

A REVIEW OF SELECTED SOUTH AFRICAN URBAN TRAFFIC CONTROL SYSTEMS

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1. INTRODUCTION

1.1 Background

The urban intersection has been described as the most critical element in the road transportation system. Although this fact is widely recognized, more often than not authorities allow the continued degradation of the quality of service at intersections by utilizing inappropriate and inadequate traffic control.

This inevitably leads to congestion, accidents, delays, wasted fuel, and conflicts between the dual functions of the road system - namely mobility and access to adjoining land. All of these factors contribute to the higher cost of road travel and increased frustration of the motorist.

Under these conditions the authority will soon justify the installation of a traffic signal, which many perceive as the answer to all traffic congestion problems. A traffic signal that is properly justified, designed, installed, operated and maintained can have many positive and real benefits. On the other hand, however, a poorly motivated and designed traffic signal can be particularly inefficient and unsafe. In many cases traffic signals are inappropriately installed due to poor evaluation of prevailing conditions.

Traffic simulation / analysis programs such as TRANSYT [and more recently SIDRA] has been used very effectively to calculate signal timings worldwide for nearly thirty years. As a matter of course, when a traffic signal is installed, the traffic engineer has to provide a detailed description of the signal network as well as comprehensive traffic flow data. With the help of the analytical tool decisions are made on the number of plans required, the best cycle times, offsets and the green splits.

Typically, however, these timings are not revised over a period of years and coupled with any number of minor faults within the controller (such as inaccurate clock) there is inevitably a deterioration of operational levels of service until further remedial measures are put in place. Without this monitoring, evaluation and implementation cycle congestion problems arise, with increased fuel consumption and flared tempers as motorists now wait at inefficiently timed traffic signals. Consequently safety is threatened as increased frustration at poor traffic flow conditions can lead to collisions, despite the traffic signal.

Due to increasing traffic volumes coupled with financial, environmental and other constraints that restrict or limit the expansion of road networks there is an increasing need to make more efficient use of the existing urban transportation system. As a consequence, traffic management has become a widely applied principle of operation but, although the benefits of traffic management have been thoroughly documented, traffic authorities have difficulty obtaining approval to increase or acquire properly skilled staff. As such the area traffic control of signalised road networks is an invaluable tool to facilitate the timeous reporting of signal faults and the frequent reassessment and adjustment of timing parameters to reflect traffic conditions more accurately.

1.2 History of UTC in South Africa

Urban Traffic Control (UTC) systems have evolved extensively over the past 15 years or so. In some parts of the world, monitoring road conditions through CCTV, responding to events by changing variable speed and message signs or even updating motorists via in-vehicle monitors have become just a subset of management functions undertaken in today's UTC systems. Advances in technology offer more, the public expects more, and policy changes mandates more from UTC.

We have certainly come a long way - even in South Africa, so to put matters into perspective let's just reflect on the past for a second.

It is understood that the world's first "traffic" signal was installed in Westminster and was a gas-lit type of signal control at a rail crossing. In 1918 the first motor vehicle traffic signal was installed in New York City, consisting of 3 lights which were manually operated. The first "automatic signal control" was installed in London in 1928.

This technology took a while to reach our shores and it was 1929 before the first South African traffic signal was installed in Johannesburg. Durban's first signal, installed in 1930, was in fact 2 feet shorter and used a Tokheim controller, operating on one set of timings for the whole day. At about the same time (1932) vehicle actuation was implemented in London but these "electromagnetic traffic actuated control pads" were not successful in South Africa. Again, we were nearly 20 years behind before pneumatic vehicle detectors were installed at traffic signals in Durban's Point Road.

Arterial systems providing progression came in to being in the early 1930's. The first systems changes all signal for the major road along the corridor to green simultaneously. This system, known at the time as "synchronized control" reportedly resulted in reckless driving as motorists drove at high speeds to pass as many green signals as possible. This type of synchronized control was soon replaced by either "limited progressive control" or "flexible progressive control" systems, which are similar to today's local co-ordinated control systems.

Various systems were introduced to provide limited linking of adjacent traffic signals but in 1962 Durban installed an STC electro-mechanical operated linked system, controlling approximately 50 signals in the city centre. The STC system provided 6 timing plans selectable by time and day schedule and was considered at the time to be in advance of most systems available internationally. Similar systems were installed in Cape Town during this period.

In the early 1970's South Africa's first computer controlled UTC systems were installed in Durban and Cape Town, by Plessey SA and Siemens, respectively. The cost of the Durban system was R 1,400,000 and controlled 126 traffic signals in the central business district of the city. The Cape Town system controlled 82 traffic signals. Subsequent to this these system have undergone a series of upgrades. Port Elizabeth, Durban, Pretoria, Cape Town, East London and Johannesburg all have modern UTC systems offering some form of adaptive control.

G Schermers and W M Skowronski conducted a survey of traffic signal controllers in 1986. Table 1 compares these results with the number of controllers in use today in selected cities. A subsequent survey of certain Local Councils in South Africa was conducted by the Urban Traffic Control Users Group of South Africa [*a sub-group of the Advanced Traffic Management Systems (ATMS) workgroup of ITS SA*] to determine the status quo regarding traffic signal controllers and UTC. The results of the survey are reflected in Table 1.

Table 1: Traffic Signal Controllers in selected South Africa cities (1986 vs 2000)

CITY	1986		2000		
	No.	Principal Make	No.	Principal Make	UTC
Cape Town	319	Plessey, Siemens, GEC, VA	1100	Tellumat, Siemens, Automotor	678
Durban	375	Messina, Plessey, GEC, STC, VA, Crouse Hinds	580	Automotor, Tellumat	405
Greater Johannesburg	805	Automotor, Crouse Hinds, own controller	1300*	Siemens, Automotor	628
East London	45		80*	Tellumat	67
Port Elizabeth	80	Siemens	125	Siemens	120
Pretoria	265	Siemens, Automotor, Crouse Hinds	500	Tellumat, Automotor	450

**estimated*

Other cities such as Pietermaritzburg and Van der Bjl Park also have UTC linked controllers operating under central control.

It is estimated that there are about 6500 operational traffic signals in South Africa at present. The main suppliers of traffic signal controllers are Tellumat, Siemens and Automotor. Of these signals about 2500 are connected to modern central computer systems supplied by Tellumat and Siemens. The remaining signals are either isolated or co-ordinated via some form of local linking, either wireless or cable linked.

2. CURRENT UTC SYSTEMS IN South Africa

2.1 Remote Monitoring Systems [RMS]

RMS, in a traffic management context, are traffic control systems that connect a roadside controller to a central computer to provided a remote monitoring facility of the traffic signal equipment. The intelligence of the system primarily lies with the roadside controller with the central computer providing auxiliary support.

These RMS primarily offer centralized monitoring of traffic signal operation such as lamp, controllers and detector loop status. In addition, these systems can provide a range of other features such as remote up/down loading of signal plan configuration details, traffic data collection and remote clock setting. Some of these systems can switch plans on the basis of traffic demand. Communication between the central computer and the roadside controller is, amongst other methods, either a dedicated connection via the Public Telephone Network [PTN] or wireless system using radio telemetry. Most of the Southern African systems utilize dedicated PTN connections.

Examples of these systems can be found in Pretoria, East London, Durban, Windhoek and Gaborone.

2.2 UTC Systems

A typical UTC system provides direct control of the signalized intersection from a central computer. The road-side controller holds most of the safety critical functions, like minimum stage lengths and intergreen parameters, while the central computer manages the stage timings, plan changes, and auxiliary monitoring functions.

An UTC system offers additional flexibility, compared to a RMS, in that the instation computer provides immediate and direct control of signal timings. New signal timing plans don't have to be down loaded to the road side controllers but can be developed directly on the central computer and initiated at short notice. This offers significant speed advantages when developing timing plans to deal with special or unplanned events. These systems generally offer full monitoring facilities along with traffic flow enhancing facilities like Traffic Responsive Plan Selection [TRPS], where the system selects sets of signal timing plans on the basis of traffic demand.

Communication with the central computer is almost always wire based due to the quick message turn around required for this kind of system. Reliability of the communications network is particularly important for UTC system. However, modern UTC systems usually have robust fallback plans [driven by the roadside controller] in the event of a loss of communications between the roadside controller and the central computer.

Examples of this type of system can be found in Johannesburg, Port Elizabeth, Durban and the Cape Metropolitan Area.

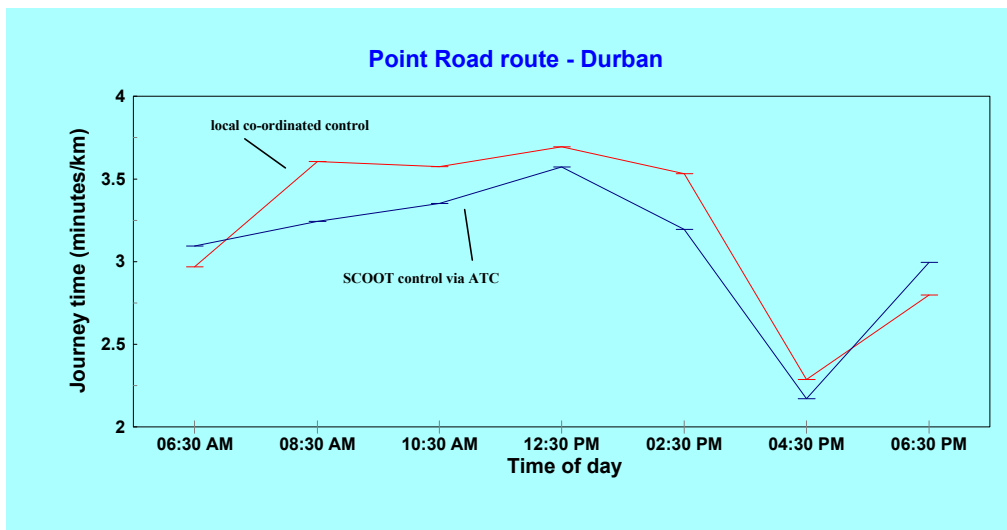
2.3 SCOOT Control

In the 1980's and early 1990's Durban, Port Elizabeth and the Cape Metropolitan Area installed modern adaptive control systems. Of the two [major] commercially available systems, SCATS and SCOOT, all three cities selected SCOOT based systems. SCOOT stands for Split, Cycle, and Offset optimization technique.

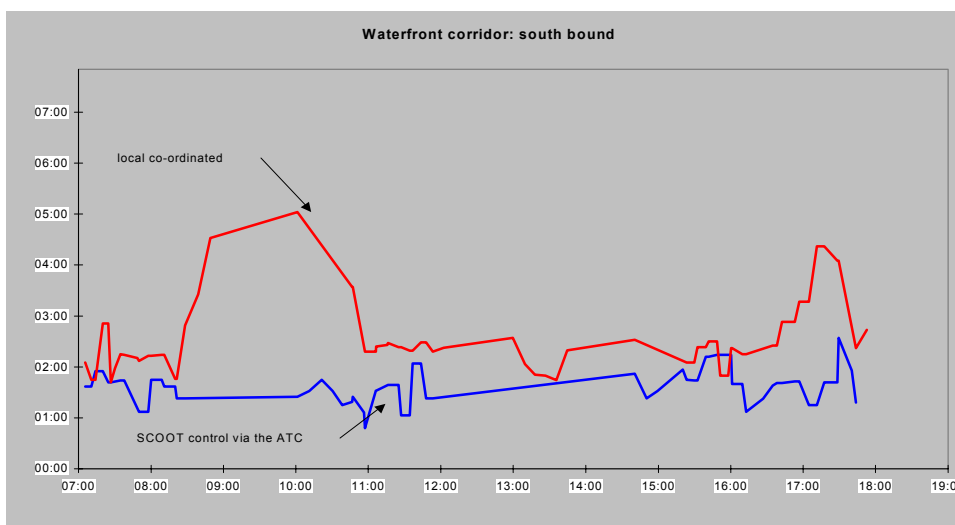
Unlike TRPS based systems where macroscopic timing changes occur according to traffic trends, the SCOOT based systems offer microscopic real time adjustments to signal timing parameters according to actual traffic demands, generally in advance of the traffic platoons arriving at the stop line. This means that timings are adjusted to suit arriving traffic patterns. The SCOOT kernel [or engine] requires an UTC platform to operate. The SCOOT kernel monitors traffic patterns, determines optimal traffic signal timings, and instructs the UTC system to display the optimal timings on the roadside.

The benefits in some spheres of UTC applications have been evaluated. The implementation of an Area Traffic Control System saves motorists in the Cape Metropolitan Area in excess of R3 million per month [implementation at a cost R36 million, and ongoing monthly operating cost of R0,15 million].

The graphs below show a typical evaluation of the performance of the fully adaptive Area Traffic Control system (SCOOT) when compared to an optimized coordinated fixed-time system. The shown in Graph 1 is for the Point Road route in Durban with about 45,000 vehicles per day. These results compare favorably with those shown in Graph 2 for the corridor adjacent to the Cape Town waterfront, which carried about 70,000 vehicles per day through a number of signalized intersections. The graphs compare SCOOT control to optimal coordinated fixed time control for a typical day [12-hour period]. A number of journey time runs were undertaken over a period time for alternatively fixed time and SCOOT control. No significant differences were noted in the length of side road queues between the two modes of operation. The overall saving to motorists in time and operating costs has been estimated to be in the order of R3 million per annum on the Cape Town Waterfront corridor and R 2,5 million in Durban's Point Road.



Graph 1: SCOOT control in Point Road, Durban



Graph 2: SCOOT control in Waterfront area, Cape Town

2.4 Typical System Architecture for a traffic control system

Figure 1 below shows the integration of the various components of a typical UTC system, including the front end processors that provide an open interface with controllers from different manufacturers and the SQL server comprising the Traffic Management Database.

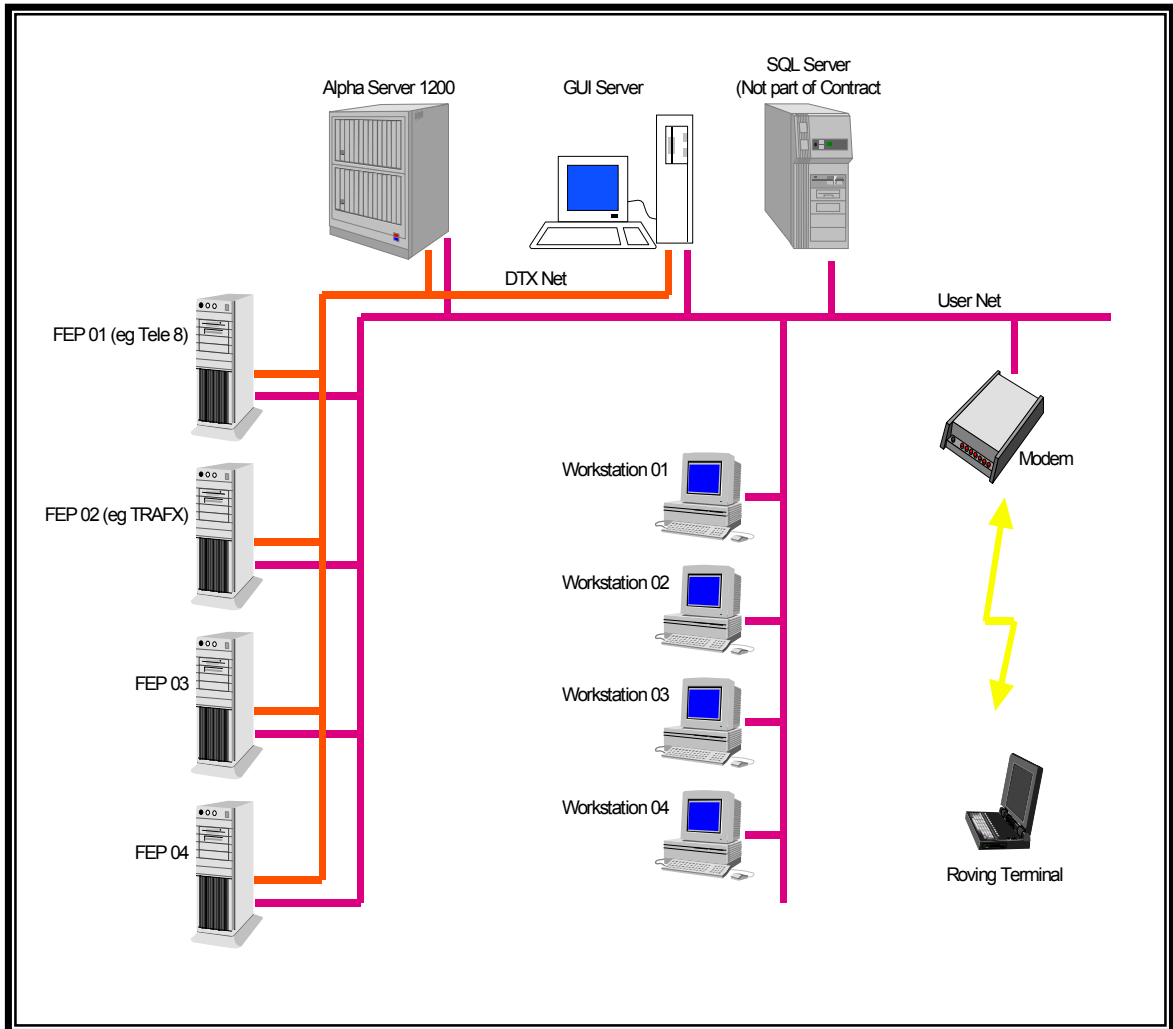


Figure 1: Typical UTC Management System

The AlphaServer provides the processing platform for the SCOOT and UTC systems, while the front-end processors [FEP] provides the communications management. The central computer to road-side controller communication is define according to [generally] proprietary protocols such as the Tellumat Traftx protocol which is carried by the DTX [data transmission] network.

The operator interface is provided by the workstations. These workstations operate on either a local area or wide area [user] network. The remote or roving terminal provides street corner functionality, which is useful during system configuration or for on-site diagnostics.

4. AUXILLARY TRAFFIC MANAGEMENT SYSTEM

4.1 Dynamic Message Signs (DMS)

A trial system will be implemented with the current upgrade to the UTC system software using a free formatted sign incorporated on a proposed "WELCOME TO DURBAN" gantry on the Southern Freeway link to the city. Messages will either be typed by traffic control staff or automatically selected by an incident detection algorithm using induction loops in the road surface and sent from the control centre to selected signs using cell phone technology.

4.2 CCTV Systems

Durban developed a CCTV system that was commissioned 25 years ago, in conjunction with the UTC system, to monitor traffic conditions in the CBD using 40 cameras on a coaxial cable network. This CCTV system was recently upgraded with more reliable equipment incorporating the latest available technology, while at the same time providing additional facilities for night viewing, video recording and shared control for the City Police Department.

There are currently 65 cameras on the system and the area of CCTV influence has been expanded to include the beachfront area with the recent installation of 15 strategically positioned, high resolution colour cameras, suitable for day / night crime surveillance. These have proved to be very effective in assisting the Durban City Police to restore reasonable order to the previously crime ravaged Durban beachfront.

There is a project in progress to make selected pictures of the main freeways available to the public over the Internet. The usual pan-and-tilt cameras are supplemented by an extra two fixed cameras which each send a dedicated view of the traffic conditions to the Traffic Control Centre for relaying a video picture over the Internet. Another project will use the CCTV system to facilitate tourist support points with a push-button, eye level camera and microphone flush mounted on CCTV poles to provide security or assistance from the City Police Control Centre. A person in distress would only have to press the button to be connected to the officer on duty who could then offer directions or dispatch a patrolman to the scene.

Johannesburg initiated a pilot CCTV system in the late 1990s on their southern freeway network at a cost of in excess of R4 million Rands.

5. THE FUTURE OF UTC IN SOUTH AFRICA

A detailed survey was undertaken among selected cities in South Africa to identify future traffic management needs. The results of the survey are shown below in table 2.

<i>UTC Service</i>	<i>Durban</i>	<i>Cape Town</i>	<i>East London</i>	<i>Port Elizabeth</i>	<i>Johannesburg</i>	<i>Pretoria</i>
Dynamic Message Signs	#	❖	⌘	☐	☐	⌘
Internet broadcast	#	❖				
Area Traffic Control	☐	☐		☐	☐	☐
Scoot control	☐	☐	⌘	☐		#
Closed Circuit TV	☐	❖	⌘	#	☐	☐
Remote workstations	☐	☐		☐		
Incident detection	#	#				⌘
Red light violation detect	#	❖	⌘			☐
Ramp metering		⌘				
Automated traffic counting	☐	☐	⌘	⌘		☐
Bus priority	#	#		☐		⌘
Weigh in motion	☐	#	⌘			
Speed monitoring	#	❖				
Integrated database	☐	☐		☐		☐
GIS based database	☐	☐		☐		⌘
Over height detection			⌘			
Public transport trip information						

☐ operational ❖ being deployed # in planning ⌘ considered

The table provides a summary of current trends in urban traffic control in selected cities across South Africa.

6. PROBLEMS

6.1 Technology

Many of the UTC implementation projects to date in this country compare favourably with those found elsewhere in the world - large, highly visible, extremely expensive - a typical profile of an "early adopter" purchase.

As the underlying technology matures users should be looking beyond the fulfilment of their immediate requirements, to systems that can be efficiently operated, maintained and expanded to meet their ever-changing needs. Equipment manufacturers and technology supplies need to adopt a revised approach with the use of off-the-shelf products with flexible customisation tools, incorporating support for open standards. The move from expensive one-of-a-kind, proprietary systems to off-the-shelf components is a familiar path in the world of information technology and the development of UTC technology can benefit from previous examples of this transition, such as with computer aided design (CAD) software.

In the 1960s CAD systems were run on large mainframe computers and big companies spent millions of Rands building and supporting their own proprietary systems. More and more money went into development and maintenance yet the systems could not easily be used in other environments as exchanging of data was difficult or impossible, due to the proliferation of poorly supported proprietary standards. From the 1980s onwards the CAD market has shifted towards the use of standard products run on standard computer platforms, such as AutoCAD. Organisations can today concentrate on their core business and avoid the need to develop complex software systems.

The development of UTC systems seems to be progressing along very similar lines. Many of the first generation of UTC systems in the country are proprietary solutions implemented on a site specific, ad-hoc basis and consist of one-off software systems written for particular clients. The value of this technology cannot be questioned, the systems have proved to be extremely effective in addressing the traffic control issues they were designed to solve. However, these dedicated systems are not flexible enough to meet the constantly changing demands of the transport arena nor to keep pace with the rapid changes in computer technology.

In a nutshell, if you purchase a large, complex, customised UTC product you are less able to benefit from the competitive marketplace - you are effectively tied to a single supplier and reliant on him keeping your system abreast of technology.

6.2 Standards

Buzz words that encourage the adoption of standards in the UTC field abound - interoperability, synergy, integration and co-operation to name a few, but the overriding issue is that it is in the national interest for random, ad-hoc implementation of UTC projects to be abandoned as soon as possible.

There are a number of existing standards that should be supported by any UTC product if it is to work effectively with other systems and be maintainable and replaceable in the future.

- a) The USA communication standard, National transportation Communications for ITS Protocol (NTCIP) ensures that all outstation equipment can communicate effectively with the Traffic Control Centre (instation) using common protocols.
- b) Structured Query Language (SQL) allows access to information held in many different databases. Any UTC system must support this standard to enable it to store data in an open and reusable manner and utilise legacy data.
- c) Transmission Control Protocol / Internet Protocol (TCP/IP) is a communications protocol that allows remote and distributed access between processes running on different types of machines on local networks or over the Internet. An open system based on TCP/IP communication is more easily integrated with other systems and applications and also means that the components of the system can be geographically separated (i.e. remote operator terminals), if required.

- d) A GIS can be a key component of an UTC system, offering a platform for managing spatially referenced information and applying it to all aspects of transportation management. Since most transportation activities and facilities are graphically distributed, most information used by a transportation authority can be referenced by location. As a result, GIS offers the opportunity to establish a corporation-wide information resource that helps integrate all transport operations and share information using location as a common reference to different types of data.
- e) The emerging Open GIS Consortium (OGIS) standard defines a common object model for a GIS and greatly aids the exchange of data between different systems because all compliant systems use a common feature representation.
- f) Support for standard language customisation tools such as C++ and Java enables system integrators to customise and extend systems without having to learn specialist or proprietary languages and without having to “re-invent the wheel”.

However, existing overseas standards will not satisfy all our UTC requirements and it is necessary to develop a national functional architecture which identifies all possible components of ITS specific to South African conditions to ensure their overall compatibility. ITS SA is a national committee that is currently addressing this matter.

7. CONCLUSION

7.1 Looking ahead

While the concept of UTC is not new in South Africa, there is currently no coordinated effort between the various Provincial road authorities and Local Councils. This has unfortunately resulted in numerous ad hoc UTC type projects being implemented with no thought of overall standardization or sharing of resources. A classic example of this is the different VMS systems on the N1 highway operated by Midrand and the M1 highway operated by Johannesburg - essentially on the same road for a huge volume of traffic.

Sophisticated Area Traffic Control systems have been operated in our major cities for well over twenty years. Variable message sign systems have been utilized on freeways in major metropolitan areas and in tunnel control applications for a number of years. Closed circuit traffic surveillance systems are operated extensively in the major metropolitan areas.

The current National Traffic Information System (NaTIS) is one of the only databases of its kind in the world (as most other countries only do this on a regional or provincial basis). It is a real-time, distributed, replicated system which stores and maintains the data required to enforce the Road Traffic Act of South Africa, providing updated real time traffic information ranging from vehicle ownership to outstanding traffic fines and licence fees.

The future of UTC lies in the development of 6 main functional areas:

Traffic control

- traffic signals
- ramp metering
- lane control
- speed control

Traffic information

- real time traffic flows
- origin / destination
- roadway condition
- violation monitoring
- dynamic traffic information

Traveler information

- pre-trip
- on-trip
- on route guidance & navigation

Enforcement

- red light
- speed (point)
- speed (section)
- overload
- static violations
- toll violations

Demand management

- parking
- special events
- metering

Vehicle priority

- public transport
- HOV
- emergency vehicles

7.2 Go for the jugular

The launching of Intelligent Transport Systems (ITS) South Africa in May this year has given a new direction for UTC systems in this country. UTC is represented by the Advanced Traffic Management Systems working group, under the chairmanship of my co-author, Douglas Davey of the Cape Metro Council.

The short-term emphasis will be on the introduction of standards governing the implementation of UTC projects to ensure interoperability on a national level. It is absolutely essential that traffic authorities move away from proprietary, closed systems and that manufacturers of traffic control equipment adopt an open-systems architecture. This will improve future flexibility of UTC by allowing the merging of existing legacy system with new systems and also enhance deployment and operational strategies through national cooperation.

The fact that we are effectively behind in the UTC technology race can also work to our advantage. We have the opportunity to leapfrog old technology as well as to learn from the mistakes of other countries. Much of the technology required for UTC is already available in South Africa and we can now use the experience already gained from UTC deployments the world over, to ensure that money is not wasted on systems that are not ultimately compatible.

The motivating force behind ITS initiatives in South Africa is currently:

- The interest in electronic toll collection and electronic licensing,
- Metrorail's imminent introduction of smart cards for fare payment, and
- National taxi recapitalisation incorporating a number of ITS features.

Opportunities for public / private partnerships have been identified in each of these areas and UTC must ride the wave of publicity that has been created and in particular benefit from the fast tracking of national standards. There is also a dire need for UTC system "success stories" to promote the achievements in this field and improve its priority status with regard to attracting funding for future projects.