ABSTRACT

After the launch of the pilot Freeway Management System (FMS) along the Ben Schoeman Freeway in Gauteng, systems were rolled out in the larger Gauteng Area, the Western Cape and KwaZulu-Natal. There are currently projects in place to expand the current systems which cover nearly 500 kilometres of freeways and which are controlled from three state-of-the-art control centres in Midrand, Cape Town and Pietermaritzburg. Although, the local systems are advanced, many of the management tasks are still being conducted manually, but even so several benefits of the systems can be demonstrated.

This paper explores the benefits of the FMS’s in all three regions in terms of operational improvements in the case of incidents, safety improvements during incidents, response times to incidents, clearance times of incidents and improved coordination amongst all the response services. The systems have been in place for nearly three years and the some of the collected data is presented to show operational trends and improvements.

In the case of major incidents on a freeway which can lead to road closures for prolonged periods of time, the ability to inform the public through various media has significant operational benefits. This paper illustrates the types and availability of the traffic information and the numbers of road users exposed to the information.

1. INTRODUCTION

The South African National Roads Agency Limited (SANRAL) deployed a Freeway Management System (FMS) along its major freeways in three metropolitan regions in Gauteng, KwaZulu-Natal (KZN) and the Western Cape (WC). The FMS has been in operation for nearly three years in all three regions, although the initial pilot project which was rolled out in Gauteng has been operational for more than 5 years. The extent and the associated benefits of the FMS and the enabling Intelligent Transport Systems (ITS) infrastructure are discussed in this paper. The SANRAL is currently in the process of enhancing and extending the system in each of the three regions.

2. BACKGROUND AND OVERVIEW OF THE SYSTEM

The FMS system essentially comprises of a network of CCTV cameras along the freeways that are being monitored by operators for incidents. Once an incident is detected, the information is relayed to the necessary responding agencies and if relevant, to the travelling public by means of Variable Message Signs (VMS) located at strategic locations on the network. The information is also displayed on a website and posted on social media such as Twitter and Facebook. Many radio stations also use the information to include in their traffic bulletins. The FMS Operations are centred at three Traffic Management Centres (TMC’s) located respectively in Midrand in Gauteng, Pietermaritzburg in KZN and Goodwood, Cape Town in the WC. FMS Operators at the three TMC’s work shifts to monitor the freeways 24/7. Incidents can also be called/radioed to the TMC by the emergency and traffic services.
A summary of the three regions is provided in the following table as well as in Figures 1 to 3.

<table>
<thead>
<tr>
<th>Region</th>
<th>Extent</th>
<th>Routes</th>
<th>Cameras</th>
<th>VMS’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauteng</td>
<td>243 km</td>
<td>N1, N3, N4, R21, M1</td>
<td>250</td>
<td>50</td>
</tr>
<tr>
<td>KZN</td>
<td>93 km</td>
<td>N2, N3</td>
<td>118</td>
<td>18</td>
</tr>
<tr>
<td>WC</td>
<td>154 km</td>
<td>N1, N2, N7, R300, M5</td>
<td>221</td>
<td>48</td>
</tr>
</tbody>
</table>

The objective of freeway management is generally three fold:

- Improved freeway operations and user experience by providing users with timeous information of roadway conditions to allow route planning, both pre-trip and en-route.
- Faster response times to incidents to not only improve emergency services response times, but also to reduce the overall traffic impact of the incident.
- Improved incident management and specifically management of the scene through improved coordination on the scene amongst the various role players.
Figure 1: Extent of network covered by Gauteng FMS Operations

Figure 2: Extent of network covered by KZN FMS Operations

Figure 3: Extent of network covered by WC FMS Operations
Apart from the benefits derived from the above, an ensuing benefit of the FMS is the collection of relatively accurate accident information. Not only can the position and the number and types of vehicles involved in the incident be determined, but where the actual accident is captured on camera, the cause of the accident can be construed. In some of the regions another obvious derived benefit is the improved cooperation amongst the different service providers, not only during the management of an incident, but also in the sharing and deployment of resources. This data is being used by the road authorities to identify safety and capacity improvements on the network.

3. DATA COLLECTION

Operators and supervisors based at the three TMC’s are responsible for visual surveillance of the freeways to detect any freeway related incidents. Incidents are defined as anything that could impact on traffic conditions and include accidents, stationary vehicles, congestion, lost loads, strong wind, veld fires, events, rain, etc. Not all incidents are always visually detected and often it is phoned and radioed in by traffic and/or emergency services. The actual split in the detection methods of all types of incidents is illustrated in Figure 4 for the WC region. It is evident that on average, more than 80 percent of the incidents along the WC freeways are detected by the operators employing the live CCTV video feed.

3.1 Types of Incidents

The majority of the incidents that are captured by the FMS operators are stationary vehicles. These include only vehicles that either stop in a lane or on the shoulder for longer than 3 minutes and which have an impact on the traffic flow. It is surprising how many vehicles actually stop along the freeways. For a time, all stationary vehicles were recorded and this resulted in nearly three times more incidents being recorded. In Table 2 is summarised the split in the different types of incidents that have occurred on the WC freeways over nearly three years. Nearly 80 percent of all recorded incidents were either accidents (20 percent) or stationary vehicles (59 percent). Roadworks accounted for the third most number of incidents.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>TOTAL</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Accidents</td>
<td>4 265</td>
<td>20%</td>
</tr>
<tr>
<td>Stationary Vehicles</td>
<td>12 750</td>
<td>59%</td>
</tr>
<tr>
<td>Road Works</td>
<td>1 938</td>
<td>9%</td>
</tr>
</tbody>
</table>

Figure 4: Detection method over time for WC FMS Network
3.2 Type of Data Collected

Detail information for every incident is captured and includes, amongst others the following:

- Date and time of incident
- Cause of incident
- Severity of incident, fatalities, injuries and the number of vehicles involved
- Co-ordinates of incident and the direction of travel
- Lane closures and delays/queues
- Services responding to the scene
- Detection-, Verification-, Notification-, Response- and Clearance times
- Video and still images of the incident and the aftermath is saved for each incident.

Not all the information is always available to the FMS operators. For example, the number of fatalities and/or serious injuries is not always obvious from the video feed. The operators are then required to call the relevant emergency service in an effort to obtain the information. Similarly, the true cause of the accident is seldom obvious, specifically if the full sequence of events is not captured on video. From the historical data, accident rates are calculated and displayed on regional maps to identify sections on the network with significant accident rates in comparison with other sections. Accident rates are expressed as accidents per million vehicle kilometres and evaluated over the full day or any other specific period of the day.

3.3 Relevance and use of data

In line with the objective of FMS, the data collected are used for effective and efficient freeway management and specifically for the following:

- Incident management (response and scene management)
- Information to the driving public using VMS’s (relevance and content)
- Information via Twitter site (relevance and content)
- Reports and debriefing to emergency-, traffic services and road authorities
- Trends in:
  - Types of Incidents
  - Detection Times
  - Response Times
  - Clearance Times
- Accident data analyses, causes and mitigation
- Prosecution of negligent driving
- VMS use and activations.

3.4 Reporting

In all three regions, monthly reports are prepared in which the collected data is summarised for the month, and compared with previous months and other regions. The reports are useful tools to further solidify cooperation, not only amongst road authorities, but also amongst the different emergency and traffic services active on the freeways. The reports are also useful tools to illustrate to politicians and the public how the funds are being used.

4. TRAFFIC INFORMATION

Various media have been established to inform road users about traffic conditions along the freeway network and feeder routes and to assist them with the following:
- Pre-Trip Planning (Website and Twitter)
- En-Route Decisions (VMS’s and Radio)

The information of a specific incident is captured directly into a web-based interface (Advanced Traffic Management System, ATMS) where it is stored and directly posted to a public website (www.i-traffic.co.za). Secondly, when appropriate, VMS’s are activated by the operator. Information about the incident is also Tweeted and in some instances loaded onto Facebook. Most radio stations will follow the website and/or the Twitter feeds and will relay the message to their listeners. As the incident unfolds, continuous updates are posted to the VMS’s, webpage and Twitter feeds.

4.1 i-Traffic website
The i-Traffic site (www.i-traffic.co.za) is a public website on which the live incident information is posted. This is only a recent addition to the system and has been active since October 2012. Live traffic incidents logged by the FMS operators can be viewed on the network maps representing the three regions. An example of an incident posting can be seen in Figure 5.

![Figure 5: Example of an incident on the i-Traffic website](image)

Although, the website only went live in October 2012, there are already more than 10 000 hits per month showing a steady growth in visitors. Refer to Figure 6.
4.2 Variable Message Signs (VMS)

VMS’s are placed strategically upstream of major interchanges to inform motorist and to allow them time for a decision to use an alternative routes. Figure 7 indicates the number of VMS activations per month for the 48 VMS’s in the WC. The initial ramp-up period is evident and so are the high incident periods during winter and the lower number of incidents during the December holiday periods. The number of VMS activations on any of these signs vary between 1 000 and 2 000 per month. In the same figure, the total display times of the VMS messages are also expressed as a percentage of the total available time during a day. This indicates that one or more messages are displayed on one or more signs for a total time of between 12 and 25 percent of a 24-hour day, i.e. between 3 and 6 hours.

Although an economic evaluation of the FMS system is not the purpose of this paper, it is interesting to think about the exposure of the public to these messages and the possible economic impact. The Annual Average Daily Traffic (AADT) volumes on the WC network along which the VMS are places vary from between 50 000 vehicles per day to 120 000 vehicles per day at each of the VMS’s. To determine the exposure of the number of motorist to these messages it cannot just simply be the sum-product of the number of messages per...
VMS with the AADT, since many trips are longer distance and will encounter at least five or more VMS’s. However, based on a conservative estimate at least 500 000 individual vehicle trips pass one or more VMS’s on a typical weekday. Based on the exposure time of a message on one or more VMS’s of between 12 and 25 percent, it is reasonable to assume that at least 15 percent or 75 000 of these vehicles will drive past a VMS with a message displayed. If it is further assumed that for 10 percent of these vehicles, the displayed VMS information have an impact on their route choice, such as accident information and because of this saves 5 minutes of travelling time it can add up to 625 hours of delay saved on a typical weekday. Based on a conservative value of R100 per hour and single occupancies this can amount to R62 500 per day or approximately R20 million per year. The above saving excludes significant times savings in the case of major accidents resulting in the closure of the freeway and safety benefits resulting from motorist being more careful when warned about road conditions ahead.

4.3 Twitter
The three TMC’s operate three different Twitter sites where information about incidents is published regularly throughout the day and for all incidents. Some TMC’s post photographs of the road conditions and of the incident together with the text describing the impact. Twitter followers are in a position to do route and trip planning based on the tweets that they receive on any web based device, most notably mobile phones.

The numbers of FMS Twitter followers have grown rapidly over the past year in all three regions. The WC was the first area to start with the Twitter site and their followers have grown steadily over the past year (See Figure 8). The site was never advertised and the growth is essentially by word of mouth. The other two regions started later with their Twitter sites and since August 2012 they have also been advertising the sites on the VMS’s. A total of approximately 30 000 individuals follow one of the Twitter sites. Many of the Tweets are re-tweeted and are used by sites such as the radio stations. So the information is spread much wider than just the approximately 30 000 followers.

![Figure 8: Growth in the number of Twitter followers per region](image)

4.4 Radio
Radio traffic reports reach a vast number of road users. Most radio stations have a half hourly traffic report, mostly in the peak periods. An informal information sharing agreement exists amongst many of the radio stations, specifically in Gauteng with Radio 702, Highveld Stereo, Kaya FM and Jacaranda FM. The radio stations rely on the Twitter feeds and email communication from the TMC to the radio station. In the WC, Radio 567 Cape Talk transmits the traffic reports directly from the TMC. The benefit of the Cape Town TMC is that it houses
not only freeway management, but also the municipal and provincial traffic services, as well as the traffic signal section of the City. Hence, information is not only available for the freeway traffic conditions, but also for all the other roads and signalised intersections in the City. An estimate of the listener groups in the various regions are summarised in Table 3.

### Table 3: Radio stations and listener estimates

<table>
<thead>
<tr>
<th>Station</th>
<th>Million listeners per week</th>
<th>Language</th>
<th>Gauteng</th>
<th>KZN</th>
<th>WC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ukhozi FM</td>
<td>6.30</td>
<td>isiZulu</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Metro FM</td>
<td>5.55</td>
<td>English</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Umhlobo Wenene</td>
<td>4.76</td>
<td>Xhosa</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Lesedi</td>
<td>3.78</td>
<td>Sesotho</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Thobela</td>
<td>2.98</td>
<td>Sepedi</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Motsweding</td>
<td>2.90</td>
<td>Setswana</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>S FM</td>
<td>2.38</td>
<td>English</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Jacaranda FM</td>
<td>2.00</td>
<td>English/Afrikaans</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>RSG</td>
<td>1.84</td>
<td>Afrikaans</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Munghana Lonene</td>
<td>1.44</td>
<td>Tsonga</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Iwadele FM</td>
<td>1.43</td>
<td>isiNdebele</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>94.7 Highveld Stereo</td>
<td>1.30</td>
<td>English</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Lugwaqwa</td>
<td>1.28</td>
<td>isiSwati</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>KFM</td>
<td>1.16</td>
<td>English</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Phalapha FM</td>
<td>0.84</td>
<td>Venda</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Radio 2000</td>
<td>0.72</td>
<td>English</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Good Hope FM</td>
<td>0.62</td>
<td>English</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>SAFM</td>
<td>0.56</td>
<td>English</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Heart 104.9 FM</td>
<td>0.55</td>
<td>English</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>702</td>
<td>0.54</td>
<td>English</td>
<td>Y</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Lotus FM</td>
<td>0.47</td>
<td>English</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Radio Pulpit</td>
<td>0.12</td>
<td>English</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>567 Cape Talk</td>
<td>0.12</td>
<td>English</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td><strong>Estimated Total Listenership</strong></td>
<td><strong>40.49</strong></td>
<td></td>
<td><strong>26.25</strong></td>
<td><strong>18.6</strong></td>
<td></td>
</tr>
</tbody>
</table>

### 5. IMPACT OF FMS OPERATIONS

As outlined in Section 2, there are several objectives for the roll-out and operation of the FMS. This section of the paper provides feedback on how some these objectives are being achieved.

#### 5.1 Clearance Times

As pointed out previously, the full time line of each event is recorded as accurately as possible and these are reported on monthly basis. These monthly reports are used to illustrated trends and patterns in the data. The average clearance times for accidents in the WC that involve fatalities are illustrated in Figure 9 from October 2010 to December 2012. The challenge with clearing a site with a fatality is all the investigative police work that is required and in most cases a vehicle from the morgue has to come to move the bodies. The number of morgue vehicles in the WC is limited and it is a challenge to get a morgue vehicle to the scene of an accident. The average clearance time is for all accidents, regardless of where they occur. The response time is obviously dependent on where the accidents occur and the proximity of the nearest morgue vehicle to the scene of the accident. It is not uncommon to have incident durations of well of three hours, if there are fatalities involved.

Since the start of the FMS project significant effort went into getting the different role players to work together and to educate the field personnel about the role of the TMC and the fact that it is now possible to clearly see what is going on at the scene of an accident. Representatives of most of the role players are also present in the TMC which greatly assist with the coordination both on the scene and getting the right players to the scene. From the graph of the clearance times, it is evident that since March 2012 there has been a significant reduction in the average clearance times of nearly 2 hours. This is attributed to the improved cooperation between the different players both on the scene and getting the required responders to the scene as soon as possible.
5.2 Capacity: Lane hours lost

The duration of an incident can have a significant impact on traffic flow by temporarily reducing the capacity of the road. This impact can be measured in “lane hours” lost. Lane hours lost is a function of the number of lanes closed or affected by an incident and the length of time the lane or lanes are impacted on as illustrated in Figure 10.

In Table 4 is summarised an estimate of the lane hours lost due to accidents and stationary vehicles in Gauteng, based on the average number of stationary vehicle incidents and accidents per month. The percentages included in the table refers to the proportion of the hour lost per lane in a typical peak period. Based on this illustration, the hourly capacity on all the Gauteng freeways are typically reduced with approximately 9 500 vehicles per hour during the daily peak periods.
The objective of the FMS in all three regions is to reduce the number of lane-hours lost and hence improve the overall capacity of the network.

5.3 Congestion Management

The expansion and upgrade of several freeways in Gauteng was completed within the Gauteng Freeway Improvement Project (GFIP). More than 185 km of Gauteng’s freeways was constructed or upgraded. These improvements resulted in an increase in capacity over most sections of the freeway network. From the TMC an interesting phenomenon was observed on how the peak period in the morning adjusted to the new capacity provided, as illustrated in Figure 11.

![Figure 11: Pre- and post-GFIP capacity and driver behaviour](image)

The objective of the FMS is to maintain the post GFIP capacity and to ensure that as few lane-hours as possible is lost because of incidents and accidents. As part of the future expansion of the system several ITS type improvements will be evaluated to maintain and increase the system capacity, specifically under peak demand periods. These could include, amongst others, measures such as ramp metering and variable speed control.
6. SUMMARY
The FMS’s deployed in three of the major metropolitan regions in the country has been operational for more than two years and is currently being expanded and improved. This paper outlines the extent of the system, the types and relevance of the data that is being collected, how it is distributed to the travelling public and some of the initial successes of the system. Apart from providing direct benefits to the traveling public in terms of timeous information for pre-trip planning and en-route decisions, the system also allows faster detection times of incidents which of course is not only essential for rapid medical response but also allows clearing of incidents faster and reducing the overall impact on the road network. The availability of accurate accident and congestion data allows the operations teams to identify safety and capacity improvements to the network which have direct impacts on the travelling public.