WORKING PAPER
ITS-WP-98-25

An Overview of Intelligent Transport Systems Research at the Institute of Transport Studies at Monash University

by

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October 1998

ISSN 1440-3501

Established and supported under the Australian Research Council's Key Centre Program.

INSTITUTE OF TRANSPORT STUDIES
The Australian Key Centre in Transport Management

The University of Sydney and Monash University

NUMBER: Working Paper ITS-WP-98-25

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ABSTRACT: The Institute of Transport Studies was established in 1995 as a joint venture between Monash University and the University of Sydney. This paper provides an overview of current research at ITS (Monash) which is concerned with Intelligent Transport Systems. The main areas of research in that field relate to Advanced Traffic Management Systems (ATMS) and Advanced Traveller Information Systems (ATIS). A number of specific projects are reviewed including the prediction of incident induced delays on freeways, improving the delivery of roadside assistance services, travel time prediction for freeways, traveller advisory telephone systems and financing models for ATIS systems.

This paper was presented at a workshop on Intelligent Transport Systems hosted by INRETS in France from 5 to 9 October 1998.

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Introducing ITS (Monash)

There has been an active Transport Group within the Civil Engineering Department at Monash University for nearly 30 years. The group has been one of Australia's leading centres in traffic and transport education and research.

In recognition of its excellence, the Federal Government provided funding to Monash University, together with the University of Sydney, for the establishment of a Commonwealth Key Centre of Teaching and Research in Transport Management. The Centre, which commenced on 1 July 1995, is known as the Institute of Transport Studies (ITS) and has one node at Monash University and the other at the University of Sydney. The Director of ITS is Professor David Hensher, Professor of Management at the University of Sydney. Dr Geoff Rose is the Head of the Institute of Transport Studies at Monash University.

The staff at ITS (Monash) include:

- Professor Bill Young (returning from sabbatical leave at the end of 1998 to take up the position as Head of the Department of Civil Engineering)
- Professor Ken Ogden (Adjunct Professor, currently General Manager, Public Policy with the Royal Automobile Club of Victoria)
- Dr Geoff Rose, Senior Lecturer and Head of ITS (Monash)
- Ms Samantha Taylor, Lecturer
- Mr Peter Daly, Lecturer
- Ms Brenda O'Keefe, Administration Manager
- Mr Andrew Haines, Computer Officer

ITS provides education programs at a range of levels: Masters and Graduate Diploma, PhD programs, continuing education workshops and Certificate programs. In addition, ITS conducts transport related research. The Institute also has an extensive program of related activities including publications, participation at conferences, software development and links to other leading transport research institutes.

This paper has been prepared for presentation at a workshop on Intelligent Transport Systems organised by INRETS in France. The following section provides an overview of the research activities at ITS (Monash) and places the intelligent transport systems research into perspective against other research activities. Later sections provide greater detail on current research projects in the intelligent transport systems field.

The ITS (Monash) Research Program

Research at ITS (Monash) is focused into four program areas:

- Transport Technology
- Travel Behaviour
- Road Safety

- Transport and Traffic Engineering

Appendix A identifies the range of active projects in these program areas.

The research dealing with intelligent transport systems forms part of the transport technology research area. The current research projects relate to advanced traffic management systems (ATMS) and advanced traveller information systems (ATIS) (See Appendix A).

The recent research on ITS began to gather momentum in the mid 1990's with projects dealing with the impact of traffic information on motorist's route choice behaviour in Sydney (Ho, Rose and Mehaffey, 1995), the role of ITS as part of the transportation system for sports and entertainment precincts (Rose, Young and Illion, 1996) and freeway incident detection using artificial neural networks (Rose and Dia, 1995; Dia, 1996; Dia, and Rose, 1997). The latter project developed an artificial neural network (ANN) incident detection model using real data from operational freeways. The ANN model was shown to have superior performance to the algorithms which were being used by the state road authority (Dia, Rose and Snell, 1996). The freeway incident detection work stimulated an interest in motorway operations which resulted in a review of variable speed control systems for motorways (Rose, 1997).

To a large extent the emphasis from that earlier work on motorways is still reflected in the ITS research program but in recent years it is being complemented by new research projects in the ATIS field. The following section provides an overview of a number of the current research projects.

Overview of Current ITS Research Projects

Predicting the duration and traffic impacts of freeway incidents

The field of freeway incident management has gained increased attention in recent years as road authorities have come to appreciate the magnitude of incident induced delays on these facilities. This PhD project, being undertaken by Darryn Paterson, focuses on the prediction of the duration and traffic impacts of freeway incidents. It is specifically targeted at identifying ways of predicting the congestion and delays that result from both planned (eg. maintenance) and random (eg. accidents and breakdowns) events on freeways. The model is intended to assist in incident management as well as in the provision of more comprehensive information to road users regarding the magnitude and anticipated duration of delays.

Two surveys have been conducted as part of the model development effort. The first survey collected weekday traffic data for a "normal" day: that is a day when no incidents occurred. The survey was limited to the period between 6:30am and 11am on the M1 freeway in Melbourne, between Warrigal Road and Punt Road on the inbound carriageway. This section of freeway is subject to recurrent traffic congestion during that period. The survey involved collecting travel time data using a timed number plate survey with observers at five points along the link, as well as inductive loop data. The loops are located about every 500 metres along the facility and provide flow, speed and occupancy data every 20 seconds. The second survey collected data on the effects of a planned incident, in the form of a major resealing operation. The survey was conducted on a weekday between the hours of 9am

and 4pm on the M1 freeway between Ferntree Gully Road and Wellington Road in Melbourne. The data collected included travel times, inductive loop data, video recordings, and written observations of the changing conditions and activities in the maintenance section.

Macroscopic traffic flow models are being developed as the first step towards the broader framework required to represent incidents and their effects. One model is based on the cell transmission model (Daganzo, 1994, 1995) and the second on a two-regime model. Both of these models have the necessary characteristics required for the final model of traffic impacts. Both models are being calibrated on the data obtained from the normal traffic conditions, obtained through the first survey, before being tested on the data obtained from the maintenance survey. While constraints were required on the models to adequately replicate the conditions observed in the surveys, both models illustrated that they have the potential to predict traffic flow for both normal conditions and within planned incidents. Both models also illustrated the capability of operation in a real time environment, which will allow realistic estimates of the duration and effects of incidents for the purposes of management and control.

The models are being further tested under "controlled" conditions, reflecting planned incidents, before the next stage of the project which will extend the models to consider random incidents.

Travel Time Prediction on Motorways

Drive Time is a traffic information system for freeways developed by the Victorian State Road Authority (Vic Roads). The Drive Time system provides motorists with an indication of the travel time to various exits along the freeway and a colour-coded indication of the level of congestion in-between exits (Figure 1). Drive Time has been installed on three radial freeways in Melbourne (the South Eastern, West Gate and Eastern Freeways – See Figure 2) and is being progressively extended to other metropolitan freeways.

The Drive Time system has been well received by road users. A study carried out by the Australian Road Research Board found that 90 per cent of motorists on the South Eastern Freeway considered Drive Time useful and that most motorists who altered their route in response to Drive Time information felt they had a faster trip.

The Drive Time system relies on speed data received each 20 seconds from inductive loop detectors located about every 500 metre along the freeway. This speed data is used to estimate the travel time along each segment of the freeway.

Monitoring of the Drive Time system undertaken by VicRoads highlighted that under certain conditions the system produces inaccurate estimates of the travel times for some origin-destination pairs in the network. The purpose of the current research project is to improve the core algorithm used to compute the travel times. In particular, the enhanced algorithm is intended to enable more accurate travel time estimates to be obtained in the pre- and post-peak periods. This amounted to a software improvement to the existing Drive Time system. No changes were required for system hardware nor is any additional data required to operate the enhanced algorithm.

The difficulties with the existing algorithm relate to the inability of the spot speed data provided by the loops to account for the build up or decay of traffic queues due to 'bottlenecks'. The enhanced algorithm uses a deterministic queuing approach to anticipate the build up and decay of queues.

As part of the calibration and validation of the enhanced model travel time data have been collected using a timed numberplate survey. This will enable the performance of the existing and enhanced algorithms to be compared. Initial analysis has focused on plots of observed and estimated travel times by time of day and aggregate error measures are being developed. The travel time surveys have highlighted the inherent variability in actual travel times. The initial results suggest that the improved algorithm is able to provide more reliable predictions of "average" travel times in the peak period.

Figure 1 : Drive Time Roadside Display

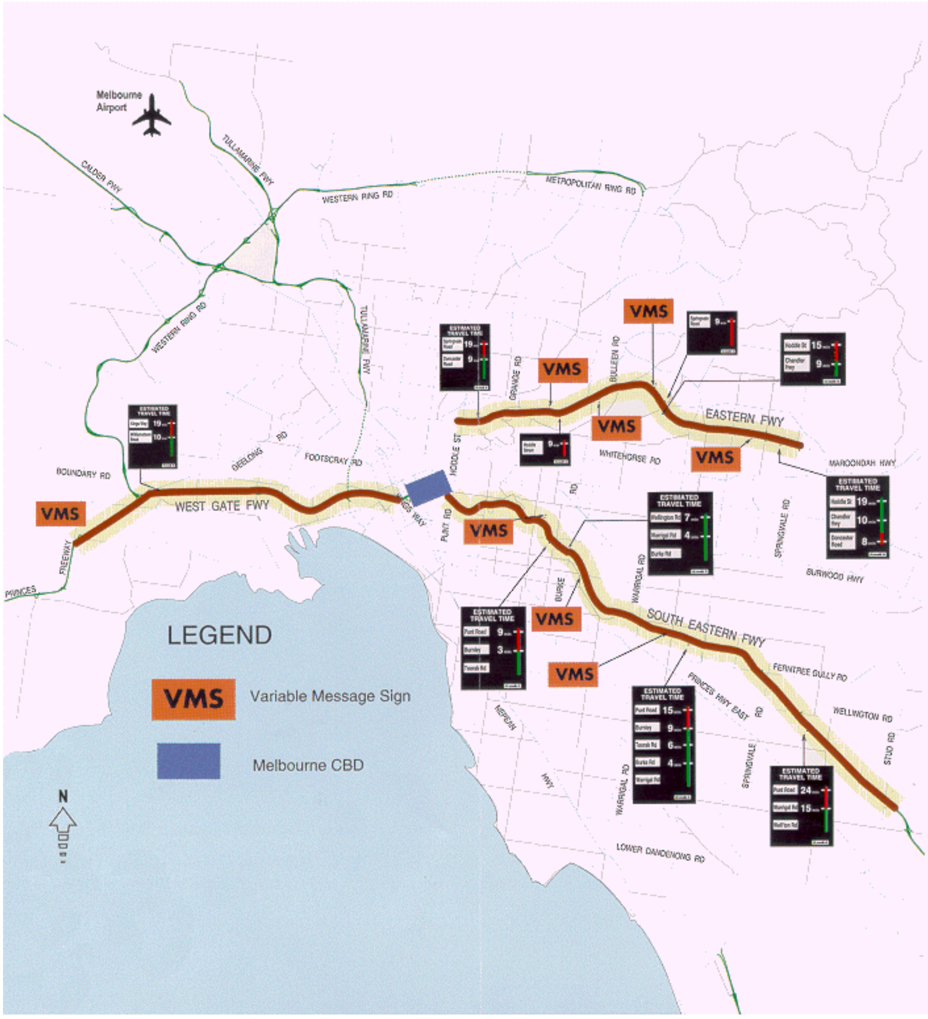

Figure 2: Location of the Drive Time Displays in Melbourne

Patrol Areas and Staffing Levels for Roadside Emergency Service Systems

In most parts of the world, organisations exist to assist motorists when their cars breakdown on the highway. In some cases the assistance offered is to tow the faulty vehicle to the nearest garage; in other cases there is a commitment to get the car started if possible in situ.

Increasingly, emergency services are having to become more efficient in their operations. Funds are becoming more restricted and customer expectations are rising. A great deal of work has been done on various aspects of emergency service operations, especially in cases where the server returns to a depot upon completion of each job, as in the cases of the ambulance and fire brigade. However, the more difficult problem where the server moves directly from one job to another in sequence, as in roadside emergency service systems, has received little attention.

This PhD project is being undertaken by Jim Youngman, a staff member from the Royal Automobile Club of Victoria (RACV). The RACV is the largest motoring membership organisation in the state. Data is being made available from the computer aided dispatch

system which the RACV currently uses for its roadside service units. All service vehicles are GPS equipped and drivers use in-vehicle touch screens to enter and transmit data back to the control centre about the nature of the fault, correction times, vehicle location etc. This system provides a very rich source of data on the demand for roadside service.

The study is concerned with the strategic planning of the roadside emergency service. In particular, there is a need to make decisions about the definition of service areas (beats) and the number of servers to allocate to each service area. The study is developing a model of a mobile server system which aims to minimise the median or mean response time, while keeping the probability of exceeding the critical maximum response time to a small value.

Traveller Advisory Telephone Systems

An important application area within ITS is Advanced Traveller Information Systems (ATIS). These systems can take many forms including radio, internet or telephone-based systems. Of these, there is growing world-wide experience with the telephone-based systems which are also known as Traveller Advisory Telephone Services (TATS). Since TATS rely largely on existing infrastructure for provision of their service to users, they can be considered to be an 'entry-level' ATIS, or at least an initial technology for information dissemination, even if other means of dissemination are to follow or complement the TATS system. The growing world-wide implementation of these systems provides an opportunity to learn from these existing systems in order to improve their operational effectiveness and also as a basis for improving the design of new systems in other cities.

A collaborative study involving ITS (Monash) and ITS(University of California, Berkeley) is exploring a variety of issues relating to operational TATS. This includes reviewing the systems used to collect, process, store and disseminate the information to users. While systems can vary in detail, most operational systems can be regarded as essentially a voice mail system, where messages regarding traffic/transport conditions are pre-recorded into various 'mailboxes'. The user then accesses the information through a menu system. In this context the menu choices relate to the locations or services for which information is required, for example a particular highway.

The research is currently focused on two operational TATS: one from San Francisco in the USA and the other from Melbourne, Australia. The features of the two systems being examined include differences in:

- institutional structure,
- funding arrangements,
- scope (the Melbourne system provides only freeway information while the San Francisco system also provides access to public transport information),
- the nature of data/information provided, and
- usage experience and insight into users' willingness-to-pay.

By comparing and contrasting these two systems it is possible to identify a number of issues which potentially influence the success of operational systems. Particular attention is being paid to the needs of the user and the scope for offering additional features/services to reduce access 'costs' for users and thereby increase usage of these systems.

Financing Models for ATIS

Many developed cities have some form of advanced traveller information system (ATIS). Traveller information can be provided for public transport passengers and road users, both private and commercial. Historically, provision of traveller information has been a government role. Recently, however, many governments have indicated a desire to increase private sector involvement in provision of traveller information, in some cases wanting the private sector to finance the service and provide it on a commercial basis. In some places, the private sector has also been the initiator of independent commercial traveller information systems.

The private sector has been involved to various levels in existing systems, and future plans also rely on private sector input. Systems already operating provide models for various levels of private sector involvement. A workshop held in San Diego, California, late in 1997 focused on operational models for traveller information systems (ITS America, 1997). Orski (1997) categorised the US projects on the basis of the public/private partnership model that had been developed:

- Public Model, where collection, packaging and distribution are all in the public sector example, Montgomery County, Maryland.
- Private Model, where private traffic reporting services feed information directly to radio and TV. These are generally airborne services, or ones with information from cameras, etc, put up by the private companies. Examples are Metro Networks and Shadow Broadcast Services.
- "National Weather Service" Model. In the USA, publicly collected weather information is available to anyone to be packaged and sold to broadcasters, or for specialised aspects of it to be sold to specific market sectors requiring weather forecasts in different forms.
- Franchise Model. This involves franchising traffic information, providing raw data to private firms that have been awarded the franchise rights for a certain region. Revenue would be shared between public and private sectors.
- Outsourcing. Under contract, the private sector runs the traveller information centre for a set fee, under the management of the public agency. Examples are in Long Island and Westchester County, New York.
- Public-Private Partership. This is likely to involve enhancement of publicly collected data with private data collection, packaging of these two sources of information and onsale of it, with a variety of revenue-sharing and access-to-information arrangements. Examples are Orion, Minnesota and Parners in Motion, Washington DC.

This study is being undertaken by Anita Curnow as part of a minor thesis in the Master of Engineering Science degree. The objectives of the study are:

- To identify and group existing models of private sector involvement in provision of traveller information systems,
- To identify the social, political and physical conditions under which each model can be utilised, and
- To explore the opportunities for commercialisation of traveller information.

While the examples quoted earlier illustrate the range of models in use in the USA, additional insight will be provided by this study through consideration of financing models operational elsewhere in the world.

This study will identify existing models of private sector involvement and determine to what extent traveller information can be commercialised. Analysis of the models will be used to gain insight into possibly optimal situations/arrangements for private sector involvement. Some of the dimensions to be explored in this study are:

- *Initiator of ATIS:* who thought of it - government or private sector?
- *Pre-existing conditions*: what base was there already, and what are drivers' expectations?
- *Traffic information sources:* does it come from traffic management data, is it developed specifically for ATIS, or a mixture?
- *Charging policy*: should basic services be free, and must they be provided?
- *Money-making mechanism:* how does the private sector get its money, exactly: by advertising, direct payment for services, a subscriber list, call charging, selling related equipment, on-selling of information?
- *Message content policy:* can private firms direct traffic or just inform drivers?
- *Parameters of target trips:* all trips, driving trips, public transport trips, commuter trips, tourist trips, freight trips, interurban trips, intraurban trips

Concluding Comments

While Monash University has had an active transport group in the Civil Engineering Department for nearly 30 years, the relatively recent formation of the Institute of Transport Studies has provided an opportunity to expand the activities of the group. While ITS (Monash) is active in the teaching area, this paper has focused on research activities in general and research related to ITS in particular. The current research program in that area is focused on ATMS and ATIS.

ITS (Monash) is in the process of upgrading its web site to provide a convenient access point for individuals wishing to learn more about our activities or to contact our staff. Please bookmark our web site at:

http://civil-www.eng.monash.edu.au/centres/its/index.html

and watch for the enhancements we plan to introduce in December 1998.

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Appendix A: Summary of Current Research

Research Program Area	Research Focus	Projects
Transport Technology	• Intelligent Transport Systems (ITS) specifically: - Advanced Traffic Management Systems (ATMS), and - Advanced Traveller Information Systems (ATIS)	ATMS • Predicting Incident Duration and Effects on Motorways • Travel Time Prediciton on Motorways • Variable Speed Control on Motorways • Patrol Areas and Staffing Levels for Roadside Emergency Service Systems • Electronic Tolling Technology ATIS • Financing Models for ATIS Systems • Telephone-based ATIS • Web-based ATIS for University Campuses
Travel Behaviour	• Understanding, forecasting and influencing travel behaviour - Personal travel and freight	Mobility Management • Travel Blending • Car Sharing Travel Analysis & Forecasting • Modelling Demand and Parking Management • Analysis of Activity Chaining Behaviour • Freight Mode Choice Analysis using Stated Preference Methods • Vehicle Emissions Models • Updating Future Year O-D Matrices when using Matrix Updating Methods
Road Safety	• Road Safety Programs • Road Safety Audit • Accident Investigation and Prevention	• Evaluation of Safe Routes to School Implementation • Implementation of Road Safety Audit in Local Government • Monitoring Risk in the Movement of Hazardous Goods by Road in New South Wales
Traffic & Transport Engineering	• Urban level of service • Driver Characteristics • Parking/micro traffic systems, environmental analysis • Bicycle Facilities	• Urban level of service • Level of Service for Local Residents • Study of Vehicle Kinematics, Route Choice and Driver Behaviour using an instrumented vehicle • Bikeway Level of Service • Catering for Bicycles at Intersections • Roundabout Capacity Analysis