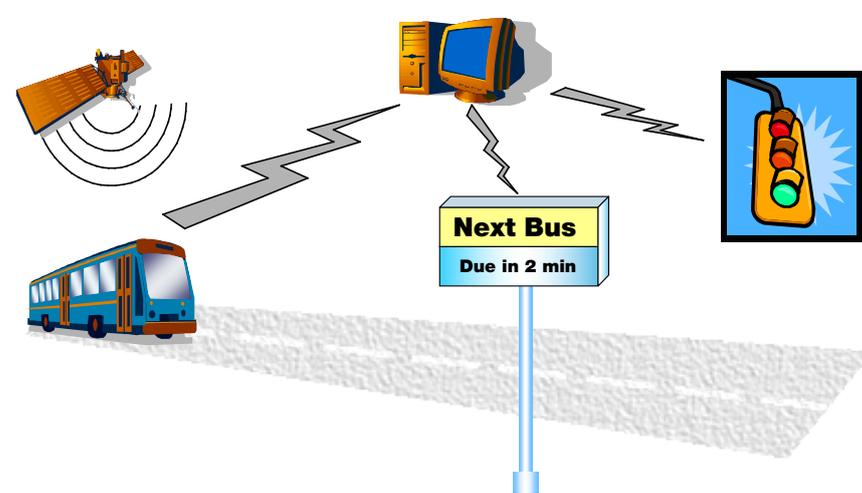
- Safety and security including emergency management.

Government has a major responsibility for these ITS user service bundles due to its current, traditional involvement as custodian of much of the road, rail and bus networks and services. Even in the area of commercial fleet management, while individual operators may generally decide for themselves whether to implement modern ITS to enhance efficiency, their decision to do so may be influenced by government regulations that set standards and routes for operations, and emission levels.

Systems for new vehicles will develop dependent on the market for these devices and initially advanced ITS will be found in new high-end cars, trucks and buses. They are also influenced by government regulations setting standards for vehicle design covering safety and emissions.

Figure 3 illustrates examples of common applications for each of the identified priority ITS user services within the identified bundles and describes briefly their purpose and how they work. Table 3 provides a more detailed summary

Figure 3: Illustration of priority ITS user services & applications

Priority ITS user services	Representative application
Traveller information	
<p>Multi-mode Real and Scheduled Real Time Information</p>	<p>Fig. 3a</p>  <p>Purpose: Assist travellers to make smart travel choices and making public transport more desirable. Examples: Hong Kong, Brisbane, London and Berlin.</p> <p>How it works: Information from various public transport systems is exchanged between the systems. Shared timetables and routes are used for trip planning across various transportation modes. Real time information is shared at connecting points and displayed to passengers. This information is used to delay departures if a connecting service is near. Each system may collect information differently using different technologies but the information is shared in a common manner.</p>
<p>Public transport Real Time Information</p>	<p>Fig. 3b</p>  <p>Purpose: Real Time Passenger Information is designed to increase the level of public transport use by increasing the perceived reliability of services and removing doubt on the arrival of the next service. Examples: Singapore, Brisbane, Strasbourg, London and many other cities.</p> <p>How it works: Buses use GPS and odometers to determine their position along a route. Position information is transmitted back to a central processor using wireless communications such as GPRS. The central system matches the actual bus location to the expected location and calculates how late the bus is. The amount the bus is late (or early) is used to update arrival predictions at other stops along route. Arrival time is displayed on variable message signs at stops, and may be sent to passengers directly using SMS or internet. To assist late buses, the timing of the traffic control signal may be modified in real time allowing a bus to get a longer green light.</p>

Priority ITS user services	Representative application
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Advanced Passenger Information System (APIS)

Fig. 3c

Purpose: APIS aims to influence driver behaviour by providing information on travel times along various route options. Using this information, drivers can avoid heavily congested areas, reducing the congestion and making more effective use of the remaining road capacity. Examples: Japan, Europe, USA, parts of Asia.

How it works: Traffic flow on various road segments is measured using loops (such as used in the traffic signal control system), and probe vehicles with GPS inputs (such as buses, taxis or some fleet vehicles). Travel profiles are developed in real time and drivers are advised of congestion levels before they commit to a particular route. Information is displayed in many forms including variable message signs on the roadside, fed directly to driver in car using wireless technology or to the driver themselves via SMS or internet.

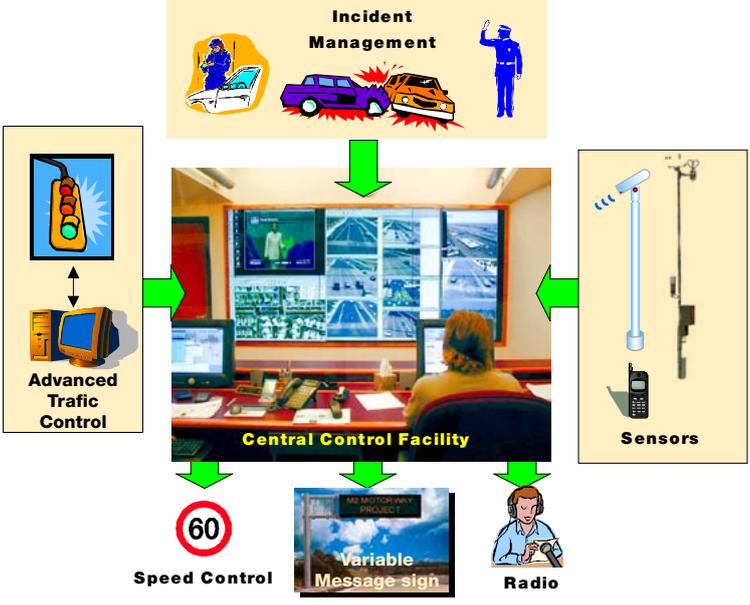
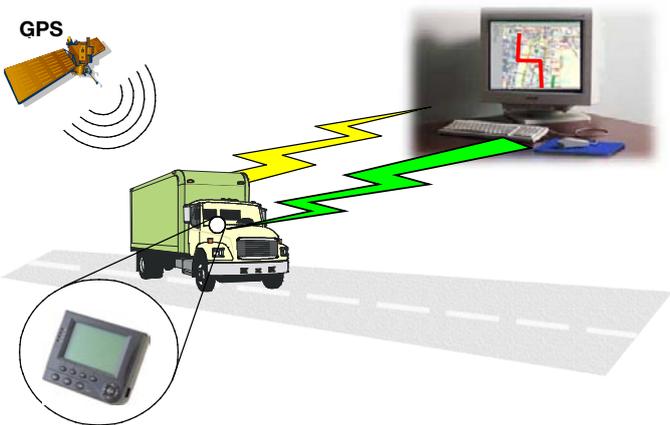
Traffic & transport management

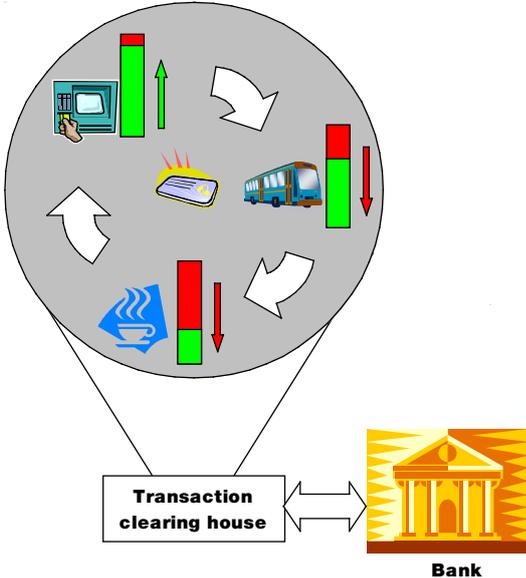
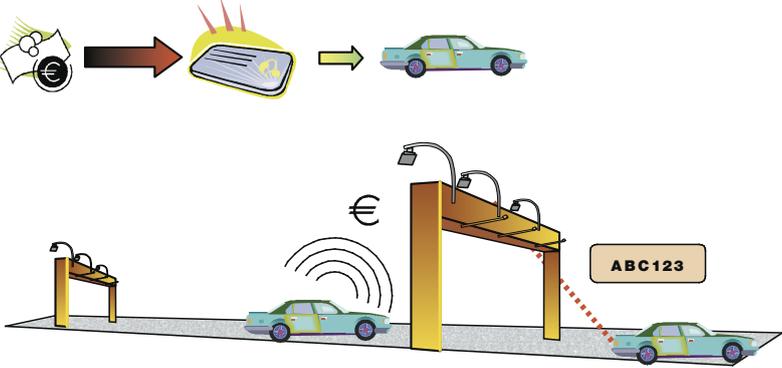
Congestion charging

Fig. 3d

Purpose: To reduce demand for vehicular travel demand and reduce congestion a toll is applied over an area. Public transport is given priority using freed traffic lanes. Examples: Stockholm, London, Singapore. Similar technologies are being used in various Italian and Norwegian cities.

How it works: Drivers who intend to enter the zone prepay their account over phone, using the internet or using their mobile phone and SMS messages. When a vehicle travels into and around the “congestion” zone the number plate is read by one or more cameras. If the user account associated with that vehicle has funds then the account is debited on entry. If there is no money in the account a fine is issued.

Priority ITS user services	Representative application
<p>Traffic control centres & Urban Traffic Control</p>	<p>Fig. 3e</p>  <p>Purpose: To provide a central point of control and visibility to manage the city transport network and reduce the cost of incidents on the road and the public transport system. Examples: Beijing, London, Madrid, Sydney, Singapore.</p> <p>How it works: Traditionally used for traffic signal control the control centre is now a central coordination centre for vehicle movement and road travel data. Centres may be multi-agency with roads, transport, public transport, police and emergency services all using one centre or may be established as a number of specialist centres with data links to all the other centres. An integrated control centre will share data and control from many ITS systems including a computerised traffic control system supplemented by CCTV, information received from the public on incidents, the RTPI system, public transport management systems and operators, APIS and CCTV cameras owned by police, traffic, toll roads and others. Control room personnel coordinate required emergency and traffic services to manage incidents, traffic flow and safety. Variable Message Signs may be used as well as radio broadcasts and other media to keep the public informed.</p>
<p>Freight transport management</p>	<p>Fig. 3f</p>  <p>Purpose: To improve the efficiency of fleet operations. Examples: UK, USA, Japan, Austria, Germany, Switzerland and Australia.</p> <p>How it works: Vehicles determine their position using GPS signals. These are sent back to the fleet manager where the locations of the vehicles are plotted on a map. Route planning software allows the truck to be diverted to additional jobs through electronic instructions sent back to driver. Detailed location history may be kept on board for later analysis. On board systems may also monitor the health of the vehicle and report to the depot base if specific events are triggered.</p>

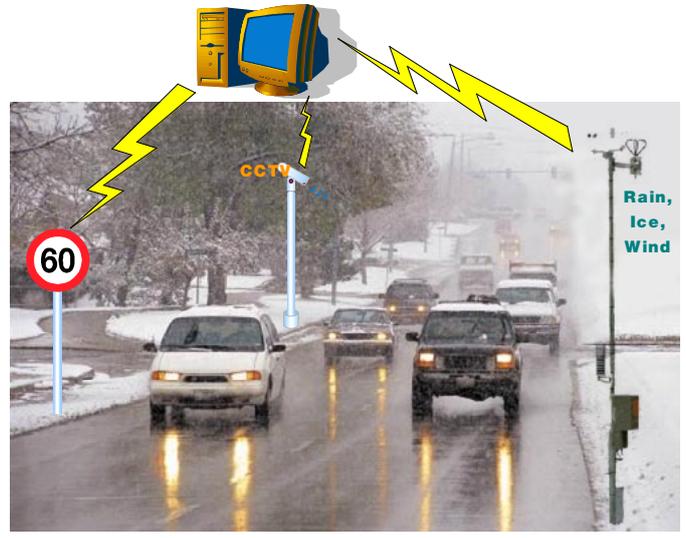
Priority ITS user services	Representative application
Electronic payment	
Electronic fare collection	<p data-bbox="363 376 448 412">Fig. 3g</p>  <p data-bbox="347 965 1461 1218">Purpose: Smart Cards are used as a form of electronic purse. The cards may be topped up at payment stations (banks, small stores) or via internet and then used to pay for goods and services. Examples: London, Bangkok, Kuala Lumpur, Bogota, Hong Kong, Singapore, Madrid. Being considered in Mumbai and Bangalore, India. How it works: By combining a smart card with other functions such as public transport ticketing wider acceptance of the card is achieved. Cards may be contact free for ticketing applications with full contact and pin access for other payments. Transactions are only between card and vendor. Alternative electronic payment systems can use mobile phones for purchases. Sales accrue on phone bill. Vendors get paid from phone company account.</p>
Electronic Toll Collection	<p data-bbox="363 1249 448 1285">Fig. 3h</p>  <p data-bbox="347 1630 1461 1995">Purpose: Electronic Toll Collection (ETC) provides more convenience in payment, requires fewer stops, reduces toll system operating costs and minimises revenue-leakage due to corruption compared to manual tolling systems. Examples: CityLink, Melbourne; expressways Malaysia; and toll roads, Brazil. How it works: Various systems exist using electronic card (tags) designed for Dedicated Short Range Communications (DSRC). Drivers prepay an account which stores the value either on the smart tag or at a central system. As the vehicle travels along road the tag is read by gantry mounted readers. The tag is validated and the system debits the user account for distance travelled at this time of day. Other systems use Automatic Number Plate Recognition (APNR) to read the vehicles' licence plates. The car number is matched with a central database and the user's account is charged. Rates can vary depending on the time of day. If there is no money in the account, no tag is fitted to the vehicle or the number plate is not registered, cameras identify and read the vehicle license plate and an infringement notice is issued.</p>

<p>Priority ITS user services</p>	<p>Representative application</p>
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Safety & security

Safety control systems

Fig. 3i



Purpose: Safety control systems are designed to reduce accidents by alerting drivers to unusual road conditions ahead. Examples: Europe, Japan, China and USA.
How it works: The systems use a range of road side sensors to determine environmental conditions. The sensor data is communicated to a central processing facility often using wireless communications. Decisions on warning messages, lanes to keep open or what speed limit to set are made by the central system in accordance with business rules and variable message signs and variable speed signs are used to convey this information to road users. CCTV cameras are used to enforce the variable speed limits and allow operators to confirm environmental and traffic conditions. Devices monitor wind, ice, fog and vehicle movements. The central system then sets the speed along the road to suit the conditions. Variable speed signs show the current speed and speed cameras are automatically adjusted to enforce the current speed.

Closed Circuit Television Camera (CCTV) surveillance at bus and train stations

Fig. 3k



Purpose: To centrally monitor bus and train stations (and other public areas) to provide assistance and emergency response if required. Particularly valuable when stations are not staffed. Examples: Europe, Japan, China, USA, Australia, Malaysia, Thailand, Hong Kong, Singapore.
How it works: Central control room staff using CCTV and advanced communications monitor public areas. Control Centre staff are linked by advanced communications to police and emergency services. Control Room staff can make announcements and ask if passengers need help. Typically, an emergency telephone is provided to enable passengers to initiate a request for assistance.

Table 3: Priority ITS user services & technologies (I)

User service bundle	User service	Examples	Description
Traveller information	Pre-trip information, on-trip driver information, on-trip public transport information	Variety of technologies/systems	Systems that may provide information on scheduled public transport services or travel times, or on real time conditions delivered via the Internet, SMS, VMS and other communications. May makes use of several enabling technologies such as GPS, wireless communications, etc.
	Personal information services	Variety of technologies/systems	Could consist of merely Internet access to information on travel conditions or location-based services (LBS) sensitive to user profile, location and preferences. LBS may make use of several enabling technologies using GSM/GPS or similar, mobile communications, etc.
	Route guidance and navigation	In-vehicle navigation systems	In-vehicle navigation system provides motorists and truck drivers with information on best routes and updates on traffic conditions, e.g. incidents.
Traffic management	Transportation planning support	Urban transportation demand models, intersection simulation models, GIS systems for geographic data management, etc.	A variety of models exist for simulation of entire transport networks or individual intersections. GIS is used to assist data storage and analysis.
	Traffic Control	Urban Traffic Control (UTC) or Area Traffic Control (ATC)	Urban Traffic Control or Area Traffic Control systems (e.g. SCATS of Australia, SCOOT of UK, ITAKA, Spain) and numerous other computer controlled traffic signal systems made in USA, Japan and in developing countries. SCATS, SCOOT and ITAKA are intelligent, dynamic systems that when fully implemented are demand responsive. To work effectively, it would often be essential to upgrade supporting civil works covering layout of intersection, pavement quality and drainage.
		CCTV – Closed Circuit TV cameras	CCTV is used to verify events by operators in traffic management centres.
		VMS – variable message signs – providing traveller information	Essential infrastructure often making use of low cost LED or changeable message sign technology which is available in many developing countries but also more expensive technologies such as Plasma and advanced LCD displays for display of public transport information. Portable VMS signs also are used to display information on temporary road works and alike.
		VSL – variable speed limit signs & supporting law	Speed limits are set to vary dependent on prevailing traffic conditions (e.g. light or heavy traffic flow) and weather conditions. Requires enabling laws to enforce speed limits and suitable proof if challenged.
		Vehicle detection by inductive loops (in pavement), infrared (above) or optical via intelligent cameras (above)	Inductive loops are the most common because of their low cost, but are less effective where road maintenance is poor. Infrared systems have been in use in some countries for many years and are not dependent on road condition. Optical detection is also increasing.
		LED traffic signals and regulatory signs	Higher cost than traditional lamps in traffic signal heads and signs but lower operating cost due to low energy consumption, longer life and brighter.
	Incident Management	Incident and congestion detection & verification, using CCTV and monitored by Control Centre	Intelligent, digital cameras mounted on suitable vantage points to monitor congestion and traffic speed and characteristics. Examples: Autoscope cameras, USA; Cetrac cameras, Singapore.

Table 3: Priority ITS user services & technologies (II)

User service bundle	User service	Examples	Description
>> Traffic management	Demand Management	AVI – Automatic Vehicle Identification Electronic payment/charging (see below for Electronic payment user bundle)	AVI systems identify the vehicle and registered owner using the vehicle number plate or an electronic identify (ID) in the form of an on-board vehicle unit (OBU) that may also be known as a Tag or Transponder. May use technologies similar used in electronic toll collection (ETC) applications for regular users with OBUs and casual users without.
	Communications		Several communication technologies are available eg Dedicated Short Range Communications or DSRC at 5.8 GHz; infrared, inductive loops. Note: optical/video systems that identify vehicle number plates and check whether a vehicle is authorized to access a controlled area or to record a charge against the vehicle obviates the need for a separate communication system with the vehicle and an OBU.
	Policing/enforcing traffic regulations	Variety of technologies/systems	Speed cameras, red light cameras, access control cameras.
	Infrastructure maintenance management	Variety of technologies/systems	Portable VMS and other technologies for managing temporary maintenance works and for supporting special events.
Freight transport services	Commercial vehicle pre-clearance & commercial vehicle administrative processes	Electronic Data Interchange	Electronic Data Interchange (EDI), or more generally electronic commerce, is a vital part of managing the paperless flow of information necessary for procuring, shipping (by ship, truck or train, etc.), loading, transferring, receiving, payment and meeting any associated legislative requirements efficiently. For efficiency, the physical process and the electronic transactions must be synchronized, regardless of the goods being involved in an international or domestic transaction. Because many of the information flows in the trade and transport industries are structured documents which are transmitted on a regular basis, EDI offers potential benefits.
	Commercial vehicle fleet management	Fleet management systems (FMS)	Using real time information on vehicle location often using GPS, FMS can monitor and control the operations of their fleet. With associated systems can monitor vehicle fuel consumption, emissions and provide diagnostics to check and diagnose problems and suggest solutions.
Public transport services	Public transport management	Fleet management systems (FMS)	Using real time information on vehicle location often using GPS, FMS can monitor and control the operations of their fleet and use the data for passenger information. With associated systems can monitor vehicle fuel consumption, emissions and provide diagnostics to check and diagnose problems and suggest solutions.
Emergency management	Emergency notification and personal security	CCTV – Closed Circuit TV cameras	CCTV is used to identify and verify events by operators in incident command centres.
	Emergency vehicle management	Fleet management systems (FMS)	Using real time information on vehicle location often using GPS, FMS can monitor and control the operations of emergency vehicles, provide advice on best routes, and traffic signal priority.
	Hazardous materials and incident notification	Fleet management systems (FMS)	Using real time information on vehicle location often using GPS, FMS can monitor locations of hazardous loads.
Electronic payment	Electronic financial transactions	Variety of technologies/systems	Includes ETC and electronic ticketing using magnetic stripe and smart card tickets.
Safety	Safety enhancement for vulnerable road users	Intelligent pedestrian crossings	Automated pedestrian detection at pedestrian crossings using microwave or infrared technology.

of the full range of different ITS applications for each identified ITS priority service.

ITS applications to benefit NMVs and pedestrians are usually deployed to support relevant traffic management measures such as exclusive NMV lanes by giving priority access to selected areas (e.g. car free zones). Traditional traffic lights may have their signal phasing adjusted to provide exclusive, all pedestrian phases (see Figure 4), or by appropriate signing to exclude cars from certain areas or streets (see Figure 5).

In the past automatic detection of NMVS such as bicycles at traffic lights has proved problematic but can be overcome, for example, by appropriate inductive loop design at traffic signals. A range of intelligent technologies can be used at signals to detect the presence of pedestrians, bicycles and persons with disabilities on and near crossings as shown in Box 1.

Figure 4
All pedestrian phase at traffic signals in Brisbane CBD, Australia.



Figure 5
Concealable barrier for cars at the entrance to a car free zone, Strasbourg.

Source: GTZ 2003

Box 1: Pedestrian safety and ITS

Pedestrian Walk/Don't Walk signals are special types of traffic control devices intended for controlling pedestrian traffic. The conventional Walk/Don't Walk messages provide pedestrians with reliable information about (a) when it is appropriate to begin crossing the street (steady Walk signal), (b) when pedestrians should not start crossing (flashing Don't Walk), and (c) when pedestrians should not be in the street at all (steady Don't Walk). To optimise the efficiency of traffic signals, many are designed to be vehicle-actuated. At actuated traffic signals, pedestrians may have to press a push button in order to receive the Walk signal and to ensure that they will have enough time to cross the street.

A problem with this arrangement is that not all individuals wanting to cross will press the push button. There are a number of possible reasons why pedestrians do not use the push button. They may not be aware that pressing the button is necessary to obtain the Walk signal, because many signals do not have a push button and automatically allocate a Walk interval on every cycle. Even when pedestrians are aware of the requirement, the delay between the time that the push button is pressed and the Walk signal appears can be long enough that some pedestrians think that the system is malfunctioning. Visually impaired pedestrians may not realize that the push button exists or may not be able to find it. Pedestrians with severe mobility impairments may be unable to press a conventional push button. In any case, the result is that pedestrians may attempt to cross against the signal.

A number of different automated pedestrian detection technologies have been proposed as a means of detecting the presence of the pedestrian, so that he/she does not have to press the button. These include the use of infrared, microwave, and video image processing.

Microwave and Infrared Technologies: A microwave detector generates a beam of energy at a particular frequency. The beam has to be targeted accurately, especially when the size of the object to be detected (e.g. a pedestrian) is significantly less than that of other moving objects (e.g. passing vehicles).

Infrared technologies are already well established for both vehicle and off-road pedestrian detection. The efficiency of infrared detection methods can be degraded if the object remains

still. Infrared devices cannot discriminate the direction of pedestrian movement, nor can they determine the number of objects detected.

Both microwave and infrared detectors work by calling the Walk signal when a person enters the detection zone. A delay can be built in so that persons are detected only if they stay within the detection zone for more than a minimum amount of time.

Experience With Automated Pedestrian Detection: In the United Kingdom, Puffin (Pedestrian User-Friendly INtelligent) crossings respond to pedestrian demand and do not delay traffic unnecessarily when no pedestrians are present. Pedestrian presence is sensed either by use of a pressure-sensitive mat or by an infrared detector mounted above the crossing location. Pressure on the mat is used both for initial detection as well as to confirm that the pedestrian has not departed the crossing zone before the Walk signal appears. Puffin crossings may also utilize an additional sensor to detect the continued presence of pedestrians in the crosswalk, thereby allowing the signal phase to be extended for those requiring additional time to cross. The conversion of a standard signal to a Puffin crossing in Victoria, Australia, reduced by 10% the number of pedestrians who started to cross before the pedestrian Walk signal was presented.

Similar results were reported in Växjö, Sweden. The Swedish results also showed that the number of vehicle-pedestrian conflicts decreased after the microwave detectors were in place.

The Dutch PUSSYCATS (Pedestrian Urban Safety System and Comfort At Traffic Signals) system consists of a pressure-sensitive mat to detect pedestrians waiting to cross, infrared sensors to detect pedestrians within the crossing, and a near-side pedestrian display. Although pedestrians perceived PUSSYCATS to be at least as safe as the old system, many pedestrians reported that they did not understand the function of the mat. As many as half of all pedestrians refused to use the system. Similar applications are being used in the United Kingdom and France.

The present data suggest that automated pedestrian detectors can provide significant operational and safety benefits when installed in conjunction with conventional pedestrian push buttons at actuated traffic signals.

Source: Evaluation of Automated Pedestrian Detection at Signalized Intersections (FHWA 2001)

2.4 Emerging ITS technologies

Emerging communications technologies that have a potentially very important role in facilitating the development of new ITS applications include:

- Personal and portable communications and multimedia;
- Internet;
- High bandwidth communication backbone; and
- Wireless communications.

Other key emerging technologies include:

- Detector and sensor systems;
- Vehicle tracking; and
- Vehicle to vehicle and vehicle to infrastructure communications.

These technologies pave the way for collection and dissemination of information in real time on people and vehicle movement and determination of their proximity to key attractors.

Detector and sensor systems are a fundamental building block in advanced traffic management (the first defined ITS user service). A range of detection techniques is required to obtain a meaningful picture of the transport network, from vehicle queue detection, vehicle occupancy for high occupancy vehicle applications, vehicle type (*e.g.* NMV), vehicle speed (for enforcement), to vehicle type classification (for toll charges), etc. Key emerging detector and sensor technologies include video (application still difficult in the highway sector), laser scanners (new systems are emerging), microwave radar (for speed monitoring and also seen as the technology of choice for vehicle-to-roadside communications), and infrared (for applications in tunnels and some vehicle-to-roadside communications).

Applications able to track vehicles across the road network, using either transponder tags, cellular phones or, more commonly, reading license plates through optical character recognition systems on video images are another key emerging technology. The tracking of vehicles offers the possibility for wide area detection without the costs associated with traditional sensor installations. It also offers point-to-point journey tracking in real time which has long been desired by traffic engineers. Vehicle tracking employs wireless communications to collect

and disseminate real time information. Though, legal issues concerning privacy can arise when tracking individuals' journey routes and times by reading licence plates (see Section 3.2).

Developments in intelligent transport systems have led to increased interest by road authorities to progressively deploying further applications. In particular, transmission of real-time information between vehicles (vehicle-to-vehicle), and with road network operators (vehicle-to-infrastructure) has considerable potential to reduce crashes and mitigate congestion impacts. Current systems are not adequate for time-critical cooperative safety applications yet.

The cooperative vehicle-infrastructure system, being developed internationally, will join intelligent vehicles and infrastructure together to deliver safety and transport efficiency outcomes. To achieve this, Dedicated Short Range Communications (DSRC) equipment operating in the frequency spectrum centred on 5.9 GHz is placed on the roadways and within vehicles. Specific applications have a broad range of uses aiming to achieve a significant reduction in vehicle crashes and reduce vehicle delay.

The USA has already led the way in allocating spectrum in the 5.9 GHz band. Europe and Japan are not far behind and there is an extensive list of research and development programs and trials in these regions using the 5.9 GHz wireless network.

Experience in Europe, the USA and Japan suggests widespread industry acceptance and collaboration between the automotive industry and government in taking this initiative forward.

Specific applications have a broad range of uses aiming to achieve a significant reduction in vehicle crashes and reduce vehicle delay including:

- Warning drivers of unsafe conditions or imminent collisions or if they are travelling too fast, about to run off the road or around a sharp curve;
- Employ collision avoidance technologies to assist drivers maintain safe distances from adjacent vehicles (front, rear, side) and avoid collisions at intersections;
- Informing road system operators of real-time congestion, weather conditions and incidents for real-time management, planning and provision of information to drivers;
- Transmit dynamic information directly into vehicles including providing variable speed limits to smooth out congestion;
- Re-routing of traffic due to construction, incidents or planned special events could be made more efficient based on the knowledge of real-time freeway and arterial traffic conditions;
- Increase traffic flow through signals through the use of vehicle speeds, traffic counts or queues at intersections, through dynamic control of the signal based in real time;



Figure 6
*Not left alone at night:
 Information on public
 transport schedules
 using SMS-technology
 in Dresden/Germany.*

Frank Müller 2002

- Transit and freight vehicles exchange real-time schedule information with a control centre, as well as with waiting passengers or customers; and
- Allow deployment of a variety of commercial applications.

2.5 How ITS differs from conventional transportation infrastructure

There are a number of differences between conventional transport infrastructure and ITS, firstly the conventional infrastructure is largely more mature technology, can readily be specified in terms of design and implementation has a multi-decade life and there is a reasonable industry of capable suppliers and contactors.

On the other hand, ITS products and services are constantly developing and evolving, hence have a much shorter life, are more difficult to describe and specify and the market of capable suppliers and contractors is more limited and diverse.

Procurement of ITS applications has to consider these differences as ITS involves different disciplines and skill sets than physical infrastructure works and when packaged together, ITS sub-contractors may be difficult to access and manage.

Evolution of technologies is influenced by government or market driven change. The private sector will develop ITS technologies where there is expected to be a market for the product or service, such as safety, in-vehicle telematics, vehicle tracking to improve logistics productivity, and expanding telecommunications markets. Often these developments may be best fostered by governments, such as to ensure access to telecommunications networks via regulation, and provide access to national digital mapping.

There are also cases where government intervention is required to foster appropriate development of technologies, such as standards to ensure interoperability between different real-time passenger information or toll road systems.

3. How ITS can assist developing cities

3.1 Common developing city transportation features

Cities have an important role as government, economic, business, cultural and educational centres. Developing countries and their key urban areas face a wide variety of circumstances.

Many developing countries have experienced strong economic growth that raised income levels significantly. Associated with that growth has been a rapid increase in motorisation (generally greater than 10% per annum (p.a.) in both rich and poor countries). There are diverse motorisation experiences in developing cities.

In the major developing, metropolitan cities, traffic congestion has been apparent for over two decades but is now spreading over large geographic areas and over many hours of the day. Many regional cities, which are increasing in number, are now experiencing significant congestion. In China, for example, in 2000 there were 11 cities with more than two million people and 23 cities with between one and two million people. By 2015, as shown in Table 4, it is forecast there will be 40 cities with more than two million and 69 cities with between one and two million people. In Indonesia the number of cities with more than two million is expected to increase from three to five.

Table 4:
Growth of chinese mega cities, 2000 & 2015

Category	2000	2015
> 2 million people	11	40
1 – 2 million people	23	69

Source: China Statistical Yearbook. Forecasts for 2015 from United Nations (2001), World Urbanisation Prospects.

On regional road networks, until a decade or so ago, most interurban highways were two lane roads. New interurban expressways have been built and many more are planned. Significant congestion can occur in and around urban areas, but the major problem is a lack of safety due to poor driver behaviour, vehicle composition and associated speed variability and the results



Figure 7
Assisting Bogota's public transport: TransMilenio Management Center.

Karl Fjellstrom 2003,
GTZ Urban Transport Photo CD

of inappropriate road design, construction and maintenance.

Developing cities have very varied public transport modes. There is incredible variety not only between cities but also within cities. There may be existing urban sections of generally old inter-regional rail systems, new urban rail or mass transit systems, small and large buses with and without air conditioning, van transport operating on fixed routes, point to point or on a non fixed route basis; taxis; small motorised two and three wheeled vehicles including motorcycle taxis, or non motorised vehicles (NMVs) providing access to trunk line bus and rail systems. These individual modes provide a variety of qualities and levels of service and charge different fares thus catering for different market niches.

Within cities the varied vehicle mix and the many different road users including pedestrians and NMVs have different needs that are frequently conflicting. Appropriate management of

traffic in this environment poses special challenges for transport agencies.

In all countries, but particularly in countries with many large and mega cities, there is a need for strong local governments to plan, fund, implement and manage their transport networks. Unfortunately, in many countries and in many cities within countries, local governments are constrained in their depth of responsibilities and capacity. National agencies, which may also be weak and not well coordinated, cannot cope in a timely and mature way with the transportation needs of their many growing cities.

In cities with low car ownership the proportion of trucks in the traffic stream can be quite high. While many of these trucks are old and polluting they serve an important economic function.

These characteristics affect all aspects of transportation management. ITS have a role in assisting with improved management of the transport system in a way that contributes to the identified desirable transport outcomes listed in Section 1.

3.2 ITS can assist achievement of desirable outcomes

Each identified priority ITS user service bundle may contribute to more than one desired transport outcome in a direct way as shown in Table 5. For example, the user service bundle "traffic management" can contribute to all desired outcomes in a variety of ways. Other ITS user services are more specific in their contribution to outcomes. Further description is provided below.

Table 5: Contribution of priority ITS user service bundles to desired outcomes

Priority user service bundle	Equitable access and improved mobility including demand management	Improved transport efficiency & productivity	Improved safety and security	Reduced environmental impact
Traveller information	Yes	Yes	Yes	Some
Traffic (and transport) management to reduce the demand for motorised travel, and to give priority to buses, NMVs and pedestrians	Yes	Yes	Yes	Yes
Freight transport management	Yes	Yes	Yes	Yes
Public transport	Yes	Yes	Yes	Yes
Electronic payment	Yes	Yes	–	Some
Safety & security including emergency management	–	Yes	Yes	Some

Box 2: London and Stockholm congestion charging

The **London scheme, a cordon pricing scheme**, the largest of its kind in the world at the time, charges vehicles driving into central London a flat fee of £ 8 per day between 07:00 and 18:30, Monday to Friday. The charge area is 21 square kilometres and involves monitoring and charging 200,000 vehicles per day.

Traffic conditions and public transport services had deteriorated to an extent that various opinion surveys showed that overwhelmingly Londoners wanted less traffic and better public transport. There was general acceptance from the public that something had to be done. Thus, this became a key part of the platform of Ken Livingstone when he ran for mayor in 1999/2000.

The London scheme was made possible by the Transport Act (2000) which gave all local authorities in the UK the power to introduce (Goodwin 2004):

- Road User Charging; or
- A Workplace Parking Levy.

The Transport Act guarantees that revenue will be retained locally and ring-fenced for at least 10 years to fund improvements in local transport. Ministers have said this revenue will be additional to that provided by the taxpayer (Goodwin, 2004). The London scheme was developed as part of an integrated package of transport improvements as required by the Transport Act (2000).

Charging is based on automatic number plate recognition technology using cameras situated on the boundary and throughout the charging zone. The charge can be paid using online means (*i.e.* Internet), telephone, SMS text messaging, post and retail outlets. Paying vehicles are registered in a data base which the system accesses to check captured images of licence plates of vehicles entering the zone. The main reason for choosing this type of proven technology was that as a charging scheme had to be introduced with the first term of Mayor Ken Livingstone, then only a small area of central London could be charged which predicated that most vehicles in Greater London would not be regular users. The project's design will allow migration to a system with more advanced technology and more sophisticated pricing. The scheme came into operation in parts of Central London on 17 February 2003 and it was extended into parts of West London on 19 February 2007. A payment of £ 8 is required for each day a chargeable vehicle enters or travels within the zone between 07:00am and 06:00pm; a fine of between £ 60 and £ 180 is

imposed for non-payment.

Benefits: Based on the first 12 months of scheme operation the scheme has been successful in reducing traffic levels and effecting a switch to public transport, in and around the charging zone. Dix (2004) reports that within the first six months the introduction of the scheme had the following effects:

- 10% to 15% reduction in traffic in the zone;
- Congestion reduction of 30% inside the charging zone;
- Journey time reliability has improved by an average of 30%;
- Small changes in orbital traffic but no significant diversion to local roads;
- 60,000 fewer car trips coming into zone;
- 4,000 people no longer travelling to central London as a result of congestion charging; and
- Public transport largely catered for people switching from car.

The Stockholm **congestion pricing system** was implemented on a permanent basis on 1 August 2007, after a seven-month trial period between 3 January 2006 and 31 July 2006. The primary purpose of the congestion tax is to reduce traffic congestion and improve the environmental situation in central Stockholm. It uses similar technologies to the London scheme.

Source: Transport for London and Wikipedia http://en.wikipedia.org/wiki/Stockholm_congestion_tax, accessed 24 December 2008



Figure 8
Congestion charge reminder at a busstop in London.

Dr. Gerhard Metschies 2003



Figure 9
ERP Gantry Singapore.
 Karl Fjellstrom 2002,
 GTZ Urban Transport Photo CD

Society wants *equitable access to community services and adequate mobility* by all modes. However, the absence of an equitable pricing regime for public transport versus cars and personal convenience and flexibility afforded by the motor vehicle, encourages excessive car use. Cars are low occupancy vehicles that in peak periods do not pay their way taking into account the extra congestion, pollution and crashes they cause. It is also a barrier to enhanced public transport use.

ITS technologies can assist in implementing traffic restraint schemes such as the application

of road use charges (often called road user charging or road pricing) as now exist in London and Singapore and vehicle access management schemes as exist in several European cities such as Rome, Milan and Durham.

Singapore's electronic road pricing (ERP) scheme which has been operating since 1998 illustrated in Figure 9 (having been converted from the manual Area Licensing Scheme which commenced in 1975) is no longer an exception. Since 2003, London has charged cars for travelling into central London as described in Box 2. Stockholm, Sweden, followed with their own charging scheme in 2006 as shown in Box 3. Other cities in Europe (Milan, Rome, Durham and other cities) are adopting similar strategies to reduce the impacts of cars on historic city centres, and ITS is playing a major role.

ITS has a valuable role in provision of information on scheduled and actual transportation services by all modes as shown in Figure 10. This information enables better planning of trips for travellers of all ages, with or without disabilities. ITS enables real time information to be provided on bus, tram and train arrivals that benefits travellers prior and during their journeys. By encouraging public transport use, ITS also encourages increased walking and cycling that facilitates access to public transport stops and terminals.

Box 3 describes Singapore's long running I-Transport Project—a multi-modal project—which encountered many difficulties during its implementation, illustrating the need for proper resourcing and realistic expectations. A vital part of any city's traffic and transport control arrangements is the use of ITS for protecting pedestrians and cyclists and giving them priority access to desired routes and "green" areas.

Reducing the demand for private modes of travel and shifting the balance in favour of public transport, walking and cycling can be done by providing accurate information on modes, routes and timetables in real time. Box 4 describes Hong Kong's recent experience with provision of real time traveller information.

New electronic ticketing technologies provide automated payment and convenience to consumers. Advanced ITS technologies can also provide priority to buses, bicycles and other

Figure 10
Public Transport Real Time Information Display, Strasbourg.
 Source: GTZ



Box 3: Singapore's I-Transport

In September 1997, the Singaporean Government approved the Integrated Transport Management System (ITMS) project which aims to integrate all ITS including obtaining real time travel time information on the surface street system, the interface with car parks, mass transit, bus transport and the associated interchanges. It may also include data from the fleet management systems of private operators and possibly other systems under private sector ownership. During 1999, ITMS was renamed as i-transport. The concept of i-transport is illustrated below:

- **Phase 1: Integration of Traffic Information (Traffic.Smart)** – The system collects data from Expressway Monitoring and Advisory System, probe vehicles in TrafficScan, ERP, GLIDE traffic signals, and the Roads Information Management System. These data are processed by the Transport Information Hub (TIH) server of i-transport and since August 1999 have been disseminated to the public via the LTA website, later also via wireless communication networks.
- **Phase 2: Integration of Public Transport Information (TransitSmart)** – public transport information integration; an island-wide Bus Travel Information System to provide highly accurate, real-time bus travel information covering 4000 buses and 1000 bus-stops. It involves building the first and largest private Tetra communications network in Asia. Transit.

Smart integrates data from the following sub-systems: the fleet management systems of bus operators (FMS), Rail Travel Information System (RATIS) and the Electronic Travel Guide (aimed at providing intending travellers the best **routes in terms of times and costs on public transport between any two points**) all of which are to be developed under this phase and associated projects. In addition, some 1,000 bus stops were fitted with VMS signs (LED) giving real time arrival information to bus passengers. The locations are tracked using GPS systems supplied by Singapore's smart card project (Enhanced Integrated Fare System or EIFS). Singapore's 3,800 urban buses are polled every 25 seconds using a dedicated radio communication network supplied under this phase.

- **Phase 3: Multi-modal Route Advisory System (Route.Smart)** – This phase involves the integration of real time public transport and traffic information to provide multi-modal route advisory information. It is designed to provide Singapore-wide multi-modal travel information and planning advice based on the traveller's selection criteria, real time traffic conditions and public transport information.
- **Phase 4: Manage.Smart – integrated traffic management systems** for management and monitoring was added as a new concept around 2000.

Source: Sayeg and Charles, (2004a)

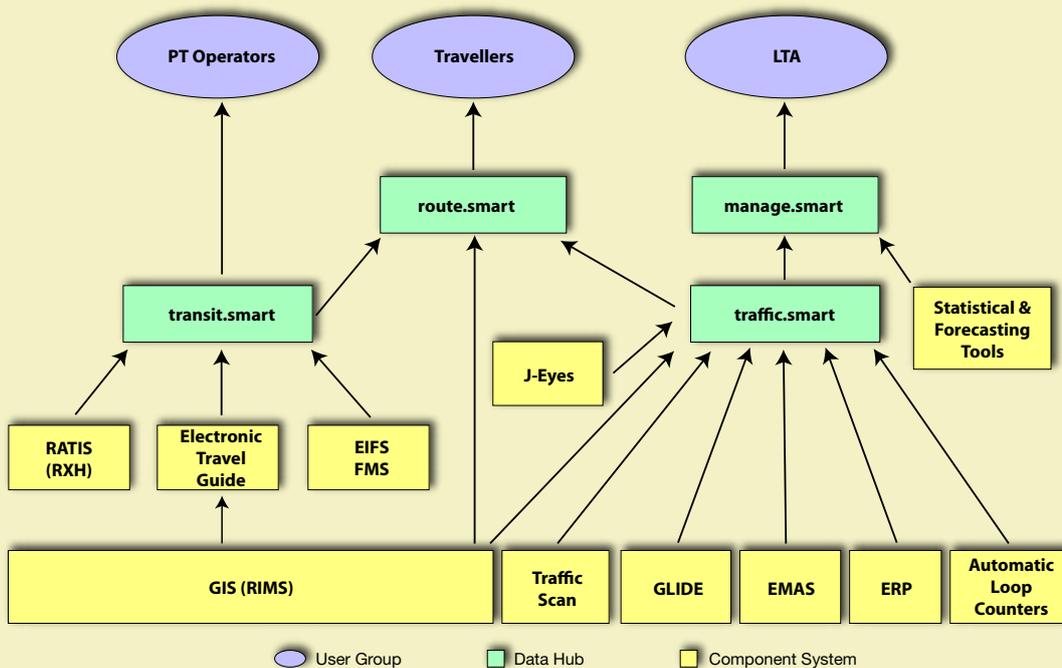


Figure 11
Scheme of i-Transport,
Singapore.

Sayeg and Charles, 2004

Box 4: Real time public transport information, Hong Kong

Hong Kong has a significant urban bus fleet consisting of about 13,300 buses and several thousand mini-buses (public light buses). The main public bus companies are:

- New World First Bus Services Ltd (owned 100% by New World);
- The Kowloon Motor Bus Co (1933) Ltd (KMB) with its subsidiary Long Win Bus Co;
- New Lantau Bus Co (1973) Ltd; and
- Citybus Ltd (now wholly owned by Stagecoach).

Despite earlier failed attempts, by 2003, all bus companies had committed to using GPS but progress has been slow. The feasibility of using an enhanced GPS-based fleet management system was recently demonstrated in a field trial conducted by Citybus. A consortium led by Marconi Communications Asia Limited used an integrated combination of three methods to calculate the location of a vehicle:

- GPS;
- Differential positioning; and
- Direction and dead reckoning.

This integrated method was required to overcome the “urban canyon” type problems that are quite common in a dense city like Hong Kong. KG Intell (referred to below) regards their ability to blend these technologies to provide accurate positioning in major cities a key competitive advantage.

Recently, LED display showing the route number, the next departure time and the fare have been put on trial at selected bus termini. Transport Department is expanding the development of bus-bus and bus-rail interchanges especially in the New Territories where the massive new urban rail projects have been developed.

KMB had installed integrated bus service information display systems at 19 bus termini by end of 2004. The system displays information such as the next departure times, bus route destinations and fares on large LED or plasma display panels. Messages may also be displayed to alert our customers about emergencies, major traffic disruptions, etc. The closed circuit television systems and public address systems installed at the bus termini enable monitoring of the local traffic and operating conditions from the regulators' offices and also the main control room at KMB Headquarters. There are also three “Cyber Bus Stops”, at the Star Ferry, on Canton Road, and on Nathan Road outside Grand Tower, equipped with a built-in computer and a touch-screen LCD panel, which enables passengers to visit KMB's website and obtain bus route details. Each Cyber Bus Stop is fitted with a broadcasting system that announces details of bus routes in Cantonese,

English and Putonghua. The multi-purpose Cyber Bus Stop has been granted a patent certificate by the Intellectual Property Department. Web site: <http://www.kmb.hk/english.php?page=profile&file=tech/index.html>

ESRI Hong Kong implemented GIS map support systems for KMB's and New World First Bus's hot line enquiry systems (see below for New World First Bus). Both KMB and New World First Bus were having preliminary talks on offering a joint passenger enquiry and information service in 2006. Web Site: <http://www.esrichina-hk.com>

Further developments by KMB since 2004 include automated bus stop announcements including tourist announcements on Route 15 generated by AVL systems. KG Intell of Hong Kong were involved in the development and are actively pursuing integrated RTPI, fleet management and ticketing solutions for bus and other transport and are making initial advances in China. Web Site: <http://www.kgintell.com>

New World First Bus (NWFB tested GPS and associated fleet management and RTPI systems in 2006. An interactive Electronic Route Map (NWFB Route Guide) has been put on trial at the Immigration Tower (Transport Department's building) bus stop. It comprises a route map and an announcement system which provides commuters with NWFB's route information and guide them to the right NWFB bus stops to take the buses. Web site: <http://www.nwfb.com.hk/chi/index.htm>.

Under the “A Smart Way for Safety and Efficiency” implementation of a Journey Time Indication System (JTIS) was initiated in 2002. The JIS was intended to assist motorists make a more informed choice (when travelling from Hong Kong Island to Kowloon via the three cross-harbour tunnels) by providing real time information on actual traffic conditions on all crossings. Commissioning of the main indicator signs took place over June 2003 to December 2003. The journey times on display are calculated from the locations of the indicators to the Kowloon exits at the tunnel toll plaza. They are updated at least every five minutes. The system features data acquisition, a communications network, a remote on-site LED display and a Central Control Centre. Apart from detection cameras to collect traffic data, the system has in-vehicle Global Positioning System (GPS) units installed on 82 buses to provide GPS data for analysis. Journey times to Kowloon through the Cross Harbour Tunnel, the Eastern Harbour Crossing and the Western Harbour Crossing is shown on the indicators in green (low congestion), amber (moderate congestion) or red (congested). Hong Kong Intelligent Transport Services Ltd implemented and currently manage JTIS for the Transport Department. They also worked on an early RTPI pilot for KMB in 2002 plus back office support systems for passenger enquiry services at KMB. Web Site: <http://www.hkits.com.hk>.

NMVs within complex traffic management systems. These ITS systems also enhance the ability of public transport operators to manage relationships with many millions of customers using electronic tickets or on-line payment and information services for mutual benefit. Bogota's TransMilenio Bus Rapid Transit (BRT) uses a prepaid ticketing scheme that was provided by a private concessionaire selected through an open bidding process. Passengers use contact-less electronic cards to access stations where they load the buses through multiple doors. The fare collection system includes producing and selling electronic cards, acquiring, installing and maintaining equipment for access control and validation, information processing, and money handling (Castro, 2003). Refer to Figure 12 for an image of an electronic ticketing application. In Mumbai, India there is a limited integrated electronic ticketing system operating between a major bus operator and one of the two railway operators. Both Mumbai and Bangalore have plans for more major integrated ticketing systems.



Figure 12
Smart Card Ticket Validation, USA.

Box 5: **Paris' vélib cycle sharing initiative**

More than 10,600 bikes on 750 self-service docking stations were made available in central Paris in July 2008 in an inexpensive program that provides access in eight languages. With the number to grow to 20,600 by the end of the year, the scope of this initiative – dubbed Vélib', a name that fuses the terms "vélo" (bike) and "liberté" (freedom) – is by far the most ambitious in the world. It is the latest in a string of European efforts to reduce the number of cars in city centers and give people incentives to choose more eco-friendly modes of transport. First indications are positive. Even before the docking stations opened, some 13,000 cyclists had bought annual subscriptions online. To deter thievery, cyclists are obliged to leave credit card details (a € 150 deposit will be debited if the bike is not returned).

"This is about revolutionizing urban culture," said Pierre Aidenbaum, mayor of Paris' third district, which has the highest share of bikes per inhabitant and which opened 15 docking stations. "For a long time cars were associated with freedom of movement and flexibility. What we want to show people is that in many ways bikes fulfill this role much more today."

Moreover, the program could bring about € 30 million in rental receipts into public coffers, city hall officials say. The advertiser JC Decaux is paying for the docking stations, the bikes and their maintenance, in exchange for exclusive use of 1,628 urban billboards.

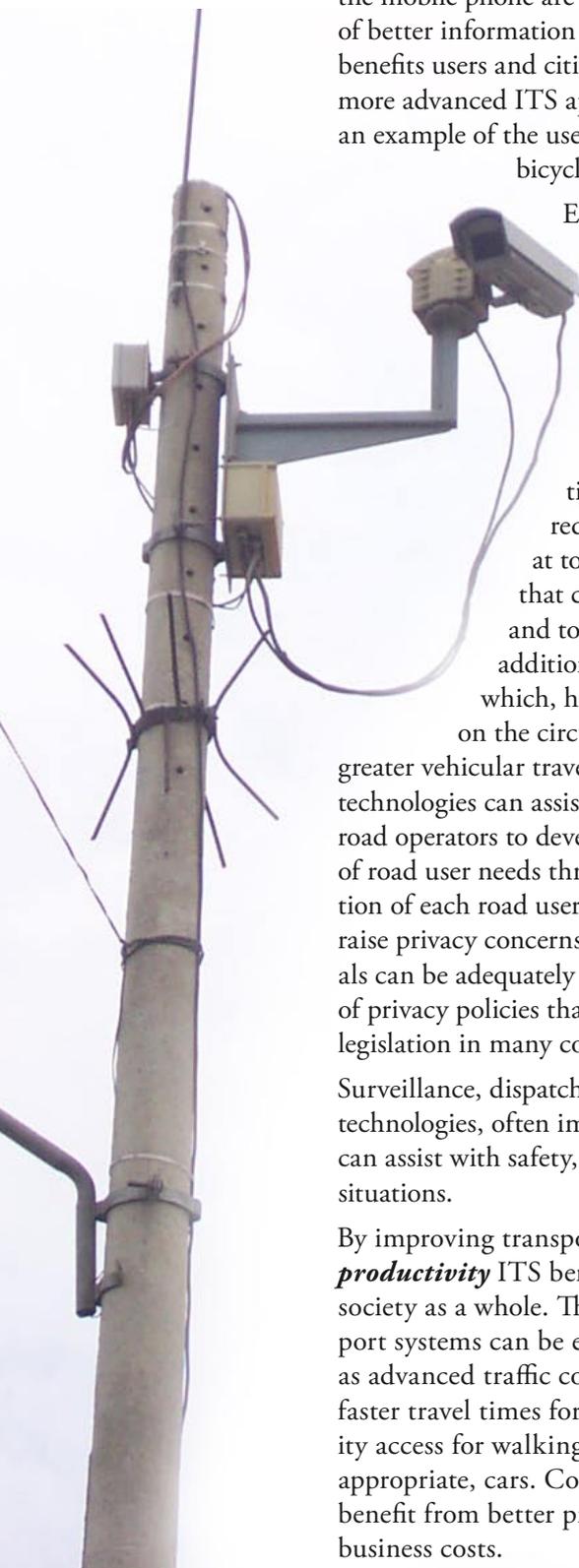
Vélib' is the brain child of Paris' mayor, Bertrand Delanoë, a Socialist and longtime green campaigner who has pledged to double the number of cycle lanes in the French capital by 2008 and reduce car traffic by 40% by 2020. Since he took office in 2001, Delanoë has built almost 200 kilometers, or 125 miles, of additional cycle paths, ripping up car lanes and earning him accusations from drivers of aggravating congestion in the city.

City Hall is hoping to encourage people of the large pool of bike sceptics to use the bicycle more often by drawing on the experience of smaller-scale rental programs in other French and European cities, including Berlin, Barcelona, Brussels, Vienna and Stockholm. The programs differ in a number of ways, but they all seek to address the concerns about theft and financial viability that brought down the pioneering "White Bike" experiment in Amsterdam in the 1960s.

Source: International Herald Tribune, Article by Katrin Bennhold, published: 15 July 2008

Figure 13
CCTV-use in public
space in Cartagena,
Columbia.

Klaus Banse 2003,
 GTZ Urban Transport Photo CD



Internet applications for payment which are used as one payment channel for London's Congestion Scheme and many toll road schemes for occasional users are now being used for bicycle sharing schemes. In that way, the Internet and the mobile phone are providing the benefits of better information and convenience which benefits users and cities in the same way as more advanced ITS applications. Box 5 presents an example of the use Internet for booking of bicycles in Paris.

Electronic Toll Collection (ETC) is used to support road use charging schemes which are designed to restrain demand for private car travel and/or to raise revenues. At the same time, ETC can be used to reducing delays to motorists at toll booths, reduce fraud that causes revenue leakage, and to support development of additional road infrastructure which, however, may, dependent on the circumstances, encourage greater vehicular travel. The electronic payment technologies can assist road managers and toll road operators to develop a closer understanding of road user needs through unique identification of each road user's vehicle. While this may raise privacy concerns, the privacy of individuals can be adequately protected by the adoption of privacy policies that are now mandated by legislation in many countries.

Surveillance, dispatch and communication technologies, often implemented in real time, can assist with safety, security and emergency situations.

By improving transport system *efficiency and productivity* ITS benefits individuals and society as a whole. The management of transport systems can be enhanced by ITS, such as advanced traffic control systems, to ensure faster travel times for public transport, priority access for walking and cycling and where appropriate, cars. Commercial fleet operators benefit from better productivity and reduced business costs.

Advanced ITS can be used to make effective use of limited road space by creation of an advanced traffic management to automatically and safely allocate traffic lanes to favour peak directional bus movements.

Logistics is the process of planning, implementing and controlling the efficient, cost effective flow and storage of materials, in-process inventory and finished goods, and related information from point of origin to point of consumption for the purposes of providing cost-effective customer service. Freight is one part of a management process concerned with the transport, storage and handling of commodities.

Electronic commerce in the freight transport sector is a vital part of managing the paperless flow of information necessary for procuring, shipping (by ship, truck or train, etc.), loading, transferring, receiving, payment and meeting any associated legislative requirements efficiently.

Additional fleet management and navigation technologies also compound these e-commerce and network-wide benefits for commercial fleet operators who value speed and reliability. These benefits flow through to consumers through lower prices.

As an early response to growing traffic congestion many developing cities have limited truck entry into city centres for many years. However, blanket bans may merely shift congestion to other locations and time periods. Increased costs in freight transport will partly be passed on to consumers and economic growth may be impaired. ITS technologies can assist to selectively monitor and manage heavy vehicle movements to minimise congestion and externalities while at the same time enhancing freight efficiency.

ITS improves *safety and security* by providing transport system managers with real time information on the locations of vehicles and better management of the road system and its performance. ITS can assist with routine management and with management of extraordinary events.

Car, bus and truck owners can directly benefit from the new and emerging Vehicle Safety Systems including mayday, drowsy driver warning,

cruise control, crash warning and avoidance, smart restraints and engine diagnostics. Both the incidence and severity of crashes can be reduced in cars, buses and trucks.

At public transport terminals surveillance of stations using Closed Circuit Television (CCTV) cameras and emergency communication points can assist in providing secure environments for waiting passengers, especially at time of low demand.

Transit and cross-border security is now a key issue for society—ITS can assist here with smart technologies to screen and approve access and for surveillance. ITS can improve preparedness, prevention, protection, response and recovery in the event of a national disaster or a security-related event. In many rural areas during periods of flooding or at times of natural disaster, delivery of accurate, timely information on the availability of bridges and highways is critical and can be facilitated by use of Internet, SMS messaging and other modern communication technologies.

ITS can benefit the *environment*, too, by providing automated systems for fleet managers to ensure their vehicles take the most efficient route thus saving fuel and green house gas emissions. Other emissions, such as particulates, carbon monoxide and hydrocarbons that affect human health, cause smog and damage the environment, are reduced, too. ITS technologies may assist in moderating transport demands by encouraging increased public transport usage, and higher vehicle occupancy.

4. Status of deployment of ITS in cities

4.1 Current status

Considerable variation in ITS deployment may usually be found between cities of different sizes within the same country. This is appropriate—small cities have different characteristics and needs compared to larger cities.

Generally speaking, in developing cities, ITS applications that have been deployed to date have been stand-alone systems developed by different agencies. Often, the ITS systems have been associated with large infrastructure projects. Usually, there is no strategic framework for ITS planning and deployment with the result that ITS applications are not integrated and interoperable with each other.

Some examples of practical difficulties that result from a lack of integration are:

- Users of electronic ticketing on public transport must purchase new tickets when transferring from bus to bus and bus to train;
- Intending travellers can only access information on the timetables of each public transport company one at a time, rather than seeing all available travel options including the possibility of multi-modal journeys; and
- With different proprietary electronic tolling systems in the one city, motorists that wish to use multiple toll roads on a regular basis must purchase different in-vehicle tags at increased cost and inconvenience, and often with additional delays.

Both ETC and UTC have been given priority in both developed and developing countries to date. UTC and ETC are seen to represent the platform on which more sophisticated ITS applications can be developed.

ETC technologies improve the efficiency of toll collection operations, improve the commercial viability of highway development and, where commercial viability is proven, serve to attract private finance to operate toll collection operations. It is common to find that, initially, proprietary technologies provided by particular firms are employed. In that case moves to define standards and protocols to ensure interoperability have to be made.

Figure 14

ITS can help in making urban infrastructure more efficient and in reducing land consumption.

Karl Fjellstrom, Beijing 2003, GTZ Urban Transport Photo CD



Because of the important role of the World Bank, Asian Development Bank and other international institutions in funding expressways in many developing countries, well developed specifications and procurement procedures (International Competitive Bidding) tend to exist for national expressway projects (including tunnels and other major fixed links).

Where projects are locally funded, and projects not subject to International Competitive Bidding, there is no guarantee that specifications are well defined or procurement procedures are transparent.

In the UTC area, international organisations have had limited influence to date. Numerous international firms with their own proprietary UTC systems are active in the market. This often leads to a situation that once a particular (proprietary) UTC system is established in a city, purchasers are locked into a limited range of suppliers and higher maintenance costs than if an open system had been employed. As UTC

systems have a life of up to 20 years, the ongoing cost penalty of use of proprietary technologies can be significant.

Traffic management in developing cities is often the responsibility of the traffic police who are usually not qualified as traffic engineers. Traffic police usually, and appropriately, focus their efforts on operations and enforcement. In many cities there has been little attention paid to the broader aspects of traffic management planning and design and police have tended to use measures that are easy to regulate and enforce such as one-way street systems and parking bans.

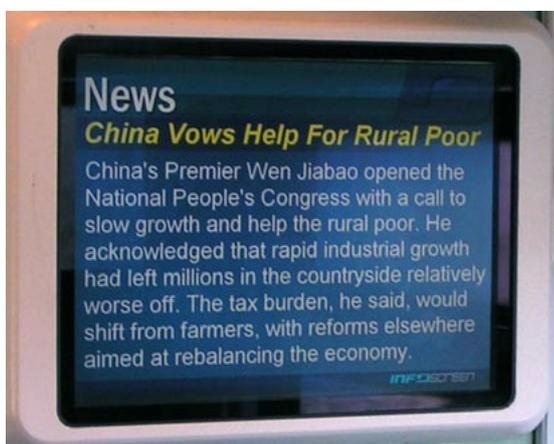
In many cities, there is a growing recognition that a more comprehensive approach to traffic management is needed. Attention is now focussed on UTC systems and other associated ITS including red light cameras and CCTV. Because the police are not traffic engineers, they may not have not fully realised that UTC systems alone will not achieve the potential benefits without better supporting physical treatments such as proper line marking and intersection design.

In some developing cities, such as in China and Brazil, attention is also being placed on developing advanced public transport management systems. There are examples of buses using locally manufactured automatic vehicle location (AVL)/fleet management and dispatch systems. Similarly, real time passenger systems using variable message signs (often using LED technology displays) are being deployed in some cities. For example, China's first central bus dispatch centre was completed in 2004.

Figure 15

News and passenger information on flatscreens onboard Kuala Lumpur's MRT.

Stefan Opitz 2004, GTZ Urban Transport Photo CD



Similar small scale AVL/fleet management systems are being implemented in some taxi and truck fleets in other locations.

It is, unfortunately, too often the case that, generally speaking, ITS owners are reluctant to pay for spare parts and maintenance.

Where contracts for the development of important ITS infrastructure is given to firms through non transparent/non competitive bidding processes (e.g. Smart Cards) a variety of problems can occur such as:

- Where implementation progress has proved to be slow, the existing incumbents with the rights to develop these projects would be expected to attempt to prevent proper implementation in these cities; and
- Similarly, companies with rights to proprietary products may often seek to use their influence to have their product adopted as a national or regional standard.

In the short term (three to five years), it would be expected that the main ITS applications are likely to be much like what has been deployed

to date—with an emphasis on UTC, ETC and expressway monitoring systems. However, an increasing and progressive interest in new ITS user services (congestion charging and advanced public transport) and the development of advanced traveller information systems is already apparent in the larger developing cities. Yet, systems planners will need to develop appropriate capacity and procurement modes before the planned ITS systems are truly effective, as illustrated in Box 6.

In many of the large cities in developing countries, average incomes may be many times the national average, and here there is an established demand for mobility by mechanised means (cars and public transport) and use of modern communications. To some extent, as is well known, these cities may have the ability to “leap frog” or to catch up to developed cities—an example is in the mobile communications area, where the growing number of mobile phone users presents new ways of disseminating information (news, business, traffic, etc.). In

Box 6: BRT and ITS applications in India

BRT systems are being promoted in several cities in India with implementation proceeding with support from the Jawaharlal Nehru National Urban Renewal Mission (JnNURM), providing grant financing in the following nine cities; Ahmedabad, Surat, Rajkot, Bhopal, Indore, Pune, Vijaywada, Vizag and Jaipur.

Conditions by Government of India for sanctioning BRT projects, and associated financing, are that each city must implement the following key reforms: (a) create a Unified Metropolitan Transport Authority (UMTA) (b) establish a State and City level Urban Transport Fund (UTF), and (c) implement parking and bus advertising policies, the latter to assist in raising revenues to support bus operations. Designed to respond to growing urban transport challenges, Unified Metropolitan Transport Authorities (UMTAs) are promoted by the NUTP in all cities with more than one million people. The overall aim of an UMTA is to promote public transport in urban areas through formulation of appropriate policies, programmes and regulations. Its functions include facilitation, coordination, planning and implementation of urban transport

programs and projects in an integrated management framework.

It is planned that intelligent transportation systems (ITS) in the form of bus tracking, and passenger information signs (at major bus terminals) and on-board buses will be introduced in association with BRT, but details of how this will be done are sketchy. Similarly there are few plans on providing traffic signal timing adjustments for buses at intersections particularly where they have to turn left across other traffic.

When first commencing operation, the BRT system will face inevitable teething problems. The design of facilities may prove inadequate, bus waiting space may be too limited, bus operator discipline may require strengthening, timetabling of buses may favour heavy demand periods. The cities planning ‘open’ systems of bus operation (BRT buses also run on ordinary streets) may induce significant unreliability of the bus system causing both gaps in service on the BRT system and bunching of buses in other locations. Proposed intelligent transportation systems may not work as intended and even if working perfectly would be unlikely to resolve other likely operational problems such as bunching.

Source: Authors

China, in 2003, the number of mobile phone users exceeded the number of fixed line users (around 200M) for the first time.

4.2 Appropriate ITS by city size

For the priority ITS user services identified in Table 6, an assessment of the likely appropriateness of each ITS user service and representative

technologies or systems (*i.e.* generally groups of technologies that work together to make up an ITS application) for small, medium and large cities is made. There is considerable similarity between medium and large cities, although more complex, widespread systems would generally be expected to be appropriate for large cities. The differences with small cities are more pronounced as would be expected.

Table 6: Appropriateness of priority ITS user services by city size (I)

User service bundle	User service	Examples	Small City < 0.5M	Medium City > 0.5M & < 1.5M	Large City > 1.5M
Traveller information	Pre-trip information, on-trip driver information, on-trip public transport information	Variety of technologies/systems	No	Yes	Yes
	Personal information services	Variety of technologies/systems	No	No	Yes
	Route guidance and navigation	In-vehicle navigation systems	No	No	Yes
Traffic management	Transportation planning support	Urban transportation demand models, intersection simulation models, GIS systems for geographic data management, etc.	Very simple applications only	Yes	Yes
	Traffic Control	Urban Traffic Control (UTC) or Area Traffic Control (ATC)	Yes, but simple fixed time signals likely to be appropriate, with computer linking as cities grow	Yes. Fixed time signals	Yes. Dynamic (ie demand responsive) UTC necessary.
		CCTV – Closed Circuit TV cameras	Yes	Yes	Yes
		VMS – variable message signs – providing traveller information	No	Yes	Yes
		VSL – variable speed limit signs & supporting law	No	Yes	Yes
		Inductive loops (in pavement), infrared (above) or optical via intelligent cameras (above) for vehicle detection	Yes	Yes	Yes
		AID – Automatic Incident Detection System, includes congestion identification	No	Yes	Yes
		LED traffic signals and regulatory signs	Yes	Yes	Yes
	Incident Management	Incident and congestion detection & verification, using CCTV and monitored by Control Centre	See above	See above	See above
	Demand Management	AVI – Automatic Vehicle Identification	No	No	Yes
Electronic payment/charging (see below for Electronic payment user bundle)		Yes	Yes	Yes	

Table 6: Appropriateness of priority ITS user services by city size (II)

User service bundle	User service	Examples	Small City < 0.5M	Medium City > 0.5M & < 1.5M	Large City > 1.5M
>> Traffic management	Policing/enforcing traffic regulations	Variety of technologies/systems	Yes	Yes	Yes
	Infrastructure maintenance management	Variety of technologies/systems	Yes	Yes	Yes
Freight transport	Commercial vehicle pre-clearance & commercial vehicle administrative processes	Electronic Data Interchange	No	No	Yes
	Commercial vehicle fleet management	Fleet management systems (FMS)	No	Yes	Yes
Public transport	Public transport management	Fleet management systems (FMS)	No	Yes	Yes
Emergency management	Emergency notification and personal security	CCTV cameras	No	Yes	Yes
	Emergency vehicle management	Fleet management systems (FMS)	No	Yes	Yes
	Hazardous materials and incident notification	Fleet management systems (FMS)	No	Yes	Yes
Electronic payment	Electronic financial transactions	Variety of technologies/systems	No	Yes	Yes
Safety	Safety enhancement for vulnerable road users	Intelligent pedestrian crossings	No	Yes	Yes

5. Setting the right framework for ITS

While both the private sector, the community and national and local governments are key stakeholders in planning and deployment of ITS, government has a crucial role which should include providing strategic leadership, ensuring that appropriate standards and interoperability are achieved, and coordinating the various concerned stakeholders.

Setting the appropriate framework involves government to take the lead in:

- Establishing an overall strategy for ITS—
Box 7 sets out an example for Japan—within the context of transportation policy;
- Developing standards, protocols and policies and translating these standards to local jurisdictions—refer Box 8 and 9 for examples for PR China;
- Developing demonstration projects; and
- Facilitating development of local public and private sector expertise.

The example of Singapore shown in Box 9 is particularly important as it demonstrates the use of a holistic approach across transport, industry, and communications including ITS. However, Singapore is no exception—for example, in the Asian region, Malaysia, South Korea, Japan and China have now adopted, a mature, more integrated approach to ITS.



Figure 16
Singapore's well developed urban transport system has a strong ITS component.

Karl Fjellstrom 2004,
GTZ Urban Transport Photo CD

Box 7: ITS strategy in Japan

The ITS goals for each of these categories are as follows:

1. In safety and security, ITS Japan aims first to achieve, in a model space, a zone where traffic accident fatalities are reduced to zero. This accomplishment is then to be deployed nationwide, contributing to a 50% reduction of total traffic accident fatalities on all roads by 2010.
2. As a target for efficiency and environmental preservation, ITS aims to provide a zone of zero traffic congestion. Achieving this objective is expected to contribute to reducing CO₂ emissions by road transport vehicles to the government's target of 1995 levels by 2010.
3. In terms of convenience and comfort, ITS Japan aims to upgrade the public infrastructure to create a comfortable transportation environment, to provide cities and spaces where transportation is an enjoyable and convenient experience for pedestrians, drivers and users of public transport alike.

The scenario ITS Japan envisions for transportation in the medium term is one in which:

- (1) Safe and secure "ITS zones" are constructed, with the goal of reducing traffic fatalities to zero.
- (2) Improved logistical flow and development of automated driving systems of logistical vehicles on limited stretches of road, with the aim of reducing traffic congestion to zero on those sections.
- (3) Commercialization of "Human navigation systems", to make the transportation experience more enjoyable in a "comfortable transportation zone", including the nationwide deployment of "Smart Towns", promoting multi-purpose use of ETC and provision of traffic congestion information.
- (4) A comprehensive ITS platform is in place.

Source: ITS Japan (2003)

Box 8: ITS standardisation in China

Although ITS development in China started in the 1970s with the first implementation of traffic signals and early research into advanced traffic systems, rapid economic development in the 1980s and 1990s led to uncoordinated traffic, toll road and public transport systems in many cities and in many inter-urban applications.

Since the early 1990s, the ITS Research Institute (part of the Research Institute of Highways) and now called the National ITS Centre has been far more systematic with the development of ITS including the development of ITS strategies, ITS standards and protocols and demonstration projects.

The National ITS Plan for 2001 to 2006 shows that priority was given to the following:

- ITS demonstration in urban and inter-provincial expressway systems;
- Integrated traffic information service system;
- Urban traffic management system;
- Incident management system;
- Transport management system;
- Public transport system;
- ETC;
- ITS national, provincial and city architecture; and
- Standardisation.

Source: Sayeg and Charles (2004b)

Box 9: Priorities for ITS in China at end 2003

- The Development of ITS Standardisation;
- Establish China ITS standards: From ITS Architecture to Standard Architecture & Interface standards;
- Policy and Software Research: China ITS Development Strategy Research, ITS Architecture (National architecture V2.0 & Province and City ITS Architecture);
- Training System: Establish six regional ITS Training Centres;
- Technology Research and Development: The Traffic Capacity in City Throughway;
- Transport Information Collection and Fusion;
- The Optimising Technology for Public Transport System;
- The Management Technology for ITS Data;
- The Evaluation Technology for ITS Projects;
- DSRC Development and Application;
- ITS Demonstration in Cities: Demonstration projects in 10 cities;
- ITS demonstration in Highways: Toll Collection System and ETC for National Expressway (Beijing To Shengyang Expressway); Integrated Highway Management System

(Beijing to Tianjin Expressway, Langfang Region); Inter-Urban Passenger Transport System (Hangzhou – Hefei – Chengdu – Chongqing);

- ITS Special Project for Olympics: Transport Plan; Intelligent Traffic Management System; Intelligent Parking Guidance Systems; Public Transport Dispatching System; Integrate Transport Information Platform.

Source: Sayeg and Charles (2004b)

Box 10: Singapore's holistic approach

An integrated, concerted whole-of-government approach has been evident for many years in Singapore. The Singaporean Government set up the Land Transport Authority (LTA), under the Minister of Communications, in September 1995 to coordinate all efforts in the land transport sector including the development of ITS. The White Paper and the creation of the LTA set the objective of developing a “world class” transport system by 2010 to enhance quality of life and assist economic growth. The basic policy adopted is to provide a comprehensive range of high quality public transport options at reasonable cost and further restrain private car travel (by pricing and other means).

There is now over almost ten years of experience with the operation of its sophisticated ERP scheme (see Figure 5.1) that replaced the previous manually operated restricted zone. LTA have taken advantage of the greater flexibility offered by the ERP system to effect a policy shift in Singapore's transport strategy. More emphasis is now placed on regulating or controlling vehicle usage than on controlling vehicle ownership. Initial taxes and registration fees on vehicles were generally reduced while the vehicle tax structure was also rationalised, with most vehicle owners benefiting from lower annual vehicle taxes. Due to its flexibility (e.g. variable pricing) ERP managed to achieve a dramatic reduction in traffic usage of the network—from 21% in the morning peak period to 27% during the evening peak period—even though the ALS was previously in place.

Singapore is vigorously promoting the development of ITS and related technologies to support sound transport policy and the competent organisations established to manage the transport system.

6. Planning and implementation

6.1 ITS planning

The recommended first step in deploying effective ITS applications is to establish an ITS strategic plan and implementation program. This will ensure that the ITS applications provide the greatest benefits and are the most cost effective in addressing the transport needs of the region. It will also help to achieve consistency of approach and allow ITS projects to build on core technologies.

ITS strategic plans are most effective at a national, regional or city level, rather than at a localised level, as ITS applications generally apply across a region or city, including making allowance for future growth needs and funding availability.

An ITS strategic plan should contain the following elements:

- Current and future transport needs and challenges and their priority;
- An inventory of existing and proposed ITS applications, such as ad hoc installations by different agencies, demonstration projects, research and development projects and ITS projects in forward programs and budgets;
- An outline of current technology infrastructure as relates to ITS applications, especially telecommunications and any systems architecture and standards in use;
- A description of existing and desired institutional arrangements, including roles and responsibilities and funding arrangements;
- Identified key stakeholders and their interests (refer Table 7).

Table 7: Examples of stakeholders for ITS projects

Operational requirements	Stakeholder groups	ITS examples
Improved urban traffic management	<ul style="list-style-type: none"> ■ Local traffic management agencies ■ Regional transportation authorities ■ Bus operators 	<ul style="list-style-type: none"> ■ Real time adaptive traffic signal control ■ Integration of urban arterial and urban freeway traffic management systems ■ Introduction of active bus priority schemes
Reduction in traffic demand	<ul style="list-style-type: none"> ■ Local traffic management agencies ■ Local businesses ■ Motorists ■ Community ■ Truck operators ■ Bus and rail transport operators 	<ul style="list-style-type: none"> ■ Congestion charging – e.g. London Congestion Charging Scheme
Introduction of new automatic payment systems	<ul style="list-style-type: none"> ■ Toll road operators and managers ■ Local traffic management agencies ■ Bus and rail operators, passengers 	<ul style="list-style-type: none"> ■ Nonstop electronic tolling ■ Multi-modal electronic ticketing
Strategic and tactical management of inter-urban traffic	<ul style="list-style-type: none"> ■ Expressway, toll road, and freeway operators and managers ■ Local traffic managers ■ Traffic police and emergency services 	<ul style="list-style-type: none"> ■ Regional traffic control centres ■ Incident detection ■ Emergency response ■ VMS and driver information support
Better integration of transport modes	<ul style="list-style-type: none"> ■ Operators of bus companies, urban rail and associated terminals and interchanges ■ Transport management agencies ■ Private information service providers ■ Vehicle manufacturers 	<ul style="list-style-type: none"> ■ Multi-modal transportation information ■ Fleet management systems ■ In-vehicle navigation systems

Source Adapted from Table 4.1, Chen & Miles (2000)

Box 11: Development of ITS architecture – Canadian example

Under the guidance of a steering committee of public and private sector representatives from the Canadian transportation industry, the development of the ITS Architecture for Canada was initiated in August 1999. In general, the Canadian effort subsumes all of the U.S. National ITS architecture work and extends and modifies it to provide new services and areas of coverage, and to reflect differences between the nations and the existence of new and different stakeholders.

The development included an extensive review of other relevant ITS Architecture and Standards initiatives. Based on the review as well as significant ITS stakeholder input, an initial draft ITS Architecture Framework was developed that defined the User Services, User Sub-Services, and Market Packages applicable to Canada. Following a review by ITS stakeholders, the revised ITS Architecture Framework was used to develop definitions of both the Physical and Logical Architectures of the ITS Architecture for Canada.

The **Role of Architecture** – The ITS Architecture for Canada provides a unified framework for integration to guide the co-ordinated deployment of ITS programs within the public and private sectors. It offers a starting point from which stakeholders can work together to achieve compatibility among ITS elements to ensure unified ITS deployment for a given region. The Architecture describes interaction among physical components of the transportation systems including travellers, vehicles, roadside devices, and control centres. It also describes the information and communications system requirements, how data should be shared and used, and the standards required to facilitate information sharing. Overall, the ITS Architecture for Canada defines the functionality of ITS components and the information flows among ITS elements to achieve total system goals.

The components of the Logical Architecture required for the Architecture Framework have also been defined, including components such as User Service Requirements, Process Specifications, Data Flows, and Data Flow Diagrams. The Logical Architecture of the ITS Architecture was

developed in parallel with the Physical Architecture. This is unlike the U.S. work that developed the Physical Architecture based on the Logical Architecture.

ITS Standards are fundamental to the establishment of an open ITS environment. Standards facilitate deployment of interoperable systems at local, regional, national, and international levels without impeding innovation as technology advances and new approaches evolve.

The Canadian ITS Architecture is a reference framework that spans all ITS standards activities and provides a means of detecting gaps, overlaps, and inconsistencies between the standards.

Development of Standards – The development of ITS standards is undertaken by Standards Development Organizations (SDO). Canada is a member of the International Standards Organization (ISO) through the Standards Council of Canada (SCC) and participates as a voting member of ISO/Technical Committee 204 for ITS. Canadians also participate actively in U.S.-based SDOs engaged in ITS standards development activities.

Standards development requirements have been allocated to the following standards development organisations in the US:

- ASTM (American Society for Testing and Materials);
- IEEE (Institute of Electrical and Electronics Engineers);
- SAE (Society of Automotive Engineers);
- ITE (Institute of Transportation Engineers);
- NEMA (National Electrical Manufacturers Association);
- AASHTO (American Association of State Highway and Transportation Officials).

Although each standards activity is allocated to a single standards development organization (SDO) in this mapping, it should be noted that many of the standards efforts are collaborative between multiple SDOs (e.g. NTCIP Joint Steering Committee is comprised of representatives from AASHTO, ITE and NEMA).

<http://www.itscanada.ca/english/architecture.htm> (accessed 12 March 2004)

Source: ITS Canada

- Assessment of the potential for ITS to address transport needs and identify priority information technology (IT) applications for deployment;
- The requirements for ITS architecture (refer Box 11);

The ITS Strategic plan is then followed with a more detailed ITS Implementation Program, with the following elements:

- An outline of the priority ITS applications and projects for deployment—an analysis of stakeholder needs, institutional frameworks and technical requirements helps formulate the program—refer Box 12;
- Organisational framework for the deployment and operation of ITS, including inter-organisational agreements;
- Detailed projects and funding arrangements, for the near term, plus proposed projects for the mid and longer terms.

6.2 ITS costs and benefits

ITS applications are usually low cost compared to traditional transport infrastructure and can often yield benefits that significantly exceed initial and ongoing operating costs. However, ITS applications may still entail significant expenditure. For example, the capital cost of several key applications would be roughly as follows:

- Traffic management centres and modern UTC systems may cost between US\$50,000 to US\$120,000 per traffic signal for larger applications (say over 200 sites) and would include the cost of development of a traffic control centre and, for the higher cost range, a dedicated communications system;
- Vehicle tracking systems for larger applications of several hundred vehicles would cost of the order of US\$1,500 to US\$3,000 per vehicle including provision of GPS units in vehicles, a home base and dedicated computers and software for fleet tracking and control, plus communications;
- Bus passenger information systems, added on to a bus tracking system, here information is distributed to VMS signs at bus stops, could cost between US\$2,000 and US\$10,000 per sign (including communications and software provision) dependent on the size and type of VMS sign;

Box 12: Implementation plan: analysis framework

Stakeholder analysis:

- Who are the major stakeholders in this domain and how would they be impacted?
- What ITS does each stakeholder have now?
- What plans (short, medium and long) does each stakeholder have to develop ITS?
- What aspects of the planned ITS would each stakeholder view positively and/or regard as high priority?
- Are there ITS functions all stakeholders would buy into?

Institutional analysis:

- Which organisational units are in a position to provide leadership in developing ITS in this domain?
- What organisational models are suitable for operating ITS in this domain?
- How well do existing institutional arrangements match these models?
- Are there any obvious organisational gaps or weaknesses? How might they be rectified?
- What legal, contractual and organisational arrangements are required between agencies? How can they best be introduced?
- What means are available for consensus building among stakeholders with regard to planned ITS?

Technical analysis:

- What legacy ITS applications are already operated by the agencies in the region?
- What are requirements for interoperability, both now and in the near-term/medium-term future?
- Where is it necessary to achieve compatibility and where is it optional?
- What communications infrastructure is available for ITS?
- Where do data or information need to be exchanged between agencies?
- Are digital mapping and location referencing systems in place?
- What data dictionary and data exchange standards have been adopted?

Source: Adapted from Table 4.1, Chen & Miles (2000)

- The cost of toll collection systems for a major toll road would generally be around 2% of total capital cost, but for very advanced systems could cost up to 5% of capital cost.

On-going operating costs can be high for several reasons:

- Staffing of traffic control centres or vehicle dispatch centres;
- On-going communication costs; and
- High depreciation allowances needed as the life of computers, VMS and other advanced technologies can often be less than 10 years, which is quite short compared to traditional infrastructure.

Even though for these reasons annual operating costs can range between 10% to 50% of capital costs there usually are significant monetary savings to be made compared to the manual systems which they replace and/or other benefits can be quite high in terms of reduced delays and improved levels of service which may be translated into higher revenues.

For example, the provision of electronic fare collection in a public transport system would save labour costs, reduce possible fraud, and increase customer convenience compared to manual fare collection.

It must be stressed that the capital and operating costs of ITS applications can vary widely as can the benefits able to be achieved. Fortunately, the US DOT has recently published several authoritative reports and other documents providing information on the unit costs of ITS technologies (that combined may make up an ITS application), as well as on the representative costs and the likely benefits able to be achieved from a wide range of ITS applications (Please see <http://www.benefitcost.its.dot.gov>).

6.3 Project management and deployment

Implementing the ITS Program requires careful planning and consideration of individual projects, their development, evaluation, selection and procurement.

Evaluation of ITS projects needs to consider the difficulty in valuing benefits and it may be worth considering a multi-criteria analysis process. Objective evaluation of costs and benefits of alternative solutions is an essential element of project planning.

Procurement of ITS applications is different from procurement of traditional infrastructure and consideration of these differences will ensure success. A key difference with ITS technology which involves computers and other high technologies, for example, is that many of these technologies have much shorter lives than traditional infrastructure.

The project goals need to be clearly identified and agreed with key stakeholders. The roles and responsibilities of the team member organisations and the timetable for completion also need to be agreed. Standard approaches to project management for information technology projects need to be applied, considering that ITS projects often have a computer software development or integration component as well as infrastructure and equipment supply elements.

In deploying ITS applications it is worthwhile considering the underlying technology infrastructure that is common to a number of applications, and build on existing facilities, such as communications infrastructure.

6.4 Operations & management

Most ITS systems have a large ongoing operations and management component, requiring resourcing (skilled people, funding, etc.). This

Figure 17
Parking fees can be used to finance urban ITS-applications.

Karl Fjellstrom, Singapore 2004, GTZ Urban Transport Photo CD



Table 8: Considerations for deployment of ITS projects

ITS Service	Institutional preconditions	Enabling technologies	Early ITS actions	Precautions
Traffic control	Interagency cooperation – traffic, police, etc.	Traffic sensors Communications systems	Share traffic information	Share information without surrendering control
Electronic toll collection	Agreement between transport agency & toll company	DSRC	Pilot tests of ETC	Anticipate new technology
Motorist information	Cooperation between traffic management centre & information provider	Electronic data collection and interchange	Call centre Internet website	High cost of call centres Accuracy of information
Transit management	Cooperation between transit and traffic agencies	Vehicle location, GPS	Transit priority at traffic signals	Clear roles & responsibilities

Source: Adapted from Table 5.1, Chen & Miles (2000)

requires an ongoing commitment to training, data collection and analysis, subsequent review and adjustment of procedures.

Some guidelines for the deployment of ITS projects are given in Table 8.

6.5 ITS Financing

There are three main areas from where ITS receive funding: the government, private funding and a hybrid of the two.

6.5.1 Government funding

Traditionally the major investor in infrastructure, government now sees ITS as a valuable part of the total road infrastructure picture. Government funding is highly selective with most governments not funding areas that have direct commercial application.

Justification for expenditure is made on traditional grounds of economic valuations for such things as reductions in travel times, increased safety rates or modal shifts to public transport and the perceived community benefits that result.

Typical areas that receive funding are:

- Road monitoring infrastructure;
- Traffic control centres;
- Traffic management and control; and
- Traveller information services.

Some countries such as Canada also take on a role to foster local ITS innovation through supporting research and development activities

with local trials and industry assistance. The government has the dual objectives of gaining the benefits of the ITS and local capacity building in this growing field.

Historically government funding was typically localised to a state or single country and was authorised on an annual basis. This is now changing with programs such as the European Commissions TEMPO project delivering funding across a range of countries and over a five year period. Similarly in the USA funding through the Transportation Equity Act for the 21st Century (TEA-21) delivers long term recurrent funding for ITS on a national basis allowing for far greater integration and increasing confidence in long term projects.

6.5.2 Private funding

Private funding of ITS occurs when there is a commercial justification for doing so. In effect the consumer must be willing to pay to use the infrastructure and/or services that are supported or provided by the ITS. There are many instances where this is the case including tolling, smart card ticketing systems and in car navigation systems. In the case of tolling the lower cost of transactions achieved through new technology drives the implementation, in-car navigation systems are driven by competitive forces and a desire to differentiate. Fleet tracking is funded because of the clear benefits it is able to bring to those transportation companies where it is properly applied.

There are also some areas where the business case makes it difficult to achieve a commercial solution. Advanced Traveller Information is one technology where the willingness of the public to pay for service has held up implementation and the right pricing model has not yet been found.

6.5.3 Combined funding

There is also a smaller but growing amount of funding for ITS that comes from a combination of private government funding with government establishing the framework, including possible financial support, that permits the private funding to take place. Such a combination is seen in privately funded and operated concessions using electronic tolling technology (*e.g.* toll roads, Germany Truck tolling) and public-private transport management centres (VMZ Berlin, and UK Highways) where the government mandates the technology and associated service standards but they are paid for by the private sector. This allows for wider community benefits by ensuring inter-operability between different systems that may be provided by a range of firms.

7. Challenges

Several challenges confront transport and ITS professionals when seeking to plan, deploy and operate ITS applications appropriate to the needs of their cities.

7.1 Awareness is needed, but understanding is critical

While there is wide awareness of ITS in developing cities, there is few understanding of how to apply ITS or a realistic knowledge of the benefits that ITS can bring, nor of the institutional arrangements for successfully planning, procuring, implementing and operating ITS. There are too few examples of effective ITS in developing countries.

A key form of ITS in cities is traffic management systems or urban traffic control (UTC). While a need for UTC is often appreciated, the perception of what UTC is and of what it can achieve, is frequently way off the mark in many developing cities. In the west, UTC is seen as an integrated mechanism for the management of urban traffic, including not just computers and traffic signals and communication links, but also the whole management infrastructure including traffic engineering expertise, maintenance facilities and political interfaces that are taken for granted at any local government institution.

However, in many developing cities, the implementation of an UTC system and other ITS is seen as the complete panacea for all urban traffic problems. Why bother with the reengineering of an intersection when UTC will take care of everything? Such is the expectation of a system marked with the 'hi-tech' tag. To be fair, this situation has been somewhat exacerbated by the system suppliers overselling the benefits of technology because their main interest is to gain a foothold in what has been seen as a potentially huge market (Powell, 2003). Not only awareness of ITS is needed, in fact, it is of paramount importance that there is a mature understanding of the limitations of ITS and the associated policies, actions and complementary ITS applications.

Good institutional coordination and procedures to get the most out of ITS are required (traffic

and incident management, etc.). A lack of understanding of ITS has to date often resulted in poor maintenance of equipment by responsible agencies.

7.2 Sound transportation policy framework and institutional base essential

ITS can be an important complement to traditional approaches of traffic engineering and transport planning. As discussed, ITS cannot take the place of a sound, consistent transportation policy and competent institutions.

But reality in many cities is different. There is often a fragmentation of resources within government agencies that may hinder the effective planning and deployment of ITS. Technical capacity may also be limited. The lack of clear policies for private sector involvement in developing ITS can also be an issue.

Local governments in many developing countries are weak and are limited in their scope by national government policies. Dealing with urban transportation problems across a nation in a timely and appropriate manner requires the strengthening of local government capabilities. Until that occurs, and it may take many years, the investment decisions of national government agencies for new roads and associated ITS, may have significant impacts on regional and metropolitan cities.

Figure 18
Passenger information display at streetcar/bus stop "Luisenplatz", Darmstadt.

Frank Kraatz 2004,
GTZ Urban Transport Photo CD



7.3 Integration is important

Often ITS equipment is only used in simplest form (*e.g.* for data collection, and not enforcement). And there is often little integration of new systems with legacy systems. There is often a lack of compatibility between ITS systems. Appropriate standards and specifications are needed to encourage development of open architecture ITS applications.

National ITS strategies and standards development is proceeding in many developing countries. But even where good progress has been made nationally, standards and city level protocols are still emerging.

7.4 Budgeting and procurement

A number of budgeting and procurement issues may hinder the proper development and procurement of ITS:

- Budgeting may not be done on a multi-year basis—this for example may be a problem with projects that take more than one year to implement. In Indonesia, for example, the absence of multi-year funding leads may lead to a series of small, sub-optimal contract packages;
- Lack of transparent procurement system—the absence of competitive bidding may lead to choosing inexperienced bidders for complex projects, inappropriate or expensive proprietary technologies that may never work;
- Other inappropriate regulations may hinder the optimal packaging of projects. For example, in China, within local governments, according to government rules, computer procurement for a UTC project may normally be handled by another department within the same agency, or civil works upgrading could be separated from the UTC purchase decision. This can lead to uncoordinated acquisitions or inappropriate purchasing of equipment;
- Specifications are written with a technology in mind—where specifications are written around a certain technology, this leads to selection of proprietary technologies, which may not be always the best purchase decision;
- Cumbersome procurement rules, which cause to long delays, can lead to specifications being written several years before the tendering process occurs (this is not uncommon in many countries, *e.g.* Thailand, Taiwan); Where a specification specifies a particular technology or type of equipment (*e.g.* a specific computer chip), these computers are now obsolete yet for a prospective tenderer to offer the latest model of computer would not satisfy the tender. This is a common situation in many developing countries.

8. Strategies to address challenges

Timely addressing of the identified challenges can be expected to lead to an increased and more detailed understanding of the nature of ITS, the benefits to be derived, and supporting requirements for successful design, procurement, implementation and operations among decision makers and professional staff at all levels of government and the in the private sector.

Appropriate high level strategies include:

- **Policy leadership to establish a framework for ITS** – National government should provide the leadership to establish the framework for ITS development which would set clear priorities and support the take up of ITS. The development of a national strategy for ITS—the ITS Strategy for Japan shown in Box 7 is an example—is a first crucial step. National, regional and local governments should also take the initiative with:
 - development of standards, protocols and policies and translating these standards to local jurisdictions;
 - targeting support including development of demonstration projects aimed at desired priority outcomes;
- **Strengthen legislative and regulatory framework** – Governments need to establish the legal and regulatory instruments to enable new technology to be effectively used—*e.g.* provide regulations to enable electronic enforcement (red light cameras, speed cameras, toll collection, variable speed limits).
- **Facilitate development of local public and private sector expertise**
 - dissemination of good ITS practice (case studies, etc.) from within the nation and region in question, and from farther a field;
 - promotion of research and development;
 - workshops and courses (including distance learning) on ITS covering a range of aspects with such topics as; Introduction to ITS; Management and Operations of ITS; Public-private partnerships in ITS;
 - more advanced technical topics;
- **Facilitate partnerships** – at all levels of government; research & development centres;

and the private sector – public-private partnerships to share resources, risks and returns; and

- **Develop competitive and transparent procurement processes** – model procurement documents and functional specifications for particular ITS applications;
- **Encourage international cooperation** – to transfer knowledge and to assist in

Box 13: EU cooperation with China

Since 1997, the European Union (EU) has had a long running technical cooperation program with China in several industrial and technological areas including ITS. Box 8 sets out a number of the initial key ITS initiatives undertaken with EU assistance. While China has cooperation programs with Japan (ITS Japan), Australia (ITS Australia) and to some extent the USA (ITS America) its EU Cooperation program is the most formal, longest running and the most active.

The most recent EU funding program BITS project was officially launched in July 2002 as a 15-month activity, and was cofinanced by the Asia Information Technology and Communications (IT&C) program of the European Commission. During the 15-month period the general objective of the BITS project is to increase the use of European developed IT&C for the transport sector in China and in particular the use of ITS. BITS aimed to:

- Support the European industry to respond to emerging business opportunities in China;
- Create consortia of European and Chinese ITS experts from the industry, research sector and public authorities;
- Enhance the negotiations with the relevant authorities to pave the way for EU-China industry cooperation projects;
- Make recommendations for new ITS research activities in China to be funded by Commission programs;
- Continue the work of ERTICO to raise the profile of the European industry in China; and
- Encourage EU-China industry cooperation on ITS applications, cooperation projects, joint ventures, etc.

Source: Sayeg and Charles (2004b)

establishing appropriate frameworks for ITS within each nation and each city, and to support the other strategies listed above. Box 17 sets out examples of international cooperation between Europe and various areas around the world by the European ITS association ERTICO; and

- Recognise linkages with other sectors – ITS is closely related to initiatives in transportation, information technology, multi-media, communications, computing and intellectual property. A focus on ITS is appropriate while recognising the linkages to other sectors.

Figure 19

This sign is part of a city-wide parking guidance system and provides information on available space in car parks.

Armin Wagner, Frankfurt/M. 2005



9. References

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10. Resources

ITS Organisations

- ERTICO – Europe-wide, not-for-profit, public/private partnership for the implementation of Intelligent Transport Systems and Services (ITS) <http://www.ertico.com>
- ITS America: <http://www.itsa.org>
- ITS Australia: <http://www.its-australia.com.au>
- ITS Canada: http://www.its-sti.gc.ca/en/related_sites.htm
- ITS Centre, PR China: <http://www.itsc.com.cn>
- ITS Hong Kong: <http://www.itshk.org>
- ITS Singapore: <http://www.itssingapore.org.sg>
- ITS Japan: <http://www.ij.ad.jp>
- ITS Taiwan: <http://www.its-taiwan.org.tw>
- ITS Korea: <http://www.itskorea.or.kr>

Standards and Architecture

- CEN: <http://www.cenorm.be/cenorm/index.htm>
- ISO: <http://www.iso.ch/iso/en>

Government programs

- <http://ec.europa.eu>
- <http://www.ten-t.com>

Road safety and traffic

- <http://www.irfnet.org>

Other

- CITE is an organisation of universities and industry associations focused on providing comprehensive advanced transportation training and education. <http://www.citeconsortium.org>
- ITS Benefits, Costs and Lessons Learned databases (US DOT) <http://www.benefitcost.its.dot.gov>
- Road Engineering Association of Malaysia: <http://www.ream.org.my>
- US DOT ITS/Operations Resource Guide <http://www.resourceguide.its.dot.gov>
- World Bank Intelligent Transport Systems <http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTTRANSPORT/EXTROADSHIGHWAYS/0,,contentMDK:20688447~menuPK:1157552~pagePK:148956~piPK:216618~theSitePK:338661,00.html>



Figure 20
Traffic information system in Singapore.

Karl Fjellstrom 2004,
GTZ Urban Transport Photo CD



Appendix

A: Global trends in
Intelligent Transport Systems

B: Glossary

Appendix A: Global trends in Intelligent Transport Systems

Developments in three key markets are a major influence on the form of ITS deployment in other parts of the world. Research, development and deployment of ITS technologies have been dominated by three regions—North America (primarily USA and Canada), Europe and Asia (primarily Japan). For Asian markets, leading developments also often emanate from Australia.

International cooperation on ITS issues remains focussed on the major regions with ITS organisations, such as ITS America, ERTICO (Europe) and ITS Japan, (formerly VERTIS). The World Congress on ITS is organised cooperatively by ERTICO, ITS America and ITS Japan on a three-year cycle and held in Europe, North America and Asia in rotation. In addition, there are various regional and country specific ITS organisations, such as the ITS Asia-Pacific organisation, established in 1998 with the support of ITS Australia, ITS Taiwan, ITS Japan and Malaysia's ITS community, among others.

Recent developments demonstrate efforts to improve international cooperation when ERTICO, ITS Asia-Pacific and ITS America, supported by others joined together to present a global view of the future of Intelligent Transport Systems and produced the document *Intelligent Transport Systems and the Future*, in October 2002. This document outlines how 'transport in the 21st Century will be safer, cleaner, more efficient, more secure, and more readily available to more people through the effective application of modern computer and communications technology to transport'.

ITS trends in North America

America has led the way in defining the concepts and structure of the ITS revolution in transportation. The US Department of Transportation (DOT) approach divides the National ITS Program Plan into three distinct pieces: 1) Program Plan: 5-year horizon; 2) Program Plan: 10-year horizon; and 3) the National ITS Deployment Strategy.

In January 2002 ITS America in cooperation with the US DOT released the *National ITS Program Plan: A Ten Year Vision*, fulfilling the ISTEA requirement. In September 2002 the supplement – *Homeland Security and ITS: Using Intelligent Transportation Systems to Improve*

Box 14: US national ITS program plan

The Vision: Future transportation systems

- Managed and operated to provide efficient, seamless, end-to-end intermodal travel for passengers and freight movement;
- Safe, customer oriented, performance driven and institutionally innovative, enabled by information from a fully integrated spectrum of computing, communications and sensor technologies;
- Secure, responsive in times of crisis.

The Outcome

- An electronic information network that works with the physical infrastructure;
- Secure systems that can both detect and respond to regional crises;
- Fewer and less severe crashes and faster response and recovery;
- Information for operators and users to help contain congestion and increase the effective capacity;
- Facilities, technology and information that help reduce energy consumption and environmental impact.

The Goals

- **Safety** – reduce fatalities by 15% by 2011, saving 5–7,000 lives per year;
- **Security** – well-protected against attacks and respond effectively to natural and man-made threats and disasters;
- **Efficiency/Economy** – save at least \$20 billion per year by enhancing through-put and capacity through better information, system management and containment of congestion;
- **Mobility/Access** – available information that supports seamless, end-to-end travel choices;
- **Energy/Environment** – save a minimum of one billion gallons of fuel each year and to reduce emissions at least in proportion to this fuel saving.

Source:
ITS America (2002) National ITS Program Plan: A Ten Year Vision

and *Support Homeland Security* was released (see Box 14). The Plan develops a series of Programmatic and Enabling themes to describe the opportunities, benefits and challenges. *Programmatic* themes reflect opportunities to apply technology to the problems and priorities of surface transportation, while *Enabling* themes lay the groundwork for the application of the technology.

To close the gap between the great potential that ITS solutions have to offer and the current state of fragmentation, the US DOT is following a strategy for encouraging the development of technically integrated and institutionally coordinated intelligent transportation systems.

- *Showcasing the benefits of ITS* – approximately 12 sites have been funded to demonstrate the benefits of the ITS infrastructure, aiming to raise awareness of the capabilities of ITS technologies and encourage public sector officials to embrace and build locally applied ITS infrastructure.
- *Creating funding incentives* – ITS is gaining momentum under existing surface transportation programs, however not in a consistent, optimal or systematic fashion. Temporary funding incentives have proved to be effective in halting fragmentation and fostering

technical integration and institutional coordination.

- *Establishing technical standards* – in line with an overall national operating framework or architecture it is crucial to achieve technical "interoperability". Without technical standards, state and local governments as well as consumers would risk buying products that do not necessarily work together or do not work in other parts of the country.
- *Building professional knowledge* – ITS requires new skills in systems engineering, electronics and communications to become a reality.

US ITS research and deployment initiatives support programs form the core of the ITS Program, outlined in Box 15.

ITS trends in Europe

Development and deployment of ITS within Europe has been strongly directed by the work of the European Union (EU) and its succession of multi-year, multi-faceted research programs. Originally termed "transport telematics", ITS work was accelerated in Europe under the DRIVE program. The success of the early DRIVE projects led to the establishment of ERTICO (European Road Transport Telematics Implementation Coordination Organisation) in 1991. A list of ERTICO projects is included in Box 16.

The European Commission's White Paper on Transport Policy—*European Transport Policy for 2010: Time to Decide*—spells out the EC's strategy for the next 10 years. ITS surfaces as a prominent feature in both policy aims and objectives.

Organised into four main sections dealing with modal shifts, bottleneck elimination, user needs, and managing globalisation, the White Paper also contains 60 measures which aspire to fulfil this goal of a 'people-friendly' policy. In addition, the new transport policy includes an underlying emphasis on safety issues, environmental concerns and initiatives for sustainable market growth.

The overall use of intelligent transport systems' application and technology is a prominent feature of the new policy. ITS features both in explicit measures and activities, as well as implicit solutions for applying to some of the policy's key objectives.

Box 15: Major US ITS research initiatives

Safety

- Vehicle Infrastructure Integration;
- Integrated Vehicle-Based Safety Systems;
- Cooperative Intersection Collision Avoidance Systems;
- Next Generation 9-1-1;
- Rural Safety Initiative;
- Emergency Transportation Operations.

Mobility

- Integrated Corridor Management;
- Mobility Services for All Americans;
- National Surface Transportation Weather Observing and Forecasting System (Clarus);
- Next Generation 9-1-1;
- Congestion Initiative.

Productivity

- Electronic Freight Management.

Box 16: ERTICO projects

ERTICO is involved in a wide variety of ITS projects – most of these initiatives receive financial support from the EC, with ERTICO as project coordinator:

- 3GT – establishing an open in-vehicle telematics platform;
- ActMAP – actual and dynamic MAP for transport telematic applications;
- BITS – bridging the European ITS business cooperation with China;
- E-MERGE – enabling pan-European vehicle e-call services;
- EMILY – GNSS-cellular integration;
- e-Thematic – network on e-fulfilment;
- EVI – electronic vehicle identification feasibility study;
- FRAME-S and FRAME-NET – framework for European ITS architecture and support/maintenance;
- LOCOPROL – fail-safe satellite-based train location and protection;
- PRETIO – market validation for multimedia ITS on hybrid communication systems;
- RESPONSE2 – human, system and legal aspects of active safety systems;
- SAGA – setting standards for Galileo;
- SIMTAG – safe intermodal transport across the globe;
- SIT – safe and secure intermodal transport;
- VERA2 – enabling pan-European cross-border video enforcement.

Completed projects

- AGORA – universal location referencing method implementation;
- DELTA – physical integration of DSRC tolling tag;
- DIAMOND – multimedia ITS services via DAB;
- Digital Tachograph – introduced in EU, Central & Eastern Europe countries;
- EU-SPIRIT – door-to-door Internet-based journey planning;
- ITSWAP – promoting ITS applications over WAP;
- NextMAP – enhancing digital map databases;
- PEACE – Chinese-European industry cooperation;
- TELEPAY – transport payments using portable phones;
- TRIDENT – multimodal data exchange.

Source: ERTICO

One of the primary targets of the new transport policy is to improve European road safety. The EC has set a target to reduce the number of road victims by 50% by 2010 by encouraging the deployment of innovative technologies leading to the introduction of safe new vehicles on the market.

To reduce congestion, the White Paper encourages specific traffic management measures coordinated at the European level and supports the formation of traffic management plans between main trans-European links. ITS tools are integral to the functions of these centres for data collection and diffusion of information.

The White Paper states that Europe needs to rethink its international role if it is to succeed in developing a sustainable transport system and tackle the problems of congestion and pollution. Connecting the Central and Eastern European accession countries to the trans-European network can be made easier through the use of ITS technology. The introduction of the digital tachograph in these countries is just one example of effective ITS use.

Another one of the goals of the new transport policy is to rationalise urban transport by making it clean and efficient. Real-time route information and advanced purchase ticketing capacities will undoubtedly be welcome ways to realising this objective.

GNSS: Global Navigation by Satellite System

The numerous services offered by the integration of GNSS into transport have a great potential for improving transport efficiency. GNSS-based value-added services have an important role to play in transport.

GALILEO is a joint initiative by the European Union and the European Space Agency establishing the first global satellite navigation system designed for civilian needs, open to international cooperation and operated commercially.

GALILEO comprises a constellation of 30 satellites orbiting at an altitude of nearly 24,000 kilometres and helping to resolve the mobility and transport problems facing many areas of the world, as users will have easier access to signals emitted by navigation satellites,

with guaranteed reliability and much greater efficiency and accuracy.

Satellite navigation receivers are now commonly installed in new cars as a key tool for providing new services to people on the move: electronic charging, real-time traffic information, urban traffic control, speed management, emergency, mayday and breakdown assistance, route guidance, fleet management, parking management and driver assistance systems.

There are also benefits for freight and public transport operations, including route guidance, electronic fare payment, passenger information, train control, fleet and freight management, tracking and location.

ITS trends in Japan

Japan has pursued ITS technologies since the late 1970s and now leads the world in many ITS areas, particularly for in-vehicle information systems and computerised traffic control centres.

Government responsibility for ITS rests with four ministerial departments. Historically, jurisdictional competition between agencies hampered ITS deployment. In what is perhaps a role model for emerging Asian economies the Japanese agencies have set aside such differences and are coordinating their efforts through an Interministerial Council.

VERTIS (Vehicle, Road and Traffic Intelligence Society), Japan's private sector ITS body, with its membership, now ITS Japan, is a key

Box 17: ERTICO international cooperation

In the face of global competition and challenges, European business and research players are relocating their R&D activities and opening up to increased cooperation with other countries, pooling their scientific and industrial resources. As technology chains become increasingly complex, it is more and more difficult for any single player – or country – to master the complete range of know-how and technologies needed to establish and maintain leadership in a given ITS field. When the ever-increasing cost of research is added to this equation, international cooperation emerges as a key business strategy for the future.

By contributing to the establishment of European standards in emerging markets, international cooperation activities provide early market access opportunities for ERTICO Partners. To capitalise on this, ERTICO has significantly strengthened its international cooperation efforts in the past years and a number of key priority regions have been identified:

- Asia (China, India)
- Africa (South Africa)
- Southern America (Brazil)

SIMBA: Strengthening road transport research cooperation between Europe and emerging markets

SIMBA brings together the EU and the nations of Brazil, China, India and South Africa to create an international cooperation network that aims to increase road safety, improve mobility and

enhance transport efficiency through the use of ITS, automotive technological development and enhancements to road infrastructure.

The idea behind SIMBA is that stakeholders from the four regions can design and implement better and more efficient road transport solutions for the future by pooling their expertise and years of experience.

With this goal in mind, SIMBA will map national and regional R&D activities, policies and future requirements as well as propose demonstration cases and organise seminars, business meetings and industry visits in order to maintain a close contact between all key players in the four regions.

<http://www.simbaproject.org>

MODIBEC: Building cooperation on digital broadcasting convergence with mobile communications between Europe and China

The convergence of digital broadcasting technologies with mobile communications enables broadcast video and data services to be delivered to handheld receivers. As the synergies between mobile technologies and broadcast technologies become increasingly clear, telecom and broadcast industries are aligning their interests to take full advantage of the wealth of opportunities opened up by this new cooperation.

The MODIBEC Coordination Action intends to promote and support RTD cooperation between the EU and China in this area of digital broadcasting technologies – especially the convergence with mobile communications. <http://www.modibec.org>

Source: ERTICO

advisory group to the Interministerial Council on all ITS-related matters.

Japan has led the world in terms of ITS deployment, long before the ITS nomenclature was adopted. In the 1970s the NPA established the country's first computerised signal control centre in Tokyo (now the world's largest installation of its kind) and embarked on similar installations for all the major population centres in the country.

During the 1980s, the Japanese automotive industry collaborated to develop and launch in-vehicle driver information and navigation systems. To date more than 2.5M such systems, including the more advanced, real time VICS-compatible units, have been sold. Japan now has an established consumer market for in-vehicle software which will continue to develop into the next century.

Landmark achievements to date for ITS in Japan include:

- CACS (Comprehensive Automobile Traffic Control System) a demonstration project managed by the NPA in the mid-1970s that provided positive evidence in favour of emerging ITS technologies and was the precursor to numerous follow-up programs;
- VICS (Vehicle Information and Communication System) launched in April 1996, offers real time traffic information over current static navigation systems. By March 2003 there were 7.8 million VICS on board systems of 12.9 million in-vehicle navigation units;
- UTMS (Universal Traffic Management System) project headed by the NPA provides real time traffic control and information exchange between traffic control centres. It is effectively a technical specification for advanced traffic management in the country;
- ETM (Electronic Tolling and Traffic Management) technology trials were completed in October 1997. Japan has adopted the 5.8 GHz frequency band for DSRC for ETC systems. By 2004 ETC services were installed at virtually all toll gates across Japan, with 1.8 million on board units (10 million by 2010); and
- Advanced Safety Vehicle (ASV) and Super Smart Vehicle System (SSVS): ASV covers

concepts like intelligent cruise control and collision-avoidance. SSVS is designed to accommodate Japan's aging driving population and is focused on more advanced automated highway concepts.

A national ITS plan was agreed in July 1996 by the then five key ministries and agencies, with the title "Strategic Plan for ITS in Japan", setting the roadmap to deployment of ITS in the

Box 18: ITS strategy in Japan

The ITS goals for each of these categories are as follows.

- In safety and security, ITS Japan aims first to achieve, in a model space, a zone where traffic accident fatalities are reduced to zero. This accomplishment is then to be deployed nationwide, contributing to a 50% reduction of total traffic accident fatalities on all roads by 2010.
- As a target for efficiency and environmental preservation, ITS aims to provide a zone of zero traffic congestion. Achieving this objective is expected to contribute to reducing CO₂ emissions by road transport vehicles to the government's target of 1995 levels by 2010.
- In terms of convenience and comfort, ITS Japan aims to upgrade the public infrastructure to create a comfortable transportation environment, to provide cities and spaces where transportation is an enjoyable and convenient experience, for pedestrians, drivers and users of public transport alike.

The scenario ITS Japan envisions for transportation in the medium term is one in which:

- Safe and secure "ITS zones" are constructed, with the goal of reducing traffic fatalities to zero.
- Improved logistical flow and development of automated driving systems of logistical vehicles on limited stretches of road, with the aim of reducing traffic congestion to zero on those sections.
- Commercialization of "Human navigation systems", to make the transportation experience more enjoyable in a "comfortable transportation zone", including the nationwide deployment of "Smart Towns", promoting multi-purpose use of ETC and provision of traffic congestion information.
- A comprehensive ITS platform is in place.

Source: ITS Japan (2003)

country to 2015. In 2003 ITS Japan developed the current *ITS Strategy for Japan* to clarify the initial mission of ITS and establish Japan's national and international ITS Strategy. The ITS goals and high level strategies are outlined in Box 18.

ITS trends in Australia

Australia was one of the first countries to develop ITS systems, such as the Sydney Coordinated Adaptive Traffic System (SCATS) that was developed in Sydney in the 1960s to help combat rising congestion. SCATS, which has become one of the leading adaptive traffic control systems in the world, now operates in over 40 cities world-wide and controls more than 7,000 sets of traffic signals. Studies have shown SCATS can reduce fuel consumption by around 12%.

States and territories' policy and regulatory responsibilities for land transport have also led a number of regions to develop their own ITS strategies. In order to promote and implement ITS technology, ITS Australia (ITSA) was established in 1992 with the objective to support the development of a safe, efficient transport system responsive to the environment. It seeks to provide a forum for the development and integration of ITS technologies, systems and standards and information interchange, to promote awareness of the benefits of ITS, and to improve the efficiency of Australian transport systems through the implementation of ITS technologies.

The National Strategy for Intelligent Transport Systems, *e-transport*, released in 1999, included the following key strategies:

- Ensure Interoperability and National Standards;
- Create a National Institutional Framework;
- Improve Public and Industry Awareness;
- Foster a Competitive Australian-based ITS Industry;
- Promote International Cooperation; and
- Establish and Monitor Demonstration Projects.

Examples of ITS applications developed in Australia are:

- Melbourne's City Link ETC systems—a world first for a major application of non-stop tolling using DSRC 5.8 GHz communications;

- Safe-T-Cam, developed in NSW, is a heavy vehicle camera/computer-based system located at vantage points on major routes, and has improved truck safety and compliance with regulations;
- Fog warning on the F6 freeway south of Sydney has been equipped with signs which change speed limits depending on the conditions. The system also detects the speed of oncoming vehicles and will signal an advisory message to drivers who are driving too fast;
- Adelaide's Southern Expressway—reverses traffic flow on a three-lane expressway to accommodate traffic peaks;
- Intelligent Access Project, a national project, will facilitate a more flexible, performance-based approach to access management for heavy vehicles using satellite tracking;
- Melbourne's Drive Time system which detects traffic speeds on urban freeways and uses them to provide information on travel times required to reach key interchanges;
- Smart Bus Project, also in Melbourne, aims to give priority to late running buses at traffic signals and to deliver real time information.

Already some 270 Australian-based organisations are developing or exporting ITS. Although the industry is small by international standards, it is particularly advanced in certain areas of ITS, such as advanced real time traffic management, vehicle tracking, freight management, fleet management and scheduling (including taxi despatch/fleet management), integrated ticketing and use of safety cameras.

ITS standards development

Emerging ITS technologies are following established routes into recognised industry standards. Typically a national standard will emerge for a particular application which, in turn, feeds a regional standard (such as the CEN body for the European Union). Since 1990, the United States, Japan and Europe have embarked upon the development of ITS system architectures. From national and regional developments, ITS standards are filtered through the ISO into recognised international specifications. ISO work in the ITS arena is centred on the TC204 committee.

In the absence of a pan-European system architecture, ITS-related standards have developed in

a somewhat haphazard manner. However, one advantage is the role of the European standards organisation CEN as a pan-European custodian and promoter of standards. ITS standards work is focused on the CEN Technical Committee 278 (TC278) on “Road Traffic and Transport Telematics” established in mid-1991, and is effectively a parallel, but European-only, version of ISO TC204.

Historically, the head start of CEN and the proportionally strong voting rights of European ISO members has given emerging ISO ITS standards a Euro-centric bias. The Vienna Agreement signed between ISO and CEN enables working groups studying the same areas to confer with each other and simultaneously propose standards to be adopted by both organisations.

ISO is mandated to open its doors internationally and the recent growth of Asian industrial (especially in computing and telecommunications) and automotive giants will have to be represented in ISO ITS standards development work. Asian participation in TC204 is almost exclusively Japanese and Korean. At the March 1997 ITS Asia-Pacific Seminar, regional representatives voted for an agreement to apply only ISO-based standards for all future ITS installations.

Summary of international ITS trends

The following key trends have been observed:

- Strong, coordinated central government support for ITS R&D;
- Coordinated private and public sector action (through national ITS organisations);
- Identification and development of essential “building blocks” (*e.g.* national architecture);
- Contrasting bottom-up/top-down approaches to consensus-building;
- A push to standards development to facilitate implementation (and build consumer demand for ITS products);
- A focus on deployment and evaluation of benefits from ITS; and
- Mainstreaming of ITS activities into national and regional policy legislation.

Safety and Security

- Intelligent vehicle applications including intelligent cruise controls, driver assistance

(*e.g.* vision enhancement), crash avoidance and mayday (automatic wireless help signals) technologies are progressively becoming available in new vehicles;

- Dynamic speed management using variable speed limits and intelligent vehicle speed adaption to automatically regulate speed; and
- Vehicle location technologies to track and locate vehicles, including hazardous materials.

Traffic and incident management

- Improved vehicle detection technologies, including machine vision and infrared and improved incident detection and verification techniques, including use of cell phone location; and
- Greater use of lane control and ramp metering to make better use of available infrastructure.

Freight

- Weigh-in-motion and automatic pass systems to allow improved productivity for regulators and operators, plus monitoring of hazardous materials movement and improved security;
- Heavy vehicle safety systems, including roll-over and downhill runaway warning systems;
- Intermodal freight improvements through improved communications systems (customs, safety credentials, taxation, goods information) allowing more efficient cross-mode and cross-border transfers;
- Improved real-time traffic information to improve reliability and reduce costs; and
- Truck platooning capability for commercial freight movement, where multiple trucks follow one another at close headway utilising an electronic tow bar.

Public transport/transit

- Providing bus priority at signals on bus priority routes and interchanges with busways;
- Integration of transit or public transport services (rail, bus, light rail) through traveller information (pre-trip, en route), bus rapid transit (vehicle location, signal priority, real time passenger information);
- Provision of integrated ticketing and fare collection systems using smart cards; and
- Improved transit services through real-time traveller information and management of bus services through improved fleet management, utilising GPS tracking.

Pricing/charging

- Electronic toll collection and road pricing applications increasing, including public-private partnerships using electronic monitoring for payment and regulation of operators; and
- Value pricing (high occupancy toll lanes) enabled by electronic dynamic road pricing, charging higher prices for travel during peak demand periods, promoting alternative travel (modes, times, routes). Dynamic pricing enables levels of service to be maintained and allows more responsive services for time-sensitive freight and travellers.

Communication and information

- Increasing drive-time productivity through wireless in-vehicle mobile phones, Internet and email access and in-vehicle computers (including audio messaging);
- Digital satellite-based mobile radio systems providing up to 100 channels of music, news, sports and entertainment by subscription (similar to cable television); and
- ITS applications and detectors enable automatic data collection and processing, allowing better information for planning, policy and management of transport infrastructure and services.



Figure 21
Variable Message Sign.
 Armin Wagner, Frankfurt/M. 2005

Appendix B: Glossary

APTS	Advanced Public Transport System	LRT	Light Rail Transit
ASEAN	Association of South East Asian Nations	M	million
ASV	Advanced Safety Vehicle	MDI	Model Deployment Initiative
ATC	Area Traffic Control	MRT	Mass Rapid Transit
AVI	Automatic Vehicle Identification	NMV	Non Motorised Vehicle
AVL	Automatic Vehicle Location	OECD	Organisation for Economic Cooperation and Development
B	billion	OECD	Overseas Economic Cooperation Fund (Japan)
CBD	Central Business District	pa	Per annum
CCTV	Closed Circuit Television	PRC	People's Republic of China
CV	Commercial Vehicle	R & D	Research and Development
CVO	Commercial Vehicle Operations	RT-TRACS	Real-time Adaptive Signal Control System
DSRC	Dedicated Short Range Communications	SCATS	Sydney Coordinated Adaptive Traffic System
EDI	Electronic Data Interchange	SCOOT	Split Cycle Optimum Offset Timing
EC	European Commission	SOE	State-owned Enterprise
ERP	Electronic Road Pricing	SSTCC	State Science and Technology Commission, China
ERTICO	European Road Transport Telematics Implementation Coordination Organisation (also known as "ERTICO – ITS Europe")	SUV	Sports Utility Vehicle/4 wheel drive
ETC	Electronic Toll Collection	UK	United Kingdom
ETTM	Electronic Tolling and Traffic Management	USA	United States of America
EU	European Union	UTC	Urban Traffic Control (Systems)
GATT	General Agreement on Trade and Tariffs	UTMS	Universal Traffic Management System
GIS	Geographic Information System	VERTIS	Vehicle Road and Traffic Intelligence Society (Japan) now ITS Japan
GNI	Gross National Income	VA	Vehicle Actuation
GNP	Gross National Product	VICS	Vehicle Information and Communication System
GPS	Global Positioning System	VMS	Variable Message Signs
GPRS	General Packet Radio Services	WAP	Wireless Application Protocol
GSM	Global Standard for Mobile (communication)	2G	Second generation of mobile communications using the GSM standard
IC	Integrated Chip	3G	Third generation of mobile communication providing broadband packet-based transmission of text, digitised voice, video and multimedia at high data rates, up to 2Mbps (megabits per second)
ISP	Internet Services Provider		
ISO	International Standards Organisation		
ITS	Intelligent Transportation Systems		



Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

– German Technical Cooperation –

P. O. Box 5180
65726 ESCHBORN / GERMANY
T +49-6196-79-1357
F +49-6196-79-801357
E transport@gtz.de
I <http://www.gtz.de>

