25th Australasian Transport Research Forum
Incorporating the BTRE Transport Policy Colloquium
Canberra 2-4 October 2002

Deployment of Scats 2 in Melbourne, Australia

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Abstract

SCATS (Sydney Coordinated Adaptive Traffic System) is a dynamic, adaptive area traffic control system that continuously adjusts the traffic signal settings based on measured traffic demand. The system also provides route linking, real time on-line alarm monitoring and remote control of traffic signals. The system was developed in Australia and is operating in some 65 cities in 13 countries around the world.

Benefits claimed for the system are significant reductions in traffic stops and, congestion, and significant increases in traffic efficiency, increased safety, fuel economy and quality of life through fewer casualties and lower exhaust emissions resulting from its use in a city.

VicRoads, the road authority for the state of Victoria, Australia, uses SCATS as one of its primary traffic control systems. Victoria's capital, Melbourne - the second largest city in Australia - has a population of 3.4 million and is spread over an area of approximately 1700 square kilometres. Of the 2800 sets of controlled traffic junctions in Melbourne, 2400 are controlled by SCATS.

The SCATS system has been redeveloped as SCATS 2 which operates on latest computer software and hardware platforms whilst retaining and enhancing all the features and benefits that have made the system a world first in dynamic traffic control.

Rather than a traffic management system centred on advanced traffic management, SCATS2 is a platform which allows integration of a multitude of ITS applications, including advanced state-of-the-art traffic management, public transport priority, incident management systems and the like.

Following is a discussion on the background and issues addressed in the proposed deployment program for SCATS 2 in Melbourne, and the steps involved therein.

The term SCATS 2 will be used throughout this paper to delineate between this development and the current versions of SCATS ("SCATS 1"). Street traffic controller sites have been termed "junctions".

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Introduction

The SCATS system, reputedly the first fully traffic-adaptive system in the world, was developed in the 1970's in Sydney, Australia, and installed throughout Melbourne progressively from 1980.

Melbourne, Australia's second largest city and Victoria's capital, has a population of 3.4 million and is spread over an area of approximately 1700 square kilometres. There are over 2,800 sets of traffic signals in Melbourne, of which 2,400 are on arterial roads and connected to SCATS.

SCATS differed greatly from the more generally used fixed time systems in that traffic management was no longer based upon rigid time of day/day of week patterns. SCATS is able to adjust its traffic control parameters in accordance with the traffic demand as measured in the street via loop vehicle detectors mounted in the road surfaces at each stop line. Its mechanism of adjustment is through variation to **Splits** (Proportion of Red, Green) **Cycles** (Time between successive Greens and **Offsets** (delay between Greens at successive junctions).

Thus instantaneous changes in traffic demand due to incidents could be automatically handled by the system. Such incidents might include motor accidents, major sporting events or an unexpected drastic change in the weather causing hundreds of beach patrons to return home hours before normal expectations.

Co-ordination of junctions is achieved by dividing the network into sub-systems of junctions each containing one which is critical to the traffic flow from the subsystem. Decisions are made on several factors at critical junctions which apply to that sub-system, and subsystems can "marry "(temporarily lock onto) or "divorce"(act independently) according to a number of criteria (similar cycle length, etc). In this way "greenwave" progression can be approached by co-ordinating junctions over sections of an arterial road.

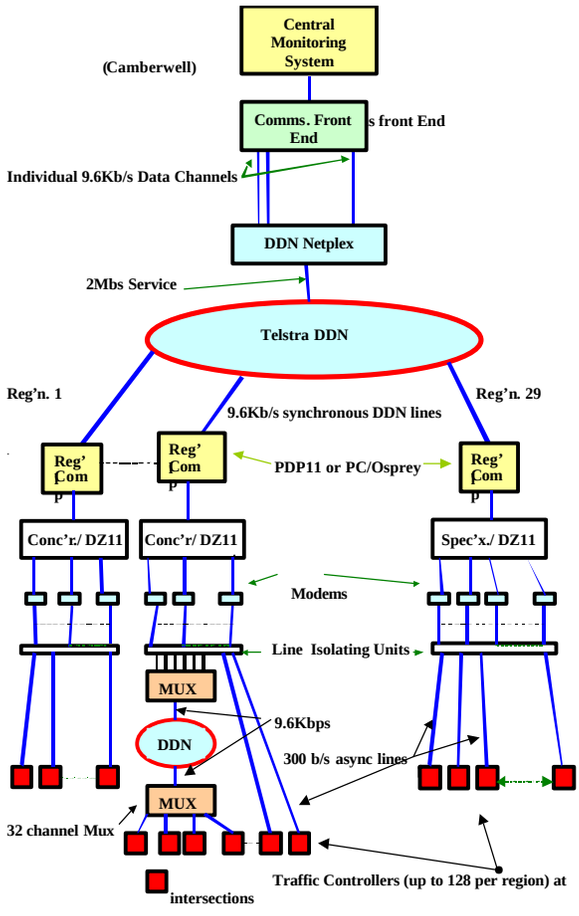
SCATS is continually reading traffic density by means of monitoring the traffic in each lane at the stop line of each junction during the Green period. This is achieved through detector loops at Stop lines. It can therefore detect changes in that traffic density and make appropriate decisions on the optimal mix of splits, cycles and offsets to provide more or less capacity to a particular stream of traffic.

VicRoads adapted the system to Melbourne's unique blend of traffic needs including tram priority and railway level crossing coordination. Throughout the years, updated versions of the software have been released. The version currently in operation in Melbourne is SCATS 5 (Digital Equipment Corporation [DEC] PDP11 and PDP11- emulated (Osprey/PC based) and SCATS 6 (Somewhat traditional SCATS 1 ported to a Windows /PC base, with enhanced facilities).

Early SCATS software development matched that of the DEC PDP11. Though arguably leading the world in traffic management capability, it was not particularly user-friendly, requiring specialised mnemonics keystrokes for operation (mouses were not available when the software development was first completed). It was also restricted in file sizes, requiring trade-offs of control span with complexity of junction, and had little provision for integrating other non-traffic control ITS functions such as Incident detection systems, VMS applications etc.

With the obsolescence of the PDP 11, some of these shortcomings could be addressed with the migration to an industrial grade Personal Computer (PC) platform - as demonstrated with the SCATS 6 release. In particular, the release of the latter removed the restriction on junction complexity versus span of control, and a full 128 junctions could be controlled by a SCATS regional computer irrespective of complexity of control required at any junction. This was achieved with no changes required to the central monitoring computer.

Figure 1: SCATS system configuration



SCATS 2 development

A number of compelling factors fuelled development of a new generation of SCATS. The increasing complexity and internationalisation of features, and an increasing emphasis in Australia and overseas on ITS applications signalled a need for improved means of realisation.

The deteriorating reliability of unsupported DEC computer hardware - some nearly 20 years old - and shortage of software expertise in DEC-based languages presented an opportunity and a desire to take advantage of technological advances in both hardware and off-the-shelf software packages.

The new platform would be Intel PC, with a Microsoft Windows NT operating system, with a range of communications options.

A more intuitive man/machine interface (GUI) would be enabled, as would be the ability to integrate a number of ITS applications such as Public Transport Priority, Sign Control and Ramp Metering, using a stylised, distributed component based platform designated TMIS (Transport Management Integration System). Proven SCATS traffic control philosophies would be retained, while enhancing traffic control with signal group control as opposed to phase control, and with enhanced performance measurement and reporting.

A superior distributed spatial database would be developed to support all attributes of SCATS control, monitoring and all ITS applications.

The new SCATS 2 system would be scalable to handle different city sizes at an affordable price, and would support the existing SCATS 1 traffic controllers in the field.

New generation controllers with orders of magnitude of additional capability would be developed for future applications. These SCATS 2 controllers would enable the full potential of the new SCATS 2 system to be realised in that they would enable a degree of sophistication of control not possible with the current SCATS 1 controllers. The latter- whilst being 3rd generation SCATS controllers, were conceived around some 14 years ago, and based on pre-PC chipsets.

SCATS 2 has been developed to meet these aims through user-friendly Windows style software standard common hardware platforms and state-of-the-art, commercially available off the shelf software packages.

The development team for SCATS 2 has worked out of the New South Wales R&TA offices in Sydney whilst the field testing has been undertaken in Melbourne. This ensures separation between development and field trialing so that the evaluation of each stage can be identified and retain independent integrity.

Development Status

The development is well advanced, a proof-of-concept, small scale “live trial” of the software being undertaken by VicRoads during 2001.

First commercial release (CR1) is scheduled by VicRoads for live street testing in September this year. It will be limited in facilities, but will be interfaced to SCATS1 controllers, will be able to handle the majority of traffic management, traffic operations and traffic engineering management tasks, performance monitoring, etc - but in a SCATS 2 format, using the new GUI. Limited Spatial database facilities will be available.

Deployment Strategy

SCATS is a critical element in Melbourne’s traffic monitoring and control system. As such, a deployment program that is transparent to road users and maintains functionality at all times is essential. System down time and service level reduction will not be acceptable within the strategy.

A strategic deployment plan was considered essential because of the

- Step change of technology
- Co-ordination by stakeholders (Regions, TCCC, traffic engineers, maintenance, operations, systems, project management)
- Significant resources required
- Significant management support required
- Need to embrace new technology with minimum risk to operations
- Modest time frame involved (up to 4 years overall)

Issues to be addressed in SCATS 2 Deployment

There are a number of sub-systems within SCATS that require specific and coordinated deployment plans. These include:

Computer System

The existing SCATS system uses three levels of control for the traffic signal junctions:

Level 1: Local traffic signal controller (2,400 sites)
Level 2: Regional Computer - controlling around 120 traffic signal sites (29 in total, in 20 sites)
Level 3: Central monitoring computer at the Traffic Control Centre (1 site)

Under SCATS 2 deployment, the computers and software at Regional (level 2) and Central Monitoring (level 3) require replacement – certainly if that existing is a PDP 11, running on SCATS 5.

No changes are required to the local traffic signal controller (Level 1) at this time. A more powerful, new generation controller will be introduced at a later time.

Given the number of Regional Computers involved in the Melbourne system and the total cost, a deployment plan staged over several years is proposed. This will also allow for implementation and staff training without effecting other services provided.

Communications System

The communications system used in current SCATS is based on the networks and services that were available in the 1980's. The communications network between level 2 and 3 of the system are dedicated, rigid and expensive by today's standards, comprising 9.6Kbps Digital Data Network (DDN) services. Level 1 communications is Bell103 at 300bps, using voice grade data lines.

SCATS 2 offers a variety of higher speed communications options, Point to Point- and Point to Multi-Point protocols - including radio and Internet Protocol (TCP/IP) addressing functionality for "future-proofing".

One of the key components of the deployment is to upgrade the backbone communications system. In order to achieve full functionality it is necessary to provide a higher speed, higher capacity, more flexible backbone communications system between the regional controllers and the central monitoring system at the Traffic Control & Communication Centre (TCCC).

This is required to enable full data connectivity to traffic engineers and others at a number of widely dispersed Regional offices (as well as at the TCCC) for monitoring of- and modifications to traffic data at specific junctions, and to be able to view on-line real time mimic diagrams of that junction from any point in the network.

After evaluation of several possibilities, a frame relay-based system was chosen, with a minimum speed of 64Kbps. It is "future-proofed" to the extent that data speed can be upgraded simply, should this ever be required in future.

The updating of the overall backbone network will be aggressively and progressively achieved for the whole network within a few months.

Traffic Operating Data

With changes to the communications network and site functionality, the traffic signal data requires restructuring. The conversion of the existing data to meet the new system is a significant task and one that must be completed prior to the traffic signal sites being connected to the new system.

What makes such data re-structuring necessary is the new way of considering a junction, and the effect of offering signal group control as opposed to the

traditional SCATS phase control. (ie., a phase being a unique movement or set of simultaneous parallel movements, (e.g., left hand turns). These “phases” call up individual signal groups (which control banks of red, amber, green and facing a single direction). All like lantern colours in a signal group appear at the same time when a signal group is activated, but 1,2, or more signal groups can be called up simultaneously by phase plans. (e.g. “straight through” group + Right Turn).

The new system will allow a stylised configuration of each junction with increased flexibility of traffic control. Configuration of new sites is expected to be simple. Whilst some computer aids for the process of restructuring in the new format may be expected, there will be a considerable traffic engineering workload in converting existing junctions to the new database.

Further, for legal liability considerations, each upgraded junction will require formal checking in the workshop, acceptance to install, and field checking and field sign-off, even though the junction may have been operating satisfactorily before the change.

Staff Training

As with all new systems, staff training is a key element of successful deployment. The new data structure, software changes and communications networks all need to be well understood by operating staff. A comprehensive training program to ensure that all staff is skilled in the new system, to participate in the deployment program and take advantage of the new system benefits is being developed.
Whilst ongoing training for SCATS 2 is designed for computer based training, initially training of key personnel from the TCCC and the Regional Traffic Engineers for the first implementation will be undertaken by VicRoads staff with the development team in Sydney. This was seen to be more efficient, and appropriate, given the knowledge inherent in the development team.

In Sydney (some 1000Kms from Melbourne), VicRoads’ experienced staff will have more opportunity to not only take a mixture of classroom and on the job training, but will also have access to the designers for specific questions and problems.

This would not be possible to replicate in Melbourne, given the specialisations of the large development team, and the logistics, funding, and impact on development involved in having the same spread of expertise made available interstate for the period of the training.

SCATS 2 Controllers

SCATS 1 traffic controllers have evolved over the years as the SCATS system has evolved.

The SCATS system has inherent fallback as standard, such that if a communications line or regional computer failed, the controller would “fallback” to either an isolated or cableless-linked, “standalone state”, and continue to control traffic according to plans stored in the controller. Should the controller itself not be able to demonstrate intelligence, then automatic switching to a flashing yellow signal is standard as a legally safe state.

However in normal SCATS operation, controllers are controlled cycle by cycle by the regional computer, with override by the local controller, should for any reason the regional computer instruct the controller to undertake an unsafe action. Thus, in conjunction with inputs from the controller, the regional computer decides splits, cycles and offsets and phase start and stop times, generally in accordance with limits designed and recorded by the traffic engineer for the intersection. These are then used to direct the traffic controller at the junction.

Further, a strong desire of SCATS designers was to have a universal configuration regardless of manufacturer, such that all controller housings would be identical in a stylised format, and intelligent control modules from any authorised supplier, would be plug-for-plug compatible with each other – allowing ready maintenance substitution.

This push, combined with the increased intelligence of the new SCATS 2 translates into a new SCATS 2 Controller with a dramatically different capability than those being currently supplied.

This controller is based on a 32 bit CPU (80486 Class), with flash EEPROM program memory, system EEPROM , and both Battery-backed Static RAM and Static/Dynamic RAM.

It boasts 32 Signal Groups (as opposed to the current SCATS 1 Controllers of 16 Signal groups), 64 vehicle /pushbutton inputs, 24 Special Facility inputs and outputs, as well as all the standard SCATS 1 controller features, such as Dual Conflict Monitors, lamp monitoring, etc,

Both Phase and Signal Group control is offered with this controller, as is a variety of communications modes and protocols. Both line and radio connection is catered for.

Up to 4 controllers (Intersection, Lane, Ramp Meter and 2 Counting Stations can be handled via the SCATS 2 Controller, all these being on different TCP/IP addresses, via a common router at the cabinet.

In addition, a number of ITS applications (e.g., Variable Message Signs, Environmental Monitoring Station, etc) can also be controlled via the 4 ITS ports provided.

The increase in complexity and capability of the SCATS 2 controllers is such as to allow the controller in a full SCATS2 implementation to undertake various computations previously retained exclusively by the regional computer.

SCATS 2 Controllers are in final stages of development. They will, at any rate, require Type Approval testing at this stage by VicRoads - customary with all new field equipment type introduced into the network. Type approval requires a combination of thorough visual inspection (for standards, suitability of components, safety, and reliability), workshop testing on system, and on-street testing under live conditions. The process can take several months.

The Deployment Plan has to take into account the necessary steps for introducing the SCATS 2 Controller to the VicRoads network, but widespread adoption is expected to lag introduction of the SCATS 2 computer system by at least one year, partially due to type approval testing delay.

Deployment Plan

In summary, the Deployment plan is as follows:-

- Identify key personnel for initial test programme
- Train with the SCATS2 development team
- Set up a test SCATS region in Camberwell
- Select sample sites for testing on SCATS 2 in the SCATS 2 Test Region
- Test First Commercial Release (CR1) on limited active sites on SCATS 2 Test Region
- Test CR2 on same sites
- Implement SCATS 2 on specific whole, working Region
- Implement on all remaining regions over 3 years
- Test and Type Approve SCATS 2 controllers
- Deploy SCATS 2 controllers around the regions.

Identify Key Staff

As previously mentioned there are a number of principal stakeholders in SCATS 2 deployment, due to the various functional disciplines and the regional nature of VicRoads. These include traffic engineers from the ITS Group and regions, computer staff, network communication staff, operations staff from the TCCC at Camberwell, installation planning and commissioning staff at each region, installation, project management, maintenance staff and contractors.

A group of highly skilled representatives from each of the active functional stakeholders has been selected and is preparing for initial tests of the first commercial Release (CR1).

Training

As indicated in Section 4 above, suitable training is a high priority. A large number of staff from all of these functional departments must be trained in all

facets of the SCATS 2 system in order to understand it, install, apply, operate and maintain it.

Training the required number of staff and contractor personnel involved with testing and deployment is not an insignificant task, given the logistics involved, the difficulty of organising time out to take the training, and coping with shift rosters.

Test Region

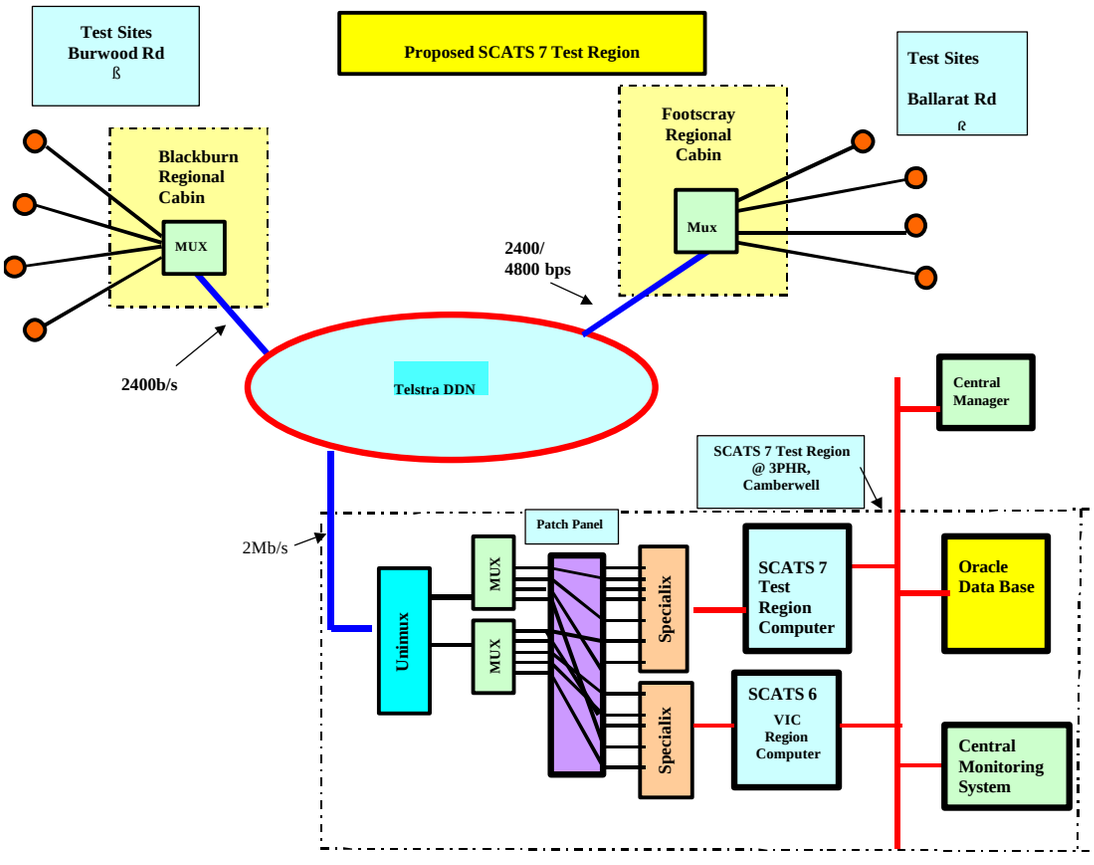
With the agreement of several stakeholders, a Test Region is to be set up at the TCCC to enable SCATS 2 ‘s Commercial Release 1 to be installed and trialled on a selection of typical , currently controlled junctions which are complex, somewhat reflective of the functions VicRoads requires from a viable SCATS 2 system.

The sites will be re-directed from Regional computers previously controlling these sites to the new Test Region site at the TCCC via multiplexers and the Digital Data Network.

At the Test Region, the lines from the multiplexers will be routed through a Patch panel feeding into a SCATS 7 test regional computer. Provision will be made for emergency fallback to a SCATS 6 regional computer at the Test Region in case of any major problem, considering the importance of the junctions to Melbourne’s traffic on these key arterials. Fallback, if necessary, will be effected manually by RJ 45 terminated jumpers in the Patch panel.

The Test Region arrangement is as shown on the following diagram:-

Figure 2 - SCATS 2 Test Region at the TCCC



Testing the First Commercial Release (CR1)

The Key personnel team will be responsible for developing a meaningful test schedule in conjunction with the development team. Agreed objectives, methodology, monitoring and performance measurement methodologies will then be applied to the working system at the SCATS 2 Test Region.

Operators who have been trained on the system will monitor the performance of the test sites along with traffic engineers from the TCCC, and regions involved along with the rest of the network.
The key personnel team will liaise with the Sydney development team as necessary to query any perceived bugs or service problems, before and during the tests. All results and observations will be recorded and copied to the development team. Up to 13 junctions will be involved in the CR1 tests. The system and software will be formally certified by the development team as safe for the purpose prior to commencement of the tests. The duration of CR1 tests could be up to 2-3 months.

Commercial Release 2 (CR2)

Since CR1 is a release which is not a fully provisioned one, it is proposed that the Test Region be retained for testing the full release (CR2). The same intersections will be used as for CR1 for a comparison between the performance of the two release versions.

This should ensure that – with the release of the additional features, none of the desirable performance features found in CR1 have not inadvertently been compromised in the later release. Conversely, it should be a safeguard in ensuring that any less desirable trait recorded from CR1 has been corrected in CR2.

This CR2 test on the Test Region is considered prudent prior to a decision to commence live deployment on a complete working Region. Duration of this series of CR2 tests should be at least 3 months.

The tests would again be conducted against a formal test schedule to be drawn up by the VicRoads team and agreed with the development team, and will form part of the system acceptance.

SCATS 2 - First implementation on a complete Region

Upon successful completion of the CR2 tests above, a management decision will be made on SCATS 2 deployment on a complete region of 128 sites. There is expected to be a considerable flow of queries between the development team and the VicRoads team handling this assignment during the first months of the project. Within 3-6 months of operation, a management decision would be expected on wider deployment.

Type Approval of SCATS 2 Controllers

Around this time it is expected that the SCATS 2 type approval tests will have been completed and type approval granted to a supplier**.**

Widespread deployment to 3 Regions

It is expected in the year following that of the first full region deployment of SCATS 2 that another 3 full regions will be cut over to SCATS 2.

Deployment to Subsequent Regions

The experienced gained from these 4 SCATS 2 region implementations will be documented, and used to gear up resources from both VicRoads staff and contractors to form at least 3 implementation teams.

Since there are 29 regions (at Present) to upgrade, the remainder of the total implementation should be completed within a reasonable time frame, and this is thought to be three years from commencement of these subsequent regions.

The proposed rollout is as follows:-

	2002/3	2003/4	2004/5	2005/6	2006/7	Total
Number of Regions Installed		**3**	**8**	**9**	**9**	**29**

Conclusion

SCATS is a dynamic, adaptive area traffic control system that continuously adjusts the traffic signal settings based on measured traffic demand. The system also provides route linking, real time on-line alarm monitoring and remote modification of traffic signal operation, and its acceptance in many world cities continues to grow.

The SCATS system has been redeveloped as SCATS 2 which operates on latest computer software and hardware platforms whilst retaining and enhancing all the features and benefits that have made the system a world first in dynamic traffic control. Perhaps more importantly, it has been developed as a universal platform for ITS co-ordination of which its advanced traffic management features are merely an important part.

The deployment of SCATS 2 is a critical task for VicRoads involving many complex elements. The deployment plan is critical to the uninterrupted operation of the overall traffic management system in Melbourne, and its world-class ITS initiatives.