FREEWAY MANAGEMENT SYSTEMS: SUPPORTING CAPACITY IMPROVEMENTS FOR ALL MODES

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ABSTRACT

Commuters on Cape Town freeways experience congestion on a daily basis. The Freeway Management System (FMS) was used to inform various studies, amongst others specific network improvement studies and the Congestion Management Strategy of the City of Cape Town. One of the outcomes of these studies identified a section of Strand Road in Bellville as a top priority. Queues of up to 5 kilometres regularly spilled back onto R300 freeway during the weekday morning peak periods. This not only resulted in significant delays to all road users, but more specially increased the risk of crashes along the freeway.

The aim of this paper is to illustrate how the identified improvements implemented along Strand Road improved not only the traffic operations for the freeway and arterial users, but also for all other modes of traffic, including pedestrians and cyclists, but more importantly all public transport users. This paper also illustrates simple design concepts, which are often neglected and which if implemented improve traffic operations and the safety and user experience of pedestrians and cyclists.

1. INTRODUCTION

The South African National Roads Agency SOC Limited (SANRAL) operates and manages the Freeway Management System (FMS) on the national roads around Joburg and Tshwane, in the Cape Town area and in the eThekwini and Msunduzi Municipal areas. The project is managed as a Design, Build, Operate and Maintain (DBOM) contract and let to a single contractor. A deliverable by the contractor is continuously seek to improve capacity and safety of the network.

The FMS has been operational in the Western Cape since June 2010 and covers approximately 154 kilometres of the busiest freeways in the Cape Town Metropolitan area. Operations on the 154 kilometres section of freeways are monitored by operators using CCTV cameras footage and detector information. The operators then in turn provide real time information to the public and road users.

FMS are primarily deployed to manage incidents on freeways and specifically for detection of incidents, quick response to the scene and active scene management. The FMS offers various benefits, such as a reduction in response times of up to 67% (Krogscheepers, 2014). Additionally, the identification, monitoring and improving of operational problems experienced on the road network, specifically related to safety and capacity, are further benefits offered by the FMS. In the Western Cape, FMS are widely used to monitor the congestion experienced on the Cape Town freeways.

Daily, both private car users and public transport commuters on the Cape Town freeways experience congestion during their commute. To address the city-wide congestion, a Congestion Management Strategy (City of Cape Town Transport and Urban Development Authority, 2017) informed by, amongst other, the FMS DBOM network improvement reports, was compiled by the City of Cape Town. In essence the Congestion Management Strategy listed network, safety and capacity improvement projects which were designed to alleviate congestion experienced during the A.M and P.M. peak hours. The 2nd highest-ranking capacity improvement project on the list was a road widening project to mitigate queues spilling back from intersections along Strand Road in Bellville onto the off-ramp and back onto the R300 freeway (See Figure 1 for locality map).

In this paper one of the benefits of the FMS is illustrated. Specifically, how a capacity improvement was identified to address congestion for road-based traffic and how this was used to also improve access and capacity for public transport, pedestrians and cyclists.

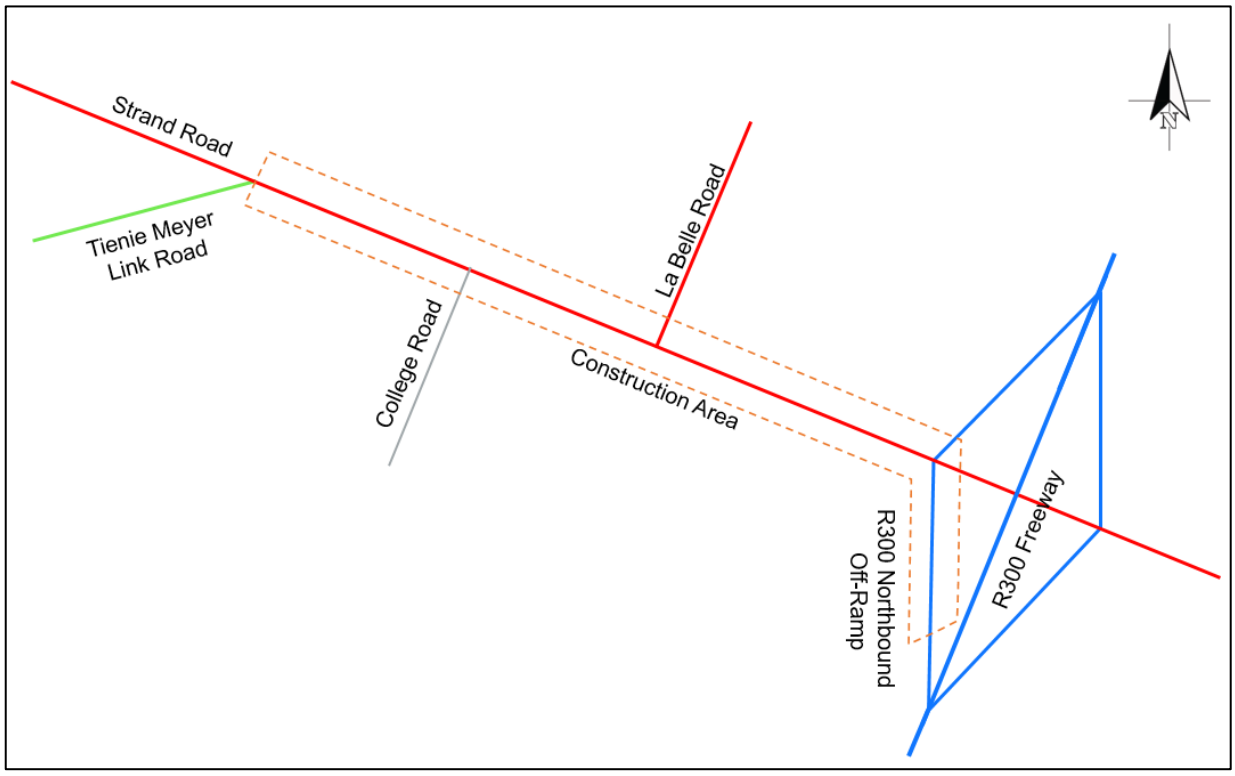

Figure 1: Location of affected intersections in Strand Road, Bellville (Source: ITS)

2. CONGESTION CONDITIONS PRIOR TO UPGRADE OF STRAND ROAD

Prior to the upgrade extremely long queues were frequently spilling back onto the R300. These stationary queues reduced the freeway capacity and were a high safety risk. During the A.M. peak hour queues frequently spilled back from Strand Road onto the freeway and often extended for up to five kilometres on the freeway. The increase in crashes along the freeway was studied and a capacity improvement (Platte, N & Coetsee, M. 2015) to Strand Road was identified as critical project to improve both capacity and safety.

Investigations were done to identify the primary cause of the queues that formed during the A.M. peak hour. The FMS CCTV camera located closest to the R300 northbound off-ramp at Strand Road was used to specifically monitor the A.M. peak hour and was used to capture images of the long queues spilling back onto the R300. The images on the next page depict these queues on the R300:

Figure 2: Southbound view along R300 at Strand Road off-ramp illustrating queues spilling back at 07:04 A.M. Source: SANRAL

Figure 3: Southbound view along R300, 1 km from off-ramp illustrating impact of queues from the Strand Road off-ramp at 07:19 A.M. Source: SANRAL

The primary bottleneck and capacity constraint were identified at the College Road intersection, approximately 1 km to the west of the off-ramp along Strand Road. The effect of the capacity constraint was queues spilling back along Strand Road, onto the off-ramp and for up to 5 kilometres along the R300. Obviously, this constraint also impacted on all nearby upstream intersections and side roads. The observed queue lengths are summarized in Table 1 and the three most affected intersections, show in Figure 3, were:

- College Road/Strand Road intersection
- La Belle Road/Strand Road intersection and
- R300 northbound off-ramp/Strand Road intersection

Table 1: Westbound queue lengths before and after road upgrades

Queue Legths during the A.M. Peak Hour Period at Strand Road, Bellville		
Location	Before Upgrades	After Upgrades
R300 Northbound Off-Ramp	Between 3000m and 5000m spillback onto freeway	Less than 150m
Strand Road/ La Belle Road Intersection - West Bound	±300m, spillback into upstream intersections	±50m, no spillback into upstream intersection
Strand Road/College Road Intersection - West Bound	±300m, spillback into upstream intersections	±40m, no spillback into upstream intersection

3. CAPACITY AND SAFETY IMPROVEMENTS

To mitigate the queue spillback onto the R300, traffic analyses and simulation of the surrounding road network was done. The focus was on a section of the westbound carriageway of Strand Road between the R300 off-ramp and Tienie Meyer Link Road. The result of the analyses indicated that an additional westbound through lane will sufficiently resolve the capacity constraints for at least the next 15 years.

The outcomes of the study and the final designs were the following and these are discussed in more detail in the remainder of this section:

- Increase in westbound capacity along Strand Road, additional through lane.
- Upgrades of public transport embayments to remove friction.
- Upgrade of pedestrian and cycling facilities to improve safety.

3.1 Increase in westbound capacity

An additional or fourth through lane from the R300 off-ramp at Strand Road up to the Tienie Meyer Link Road was proposed and designed. The traffic simulation of the additional westbound through lane indicated noticeable improvements in travel time and vehicle delays. The geometric upgrades included the following:

- Widening of the existing R300 northbound off-ramp to include a third left turn lane,
- A fourth westbound through lane along Strand Road.
- Upgraded intersections with improved pedestrian and cycling ramps.
- A pedestrian link to the existing pedestrian bridge over Strand Road.

Figure 4 below indicates the road widening along the R300 off-ramp and along Strand Road up to the Tienie Meyer Link Road. At the top of Figure 4 the widening of the off-ramp is shown and marked with a number 1. Sequentially, below that, the road widening is shown from left to right.

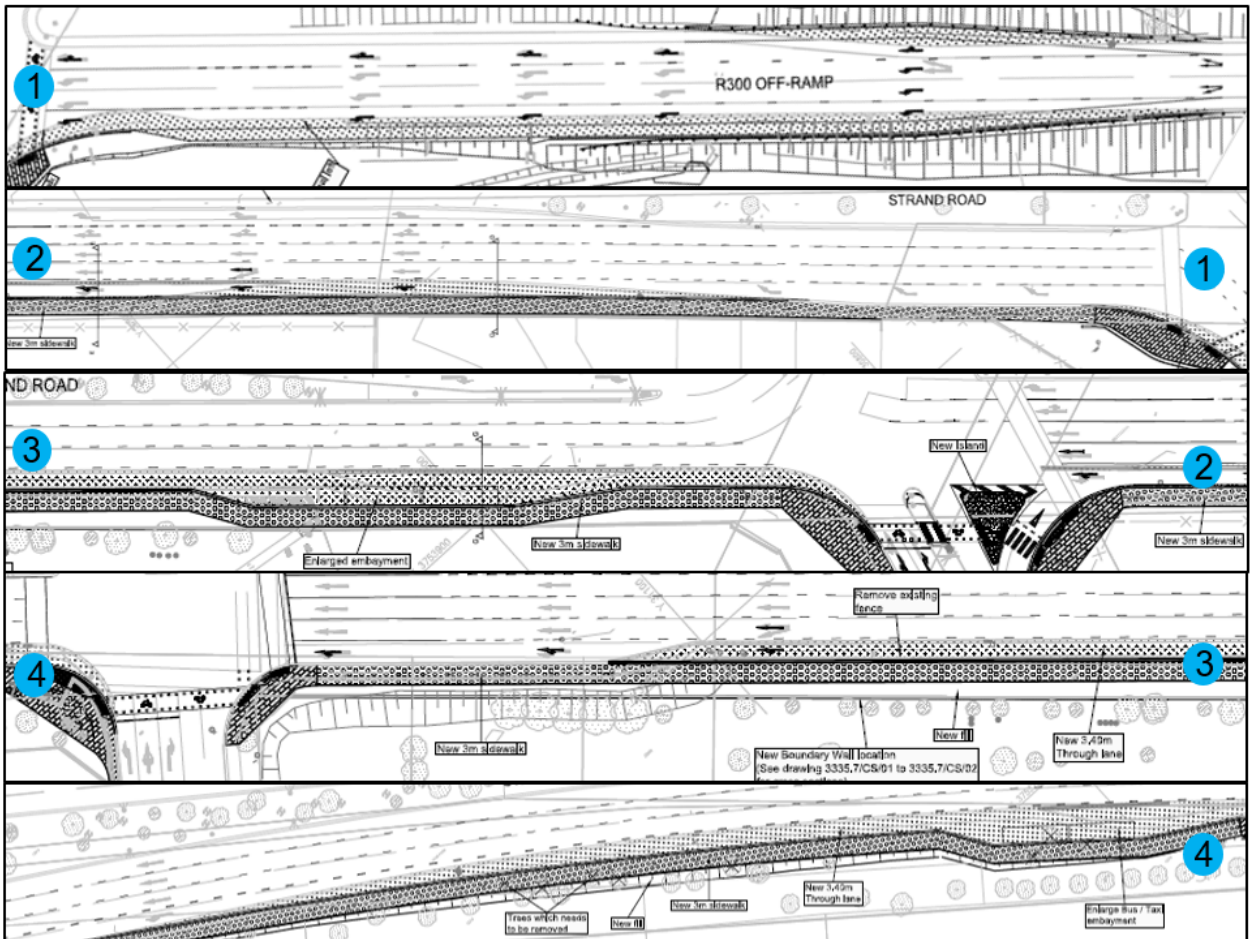

Figure 4: Road widening and NMT facilities along Strand Road (Source: ITS)

3.2 Upgrades of public transport embayment

Strand Road, which becomes Voortrekker Road further downstream towards the Bellville Central Business District (CBD), is an important public transport corridor in the road network of the City of Cape Town (City of Cape Town Transport and Urban Development Authority, 2017). High volumes of minibus taxis and commuter buses make use of this corridor to transport commuters to and from the Bellville CBD.

During the initial site visits, it was noticed that during the A.M. peak that public transport vehicles stopping and off-loading passengers at the taxi and bus embayments close to the College Road and La Belle Road intersections caused high levels friction. For instance, the one bus embayment provided adjacent to the Bellville Technical High School was not sufficient. It was observed that a bus or taxi would utilize the embayment while other buses and/or taxis, in some cases up to three buses, stop in the leftmost lane to off-load scholars and passengers.

Another embayment, upstream from the school where mostly taxis stopped could also not supply the high demand. Therefore, it was decided to increase the capacity of the embayments. See Figure 4 and Figure 5 depicting the high number of public transport vehicles and pedestrian volumes during the A.M. peak hour.

Figure 5: Taxi and GABS buses off-loading scholars (Source: ITS)

Figure 6: Delay caused by buses stopping in left lane (Source: ITS)

3.3 Upgrade of Pedestrian and Cycling Facilities.

During the A.M. peak hour large numbers of pedestrians were noticed using the sidewalk along the westbound section of Strand Road, especially close to the Bellville Technical High School. Parents with children and toddlers, scholars as well as people on their way to work was seen using the sidewalk. Although the sidewalk, varied in width of between 1.5 meters and 2 meters was marked as a shared facility, it could not be effectively used by both pedestrians and cyclists due to the limited width.

To improve safety and accessibility of the shared facility the following upgrades were proposed at three intersections:

- Widen the existing westbound sidewalk to three meters.

- Upgrade the pedestrian ramps to allow easy access for both pedestrians and cyclists.
- Maintain level crossing surfaces for pedestrians and cyclist through traffic islands.
- Widen paved areas at bell mouths to allow for easier cycle turning movements.
- Implement forgiving designs at kerbed islands and channelisation.

4. IMPACT OF THE GEOMETRIC UPGRADES

The improvements described above were implemented and all construction activities competed by September 2018. To measure and quantify the effect of the geometric improvements the FMS CCTV cameras footage was used. In addition traffic counts were conducted during the commuter peak hours. The operational and functional improvements due to the upgrades are discussed on the remainder of this section.

4.1 Queue length reduction

After the completion of the geometric upgrades an immediate effect on the queue lengths was noticed. The queues which previously spilled back onto the R300 disappeared. The queues along the westbound sections of Strand Road decreased from approximately 300 meters to less than 50 meters at all the intersections. Figure 7 illustrates a view along the R300 during the A.M. peak hour without any queues extending along the ramp and spilling back on the freeway.

Figure 7: Southbound view at the R300 northbound off-ramp after road upgrades at 07:15 A.M. (Source: SANRAL)

4.2 Increase in through volumes and decrease in delays

Furthermore, classified traffic counts at the three intersections were conducted in January 2019 which allowed comparison with the counts done in January 2018. The results of the three-hour A.M. peak period count per mode are summarised in Table 3 below.

Table 2: Classified traffic counts before and after upgrades

Traffic Counts Before Upgrade - January 2018					
Location	A.M. Peak Period (3hr) Volume				
	Total	Cars	Trucks	Bus	Taxis
R300 northbound Off-Ramp	3 390	2 710	60	60	560
Strand Rd westbound before La Belle Road	6 700	5 250	120	80	1 250
Strand Rd westbound before College Road	9 700	8 500	90	60	1 050
Traffic Counts After Upgrade - January 2019					
Location	A.M. Peak Period (3hr) Volume				
	Total	Cars	Trucks	Bus	Taxis
R300 northbound Off-Ramp	3 890	3 010	200	70	610
Strand Rd westbound before La Belle Road	9 335	7 830	170	80	1 255
Strand Rd westbound before College Road	9 935	8 600	190	90	1 055

From the above it is evident that:

- There is an increase of vehicles traveling through the upgraded section.
- The change in volumes along the R300 off-ramp of approximately 300 vehicles represent a 10 percent increase during the A.M. peak period.
- Between the off-ramp and La Belle Road, the volumes increased significantly with approximately 2 600 vehicles which represents a 49 percent increase during the A.M peak period. These are mainly vehicles exiting the Kuils River area and turning right onto La Belle Road. This large increase indicates the latent demand which existed and which avoided the area due to congestion.

The improved operations through the area also reduced the delay experienced by the motorist and passengers in public transport vehicles. The reduced queue lengths from approximately 5 kilometres on the R300 to short 50 m queues are equivalent to delays of approximately 800 vehicle-hours per 3-hour peak period. After the improvements the vehicular delays reduced to less than 80 vehicle-hours per 3-hour peak period. Considering, passengers and occupants of vehicles, these delays equate to approximately 1 200 person hours per 3-hour peak period. Based on a low value of time of R25 per hour, the value of the time lost per day is at least R30 000 which is what the current improvement saves society. Over a year period these times savings could be valued at more than R7.5 million.

4.3 Expected decrease in vehicle crashes

As part of the initial studies, the historic crash data for the section of the R300 between Stellenbosch Arterial interchange the Strand Road interchanges were analysed. The results indicate that out of the total of 110 crashes, 33% (30) crashes occurred during the A.M peak hour i.e. 07:00 A.M to 08:00 A.M (Platte, N & Coetsee, M. 2015). See Figure 8. Most of these crashes would have been as a direct result of the combination of long

queues of vehicles virtually standing still on the freeway and fast-moving vehicles passing at speeds of approximately 80km/h.

This was exacerbated by minibus taxis skipping the queue and pushing in at the front. Since the upgrades were only recently completed no definitive conclusions are possible given the limited time and the availability of data. However, it is expected that the high number of crashes during the morning peak hour would reduce to numbers similar to the rest of the day.

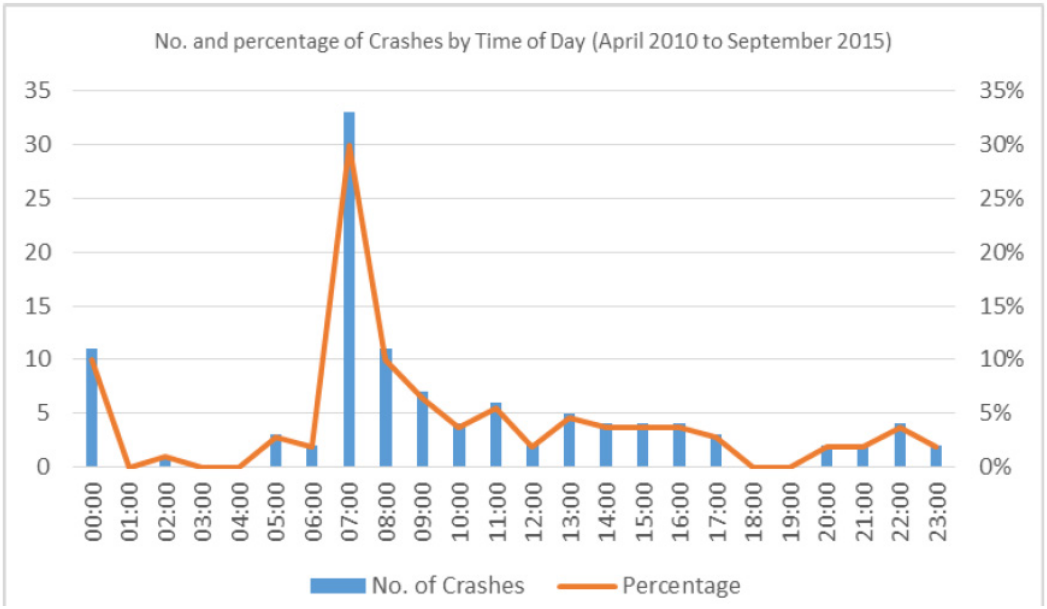

Figure 8: Number and percentage of northbound crashes (Source: SANRAL)

If the assumption holds true that the number of crashes during the morning peak period reduces to numbers similar to the rest of the day, the number crashes should reduce with between 20 to 25 crashes over a five year period, or between 4 and 5 per year. These are significant improvements specifically in the light of the value of serious crash which is in the order of R800 000 per crash (Labuschagne, F, 2017).

4.4 Better embayment utilisation and improved pedestrian and cycling facility

During site visits after the geometric improvements to Strand Road, it was noticed that increase in embayment capacity was well utilised by all public transport vehicles and to the extent that there was no more double parking by public transport vehicles in the through lanes. Not only is this beneficial for the capacity of the through lanes, i.e. less friction, but it is also much safer for vehicles and passengers.

The widened pedestrian and cycling facility allowed pedestrians and cyclists to easier navigate the intersections. Figure 9 on the next page shows a cyclist making use of the improved shared pedestrian and cycling facility. Not only were the pedestrian and cycling facilities widened, but through the intersection and specifically through the traffic islands, the facilities were kept at-grade without any kerb lips and vertical obstructions. See Figure 9. Also included in the design was the use of stone pitching to force pedestrians to walk along the designated paths and to reduce jay-walking. With very little design effort, these ideal pedestrian and cycling facilities can be implemented. This attention to detail is often neglected by many practitioners.

Figure 9: Pedestrian cycling facilities – Note detail of level crossing, channelisation and stone pitching

4.5 Channelization at traffic islands and pedestrian crossings.

Although channelization is described in Urban Transport Guideline 1 (UTG 1), it is infrequently implemented, at least in the City of Cape Town area. As described in UTG 1, channelization can be implemented to direct traffic along definite paths to simplify operations (Committee of Urban Transport Officials, 1992, p.52) and reduce the probability of vehicles hitting vertical kerbs, i.e. introducing a safer road environment.

At the Strand Road/La Belle Road intersection channelization was implemented at the traffic islands to safely direct traffic and to provide adequate approach-end treatments. This creates forgiving environments which simplifies operations and creates a safer road. See Figure 10.

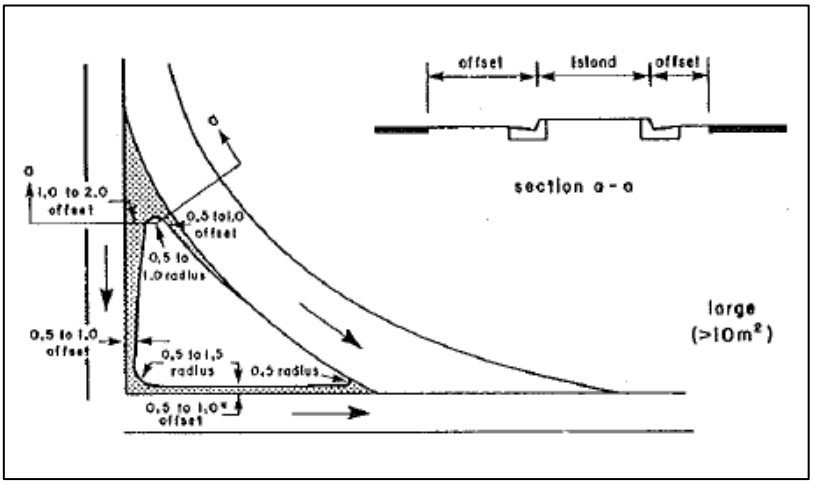

Figure 10: Example of island off-sets at traffic islands (Source: UTG1)

5. SUMMARY

Although FMS are primarily used to manage incidents on the Cape Town freeways with a strong focus on vehicular capacity, flow and safety, the outcomes of projects identified through the FMS operations can be positive for all road users. The upgrades on the R300 northbound off-ramp and along Strand Road is an example where users of all modes are directly benefitting from the improvements. These road users include private vehicle occupants, public transport passengers, pedestrians and cyclist.

With a focus on small details, such as level pedestrian crossings, stone pitching to guide pedestrians, and proper forgiving designs of traffic islands and friendly and safe road environment can be created.

6. REFERENCES

City of Cape Town Transport and Urban Development Authority 2017, *Congestion Management Strategy for Cape Town: Roads within a Sustainable Transport System,* Cape Town, Available on request.

City of Cape Town Transport and Urban Development Authority 2017, *Comprehensive Integrated Transport Plan,* Cape Town, viewed on 17 January 2019, http://resource.capetown.gov.za/document centre /Documents/ City strategies, plans and frame works/ComprehensiveIntegratedTransportPlan.pdf.

Committee of Urban Transport Officials, 1992, *Guidelines for the Geometric Design of Urban Arterial Roads: Draft UTG 1,* Department of Transport, Pretoria.

Krogscheepers, C, 2014. 'Freeway Management and the impact on response and clearance times', *Southern African Transport Conference*. Pretoria 7-10 July 2014.

Labuschagne, F, 2017. 'The cost of crashes in South Africa 2016', *Southern African Transport Conference*. Pretoria 10-13 July 2017.

Platte, N & Coetzee, M, 2015. '*Capacity and safety upgrades: Quarterly report - September 2015*, South African National Road Agency Limited, Western Cape.