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Intelligent Transport Systems - A New Era in Telematics Technology

by
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The aim of this paper is to address the question of what is transport telematics and provide the progress report of the application of telematics technologies in the transport sector. It focuses on the issue of selecting of suitable system architecture and the associated technologies of transport telematics. A summary report on the cost analysis and benefits evaluation of transport telematics in America and Australia is included. The paper concludes with a summary of number of issues in the implementation of intelligent transport systems.

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Abstract

Urban road traffic congestion problems which accounts to some substantial loss to the economy can only be reduced if the interaction between vehicles, infrastructure and transport management can be handled in a more efficient way. The emerging Intelligent Transportation Systems (ITS) or Transport Telematics technologies do, however, address many of the contributing factors which provide significant improvements in highway safety, mobility, and accessibility. This paper provides a snapshot of the latest information on the progress of transport telematics. It presents the result of the literature review of progress reports of transport telematics from America and Europe.

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1. INTRODUCTION

About 40 percent of the gross domestic product of western countries is spent on buildings and transport (Webster et.al., 1990, p.3). Whether all this money is well spent or not depends on how well the system of land development and its transport links works in terms of economic, efficiency and environmental sensitivity. The management of transport system is important and tends to be most visible when it fails. The lesson to be learned from management failure is not that we should therefore have less transport management, but rather that the management should be better informed. Urban road traffic congestion problems which accounts to some substantial loss to the economy (see Table 1 for an Australian example) can only be reduced if the interaction between vehicles, infrastructure and transport management organisation can be handled in a more efficient way. The emerging Intelligent Transportation Systems (ITS) or Transport Telematics technologies do, however, address many of the contributing factors which provide significant improvements in highway safety, mobility, and accessibility.

Table 1: The Cost of Road Traffic Congestion in Australian Cities

City	Annual cost of congestion (A$ millions)
Sydney	2080
Melbourne	1820
Brisbane	400
Perth	368
Adelaide	275
Canberra	105
Hobart	42
Darwin	24

(Source: extracted from Bureau of Transport and Communications Economics, 1995, Table 4.1, p.26)

This paper provides a snapshot of the latest information on the progress of transport telematics. It presents the result of the literature review of progress reports of transport telematics from America and Europe. The three major official sources of information that this paper is referred to are the ITS America (1996), the European Conference of Ministers of Transport (1995) and the research stream on the evaluation of transport telematics at the Institute of Transport Studies, the University of Sydney (Raimond and Battelino, 1994).

The aim of this paper is to address the question of what is transport telematics and provide the progress report of the application of telematics technologies in the transport sector. There are eight sections in this paper. Next section reviews the basics of transport telematics which includes the definition and the current scope of transport telematics. Section 3 focuses on the issue of selecting of suitable system architecture and the associated technologies of transport telematics. A summary report on the cost analysis and benefits of transport telematics evaluated by ITS America is presented in Sections 4 and 5, respectively. Section 6 describes and presents major findings from a cost benefit analysis evaluation of transport telematics in Australia. The paper concludes with a summary of number of issues in the implementation of transport telematics systems.

2. WHAT IS TRANSPORT TELEMATICS AND ITS CURRENT SCOPE

The past twenty years has been the period of rapid technological change and there is no question that computing technology has been enthusiastically adopted by transport professional and has brought about new conception which has been named differently among different countries Intelligent Transport System (ITS) in North America and Transport Telematics in Europe. In this paper, these two terms are used interchangeable. Telematics is the term for the exchange and processing of electronic data between networked computer systems. Transport telematics is the application area of the telematics technology. In general, transport telematics can be defined as the use of advanced technology, including computers, communications, sensors and control system, to improve mobility. From the system approach, transport telematics systems are made up of sets of telematic systems representing different components. Each system can keep track of their own information, execute their own telematic services. Transport telematics technologies have been encapsulated in a collection of interrelated services for transport problems. The scope of transport telematics is evolving with the changing technology and road users' demand. It can be illustrated by referring to the currently defined focus of transport telematics in the United States. As part of the US national program planning process, ITS America has defined twenty-nine user services which have been grouped into seven categories as listed in Table 2.

Table 2: Currently Defined Focus of Transport Telematics in US

Category	User Services
Travel and Transportation Management	• En-Route Driver Information • Route Guidance • Traveller Services Information • Traffic Control • Incident Management • Emissions Testing and Mitigation • Demand Management and Operations • Pre-Trip Travel Information • Ride Matching and Reservation
Public Transportation Operations	• Public Transportation Management • En-Route Transit Information • Personalised Public Transit • Public Travel Security
Electronic Payment	• Electronic Payment Services
Commercial Vehicle Operation	• Commercial Vehicle Electronic Clearance • Automated Roadside Safety Inspection • On-board Safety Monitoring • Commercial Vehicle Administration Processes • Hazardous Materials Incident Response • Freight Mobility
Emergency Management	• Emergency Notification and Personal Security • Emergency Vehicle Management
Advanced Vehicle Control and Safety Systems	• Longitudinal Collision Avoidance • Lateral Collision Avoidance • Intersection Collision Avoidance • Vision Enhancement for Crash Avoidance • Safety Readiness • Pre-Crash Restraint Deployment • Automated Highway System

(Source: ITS America, 1996)

This list of user services is neither exhaustive nor final. In fact, a thirtieth user service, Highway-Rail Intersection, is currently being developed (ITS America, 1996). Table 2 presents stakeholders with a variety of options to address their transportation needs which involve two basic activities: supply the equipment and supply the information services. These activities aim at providing end-users with the information services which can be classified into three categories: information on the network and traffic flows; route planning and guidance aimed at ensuring minimal delays; and other travel information. Basically, a transport telematics system involves three basic levels for telematics - vehicles, infrastructure (road and communication) and transport organisation management. The development of driver information services is therefore very closely linked to the responsibilities that transport authorities share with other authorities with respect to the management of road networks, safety of motor vehicle equipment, protection of the environment, and the development of industries associated with the automotive and telecommunications industries. This will call for the establishment of partnership between the public sector (infrastructure managers, police authorities, public transport, parking facilities, etc.) and the private-sector operators supplying the services.

Left without adequate guidance, stakeholders could easily develop systems solutions to their needs which were incompatible with their neighbourhood. To fully maximize the potential of telematics technologies, system design solutions must be compatible at the system interface level in order to share data, provide coordinated, area wide integrated operations, and support inter-operable services where appropriate. Therefore, what required is an overall guidance to ensure system, product, and service compatibility/interoperability, without limiting the design options of the stakeholder. This issue will be discussed in the next section of selecting a suitable basic system architecture of transport telematics.

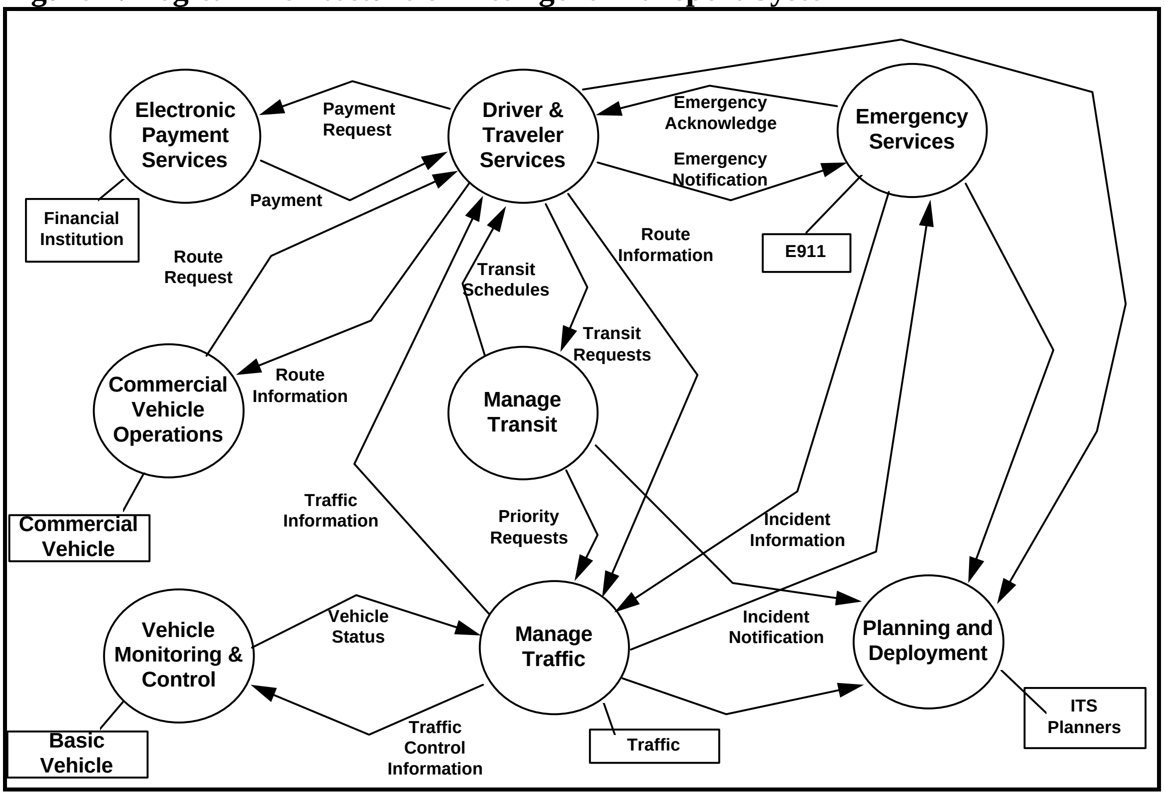
3. SELECTING A SUITABLE BASIC SYSTEM ARCHITECTURE

In searching for a suitable basic system architecture for the design and implementation of transport telematics, the key criteria is how to ensure system, product, and service compatibility/inter-operability, without limiting the design options of the stakeholder. The system architecture developed by ITS America provides the most up-to-date and complete framework for designing transport telematics systems. The significance of this framework is that it is not a system design nor is it a design concept. The framework defines the functions that must be performed, the physical entities where these functions reside, the interfaces/information flows between the physical entities, and the requirements for actual physical communication channels over which the information flows travel. In addition, it identifies and specifies the requirements for the standards required to support national and regional inter-operability, as well as product standards required to support economy of scale considerations in deployment. The basics of American system framework involves the use of two perspectives: logical and physical.

The *Logical Architecture* presents a functional view of the ITS user services. This perspective is divorced from likely implementations and physical interface requirements. It presents only the functions (process specifications) that are necessary to perform ITS services and the data flows that need to be exchanged between these functions. The functional decomposition process begins by defining those elements that are inside the architecture, and those which are not. For example, travellers are external to the architecture but the equipment that they use to obtain or provide information is inside. A financial institution is outside of the architecture but the ITS components that detect vehicles, and keep track of tolls are inside. The existing broadcasting media are outside of the architecture but the elements that provide ITS information to the media are inside.

The ITS functions are represented as *data flow diagrams*. A simplified top level diagram is presented in Figure 1. Circles represent functions that are broken down into finer detail on subsequent diagrams. The lowest level of decomposition is a *Process Specification*. (An example of a process specification is *Detect Roadside Pollution Levels*. The function detects pollution levels present in the environment and passes the pollution measurement data on to another process *Process Pollution Data* where it is combined with other such detected data.) Lines represent data flows that are also further subdivided on subsequent diagrams and are described in a data dictionary. Rectangles represent external entities.

Figure 1: Logical Architecture of Intelligent Transport System

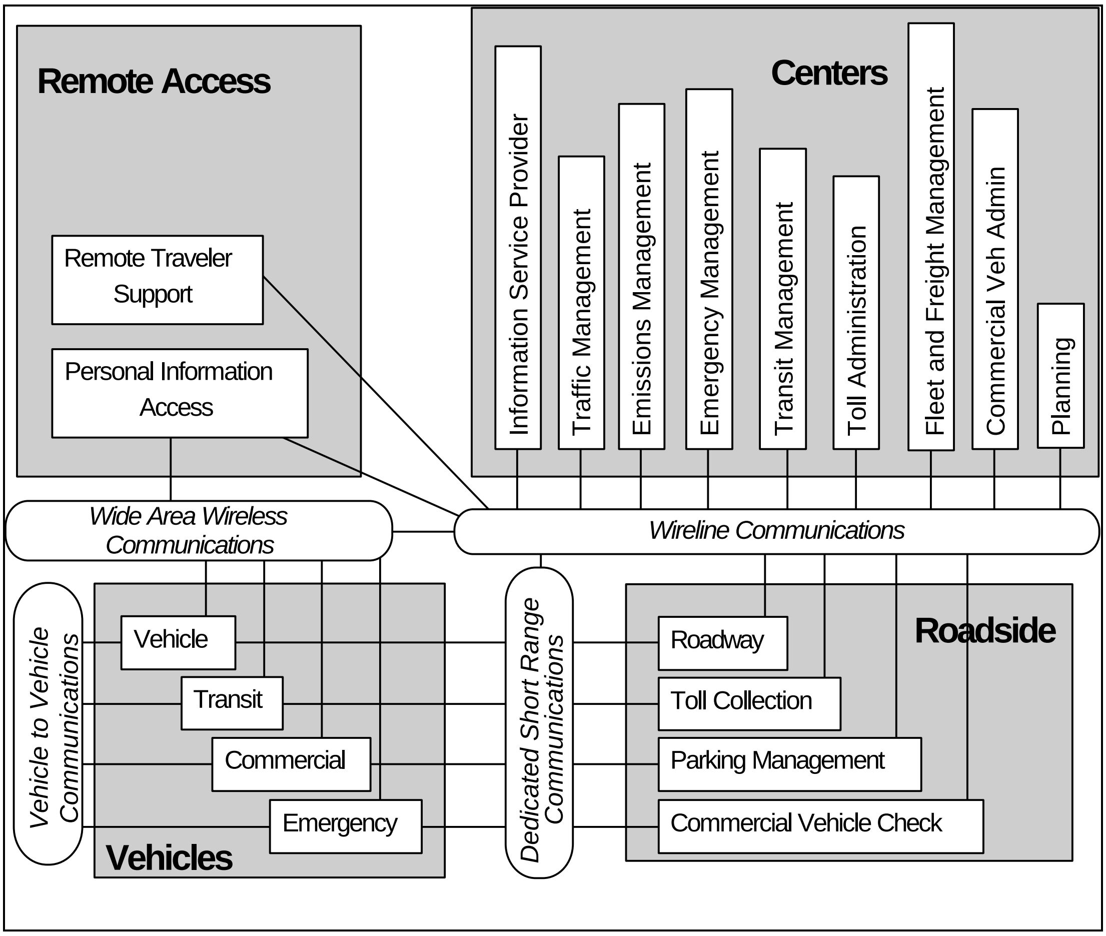


(Source: ITS America, 1996)

The *Physical Architecture* can best be described at a high level by using a simple interconnect diagram (shown in Figure 2). This diagram identifies 4 classes of subsystems (large boxes), 4 types of communications channels (boxes with rounded corners) and 19 subsystems (rectangles within large class boxes). The 4 classes of subsystems represent remote access for travelers, infrastructure centers, infrastructure distributed alongside the roadway, and vehicles. Each of the 19 subsystems represents capabilities that could be expected to reside within a single agency (public authority, private company or individual), physical entity (vehicle or building), or distributed set of assets managed by one agency.

The Physical Architecture also identifies the set of process specifications assigned to each of the 19 subsystems. The two process specifications described above (Detect Roadside Pollution Levels, and Process Pollution Data) are assigned to two different subsystems (Roadside and Emissions Management respectively). The interface between the two process specifications then becomes an element of the physical interface between the Roadside and Emissions Management subsystems.

Figure 2: Physical Architecture of Intelligent Transport System



(Source: ITS America, 1996)

The specific choice of nineteen subsystems represents a partitioning of functions that is intended to capture all expected or likely subsystem boundaries for the present to 20-year future. The inter-subsystem boundaries identify the range of possible institutional and message interfaces. The subsystems themselves are composed of Equipment Packages with specific functional requirements that represent the smallest units of ITS that can be purchased and deployed. The character of a subsystem deployment is determined by the specific equipment packages chosen. At the same time, subsystems may be deployed individually or in ‘ ‘ aggregations” or combinations that will vary by geography and time based on local deployment choices.

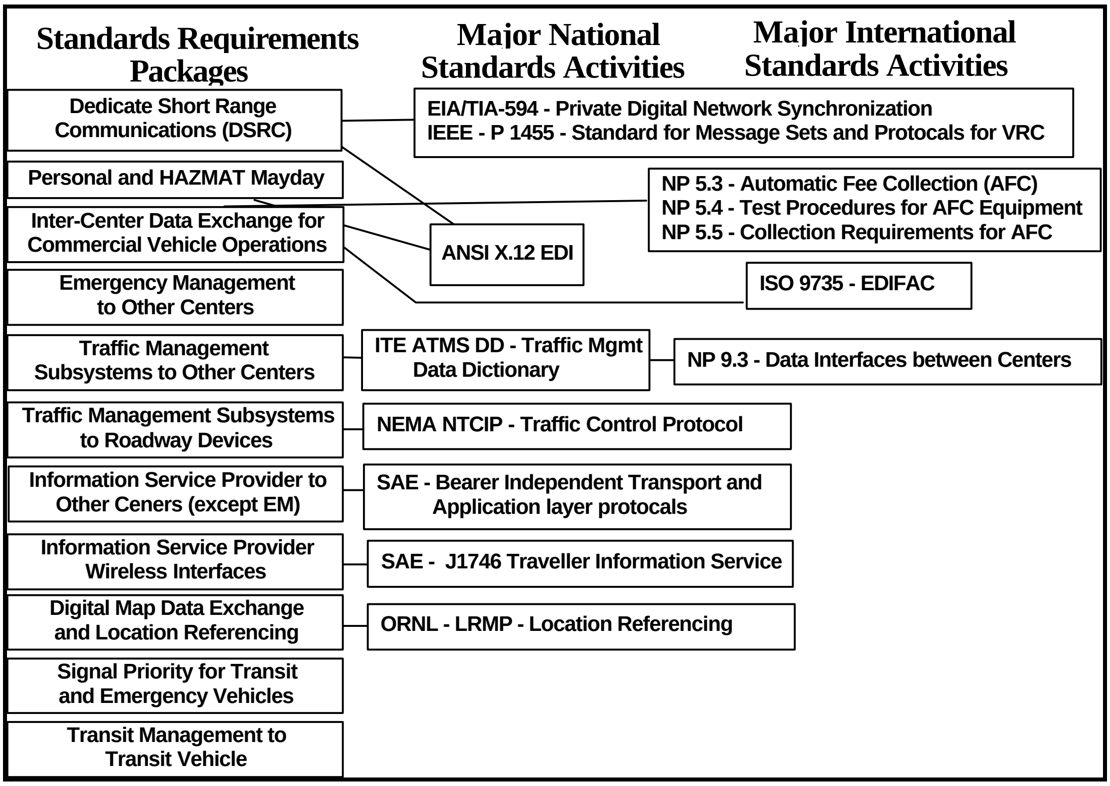
The ITS subsystems communicate with each other using the communication elements and architecture interconnect channels. The subsystems shown as single entities in the figure are representative of multiple instances of the specific subsystem. For example, several Traffic Management subsystems in a region, each with their own jurisdiction, may communicate with each other (and each with their many Roadway subsystems) to implement regional ITS policies. Several deployed subsystems of a given type may be individually operated by local, state, federal, or private institutions. The multiplicity expressed for ITS subsystems extends to the wireline and wireless communication elements as well. In the previous example, the Traffic Management subsystems may communicate with each other using a commercial wireline data communications service provider, but may have their own dedicated wireline communications elements for data communications with their many Roadway subsystems where sensors and signals are located.

The Center subsystems have no requirement to be on or adjacent to a roadway and thus can be located anywhere. To communicate with other subsystems they need access to wireline communications. The Roadside subsystems include functions that require convenient access to a roadside location for deployment of sensors, signals, programmable signs, or other interfaces with travellers, vehicles (or possibly freight). Roadside subsystems generally need wireline (or equivalent stationary point-to-point) communications for messages to/from one or more Center subsystems, and possibly also have toll-tag or beacon dedicated short range communications to some or all vehicles passing the specific roadside subsystem deployment. The Vehicle subsystems are installed in a vehicle. The subsystems may support some combination of Dedicated Short Range Communications (DSRC) (e.g. toll-tag or beacon communications) with Roadside subsystems, Wireless Wide Area 2-way or 1-way communications with Center subsystems, and Vehicle-Vehicle communications.

The Remote Access subsystems represent platforms for ITS functions of interest to travellers or carriers (e.g. commercial vehicle operators) in support of multimodal travelling. They may be fixed (e.g. Kiosks or home/office computers using wireline communications) or portable (e.g. a ‘ ‘ palm-top” computer using wireless communications) and may be accessed by the public (e.g. kiosks) or by individuals (e.g. personal computers). The ITS America Architecture provides the framework that ties the transportation and telecommunication worlds together to enable the development and effective implementation of the broad spectrum of ITS user services. There are multiple communications options available to the system designer. The flexibility in choosing between various options allows each implementor the ability to select the specific technology that meets the local/regional needs.

More detailed description of subsystems and the development of the communications architecture are covered in the ITS America Internet Homepage. In terms of standardisation, ITS America aims at developing the architecture structure in such a way it is a means through which relatively independent standards activities can proceed with harmonious results. Because the standards will be developed based on the architecture interfaces and data flows, information that cuts across standards activities is identified. Figure 3 describes the ITS America approach towards the standardisation of transport telematics systems. The architecture has identified 11 key standards areas that are relatively independent. This knowledge allows standards organisations to be aware of overlapping activities. It also permits the effective coordination of activities.

Figure 3: ITS America approach towards the standardisation of transport telematics



(Source: ITS America, 1996)

This figure indicates the standards packages along the left hand column and the current standards activities that are already addressing some of the key standards areas. Certain areas are not currently covered by any significant activities and will require new efforts. For each of the standards packages, a detailed list of architecture data flows is provided so that standards organisations can readily apply the architecture to their efforts.

4. COST ANALYSIS OF TRANSPORT TELEMATICS SYSTEMS

ITS America has spent considerable effort in the area of cost analysis of transport telematics systems. The goal of this effort is twofold. First, the evaluation is to produce a high-level estimate of the expenditures associated with implementing the physical elements and the functional capabilities of ITS Services as these services are likely to be deployed utilising the ITS America’ s National Architecture. The second goal of the cost evaluation is to provide a costing tool for ITS implementors.

The Cost Analysis document presents the estimate of expenditures for an Evaluatory Design implemented over three scenarios. One scenario includes a major urban area described as Urbansville (based on Detroit). Additional scenarios are an inter-urban area, Thruville (an inter-urban corridor in NJ/PA), and a rural area, Mountainville (a rugged rural setting based on Lincoln County, Montana). The cost evaluations are based upon a detailed physical element categorisation within each subsystem and an aggregation of total expenditures into initial investment (non-recurring) expenditures, as well as operation and maintenance (recurring) expenditures. Each scenario analysis covers a twenty-year deployment period.

Typical results of this effort are summrised in Tables 3, 4 and 5. The non-recurring expenditures for the government stakeholder group are tabulated for the deployment year milestones in which the five year summation consists of the expenditures for the year stated plus the expenditures for the four previous years.

Table 3: Government Non-Recurring Expenditures Urbansville High Market Penetration (Non Discounted)

Subsystem	Non-Recurring Expenditures (*)		
	0-5	6-10	11-20
	Years	Years	Years
Commercial Vehicle Administration Subsystem (CVAS)	$379	$1	$16
Commercial Vehicle Check Subsystem (CVCS)	$311	$0	$75
Emergency Management Subsystem (EMS)	$406	$309	$792
Environmental And Emissions Management Subsystem (EMMS)	$1	$0	$0
Emergency Vehicle Subsystem (EVS)	$1,867	$4,855	$12,560
Parking Management Subsystem (PMS)	$645	$920	$3,625
Planning Subsystem (PS)	$0	$35	$35
Roadside Subsystem (RS)	$66,969	$95,687	$229,452
Remote Traveller Subsystem (RTS)	$1,600	$3,125	$12,100
Toll Administration Subsystem (TAS)	$56	$10	$60
Traffic Management Subsystem (TMS)	$4,738	$5,662	$15,721
Transit Management Subsystem (TRMS)	$3,089	$3,168	$270
Transit Vehicle Subsystem (TRVS)	$10,220	$13,236	$29,788

Note: (*) Expenditures are in constant 1995 US dollars in (1,000's)
(Source: ITS America, 1996)

Table 4: Government Non-Recurring Expenditures Thruville High Market Penetration (Non Discounted)

Subsystem	Non-Recurring Expenditures (*)		
	0-5	6-10	11-20
	Years	Years	Years
Commercial Vehicle Administration Subsystem (CVAS)	$676	$1	$32
Commercial Vehicle Check Subsystem (CVCS)	$805	$6	$198
Emergency Management Subsystem (EMS)	$203	$203	$393
Environmental And Emissions Management Subsystem (EMMS)	$0	$1	$0
Emergency Vehicle Subsystem (EVS)	$895	$2,321	$5,380
Parking Management Subsystem (PMS)	$172	$231	$905
Planning Subsystem (PS)	$0	$35	$35
Roadside Subsystem (RS)	$6,648	$92,578	$94,420
Remote Traveller Subsystem (RTS)	$520	$1,261	$5,750
Toll Administration Subsystem (TAS)	$56	$10	$60
Traffic Management Subsystem (TMS)	$2,273	$1,313	$6,110
Transit Management Subsystem (TRMS)	$1,624	$3,548	$918

Transit Vehicle Subsystem (TRVS)	$3,649	$4,327	$9,193

Note: (*) Expenditures are in constant 1995 US dollars in (1,000's)
(Source: ITS America, 1996)

Table 5: Government Non-Recurring Expenditures Mountainville High Market Penetration (Non Discounted)

Subsystem	Non-Recurring Expenditures (*)		
	0-5	6-10	11-20
	Years	Years	Years
Commercial Vehicle Administration Subsystem (CVAS)	$338	$1	$16
Commercial Vehicle Check Subsystem (CVCS)	$403	$3	$99
Emergency Management Subsystem (EMS)	$203	$0	$196
Environmental And Emissions Management Subsystem (EMMS)	$0	$1	$0
Emergency Vehicle Subsystem (EVS)	$2	$8	$17
Parking Management Subsystem (PMS)	$0	$0	$0
Planning Subsystem (PS)	$0	$0	$0
Roadside Subsystem (RS)	$0	$1,054	$1,392
Remote Traveller Subsystem (RTS)	$0	$0	$30
Toll Administration Subsystem (TAS)	$0	$0	$0
Traffic Management Subsystem (TMS)	$0	$679	$911
Transit Management Subsystem (TRMS)	$0	$1,968	$85
Transit Vehicle Subsystem (TRVS)	$0	$133	$137

Note: (*) Expenditures are in constant 1995 US dollars in (1,000's)
(Source: ITS America, 1996)

As expected the major government expenditure item in each of the deployments is the Roadside Subsystem (RS), with transit systems (including Transit Management (TRMS) and Transit Vehicle Subsystems (TRVS)) the next largest cost items.

However, the expenditures for typical area-wide deployments have limited value to implementors outside of the order of magnitude estimate for fully deployed ITS services. Consequently, a major emphasis for the Phase II evaluation of ITS America's Cost Analysis is shifted to providing a costing methodology and ranges of unit prices for the various ITS services, rather than emphasizing a bottom line expenditure for the three scenarios. The Cost Analysis Document provides a detailed cost estimate for each equipment package in the architecture, and presents a methodology for the development of nonrecurring and recurring costs on any configuration an implementor would define. As such the actual document provides a resource guide for costing activities.

Using the methodology, and unit prices described in this document, a public sector implementor can make their own set of assumptions and compute both recurring and non-recurring expenditures. Table 6 provides a summary of the non-recurring and recurring expenditures for an individual user for three levels of service. Basic service provides the capability for drivers to interface with the Information Service Provider (ISP) Subsystem's Basic Information Broadcast Equipment Package and receive formatted traffic advisories including accurate travelling information concerning available travel options and their availability, and congestion information in their vehicle. Mid-range Service provides the Basic services plus In-Vehicle communication hardware and software, route guidance and location determination and its driver interface. The comprehensive service is defined as comprising all user services as they become available to the individual consumer group.

Table 6: Individual Non-Recurring Expenditures (*)

Basic Service	$200
Mid-range Service	$1050
Comprehensive Service	$8440**

Note:(*) Expenditures are in constant 1995 US dollars
(**) The Comprehensive Service Expenditures include $5,890 for all vehicle safety systems, and an estimate of AHS (Automated Highway System) vehicle cost.
(Source: ITS America, 1996)

Table 7: Individual Monthly Recurring Expenditures (*)

	Operation	Maintenance
Basic Service	$0	$0
Mid-range Service	$15	<$5
Comprehensive Service	$45	<$30

Note:(*) Expenditures are in constant 1995 US dollars
(Source: ITS America, 1996)

The monthly service charges for in-vehicle services are in the range of $0 to $45 per month for individual users (based on average usage) and are comparable to, or lower than, current service cost experiences for cellular telephone service (see Table 7).

Although unit price ranges available from the Cost Analysis document are based on information from recently deployed ITS projects, any effort to create summary cost numbers is highly influenced by the assumptions made in the analysis. Some asumptions might involve the definition of the elements (and the number of each) that are contained in each equipment package. For example, the Network Surveillance equipment Package (which is in the Roadway Subsystem) has a number of detector loops which is tied to the number of intersections and the penetration estimate (what percentage of intersections are instrumented). In addition, there are other assumptions which have a critical impact on the summary results. For example, are communication lines between the Roadway and the Traffic Management Subsystem owned by the public agency (and hence subject to initial capital installation costs), are they leased from a private communications provider, or are the paid for on a per use basis (again from a communications provider)? Each ITS implementor will make his/her own decision on whether to install communications or purchase the needed lines.

Another assumption which impacts the cost summaries is what elements to include as part of each ITS functionality and which to not include (e.g. new hardware, software, building space, and personnel required to provide the equipment packages).

Understanding the relationship between the assumptions made and their consequences in the costing task of is not the only contributing factor to the successful implementation of transport telematics systems. The associated benefits of the implemented systems should also be measured so that a complete cost benefit analysis can be performed.

5. MEASURED BENEFITS OF TRANSPORT TELEMATICS SYSTEMS

The deployment of transport telematics technologies has resulted in benefits that have been evaluated and measured. William S. Jones, a consultant to ITS America has compliled a list of applications (ITS America, 1996) classified under five application areas: advanced traffic management systems (ATMS), advanced traveler information system (ATIS), electronic toll and traffic management (ETTM), advanced public transit systems (APTS), and commercial vehicle operations (CVO).

The evaluation of applications from this list have shown improved safety and productivity along with a reduction in congestion and adverse environmental impacts. In the area of Advanced Traffic Management Systems (ATMS), the significant improvement is the ability to obtain and provide real-time information on traffic parameters such as speed or density. By using video detection devices incorporated in the Automated Traffic Monitoring System, the task of area-wide control of traffic signals at intersections can be enhanced significantly with more reliable traffic parameters. Table 8 provides a summary of the basic consequences of the improved systems implemented at three different states in US.

Table 8: Measured Benefits of Advanced Traffic Management Systems

	FAST-TRAC Project (Oakland County, Michigan)	**Minnesota Department of Transportation, Traffic Management Center (Minneapolis, Minnesota)**	**Texas Department of Transportation (Abilene, Texas)**
Congestion	Up to 19% increase in vehicle speeds during peak hour	Average speeds increase by 35% (34 mph to 46 mph) during rush hours Capacity of freeway increased by 22%	14% reduction in travel time 37% reduction in delays 22% increase in travel speed
Safety	89% decrease in left-turn accidents at intersections, 6% decrease in injury accidents, 100% decrease in serious injuries, 27% decrease in total injuries.	Accident rates decrease by 25% (421/year to 308/year) 20-minute reduction in response time to incidents	Not available
Environmental Impacts	Not available	Not available	10% reduction in carbon monoxide and hydrocarbon emissions

TRAV-TEK project (Orlando, Florida) - a large public/private partnership program to test an Advanced Traveler Information System (ATIS). The program involved 5 organisations, 100 vehicles, most of which were AVIS rental cards, and 4,000 drivers over an extended period of time. Vehicles had electronic route guidance systems installed. Provides detailed directions to drivers who input destination information, and GPS data on real-time location of the vehicle. The system was connected to a Traffic Control Centre via satellite. 19% reduction in travel time was evaluated. The safety and environmental impacts assessment were not available.

In the application area of Electronic Toll and Traffic Management, the PIKEPASS electronic toll collection systems implemented at Oklahoma Turnpike Authority represents the most successful project in terms of its measured benefits. This system has been operational for several years and are currently being installed in 20 states of US. Electronic toll technology uses a special RF (Radio Frequency) tag that talks to the toll gate as the vehicle approaches. The tag identifies the driver and the toll system then debits the driver's account for the amount of the toll. The vehicle does not needs to slow down at all, and proceeds through the toll plaza at regular freeway speeds, eliminating the slowdown and deceleration at toll booths. In terms of traffic safety, accidents was reduced to zero in first year (eg 71 accidents in regular toll lane, zero in PIKEPASS lane). The congestion level is greatly improved with the reduced time lost to toll congestion by 1 million hours/year. The productivity is also enhanced with reduced annual cost of operation of toll lane by 11 to 1 ($176,000 to $15,800). In terms of enviromental impact, the air pollution was reduced (Hydrocarbons by 6 to 1, Carbon Monoxide by 4 to 1, Nitrous Oxide by 2 to 1).

In the application area of Advanced Public Transit Systems, the Automatic Vehicle Location/Computer-Aided Dispatch (AVL/CAD) systems are the most popular systems. Twenty-one cities in the United States have or are in the process on installing on their buses. AVL/CAD provides precise position of the bus along its route and reports this to the central computer at dispatch headquarters. This data is used to determine the on-time performance and provides to the driver and the dispatcher a visual indication of where the bus is (if desired) and schedule adherence (ahead of schedule or behind schedule.) The systems also provide accurate run times on routes and a covert "mayday" message capability. AVL is also the basic ingredient for providing real-time schedule information to the public to make transit easier to use and more reliable. As an illustration of the measured benefit of this technology, the Baltimore MTA (Maryland) is referred. Baltimore MTA installed a system on 50 buses in 1991 and conducted a schedule performance test versus non-equipped buses. A 23% improvement in on-time performance was achieved by the AVL-equipped buses.

In the area of Commercial Vehicle Operations (CVO), a large trucking company (to maintain its confidentiality its name is not available) installed an on-board computer and communication system on its trucks. This is connected to a Computer-Aided Dispatch system at dispatch headquarters. The system allowed the company to better utilize the fleet of 10,000 trucks by an average 20-25 miles per day per truck. This is significant in an industry that operates on a low margin. An increase of 4% in fleet productivity was achieved.

Definitely, the list of benefits of specific transport telematics applications is neither exhaustive nor final. It is important in terms of demonstrating its usefulness to the community as a whole. However, the question now is the cost benefit ratio for an investment into an application of transport telematics technologies. The next section addresses this question by presenting a summary of main findings from a cost benefit analysis of transport telematics systems applications in Australia.

6. COST BENEFIT EVALUATION OF TRANSPORT TELEMATICS APPLICATIONS

The evaluation of transport telematics applications in Australia has been very limited in the literature. This section focuses on a recent cost benefit study of a transport telematics application in Australia, carried out by Raimond and Battellino (1994) at the Institute of Transport Studies, the University of Sydney. This is demand responsive bus trial project in Shellharbour, an urban fringe of Wollongong. There is much debate concerning the applicability of transport telematics to public transport improvements. In particular, computerised public transport management systems (CPTMS) are being seen by many as the answer to some of the traditional problems associated with public transport - the main one being flexibility for the user. CPTMS was trialled in a one year project, taking the form of a demand responsive bus service. The flexibility of the service came from its ability to allow on-demand route diversions from a trunk route, offering real time passenger and control centre information, and 20 minute prior telephone booking. Two scenarios were used in the cost benefit analysis - the high technology approach adopted by the project, and low technology alternative which operated for most of the trial period because of technical problems. The low technology used the lessons learnt from this project, where the operators run a similar service, but with the use of manual short-wave radio communications instead of state-of-the-art radio wave data transfer and computer control. This scenario reflects the situation which operated for about half of the monitoring period, and also represents what is perhaps a more reasonable investment possibility for a private bus operator.

Shellharbour Council arranged for a one year trial project to be jointly funded by the German and Australian Governments using a German Computerised Public Transport Management System (CPTMS). The project involved the collaboration of two local bus operators. As part of the project, they gave their bus services within the Shellharbour Municipality a common name (Translink), operated a joint booking office and control centre, bought a midi-bus each which was painted in Translink livery and put large Translink stickers on their existing fleet that operated in the Shellharbour area. At the same time, with the help of the Department of Transport, they restructured their routes, ensuring that they met minimum service requirements specified under the 1990 Passenger Transport Act.

When a person called the booking service, all they needed to tell the operator was their address, their destination, and what time they wished to reach their destination. The operator would put these details into the computer and the computer could tell which was the closest stop to their address, and what time a bus could divert to the stop given the desired time they wished to reach their destination. Passengers would be given a five minute time window in which the bus would appear at the stop closest to them. This was necessary because some flexibility was required in the timetable to account for differing numbers of demand diversions being made. As soon as the booking was made, this information was automatically transferred to the onboard computers. A display screen in the bus told the driver when to divert onto a demand loop and how many people to expect. The system allowed people to book a service as near as 20 minutes before they wished to be picked up.

The on-board computers also meant that both passengers and the control centre always knew exactly where the buses were on their routes. An on-board passenger information system electronically displayed the name of the next stop to passengers. The CPTMS also allowed for traffic light actuation, though the RTA was only willing to give the buses an advantage on a couple of unimportant traffic lights in the Municipality.

Thus, it can be seen that the new service had several advantages over traditional forms of public transport. Firstly, the addition of demand loops and a simple booking service made the service far more accessible to residents. Secondly, transfer times between modes were minimised via information available to the onboard computers — timetables were adhered to because at any time the control centre knew where the buses were, and could respond quickly to any problems. The midi-buses allowed increased frequencies, adding to the convenience of using public transport in a traditionally low density, low frequency environment. The only downside to this form of public transport was that some extra time had to be built into the timetable in order to cater for some demand loop diversions off the main route. This added some extra in-vehicle time to the normal linehaul trip.

The economic benefit of Translink to bus users is calculated using changes in fare costs, patronage levels, access and egress time to and from bus stops, waiting time, and travel time. Then the costs of operating the project are calculated. Costs include capital investments in new buses, computer and radio equipment and new bus stops and signage, operating costs associated with running the buses, renting and operating the Translink Office, and the costs of informing the public about the service. As already mentioned, a high and a low technology scenario will be used in the costing of the project.

The life of the capital investment in this project is assumed to be twelve years. It is generally accepted that the life of a standard size bus is fifteen years, so the midi-buses bought for this project are assumed to last twelve years as smaller vehicles are generally less durable. Thus, the costs and benefits of the project are calculated over the twelve year period from August 1992 when Translink began to August 2004 when the useful life of most of the hardware involved in the project will end.

Data used in this section are sourced primarily from the on-board survey of approximately 500 Translink users, particularly the information they provided about the trip they were making and how they made that particular trip prior to Translink. Some additional data came from ticketing systems of the operators. A non-user survey conducted just after the on-board surveys found no previous users who were disenfranchised to the extent that they no longer used the service. Thus it is believed that the on-board survey results are not biased by failing to capture previous users who no longer use the service.

Table 9 lists the costs, in broad categories, of the low and high technology cost scenarios. The high technology option is far more expensive for two main reasons. The first is the cost of the computer hardware, on-board computers, state-of-the-art communications technology and their installation. The second is that such a capital investment requires a control centre/office with specialist staff. Neither of these costs are incurred by the low technology option for which the main cost is the operation of the route service.

Table 9: Total Cost of High and Low Techology Options for Year 1

High Technology Option	1992 Cost	Low Technology Option	1992 Cost
CAPITAL COSTS (one-off)		CAPITAL COSTS (one-off)	
IBIS Units for buses	$179,940	Midi Bus	$115,000
Midi Bus	$115,000	Bus Stop Signs and Information	$47,258
Vehicle and Radio Equipment	$53,986	Signage on Vehicles	$3,000
Bus Stop Signs and Information	$47,259		
Control Centre Hardware	$40,682		
Office Fit-out	$13,720		
On-Board Fitting of Computers	$9,344		
Signage on Vehicles	$3,000		
Revolution Counters	$1,745		
Technicians Equipment	$754		
One Translink Sign	$168		
OPERATING COSTS (annual)		OPERATING COSTS (annual)	
Operations Centre Staff	$74,433	Bus Operating Cost	$55,608
Bus Operating Cost (total)	$55,608	Telephone	$2,533
Driver costs	*$43,536*	Public Relations	$1,500
Fuel, Oil, Tyres	*$7,920*	Office Expenses	$1,431
Repairs/Maintenance	*$2,535*	Contingency	$1,000
Fleet overheads	*$1,620*		
Salary (technician)	$42,340		
Office Rent	$35,000		
Communication Fees	$13,000		
Radio Communication	$9,994		
Additional Pilot-Related Costs (annualised)	$7,901*		
Public Relations	$5,079*		
Telephone	$2,533		
Office Expenses	$1,431		
Consumables	$1,270		
Superannuation	$1,250		
Electricity	$801		
Computer Repairs/Maintenance	$73		

Note: (*) Not necessarily incurred by an operator
(**) These costs could occur disproportionately in the first year of operation
(Source: Raimond and Battelino, 1994)

The main finding from the cost benefit analysis of the two scenarios is that although the benefit-cost ratio of the low technology scenario is slightly higher than that for the high technology scenario, the benefit-cost ratio for both scenarios is well below one. This means that the project, in economic and partly social terms (disregarding any intangible benefit), does not break even. This study raised some questions on how to value the intangible community benefits which could not be included in the formal cost-benefit analysis, such as goodwill towards the service and the flexibility it offers.

The trial was not a financial success for the operators, nor a measurable economic success for the community (in either low or high technology guise). This raises the question as what type of service would be cost-effective enough to be useful. Such an application of transport telematics should not be ignored because some important lessons have been learnt from this project may make the path to success a little clearer. The lessons for operators are many. For example if an operator wishes to implement such a system, costs can be minimised by applying the demand responsive idea to existing services using existing vehicles and office and communication facilities. The only additional costs that need be incurred are those related to promotion of the changed service. In this way, an average urban operator could serve more people without incurring significant extra costs.

Transport telematics will almost certainly have a role to play in public transport in the future, but the tasks it performs need to be better defined and more useful than in this project. The costs were simply too high for a system which was essentially used as a computerised booking system. This does not mean the demand responsive concept per se is bad. Indeed, if its benefits could be measured in social terms, it could be measured a success (Raimond and Battelino, 1994). It is also noted that, the main finding from this cost benefit analysis is related to a specific project. General inference towards the cost benefit performance of transport telematics systems obviously could not be drawn for a wide range of applications of telematics technology.

7. THE CHALLENGES AHEAD

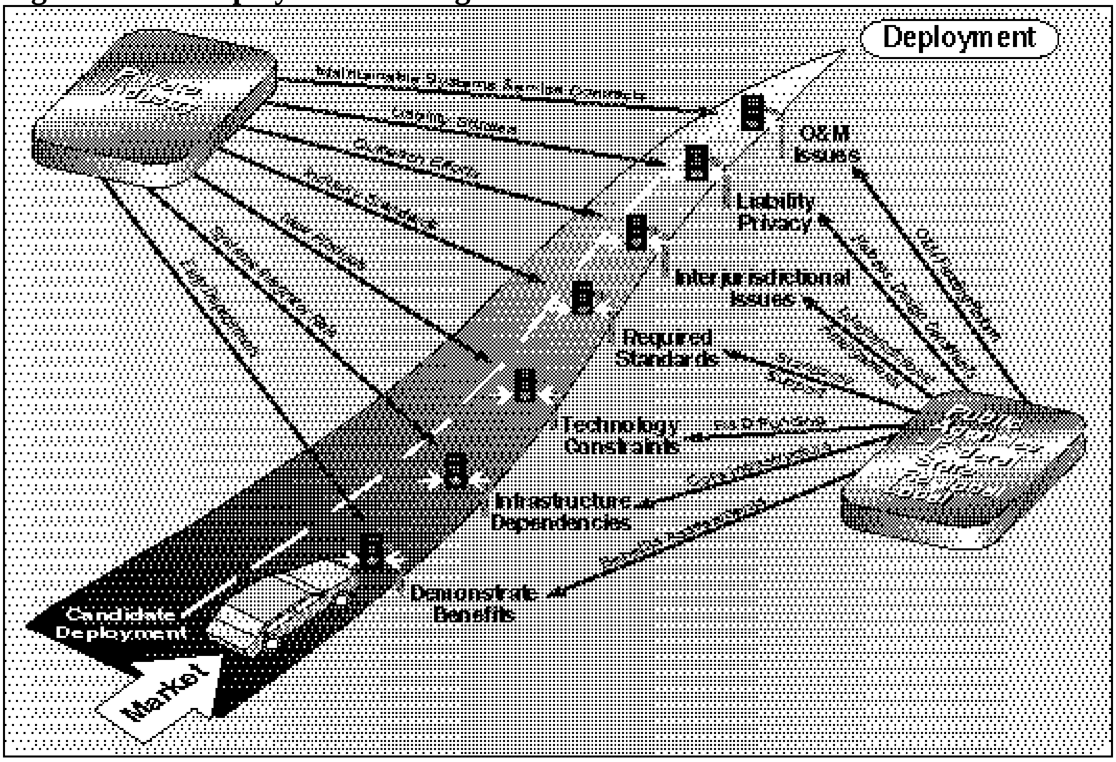
Telematics technologies have moved very quickly into the transport sector among American and European communities. In constrast, transport telematics technologies still finding their way into Autralian market. This paper is conluded with a summary of a number of barriers or challenges to the deployment of transport telematics that have been raised by American (ITS America, 1996) and European communities (ECMT, 1995). They are organisational, legal, financial and technical problems.

The organisational issue is arising from the need for partnership between service and infrastructure operators, operators of telecommunications and radio networks, managers of public transport, vehicle and telecommunications system manufacturers and the many public authorities which have access to most of the data needed to operate transport telematics applications (e.g. driver information/route guidance systems); these actors are not used to working together and are drawn from both public and private sectors. The legal issue relates to the use of in-vehicle electronic equipment such as display screens, particularly with regards to road safety; personal privacy, which might be infringed if drivers were to be identified; public safety; broadcasting of information by radio; compliance with the rules of competition and public procurement contracts; access to information concerning users and rules for interchange between managers; and liability and the roles of various actors.

Financial issues cover the pricing of services to drivers; the sale of traffic data between public and private operators and, more generally, the terms and conditions for the exchange of information; the breakdown of investment and operating costs between the expenditure needed to run the networks and the additional outlay required to provide driver information; and, from a general standpoint, all the financial links between the various public and private parties concerned. Finally, technical considerations relate to standardisation of system functions, procedures and technical equipment; standardised procedures for the exchange of road traffic information; uniform standard of quality with regard to services supplied to customers/users, more particularly concerning the presentation of messages; and harmonisation of the information production and updating services whereby it is possible to ascertain and compare the possibilities offered by networks.

As a final note to conclude this paper, due to the current economic climate, the only way to guarantee the achievement of efficient transport telematics system deployment is through public and private sector initiatives (ITS America, 1995). The question is whether Australian transport organisation management, users as vehicle drivers and our existing infrastructures are ready for this new era in telematics technologies.

Figure 4: ITS Deployment Through Public and Private Sector Initiatives



(Source: ITS America, 1996)

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