e-MOBILITY: SOUTH AFRICAN FREEWAY MANAGEMENT

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ABSTRACT

This paper reviews recent Intelligent Transport Systems (ITS) projects by the eThekwini Transport Authority, providing cost-effective Freeway Management through the implementation of ITS measures such as Ramp Metering and Automatic Incident Detection. ITS can impact on the safety, mobility, efficiency, cost-effectiveness and convenience of transportation systems and can best improve mobility for motorists by either reallocating demand (in space, time, or mode) or by increasing the effective capacity of transportation systems.

Ramp Metering is a method of controlling the traffic flow onto a freeway by signalizing the access ramp, with short traffic signal timings change quickly to allow platoons of several vehicles to merge with freeway traffic. By restricting demand, ramp metering can increase speed (and hence throughput) on the freeway, due to the decreased conflict and interference between merging traffic flows. Likewise, Incident Detection effectively improves capacity on freeways by facilitating a timeous response to accidents or break-downs and, indirectly, through providing real time information which allows motorists the option to deviate from that route.

While similar ITS projects are commonplace in USA, Asia and Europe, these initiatives are both firsts for South Africa and must be viewed in the context of competition for limited available funding with priority social ventures, such as poverty alleviation. Although transportation also contributes to poverty reduction (by enabling the productive activities that create effective economic growth, and by providing poor people with access to economic opportunities and social services) ITS continues to enjoy limited credibility and support, without active Government participation.

This paper also describes future projects involving Public Transport Express Lanes, Traveler Information Systems and Moveable Lane Barriers (implementing demand management to improve effective freeway capacity) which will be integrated with the existing ITS facilities to further complement the Freeway Management initiative.

1. INTRODUCTION

1.1 Possibility vs Probability

1.1.1 The Possibility
As the harsh African sun begins to fade across eThekwini, the afternoon peak traffic is steadily building up. Enoch Mandela checks his PDA to review his travel plan before leaving to catch his flight back home for his last, but most important, meeting of the day. At his bus stop the traveller information sign confirms that the bus should arrive at his stop within 5 minutes, so he should make the airport in plenty of time for his flight.

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As the Traffic Management operator at the Emergency Response Centre settles himself at his PC for the evening shift he notices his monitor is indicating an abnormal build-up of congestion on the feeder arterials to the Southern Freeway, the major route out of town to the airport. Selecting the bus information icon on his screen he can see that a number of buses are becoming delayed on the outskirts of the city. Scanning the freeway CCTV cameras he also notices a large plume of smoke and zooms in to see a burning cargo truck skewed across all four outbound lanes. Two "EVENT" icons have by now appeared on his PC monitor - set by his Metro Police and Fire Department colleagues at the Emergency Response Centre - and the pop-up dialogue boxes associated with the icons indicate that both services are reporting the fire. As a result, the Metro Police have closed the main arterial roads into and out of the city in this area and emergency services have been deployed to the scene. Grouping the two events into an "INCIDENT" and associating this with the traffic congestion indications, the Traffic Management operator forwards this message to the Traffic Control Centre with his preliminary assessment of the situation, for them to consider an appropriate traffic management strategy.

The Traffic Control Centre operator receives this message but has already noticed the Integrated Incident Management system has detected both the stationary truck and the extending queue on the Southern Freeway and automatically displayed warning messages on the Variable Message Signs at the key decision points on that route, to divert traffic to follow the Outer Ring Road out of the city. He acknowledges receipt of the message from his Emergency Response Centre colleague and activates the emergency plan designed to adjust traffic signal timings along that route to cope with the sudden increase in traffic volumes that is likely to result. Realising that the Outer Ring Road will now be subjected to abnormal traffic congestion, due to the diverted traffic, the operator confirms that the Ramp Metering system on the critical on-ramps have in fact automatically detected the increasing freeway traffic and have initiated the ramp signals.

At the Bus Operations Centre the Route Manager for the Northern Region has seen on his Integrated Traffic and Travel Information Display that the Automatic Vehicle Location and Real Time Passenger Information systems are reporting a number of buses approaching the city from the north being delayed. Clicking the on-screen filter for traffic information superimposes the abnormal traffic congestion information onto his display and the "INCIDENT" icon brings up the location of the fire and the diversion routes from where the arterials have been closed. The system now also displays the estimated new bus arrival times at stops along the revised routes, allowing for the current and predicted congestion levels and link-travel times (which have taken into account the major road works to the south of the City) being provided by the Traffic and Travel Information systems as well as the likely revised occupancy of buses based on historical data. The data is also transmitted to the bus and the onboard display ripples down with the revised arrival times at stops on the route.

The Route Manager selects a message to send to the Passenger Information Signs at the affected stops to advise the waiting passengers so Enoch glances up at his bus stop sign on hearing the announcement chime and heaves a despondent sigh at the message. He will miss his flight by 15 minutes but at that moment his mobile phone alerts him to an SMS message advising that a problem has been encountered with his travel plan and alternatives are available. He connects his PDA online, via the wireless network, which confirms that he will miss his connection and also that his flight is delayed by 5 minutes. The system offers an alternative. He could continue to the Rail Station on this bus and catch a mainline train running on schedule which brings him within his travel "optional connection" time zone. The travel time to the airport is 30 minutes which allows just enough time to board his flight - would he like to reserve a seat?

1.1.2 The Probability

Mobility and communication were previously mutually exclusive, making the manual co-ordination of travel and traffic information from multiple data sources both difficult and expensive to deliver, resulting in less than adequate travel information being provided to the traveller. Wireless communication is opening up new horizons in the provision of truly integrated travel information, based on data from hitherto remote and separate sources on the freeway network. As communications systems develop to provide greater data bandwidth, and increase the speed with which mobile transactions can take place, the futuristic integrated incident and travel management scenario described above will become a probability.

Successful projects implemented in USA, Asia and Europe have demonstrated that Intelligent Transport Systems technology has reached a stage where much of this vision can actually become a reality in providing true mobility for all modes of public and private transport.

1.2 Intelligent Transport Systems (ITS) for Africa

Like most major South African cities, eThekwini is experiencing a growth in development, and its associated traffic pressures. With a legacy of past racial segregation of South Africa's population, employment patterns for the larger sector of the community still involve longer journeys to more dispersed jobs. eThekwini has a comparatively well developed road network with the local freeways and arterials coping with most of the peak traffic demand. However, the public transport service is very poor and is the mode of choice only for those who have no alternative means of transport. Car ownership is building rapidly (albeit from a low base), increasing car-based work journeys and car based leisure travel increases with rising prosperity.

eThekwini therefore shares most of the traffic problems of other large cities in the developed world. The road network is close to or over capacity at peak periods. Regeneration and development are changing the traffic patterns. Traffic noise, emissions and severance are significant environmental concerns. Travellers experience congestion and journey times can be unpredictable so they are demanding more from traffic management systems - but municipal financial constraints and the high costs of systems operation / maintenance are a major hurdle to Local Authorities in meeting these expectations.

One of the difficulties implementing ITS projects in South Africa is co-ordinating all the role players involved (different traffic engineering aspects, feasibility study, funding etc) whereas respective National Department of Transports (NDoT) manage this role in most countries with a successful ITS infrastructure. Unfortunately, while our NDoT fully support ITS, they choose not to participate in the management and co-ordination of ITS in South Africa so it is up to the Municipalities to provide for this in their transportation planning and work closely together with other Transport Authorities in implementing ITS projects. The establishment of the eThekwini (Durban) Transport Authority in January 2004 has placed a greater emphasis on evaluating, testing and using reliable and cost-effective technologies to reduce traffic congestion, fuel consumption, emissions, accidents, point-to-point travel time and to improve public transportation systems. Having implemented a few ITS initiatives, by way of pilot projects, the organization is now examining the role public transport can play in the battle against congestion.

The rate of ITS deployment throughout South Africa is not proceeding as fast as expected because the perceived benefits for potential users are not compelling enough to induce the necessary investments in ITS. The Internet may hold the key to accelerating the deployment of ITS by opening revenue streams such as marketing of traveller information services.

1.3 Innovation Improves *e*-Mobility

Roads and vehicles perform the same vital function all over the world - giving unrivalled freedom of movement for people and goods - but human behaviour is the primary factor concerning the dangers associated with this mobility. New road construction is generally no longer possible because of a shortage of road reserve, environmental concerns and, most important, increasing competition for a slice of the ever diminishing financial pie. Metropolitan areas in South Africa are in transition and budget priorities dictate the diversion of funds towards social arenas such as housing, education and health. Consequently transport authorities have to look at innovative methods of improving the efficiency and effectiveness of service delivery in order to compensate for the lack of resources, funding and infrastructure. The resulting effect is that transport infrastructure is having to be developed and maintained with significantly less funds than were previously available, despite significant increases in travel demand. Transport authorities are faced with the need to provide a transportation system that allows safe and efficient movement of people and freight so public transport, traffic safety, traffic management and maintenance of infrastructure are key areas in the development of an effective transport system, aimed at improving mobility for all sectors of the community.

The primary motivation for implementing ITS is the improved mobility and safety that it imparts on a transportation system, particularly preventative safety aimed at reducing the number of potential conflicts with appropriate information and incident management systems. For mobility to be sustainable, transport should be understood as a mechanism to maximise access - not just the movement of vehicular traffic. The reason we move is to gain access to people and goods and activities but this may be better achieved through land use policies that reduce the distances between residences, employment and services. Mixed land use can actually reduce vehicle travel distance.

Such policies will, however, only be truly effective if they are combined with an integrated public transport system and accurate information (on traffic conditions, estimated travel times to destinations and public transportation schedules) is the key to attracting passengers to public transport. ITS is a tool to make that information openly and easily available to any traveller and can also improve travel time reliability through strategically placed variable message signs, warning of freeway traffic incidents. The overall effect of this quest for sustainable mobility is to reduce traffic congestion.

1.4 Congestion

Congestion effects everyone's life in medium or large size urban areas. Travellers have various perceptions of congestion which may vary with the season of the year, day of the week, hour of the day or even depending on the mood of the person at that time. What may appear to be congestion in a rural village would be considered free flow in an urban city. From a driver's point of view, congestion is the operating condition under which travel speeds drop below acceptable levels but a commuter would measure it in terms of travel time reliability.

There are two types of congestion; non-recurring and recurring. Non-recurring congestion happens due to incidents, accidents, weather conditions (rain, snow or too bright sun light) and disruption due to road maintenance or reconstruction. Recurring congestion usually takes place due to large volumes on the road causing a sudden drop in speed. Congestion monitoring is an important task, since reducing recurring congestion does not only improve travel time and delays but it may also result in a lower number of accidents which, in turn, results in reduced nonrecurring congestion. In this regard congestion measurement must account for the extent (area), duration and intensity of the traffic conditions and is related to real-time data on actual speeds rather than subjective expectations or perceptions.

Congestion occurs when traffic demand exceeds the available capacity of the freeway and as such congestion solutions have traditionally been directed at provision of extra road infrastructure (capacity) to accommodate traffic growth forecasts. This approach is however evolving towards demand oriented policies in which the implementation of strategies to manage transport services, mobility and associated factors is considered.

ITS improves safety, mobility, cost-effectiveness, convenience and efficiency of travel by:
1. reallocating DEMAND (via adjustments in routes, departure times, and/or mode) to better match travel demand and transportation system capacity.
2. increasing the "effective" CAPACITY (maximum achievable throughput) of a link, node, or entire transportation network.

It is argued that ITS cannot affect the capacity of a roadway, since capacity is the theoretical maximum throughput, so ITS primarily assists in achieving that maximum but would not increase capacity. However, weather, construction, pavement conditions, incidents and special events all affect the actual effective capacity of transportation networks. The incident management element of ITS improves this performance measure of a transportation system by providing information about, and automatically reacting to the unexpected capacity or demand changes while providing the same information to travellers for consideration in their personal decision making.

Otherwise, ITS will only really increase effective capacity on the open freeway (away from interactions at interchanges) once intelligent cruise control or automated freeway platoons are implemented, to allow shorter vehicle headways. At interchanges, however, it has already been shown that control systems such as ramp metering can increase freeway speed (and hence throughput), due to the decreased conflict and interference between merging traffic flows. Synchronising a network of ramp meters with naturally occurring gaps in freeway traffic could further improve effective capacity. So the impact of ITS on the effective capacity of individual segments and interchanges is one way that overall system effective capacity may be improved.

2. FREEWAY MANAGEMENT

eThekwini's freeway network is often close to capacity in peak traffic periods, but is subject to demands which vary by time of day and in their travel characteristics. Effective control of traffic in these circumstances (operating close to capacity) is exacerbated by comparatively minor incidents, such as a vehicle breaking down at a vulnerable location. One of the side effects of even a very minor traffic incident (such as a slow moving vehicle) is the generation of shockwaves back through the traffic and rubber-necking (distraction on the opposite carriageway) which can result in secondary accidents.

A Freeway Management system must include monitoring and surveillance of freeways, automatic incident detection / verification, provision of real-time information to the

motorists and incident clearing. Accurate and reliable detection of an incident is the key to initiating an appropriate and timely coordinated response from police, fire, towing and other emergency services to attend to the injured and restore normal traffic conditions. Fast and efficient provision of meaningful information (comparative travel times on alternative routes via variable message signs, SMS, radio etc.) to drivers approaching an accident zone will reduce the number of secondary accidents and the traffic congestion in the area.

Traffic information systems increase the driver's comfort and reduce the risk of accidents - if people know the reason for traffic conditions ahead they are then more prepared to wait or change their route. Surveys undertaken on the Ille de France freeway network show that between about 6% of the traffic will divert when congestion is announced on variable message signs and that if 2% of drivers change their route it translates to a 12% reduction in total travel time[1].

2.1 Incident Management

A freeway incident is defined as any event that causes a temporary reduction in roadway capacity (disabled vehicles, crashes, maintenance activities, adverse weather conditions, special events, and debris on the roadway), which may or may not be predictable in terms of time of occurrence, extent or location. For example, traffic accidents are unpredictable events but timely medical aid is expected by the public since a minute saved may mean someone's son, daughter, father, or mother's injury may be reduced or life saved.

Incident management is not event-specific and includes:
• detection, verification and monitoring of emergency conditions and status
• processing of data into useful information based on traffic algorithms
• assessment of damage to the transportation system
• stabilization of traffic demand in affected areas
• identification of public safety emergency evacuation routes
• management of unexpected capacity reductions on detours or evacuation routes
• traffic control strategies to support emergency response and evacuation
• development of operational strategies for emergency response
• warning and public information/traveller alerts via subsystems such as VMS

From the above it can be seen that the information necessary to adequately support effective emergency incident response is comprehensive and should also include:
• comprehensive list of responding agencies, and their estimated response times
• geographical incident boundaries
• road surface conditions at and near the incident
• accurate list of incident details and times
• categorization of incident type, severity, location, and estimated impact
• level of estimated impact on traffic operations (lanes closures and detours)
• reports of other current freeway incidents that may impact on the major incident
• projected time of incident clearance
• traffic control methods in place and who is directing operations
• aerial overview of affected area.

The overall goal of incident management is to remove the incident as quickly as possible - the longer an incident continues, the longer the recovery time - and reduce the probability of secondary incidents. Furthermore, the accident victim's chance of survival can be drastically improved through emergency vehicle pre-emption systems, which provide

authorised vehicles temporary right of way through signalised intersections on route to an accident.

The eThekwini Traffic Control Centre is equipped to enhance transportation system performance by co-ordinating technical capabilities and institutional interests to communicate information about travel conditions, adjust traffic control systems and direct response activities. As such these two facilities are particularly well suited to support public safety objectives during emergency situations and provide appropriate management of passenger and freight transportation in the immediate aftermath of a freeway incident.

2.1.1 Automatic Incident Detection

The ability to automatically detect a vehicle's presence significantly reduces the impact of an incident, especially in peak periods, and is critical to the provision of information needed for intelligent transportation systems to manage freeway vehicles effectively. Sensors are an important and integral part of the equation for the gathering of information from the roads and are typically divided into two groups - intrusive and non-intrusive. The intrusive sensors are ones that are buried under the road surface (such as detector loops) and are typically used to gather information on each specific vehicle, whereas non-intrusive sensors are typically overhead (such as CCTV cameras) and are used for the gathering of general information on the flow of the traffic.

Inductive loop detectors are one of the most common sensors in the road, simply comprising a coil of wire in the road and electronics that detect a change in inductance as the metal in a vehicle passes over the loop. In this manner basic data about prevailing traffic conditions, including vehicle presence, occupancy, flow and speed is gathered with minimal invasion of privacy since loop systems can only confirm the presence of a vehicle and cannot identify the actual vehicle detected. Authorities have always used loops as their primary source of data collection, however, alternative technologies have evolved to challenge this situation, using ultrasonic, microwave, infra red and video imaging. This has allowed city and traffic engineers the ability to implement new and radical ideas to achieve more effective methods of automatic incident detection.

Video based systems tend to capture the imagination as having the ability of the human eye to pick out and discriminate fine detail in traffic flow but there is no simple single answer as to whether this technology is better than inductive loop detectors. The avoidance of road works to install video systems is a major advantage, coupled with the low level of maintenance typically required for camera systems (compared to repairing loops damaged by excavation or deterioration in road surface). Also virtual loop positions can be quickly and easily reconfigured to suit any changes in traffic routing arrangements. Vehicle detection is based on real-time digital image processing of the different grey levels of a background image and one which includes a vehicle and associated algorithms ensure automatic detection of such critical events as stopped vehicles, slowing traffic or wrong-way driving. With video systems public privacy can be compromised in terms of the freedom of Information Act but this problem can be avoided through a policy of not maintaining video records.

However, loop technology provides much greater accuracy and does not suffer from vehicle occlusion effects which can occur with any vision system in bumper-to-bumper traffic conditions. The inductive loop and its detection electronics are taking advantage of this exciting technology age and will continue to improve in performance but both inductive loop and video systems will continue to co-exist with certain applications favouring one or the other for technical or cost reasons.

Toll tags have proven effective when using the probe vehicle approach to data collection for the traffic monitoring component of ITS systems, particularly for incident detection and collection of travel time data. Tag readers are placed at regular intervals along the freeway to match the ID on upstream and downstream locations while an incident detection algorithm keeps track of the expected travel time and its standard deviation between readers at all times to identify problems. Journey times along a route can also be determined using automatic number plate recognition (by camera) as a most reliable incident detection measure by comparing journey time with a historical profile to automatically alert operators to abnormal conditions.

The ultimate data collection infrastructure for ITS will need to anonymously and cost-effectively track all vehicles on the roadway, in real time, so that reliable forecasts of travel time, incidents, and collision hazards will be readily available to everyone.

2.2.2 Dissemination of Information

A motorist stuck in traffic is more concerned about what is going on ahead than saving time so he wants information, not data. Advice that there is congestion ahead or viewing real time video images over the web is far more useful than knowing that traffic is flowing at 2,000 vehicles per hour. Likewise non-intrusive vehicle detectors can automatically gather data on traffic volumes, speed and occupancy to determine congestion levels which can be represented as green, yellow and red bands on a map displayed over the Internet. Displaying congestion levels in real-time translates data into useful information for the traveller and is designed to improve the comfort, safety and speed of travel. It is up to the driver to decide on how to use the information and whether to choose an alternate route.

Traffic authorities obtain raw traffic data (generated mainly from freeway traffic loggers and video detection sites), add value by processing it in various ways, then communicate it to travellers through variety of channels and devices - usually road signs, such as variable message signs (VMS), but traffic radio broadcasts, information provided over the mobile phone network, the Internet and in-vehicle systems are also common.

The siting of VMS (ideally placed ahead of intersections) is very important so that any significant change in traffic conditions ahead can initiate a VMS message, effectively directing traffic flow and advising the motorist of the estimated delay. VMS systems can be either automated or manual, however, the former provides a real-time response which will maximize the effectiveness of the signs and add credibility to the information.

A typical scenario in the use of a manually controlled VMS system is where the roadway is monitored by cameras and traffic detectors feeding into a traffic management computer. The VMS sign is directed by a separate computer terminal in the control room and when an incident is detected an alarm is sounded and the system operator will reposition one or more cameras to view the source of the problem and dispatch emergency services, if needed. The operator would then post messages on one or more VMS to advise motorists to avoid affected lanes or to encourage them to use alternate routes. Even though manually controlling the VMS makes effective use of a sign system, it is not the most effective or most cost efficient way of making certain that the signs accurately reflect road conditions.

With the automated VMS systems, when an incident is detected there is still an alarm to alert the control system operators but the traffic management computer will have selected the appropriate signs on its own and, pending operator confirmation if necessary, automatically sends advisory messages to the VMS. Motorists are informed more promptly

and in the meantime, system operators are free to determine the cause of the problem and deal with resolving the situation with few distractions from the VMS system.

An automated VMS control system has two main advantages over a manually operated one. Firstly, the automated system can have a quicker response time measured from detecting an incident until the VMS signs display appropriate information to the motorists. This advantage helps to reduce congestion by giving more drivers a chance to change lanes or divert to alternate routes in the early stages of a developing freeway situation. Secondly, there is no need to dedicate anyone to directing the VMS as the traffic computer generally only needs a human confirmation before proceeding with updating sign messages.

2.2 Ramp Metering

Traffic signal control and freeway ramp metering are the only elements of ITS that truly control the traffic. Ramp metering is a term that describes the way of controlling the traffic flow onto the freeway by signalising the access ramp to maintain a smooth flow the freeway. The idea is simple in principle, but fairly complex in execution. Traffic signals on this slip road change quickly, with five to six seconds red and only two seconds or so of green, releasing single vehicles to merge with freeway traffic. The traffic signal control equipment communicates with vehicle detectors on the freeway and on the approach to the ramp to calculate an appropriate metering rate (signal timing) based on the current traffic conditions and queue lengths. So ramp metering is a dynamic traffic management measure that is dependent on the traffic itself and its operation is linked to actual traffic levels rather than strict time frames.

Consequently, the best parameter for ramp meter control is freeway speed - by manipulating ramp signal timings to keep the freeway speeds above the optimal freeway traffic flow level (see Figure 2 a,b,&c below).

In the mid-1970s ramp metering was introduced in the USA but the first trials of ramp metering in the UK only took place at a single site on the M6 motorway near Birmingham in the late 1980s. Now, in 1995, this eThekwini pilot project sees the introduction of ramp metering to Africa.

2.3 Ethekwini Pilot Project

2.3.1. Incident Management System
In South Africa the use of incident management systems on freeways has not been prevalent to date and any such efforts have been extremely rudimentary at best. The pervasive congestion has led to a less than enthusiastic interest in incident response and the culture is that nothing can be done - so why worry? Viewed in this context the automatic incident detection pilot project on the eThekwini Southern Freeway in March 2005 was a significant milestone, despite being conducted on a limited budget.

Traffic event loggers provided the incident detection via inductive loops across all 4 outbound lanes of the freeway (Figure1 below). This real-time data was relayed to the traffic control centre via dedicated cable link and processed using a simple speed monitoring algorithm. If freeway traffic slows to below 60 kmh (40 mph) an appropriate message is automatically displayed on upstream VMS sign. Traffic speeds of less than 20 kmh (10 mph) will generate a message warning of congestion ahead and suggesting motorists use the alternate route while an alarm will alert the operator on duty to deploy the appropriate response. The VMS is NTCIP (National Transportation Communications

for ITS Protocol) compliant providing an open-system architecture which permits signs and control systems from different vendors to be integrated without having to write new control software or modify existing software.

A CCTV camera will be installed for the remote assessment of incident severity once wireless communication has been implemented in this area, as cable cannot be laid to this rather remote location, so at this stage operators on duty cannot evaluate the type of incident (traffic accident, traffic hazard removal, hazardous spill, broken-down vehicle and so on). Traveller information booths will also be installed at public centres, to provide motorists with information on the freeway conditions.
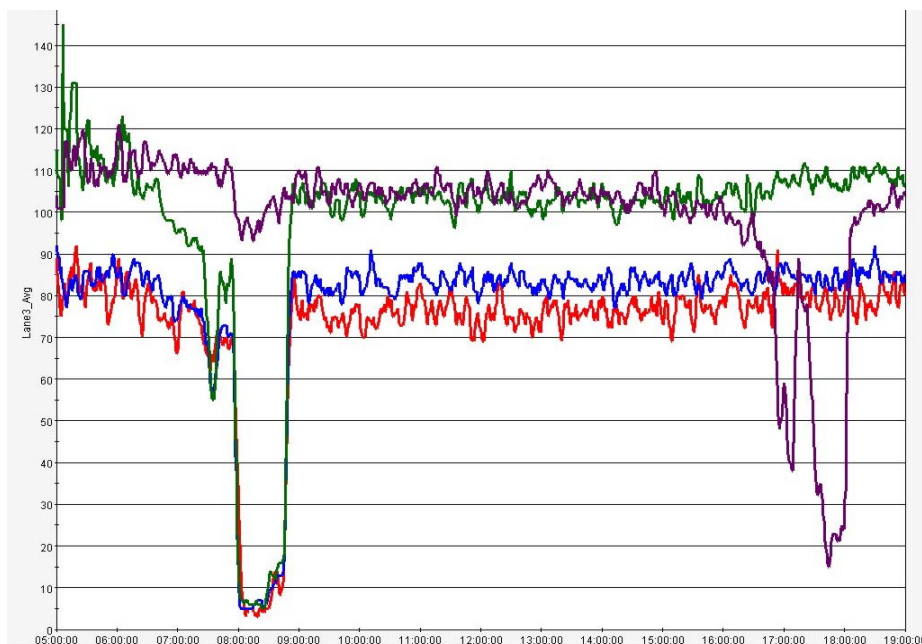

Figure 1. Automatic freeway incident detection.

This graph of Speed vs Time of Day measured by the "on street" traffic event logger, reflects Incidents in both the AM & PM peak traffic periods – shown by the radical drop in the (5minute) average freeway speed, to below 5 & 20 kmh respectively.

2.3.2. Ramp Metering System
In March 2005, ramp metering was implemented on the Blue Lagoon ramp onto the major northbound freeway leading out of the Durban CBD to the northern suburbs (Northern Freeway) in the evening peak period, to regulate the flow of traffic and reduce the heavy congestion currently being experienced there. Traffic signals at the on-ramp release one or two vehicles at a time for smoother merging with the freeway traffic. Permanent, automatic camera enforcement was introduced to encourage compliance, particularly among the errant taxi drivers who currently use this ramp to by-pass the freeway congestion.

- Feasibility Study
  AIMSUN2 (Advanced Interactive Microscopic Simulator for Urban and Non-Urban Networks), a microscopic traffic simulator purposely designed and developed to meet the requirements of ITS systems, was used to model traffic conditions at 2 candidate locations to determine their suitability to ramp metering signal control. The proposed site on the major eastbound freeway into the city was found to be unsuitable for ramp metering as the feeder road has insufficient capacity to accommodate diverted vehicles if queues spill back from the on-ramp and would required the construction of an

additional lane. On the other hand the northbound coastal freeway has sufficient stacking space on the feeder road and was the site chosen for this pilot project.

- Design and Installation
The system uses loops connected to a traffic event logger (TEL) to monitor traffic flows on the freeway as well as the ramp in conjunction with a simple control algorithm running on a central computer to control the pole mounted signals. By measuring the actual freeway speeds the on-ramp volume can be dynamically adjusted through ramp metering to ensure that the freeway (and the ramp metering system as a whole) performs optimally. Initially, it was felt that the use of SCOOT (Split Cycle & Offset Optimisation Technique) would be the ideal tool to achieve this and that integrating the ramp metering into the ATC system would be straightforward. However, it was discovered that SCOOT could not accommodate short cycle lengths of less than 30 seconds, whereas with the ramp metering at this location would require cycle lengths of about 4 seconds. Simulating the SCOOT operation can be however be achieved to some degree through the use of a series of Fixed Time (FT) plans, which can be specifically selected depending on the freeway speeds. An algorithm was therefore developed to link various timing plans to their respective freeway speeds.

The ramp signal rests in red so all vehicles must stop before being serviced. Due to the short length of the on-ramp at this location a 'single vehicle per green' approach was adopted with a minimum green phase of 2 seconds followed by a minimum of 2 seconds red phase. A ramp volume of up to 1000 vehicles/hour could be achieved and this can be further reduced by increasing the red phase (to maintain optimal freeway traffic speeds).

A Red Light Violation Camera (RLVC) has been installed to enforce observance of the ramp signals and is triggered when strategically placed detection loops detect the illegal presence of a vehicle during the red phase. However, given the short green phase, and minimum short red phase, a long vehicle, a slow-moving vehicle or even the stalling of vehicle could easily result in the unnecessary triggering of the RLVC. Simple fixed time plans will not work as the green phase must be extended, where necessary, to accommodate the abovementioned occurrences. The green extension is defines such that the green phase terminates immediately after a vehicle has cleared the loop and the following red phase is held until the second vehicle arrives at the STOP line and the required minimum red phase length is satisfied. The RLVC will therefore catch-in-action only those motorists who have violated the red signal.

- Before Study
Journey times were measured in the afternoon peak (18:00-17:30), averaged over three consecutive days, both on the freeway and on alternative routes in the area. The ramp was closed completely for a peak period to simulate the best possible freeway conditions that could be achieved through ramp metering. The speed/flow curve did not disintegrate at capacity resulting in a minimum speed on the freeway was 60kmh (cf. 30kmh usually) – confirming that the introduction of ramp metering would possible produce positive results. A video recording was made of traffic conditions on the freeway and the ramp in the PM peak period, for an entire week, to compare congestion and the traffic tail back before & after ramp metering. This showed a maximum stationary queue on the freeway of approximately 1 km while the ramp queue varied between 150m and 250m.

After Study In order to quantify the overall effect of ramp metering on the freeway traffic, journey-time surveys were conducted along 2 routes (route 1 onto freeway before ramp, route 2 onto freeway at ramp). Table1 below shows improvement in both overall journey speed and time.

Table 1. Journey / Time study results.

Peak Traffic (16:50–17:15)	Dist (Km)	Speed (Kmh)			Time (Min)		
		before	after	% inc	before	after	% dec
Freeway route 1	6.4	25	36	44%	15	11	27%
Freeway route 2	6.3	20	29	45%	19	13	32%

Freeway speed / flow was measured 50m before the ramp and Figure 2 below shows:
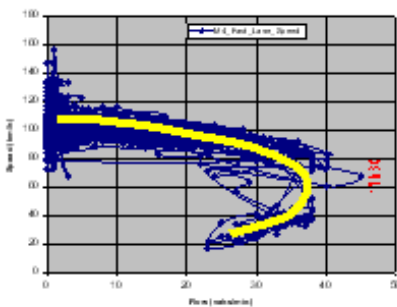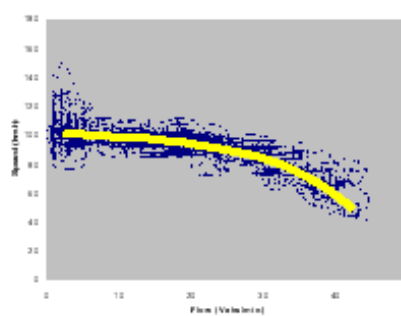

Figure 2a. No Ramp Metering.
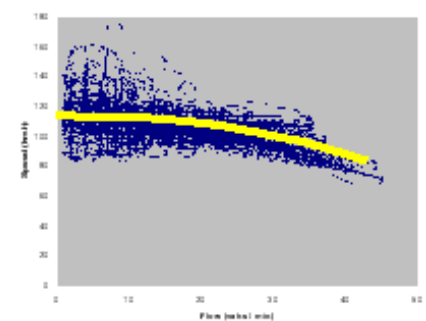
Figure 2b. Ramp Metering.

Figure 2c. Ramp Closed.

Prior to ramp metering the typical speed / flow curve was measured on the freeway (Fig2a) but after implementation, the freeway conditions were prevented from breaking down at capacity (Fig2b). Measurements were taken with the ramp closed completely (Fig2c) to prove whether this "best case scenario" would improve freeway.

3. CONCLUSION

Identifying the costs and benefits of the application of intelligence in transport is something of a challenge as many of the benefits of intelligent transport (increased peace of mind, customer satisfaction and trust in travel as a start) have no clear monetary value and hence are often overlooked in assessments. The only way to predict ITS benefits properly is to use methods that can capture the effects of variations in travel conditions, variations in demand, and the effects of ITS. Traditional traffic management systems have failed to live up to the public's expectations and generally the only elements that enjoy public support are well timed traffic signals, VMS messages (if accurate, timely, and informative) and pro-active incident management. Traffic monitoring and dissemination of information are therefore essential to the perceived success of ITS projects. Effectiveness of the eThekwini Automatic Incident Detection System is not currently measurable but, based on similar systems that have been deployed worldwide, it is predicted to improve traffic management and provide accessible traffic information to the freeway users. The ability to respond quickly to freeway incidents has improved, as the new system facilitates the monitoring of freeway conditions in real time, providing the tool to enable our traffic technical staff to apply their experience more effectively and also liaise more efficiently with other emergency services. Regarding the Ramp Metering project, the free flowing freeway traffic (albeit at 40kmh)was immediate evidence that the system was a success. Before & after journey time surveys confirmed this observation with average freeway speeds in the evening peak increasing by over 40% while travel time was reduced by at

least 25%. As expected there were complaints from some ramp users, as their short cut home had been affected. The success of these freeway management pilot projects in eThekwini will now be translated into larger scale projects as part of the 2010 Soccer World Cup transportation initiative and will include CCTV monitoring as well as the use of radar for incident detection.

4. REFERENCE

[1]   France's National ITS Policy in Focus, Tti, June/July 1998.