THE USE OF INTELLIGENT TRANSPORT SYSTEMS IN SOUTH AUSTRALIA

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Abstract: This paper aims at introducing the general principles and operation procedures of Sydney Coordinated Adaptive Traffic System (SCATS) and its application in Adelaide, South Australia. The Adelaide Coordinated Traffic Signal Systems (ACTS) which is a modified version of SCATS will be used to demonstrate its capabilities. The ACTS system is not only a traffic management device but also an advanced data gathering system responsible for the smooth flow of traffic through 560 sets of coordinated traffic signals in the Adelaide metropolitan area. The system automatically logs alarms and enables the operators to monitor and adjust the signal operation. The information captured by the ACTS can activate an immediate response to daily traffic and provide valuable data for developing new traffic solutions. In addition to the introduction of ACTS, some other developments in traffic control and management will also be discussed.

1. INTRODUCTION

With the growth of driving population in the world, the movement of people and goods particularly in urban areas, often results in the need to develop or impose regulations and control devices to better manage the deteriorated traffic problems. Similar with many other parts of the world, estimates indicate that based on current trend, Adelaide's road traffic could increase by 20% within next 5 years (Strategic Thinking Pty Ltd, 1998) – it would put tremendous pressures on the existing road systems and urban development strategies. To maximum utilise the existing road systems, different control facilities are in use in Australian cities. The traffic control devices for signalised intersections, known as Sydney Coordinated Adaptive Traffic System (SCATS) which is developed in Australia, have been highly regarded as one of the best systems in the world. Due to the reliability and effectiveness of SCATS, it has been widely used in Australia and overseas countries. SCATS monitors traffic flow, detects and adjusts timing during traffic congestion, reports traffic signal faults and coordinates signalised intersections to achieve the best possible traffic flow. Considering the fundamental concept and operating procedures, SCATS could be regarded as the first step in developing an Intelligent Transport System (ITS) as it automatically adapts and responds to the demands of changing traffic situations using highly sophisticated computer and communication systems.

To minimise the impacts of traffic congestion and road accidents, solutions are needed to ensure the sustainable accessibility and mobility. ITS, the combination of information, communications and transport technologies, can meet the challenge of tomorrow. It has been widely proven that ITS, when suitably applied, can improve travellers' comfort, increase traffic efficiency and safety, and benefit the environment. ITS provides a real opportunity for road users, policy makers, transport and telecom operators and industry to contribute and improve the traffic condition around us. The use of ITS is to provide accurate, timely and relevant information to guide drivers' choice of route/destination, mode and timing in a quicker and safer way through influencing travel demand.

2. THE DEVELOPMENT OF ITS IN AUSTRALIA

Australia has a long history in using computerised traffic control systems for signalised intersections. The basic version is SCATS - the Sydney Coordinated Adaptive Traffic System. It was first developed and applied in the early 1970s. Due to its effectiveness, SCATS has won a world reputation and been installed in more than 36 cities worldwide and around 10,000 signalised intersections are under SCATS control (TransCore, 1997).

SCATS system receives information on vehicle arrival and departure through magnetic road detector loops from each approach. The key performance of SCATS is its ability to adapt the demand by optimising the signal timings (cycle, green and red) and phase sequences. SCATS system adjusts traffic signal timing in real-time in response to variations in traffic patterns. In Sydney, the system has also been extended to provide travel time information for taxis. A component of the SCATS system is called Automatic Network Travel Time System (ANTTS). Several thousand taxis in Sydney are fitted with an ANTTS tag, which communicates with interrogators at about 200 intersections. The function of ANTTS is to identify vehicles with tags and communicate with the vehicles. It makes it possible for SCATS to compute travel times and make measures on the performance of a particular part of the network. Along with the development in Sydney, a similar system is proposed in Adelaide, South Australia. In addition to the ability of ANTTS in Sydney, the Adelaide ANTTS would be able to pass information to the Adelaide Traffic Control System (George Giannakodakis, 1998).

Automatic Network Travel Time System (**ANTTS**) is an electronic tagging and tracking system, which can be used, amongst other things, to monitor metropolitan traffic flow in real time by measuring the travel speed of tagged vehicles. Attempts can then be made to alleviate traffic congestion by adjusting signal phasing.

Over 400 buses in Brisbane have been fitted with transponders and more than 50% of Brisbane road networks have been covered with sensors which can provide real time bus data such as estimated time of arrival at the various bus stops.

A centrally located computer analysis data collected by sensors placed at strategic locations on all urban arterial routes. The sensors detect the presence to tagged vehicles at a specific location at a given point in time which is recorded to the nearest second and used to calculate vehicle speed over a known distance, ie. the distance to the next sensor. The existing traffic control system communication network is used to transfer the data.

"Tags" are transponders, which transfer data to traffic control system in real time either by propagated radio wave or inductive detector loop technology. Sensors may be loops placed in the road surface or transmitters located in the footpath nearby.

One of the interesting aspects of SCATS is that it has prompted the development of other systems in ITS. The traffic network simulation model, TRITRAM (Traveller Information and Traffic Management), has been developed jointly by Commonwealth Scientific

Industrial Reassert Origanisition (CSIRO) Division of Information Technology and Road Traffic Authority (RTA) of New South Wales in a project conducted by the Advanced Computational Systems Cooperative Research Centre (the principle as shown in Figure 1). The model has been designed to communicate with the SCATS (Sydney Coordinated Adaptive Traffic System) in real time, allowing simulation of adaptive traffic control. The system is particularly aimed at urban arterial road networks with signalised intersections. The design of TRITRAM simulator is particularly useful for the simulation of congested urban road systems with adaptive traffic control. It can also simulate fixed time traffic control systems (CSIRO, 1996).

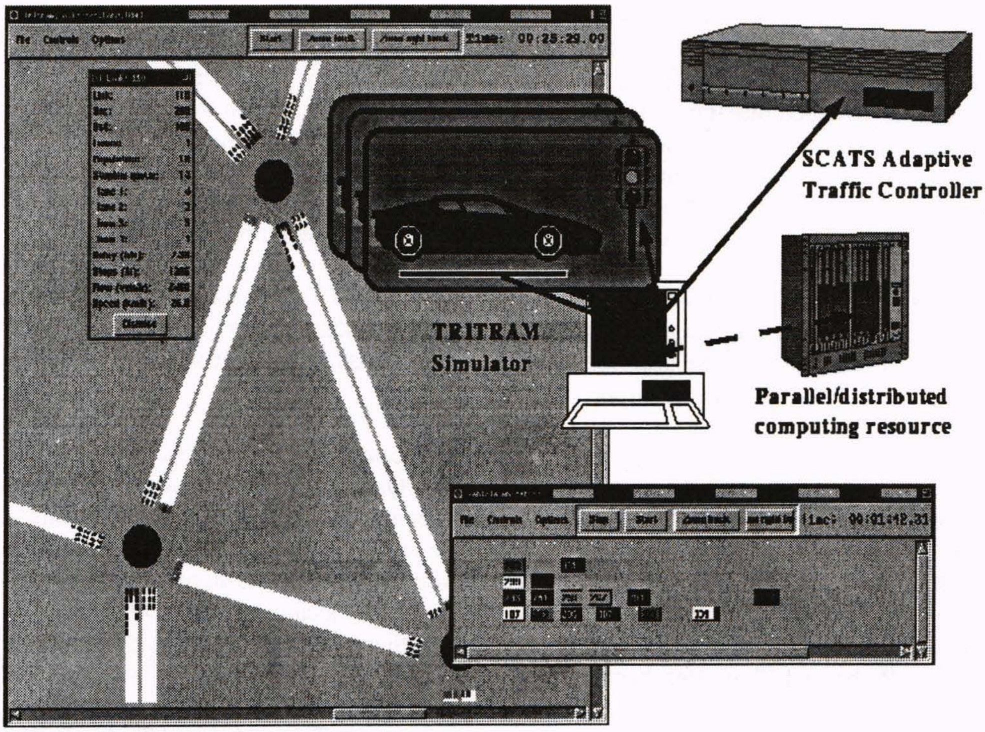

Figure 1-Information Channel of TRITRAM simulator

Roadside signalling systems, where the traffic control infrastructure communicates with motor vehicles, are on the rise throughout the country in parallel with the computerisation of traffic control. Generally, these systems use 900 MHz radio to communicate from a roadside interrogator to a tag equipped with a vehicle. The tag is usually a simple un-powered transponder that returns an identification signal when it is queried. The most common applications of these are systems such as the automatic toll-gate on the Sydney Harbour Bridge is currently trialing by RTA. Other similar systems are planned for the City Link project in Melbourne, the M2, M4 and M5 in Sydney, the Gateway Bridge in Brisbane, and three other tollways in South East Queensland (Richmond, Troy, Hensher and Bray, 1996).

VicRoads' Traffic Control and Communication Centre (TCCC) was established in the 1980s. The centre runs SCATS system to control signalised intersections. Apart from the SCATS, it has numerous other systems for detecting incidents and gathering and disseminating information. One of the imaginative services is that it provides Dial-Up System (DUST) for traffic control with remote areas. DUST is used in rural Victoria for control and monitoring of signalised intersections. Ordinary telephone lines are used to connect the TCCC to about 50 rural signalised intersections. The TCCC has the ability to overwrite the operating parameters of the lights and monitor their status and performance.

Brisbane is the only city in Australia not using SCATS as the primary control device. Queensland state traffic engineers developed the Traffic Responsive Area Control System (TRAC) in 1985. After the first attempt, a second generation called Brisbane's Linked Intersection Signalling System (BLISS) has recently been introduced. BLISS runs on a personal computer and can control 63 traffic lights. Currently, there are more than 500 lights controlled by BLISS units in Brisbane. To extend the application of BLISS, Queensland is developing a locator system for busses, which will interact with BLISS. BLISS may reduce bus travel time - buses may cross green windows through the use of BLISS. The system can be made quite a bit more sophisticated. For instance, it has been suggested that it should include a bus schedule so that if a bus is running late, special arrangements can be made to ensure it still gets priority. This system could also be expanded to include a travel advisory system like the one in Melbourne. (Hensher, 1994).

RTA New South Wales (NSW) and the Sydney University of Technology are developing a bus locator system for Kingsford-Smith Airport. The system locates a bus fleet under consideration, which can be used for computer-aided dispatch, together with arrival times advertised to passengers in the airport complex.

Using radio is not the only way one can communicate between network systems and system users. In the Culway system, developed in Queensland, the mass of a moving vehicle can be measured and informed to a central control system when the vehicle hits a specially designed weighbridge in the middle of the road. It is not necessary for the driver to slow down or take any particular action. Culway system can be used to enforce the maximum loading requirements for heavy trucks in 150 locations around the state. A similar system is in use at Mt White, on the Sydney-Newcastle Motorway, and in Darwin as well (Richmond, Troy, Hensher and Bray, 1996).

Optical systems can also be used. Truck-Scan, developed by Telstra Applied Technologies and CSIRO, is a suite of modules for checking compliance of heavy vehicle operators. Safe-T-Cam is an automated monitoring system based on digital camera technology that takes pictures of heavy vehicles, then locates and deciphers their number plates. This is possible through a series of Safe-T-Cam sites situated on the main transport routes throughout NSW. The system identifies heavy vehicles that are travelling beyond prescribed hours or at excessive average speed. Safe-T-Cam was developed after two serious bus crashes on the Pacific Highway in northern NSW in late 1989. In these accidents, fifty-five people were killed and many injured. After these accidents, the NSW Government called for an independent method to monitor heavy vehicle movements throughout the State to improve safety (especially fatigue control) on the New South Wales road network. Safe-T-Cam system is now being expanded to cover all the main transport routes in NSW and only monitors vehicles with a Gross Vehicle Mass (GVM) over 4.5 tonnes (RTA, 1998).

As drivers are always concerning their travel times from origins to destinations, a system to accomplish this objective is used in Melbourne, Victoria. The travel time system is applied on the inner 15 km of the South East Arterial. It uses Automatic Congestion and Incident Detection Systems to estimate the travel time and inform drivers through a number of electronic display boards along the road. Signs on entrance ramps advise potential motorists about the level of congestions on the freeway using light, medium and heavy (VicRoads, 1998).

The above mentioned system leads naturally to public transport as well. In Melbourne, the Public Transport Corporation has installed a real-time travel information system for passengers using the City's extensive tram system. Each tram has an on-board locator. System then estimates the time it will take the tram to arrive. A display screen is used to advise waiting passengers the time they have to wait. This system also provides emergency communication with tram drivers (VicRoads, 1998).

Public transport operators across Australia are beginning to offer information systems that list all their bus routes, timetables and other information to public transport users. In Brisbane, the system is called TransInfo and uses a map based system developed by ERSIS Ltd. A similar system can also be seen in the near future in Adelaide and Sydney (Hensher, 1994).

Intelligent Transport Systems is an umbrella term referring to the application of informed technology to transport operations in order to reduce operating costs, improve safety and maximise the capacity of existing infrastructure. In freight transport management, the system as discussed would benefit operators and regulators of the freight transport industry. The relevant applications include: automatic vehicle identification; weigh in motion - where loads are weighed without the need for a vehicle to stop; automatic vehicle location; two-way communications between fleet operators and vehicles; cargo tracking and electronic data interchange. These are generic technologies. Within most of them exists a range of specific products and possible approaches. Much of the current research is devoted to refining these and gaining competitive market advantage with a product that is reliable, cost effective and suits customers needs.

3. THE USE OF ITS IN SOUTH AUSTRALIA

Adelaide is the capital city of South Australia, with 1.2 million people situated on the Adelaide plains, a flat, fertile corridor of land between Gulf St Vincent and the arc of the Mount Lofty Ranges. Like many most urbanised cities in the world, Adelaide accommodates about one million of her population and the traffic generated.

Adelaide's road network has many unique characteristics, compared with many other cities in Australia, not the least of which is its well planned location of the CBD (between the hills - east and the coast - west) and the grid-like road network system. From Figure 2 it can be seen that radial routes along NW, NE, SW and SE directions bisect the north-south and east-west grid.

Housing development to cater for the future population growth has and will continue to occur in northerly and southerly areas, while employment growth is predicted to continue to be concentrated along the western corridor and near the CBD. There are also regional employment sinks north and south of the city in the Tea Tree Gully, Elizabeth, Woodville, Marion and Noarlunga areas (Transport SA, 1998).

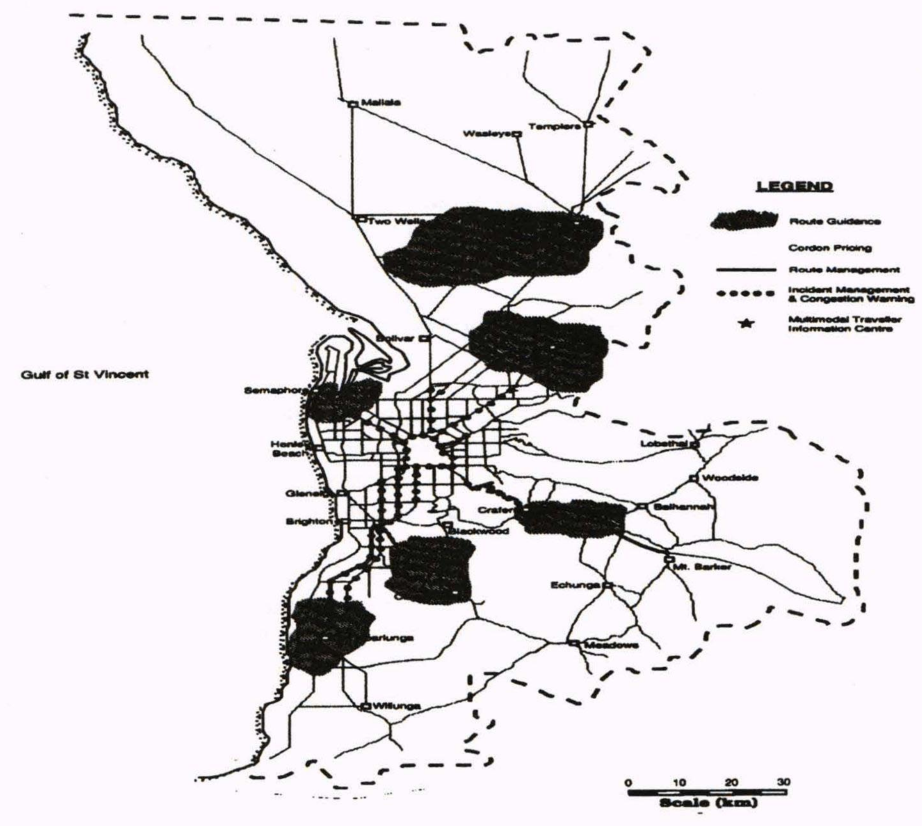

Figure 2 – Adelaide and surrounding road network

Traffic is tidal during the peak periods with growing pressure on the north-south and radial routes to cater for the future traffic growth, as there is no freeway system to cater for this demand. Although there are travel demand management initiatives planned they are unlikely to resolve much of this growth without significant cultural and attitudinal paradigm shifts, some relying on strict policies. Therefore, the city will have to rely on the efficient functioning of the majority of its north-south routes using ITS (George Giannakodakis, 1998).

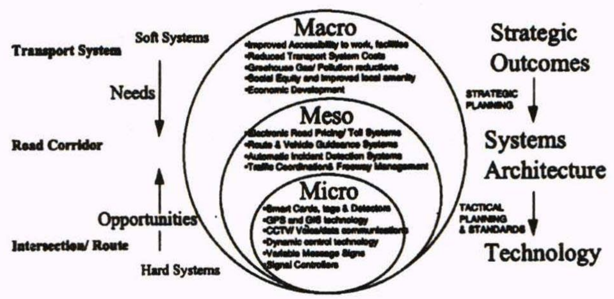

Figure 3 – Relationship between the three levels

In an attempt to establish an ITS general frame for the City of Adelaide, the considerations at micro, meso and macro levels should be also addressed apart from the use of ACTS. This general frame forms the basis for the future ITS development in South Australia. Figure 3 presents a relationship between the three levels.

- The first level (micro) of ITS development for the Adelaide metropolitan road network needs to identify routes/intersections where opportunities exist to apply initiatives that go some way toward meeting broad objectives. Some of these opportunities are often based on areas where physical constraints such as heritage buildings preclude the further widening of roads (eg. radial routes surrounding the inner ring of Adelaide) or where social and environmental impacts are expected. Performance indicators that determine the effectiveness of different systems in outcome terms need to be developed.

- The second level is to identify and evaluate the ITS applications at meso level as well the complementary road development, management and Travel Demand Management (TDM) initiatives that help to achieve the macro level aims. Performance indicators at the macro and meso levels are important in this respect. Hard systems architecture development will be central to this level.

- The third level will be to identify the management system components at the macro level that will be used to comprise these systems. Obviously a variety of options exist and in the end it will be standardisation, reliability, future compatibility with other systems and cost effectiveness that prevails.

All the above stages are of vital importance in forming a successful ITS. It outlines a process from developing initial control elements to forming a communication system and finally reaching an intelligent system.

Based on the general frame mentioned before, ITS development in South Australia is emerging. Transport SA's Traffic Control Centre (TCC), forms the central hub of a comprehensive and advanced data gathering and traffic control systems and manages Adelaide's metropolitan road network operations. There are different levels of control facilities and other elements in developing a basic form of ITS (Transport SA, 1998).

Figure 4 - Transport SA's Traffic Control Centre

Figure 4 shows the traffic control centre. Engineers in the control centre operate and monitor the system. The operators receive information from the Adelaide's Coordinated Traffic System (ACTS). ACTS is a modified version of SCATS with some additional features to suit Adelaide's situation. This enables them to respond to signal faults and monitor traffic through Closed Circuit TV cameras (CCTV) positioned at selected traffic signal sites.

Information available to the TCC includes ACTS, CCTV, and other details such as incidents, accidents and roadworks. The ACTS system is an advanced detection, computer and communication system responsible for the smooth flow of traffic through more than 560 sets of coordinated signalise intersections throughout the metropolitan region.

By coordinating traffic lights to relax congestion and improve traffic flow at network level, ACTS helps to make travelling smoother and quicker for all road users. ACTS is a dynamic system, which continually measures traffic at intersections and adjusts the time available for each movement. This enables immediate responses to peak hour traffic build-up, accidents and other factors that may impede traffic flow.

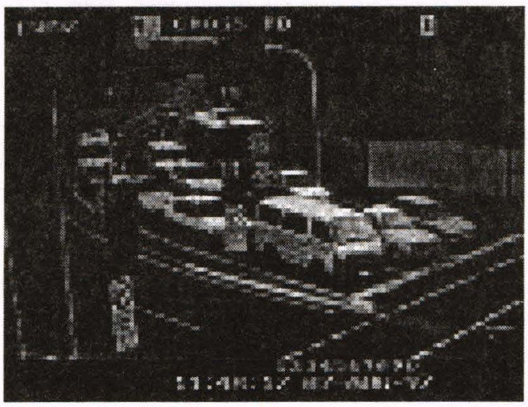

Figure 5 - A CCTV display

Figure 5 shows a CCTV display, In addition to the information from detector loops, reasons for traffic build-up can also be found out by checking CCTV. Operators in the traffic control centre can select the intersection/approach by inputting the identification number to identify potential problems. Through some necessary mechanisms, by using zoom in/out in the centre, details with an intersection/approach can be investigated.

In general, ACTS controls traffic flow at three levels through its detection, communication and computer software:

- Local controllers collect traffic flow information from detectors embedded in the road just behind the white "STOP" line at intersections.

- Regional computers then receive this information and determine when to display the green light and when to switch to amber.

- Central computer located in the Traffic Control Centre links all the regional computers, enabling staff to monitor and adjust the operation of traffic lights in all regions.

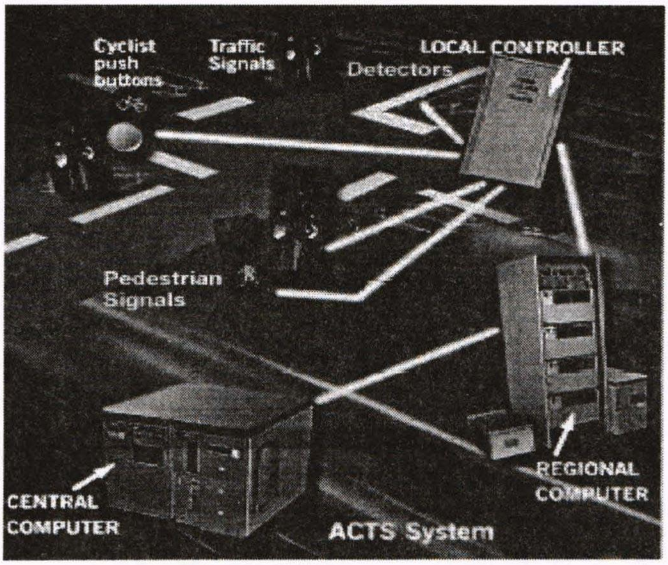

Figure 6 – ACTS system

Figure 6 presents the working relationship between controllers at local, regional and central. Central controller can overwrite the decision made by regional controllers and regional controller can overwrite the decision made by local controllers. However, local controller can work independently once the communication to up levels breaks down. This mechanism makes the system work efficient and reliable.

As ACTS can not only adapt to real traffic demand situation automatically but also can overwrite the system. To respond to demand under some circumstances, operators in the TCC can manually override signals to:

- Help emergency vehicles pass more quickly to their destination.
- Redirect traffic flow near accidents, vehicle breakdown and other incident sites.
- Move people home quicker after major events.

The information captured by ACTS not only activates an immediate response to daily traffic conditions but also provides valuable trend data to guide the planning of enhancements or changes to the existing road environment and for developing new traffic solutions. ACTS has contributed in reducing delay and queuing length, traffic congestion and the level of safety. In reality, studies have shown that compared with systems without ACTS, ACTS has achieved:

- Cut travel time by up to 20%
- Reduce stops by more than 40%.
- Reduce fuel consumption by 12%.

In 1998, the first stage of the Southern Expressway project was completed. It has a 14 km length and took 3 years for the construction (see Figure 7). As the Southern Expressway is a reversible freeway - it opens to traffic heading North in the morning and to the South in the afternoon, it brings a number of problems over traditional traffic control.

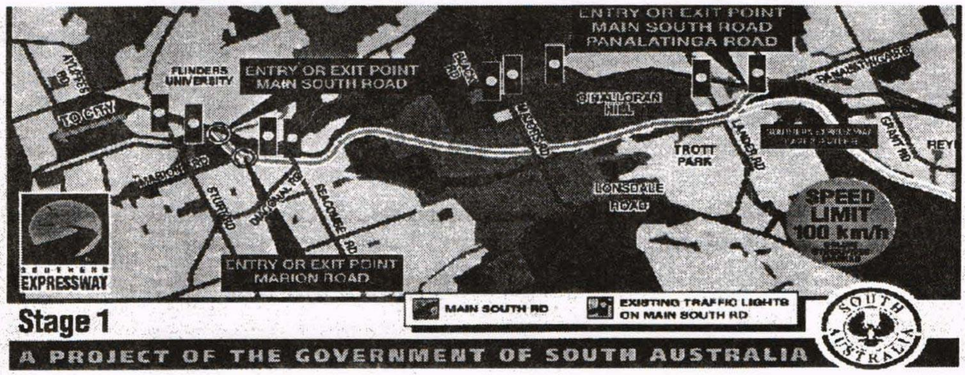

Figure 7 - Overview of the Expressway (left-N, right-S)

To facilitate and manage the traffic movement, ITS plays a major role in the process. The operators in TCC use detection, computer, communication and video technologies to monitor, operate and the flow of traffic on the Southern Expressway. The following features are those used with the system:

- Electronic overhead signs at the approaches at the entry and exit points indicate the way of right as shown in Figure 8.

Figure 8 – Electronic changeable message sign

- Any motorists attempting to travel in the opposite direction to the traffic flow will see red lights every 250m along the side of the road.

- In the event of a hazardous situation, roadside signs every 250m along the Expressway will flash either yellow to advise motorists to slow down, or red to stop..
- CCTV cameras scan the road to monitor traffic movement in case there are any problems or vehicle breakdowns.
- Emergency phones are installed every 500m which directly linked to an operator in the TCC who can call for assistance and arrange for towing if changeover is about to occur.
- Motorists can tune into 88FM radio station to hear messages on the direction and condition of the Expressway.

Although South Australia is at the beginning of applying ITS, ITS has demonstrated a strong potential in managing traffic. In general, ITS can contribute in the follows (Transport SA, 1998):

- To improve transport & infrastructure efficiency
- Improved transport user safety
- Reduce impact of transport on the environment
- Facilitate increased use of public sector transport

CONCLUSION

Through the discussions above, we can conclude that ITS offers a fundamental solution to various issues concerning governments and transport professionals, which include traffic accidents, congestion and environmental pollution. ITS deals with these problems through the use of up to date technologies in detection, communication and computers. ITS can contribute in reducing traffic accidents and congestion while saving energy and protecting the environment. ITS will improve the general efficiency of transport systems.

In the process of developing ITS, SCATS and ACTS as well mentioned other technologies could play an important role as they have been successfully tested and applied for decades. The successful experience in traffic control and management can certainly be passed on to further ITS development. The showcase of the combination of detection, communication and computer software with the Southern Expressway in Adelaide has demonstrated that current practices in traffic control and management will form the basis towards ITS (Richmond, Troy, Hensher and Bray, 1996).

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DECLAREATION

The views/comments of the authors may not reflect the views of the authors' organisation.

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