VICROADS M80 RING ROAD UPGRADE - TRAILER MOUNTED ELECTRONIC VARIABLE SPEED LIMIT SIGNS

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ABSTRACT:

This paper discusses development, challenges and benefits in using trailer mounted EVSLS's for the M80 Ring Road Upgrade Project.

The M80 Ring Road is a strategic Melbourne Metropolitan Freeway extending 38 kilometres. The $2.25 billion M80 Ring Road Upgrade involves duplication and widening works aimed at improving the safety, operation, efficiency and reliability of the M80 Ring Road for all road users.

This VicRoads Project deployed an innovative traffic management strategy using trailer mounted Electronic Variable Speed Limit Signs (EVSLS's).

A Trailer Mounted EVSLS enables remote speed limit changes to improve safety for:

- ✓ construction workers
- ✓ motorists, particularly during incidents on the M80 Ring Road and in times of congestion.

Trailer Mounted EVSLS's eliminate the need for the physical presence of traffic controllers to alter static speed signs adjacent to high speed traffic.

Compared with conventional static signs, the Trailer Mounted EVSLS's allow:

- ✓ more effective and consistent speed limit changes
- ✓ improved production of construction activities with significantly shorter times required for speed limit changes.

Issues for discussion include:

- ➢ comparison with existing practices
- ➢ evaluation of the safety and cost benefits
- ➢ key constraints and limitations.

1.0 INTRODUCTION

Strategic Principles were developed for Traffic Management on the VicRoads M80 Ring Road Upgrade project to ensure effective traffic management across multiple contracts on the M80 Ring Road both during and after construction and transition activities. One of these principles prescribe the use of Trailer Mounted Electronic Variable Speed Limit Signs (EVSLS's) for managing speeds on the M80 Ring Road when traffic management is installed.

In line with the M80 Ring Road Upgrade Traffic Management Strategic Principles, the M80 Upgrade Project has implemented an innovative traffic management strategy using Trailer-Mounted EVSLS's. These enable remote speed limit changes to improve safety for:

- construction workers
- motorists, particularly during incidents on the M80 Ring Road and in times of congestion.

This strategy has improved and provided consistency, which complements the existing use of permanent EVSLS's on the M80 Ring Road.

This paper discusses development, challenges and benefits in using trailer mounted EVSLS's for the M80 Ring Road Upgrade Project.

2.0 ABOUT THE M80 RING ROAD UPGRADE

The M80 Ring Road Upgrade will improve the 38km Western and Metropolitan Ring Roads from the Princes Freeway at Laverton North to the Greensborough Highway at Greensborough.

The M80 Ring Road Upgrade is a $2.25 billion project, jointly funded by the Victorian and Australian governments and is expected to take over five years to complete. The project involves widening to provide a minimum of three lanes in each direction along the M80 Ring Road, additional lanes at some interchanges to improve safety for traffic entering and exiting the freeway and the Freeway Management System (FMS). The FMS will include electronic lane use management and variable speed limit signs, ramp metering signals and real time traffic information.

2.1 Construction history of Western and Metropolitan Ring Roads and previous safety improvement works

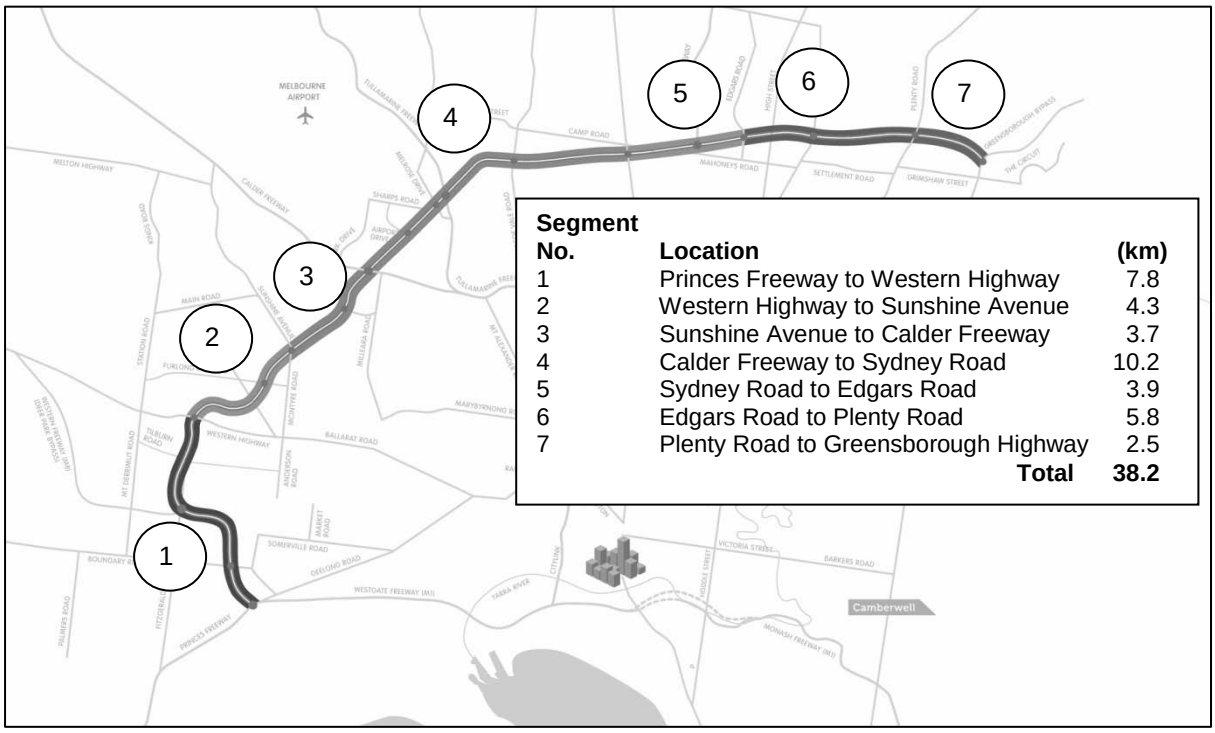
The Western and Metropolitan Ring Roads were initially constructed in stages between 1989 and 1999. In 2002, additional safety improvements were implemented along segments of the Ring Road, including the installation of permanent EVSLS's. Other improvement works included installation of wire rope safety barriers, additional help phones and bridge widening.

The permanent EVSLS's assisted improvements to traffic flow and reduced congestion by altering speed limits based on prevailing traffic conditions. The signs were placed on an 11 kilometre M80 Ring Road section between the Western Highway and Tullamarine Freeway and were located at every interchange and between the interchanges at an interval of between 600 metres and 1,200 metres. The signs displayed speed limits based on a control algorithm (using real time traffic data volumes from freeway data stations to determine appropriate speed limits based on traffic conditions) or manually controlled by the VicRoads Traffic Management Centre (TMC).

Prior to the deployment of the trailer mounted EVSLS, a number of the permanent EVSLS were removed during the early stages of the upgrade works. The inputs for the existing EVSLS system (such as detector loops that supply information to the Freeway Data Stations) were damaged or disconnected during construction and therefore, the removal and/or relocation of the permanent EVSLS's was required.

Given that the permanent EVSLS's were unlikely to be fully functional throughout the Upgrade construction period, an interim operational system was required to be adopted. This will ensure that the existing / further safety benefits were to be provided / maintained throughout the M80 Ring Road Upgrade construction works.

2.2 Current construction activities



Segment No.	Location	(km)
1	Princes Freeway to Western Highway	7.8
2	Western Highway to Sunshine Avenue	4.3
3	Sunshine Avenue to Calder Freeway	3.7
4	Calder Freeway to Sydney Road	10.2
5	Sydney Road to Edgars Road	3.9
6	Edgars Road to Plenty Road	5.8
7	Plenty Road to Greensborough Highway	2.5
	Total	**38.2**

Figure 1: M80 Upgrade Construction Segments

Construction works on the M80 Ring Road are currently underway on three segments (2, 4 and 6 – refer to Figure 1) of the M80 Ring Road as follows:

- Western Highway to Sunshine Avenue
- Calder Freeway to Sydney Road
- Edgars to Plenty Roads.

Works have been undertaken within the various construction segments over the past three years and are expected to continue over the next two to four years. Therefore, locations of roadworks, including lane closures and reduced speed limits, will vary over this period. Construction works in some segments could be completed months or years prior to work commencing in other segments.

The FMS is being progressively implemented as part of the construction works. Some segments will have construction completed months or potentially years before others. It is intended that a full and consistent FMS will be implemented along the entire corridor.

3.0 M80 UPGRADE TRAFFIC MANAGEMENT STRATEGIC PRINCIPLES AND TRAFFIC MANAGEMENT PERFORMANCE MEASURES

The M80 Upgrade Project adheres to a number of performance measures and principles which are considered before implementing new strategies.

3.2 Traffic Management Strategic Principles

The M80 Ring Road Upgrade Traffic Management Strategic Principles provide direction into the requirements for the implementation of traffic management for the Project in order to achieve a consistent approach to traffic management along the entire corridor during the upgrade works.

The Principles were considered and developed under the following headlines:

- Regulations, Codes of Practice and relevant standards
- Management of Constraints
- Communication
- Incident response / Emergency Response
- Site Access
- Work Periods
- Monitoring, Maintenance and Verification
- Management of Compliance
- Performance Indicators
- Traffic Management Measures

Adherence to the Principles will contribute to achieving these strategic objectives:

- providing a safe environment for the travelling public and construction personnel
- maximising traffic throughput during the construction phase and therefore, minimising inconvenience to the travelling public
- maintaining consistent traffic management treatments across the entire corridor;
- minimising traffic delays and disruption to all road users
- catering for the needs of all traffic
- minimising public vehicle interaction with construction vehicles and activities
- communicating the purpose of all proposed traffic events
- communicating the arrangements for and impacts of any event affecting traffic.

3.1 Traffic Key Result Areas (KRA's) and Key Performance Indicators (KPI's)

The M80 Upgrade monitors the following KRA's and KPI's:

3.1.1 Travel times

Travel time data is collected regularly and analysed on a monthly basis to monitor travel times along the route throughout the day with an emphasis on peak periods. This information is analysed to determine possible improvements to minimise any detrimental impacts from road congestion due to construction activities.

3.1.2 Reliability of travel times

Reliability of travel times is regularly monitored to ensure that any variations to travel times are within the expected levels as a long term 80km/h speed limit has been adopted as part of the upgrade.

3.1.3 Incidents

Since the commencement of construction activities on the M80 Ring Road, roadway cross sections have changed significantly. The changes included the narrowing of traffic lanes, reduced speed limits and long term traffic management devices to delineate and protect roadwork zones. Also, most of the existing emergency stopping lanes have been removed or impacted due to construction works, which poses further challenges in relation to incident management.

The number and type of incidents are monitored regularly and measures are implemented to improve safety and assist incident management efficiency.

4.0 CONSTRUCTION STAGING AND TRAFFIC MANAGEMENT

A key objective of the M80 Ring Road Upgrade Project is the consistent management of traffic along the 38km route (Average daily traffic of 140,000 vehicles per day). It is critical that there is consistency and coordination between any traffic management, in particular EVSLS's, between different construction segments. Consistency and coordination will assist in reducing the number of speed limit changes along the route; improve driver speed limit compliance and traffic safety in general.

For example, when the Furlong Road to Sunshine Road section was constructed, there was a 'gap' of approximately 3.7 kilometres to the next segment of works (Calder Freeway to Sydney Road). Management of speed limits and traffic operation within this 'gap' was necessary to improve the safety and operation of the construction segments to either side.

Subject to construction timing and methodology, the following scenarios were considered:

- existing permanent EVSLS's functional and in operation
- existing permanent EVSLS's removed and replaced with trailer mounted EVSLS's during the civil construction activities
- Trailer Mounted EVSLS's in place during transition
- Trailer Mounted EVSLS's removed following the completion of the civil construction activities
- no EVSLS's for undefined period
- implementation of a partial/full Freeway Management System (FMS) including Lane Use Management System (LUMS) (includes Variable Speed Limit Signs).

A key consideration of the EVSLS Strategy was also to address the management of traffic during the time between completion of the civil construction activities and implementation of the FMS.

5.0 M80 RING ROAD ELECTRONIC VARIABLE SPEED LIMIT SIGNS STRATEGY

The main objective of the M80 Ring Road EVSLS Strategy is to improve safety for all road users at all times.

Three key management areas are as follows:

- Roadworks – appropriate speed limits to ensure safety of road workers and motorists
- Incidents – appropriate speed limits to ensure safety of motorists during incidents on the route
- Operation – appropriate speed limits to ensure safety of motorists during times of congestion.

5.1 Speed Limit Guidelines

The Victorian Road Management Act 2004: *Worksite Safety – Traffic Management Code of Practice*, provides guidance on the selection of speed limits through worksites.

Key elements relevant to speed zoning in accordance with relevant standards and guidelines were considered in the development of the trailer mounted EVSLS's as follows:

5.2 Worksite speed limit signs

- Should be placed on both sides of the road, or each carriageway of the road, on high-speed, high-volume roads, except where permanent overhead electronic signs are installed (e.g. in freeway tunnels)

5.3 Buffer Zones

- Buffer zones should be used where the change in speed limit from the prevailing speed limit to the worksite speed limit is more than 30 km/h. However, a change from 80 km/h to 40 km/h is acceptable on low-volume roads when reducing from a prevailing speed limit of 100 km/h

5.4 Repeater Signs

- Repeater speed restriction signs "shall be placed on the left side of the roadway at a maximum spacing of 500 metres". For multi-lane roads or divided roads, repeater signs should be placed on each side of the road or carriageway where practicable.

5.5 End Speed Restriction

- It is a legal requirement that a roadworks speed zone be terminated either by another regulatory speed control sign (or end restriction sign), or other means as specified in Road Rules – Victoria. It is important that any sign terminating a roadworks speed zone is placed facing traffic exiting the work area.

5.6 Length of Speed Limits

- Minimum speed limit lengths are used to limit the frequency of changing speed limits along a route. The minimum lengths are shown in the table below.

Table 1: The minimum lengths of Speed Limit

Speed Limit (km/hr)	Minimum Length of Speed Limit (m)
40	400
50	500
60	600
70	700
80	800
90	900
100	2000

5.7 Speed Sign Sizes

- Size ‘C’ 900mm x 1200mm - This size is used to begin a new speed limit where additional emphasis is desired over that provided by the ‘B’ size. It is also generally used where the speed limit reduction is more than 20 km/h. It is also used generally on freeways, to commence speed limits, and as repeater signs, on both the main carriageways and the ramps.

6.0 EVSLS REQUIREMENTS

Photos 1 & 2: Trailer Mounted EVSLS’s on site

6.1 Signs

The sign requirements refer to the sign dimensions, sign enclosure and control system and equipment while the actual electronic variable speed limit display (signs deployed on site shown on photos 1 & 2 above) is in accordance with the Australian Standard AS 1743: *Road*

signs – Specifications,.

6.1.1 Dimensions

The speed limit display for a Trailer Mounted EVSLS for the M80 Ring Road Upgrade is based on a 'C' size speed limit sign. The enclosure of the EVSLS is specified to be square in shape 1050x1050.

6.1.2 Material and Coatings

The materials used for the Trailer Mounted EVSLS enclosure is aluminium suitably reinforced and/or braced to facilitate the installation and continued operation of the unit in the intended application.

6.1.3 Control equipment

The control equipment is configured locally at the EVSLS or remotely (master/slave). When configured as master / slave operation, the manual override control (remote) only operates from the master sign and they operate as a pair. The flashing (frequency 50 to 60 times per minute) of the annulus needs to be synchronised.

The signs are controlled via a wireless modem connection that can be accessed by both VicRoads and the maintenance crew and have simultaneous connection.

6.1.4 Sign display

The EVSLS speed display symbol (numerals and red annulus) is based on the layout of the R4-1C signs shown in AS1743 (2001): *Road signs – Specifications*. The shape and typesetting of the speed limit numerals are in accordance with AS1744 (1975): *Standard alphabets for road signs*. The Trailer Mounted EVSLS is able to display individual frames and implements all functions in accordance with the RTA Specification TSI-SP-003 Ver. 2.1 (2008): *Communications protocol for roadside devices.*

The EVSLS displays speed limits using LED pixels:

- arranged in both full matrix digits and pre-formed annulus or
- full discrete layout.

The sign is capable of displaying:

- a speed limit with a steady red annulus (indicates default speed limit of 80km/h or 100km/h); and
- a reduced speed limit with the inner 75 per cent part of the red annulus flashing at 50 to 60 Hz, and the outer 25 per cent illuminated but not flashing.

The EVSLS display face is specified to consist of a main display area consisting of red and white LED pixels on a black background.

6.1.5 Operation and maintenance

The following objectives are considered for inclusion in the maintenance and operational manual of the sign:

- Safe transport of the sign; Onsite installation; Suitable location; Setting up of the EVSLS for operation; Programming; Starting up; Shutting down; Charging of the power supply batteries; Routine maintenance; Troubleshooting; Occupational Health and Safety (OH&S) requirements.

6.2 Communication

The VicRoads ITS communications/control platform currently uses the Streams system. Alternative platforms may be considered for this purpose as outlined below.

6.2.1 Streams

Streams is owned and maintained by Transmax, a Queensland based company which is part of Queensland Main Roads. Streams is an integrated control system which is being used by VicRoads to operate its ITS Freeway Management Devices on Melbourne's freeway network. A main objective in using Streams is to ensure consistency and to meet VicRoads' requirement that all ITS field devices must be compatible with Streams.

6.2.2 Alternative platforms

The Trailer Mounted EVSLS are capable of being controlled via alternative platforms. These include Sydney Coordinated Adaptive Traffic System (SCATS) and also platforms that utilise the protocol as per the RTA Specification TSI-SP-003 Ver. 2.1 (2008): *Communications protocol for roadside devices.*

6.3 Trailer

The trailer provides two functions. It provides the base (foundation) for the actual EVSLS to be mounted on and allows portable transportation of the EVSLS. The trailer needs to act as a counterweight for the EVSLS and associated components such as the solar panels. The trailer must be limited in size to reduce its potential to become a hazard.

The trailer needs to comply with the applicable design rules and be suitable for registration in accordance with the statutory requirements of the relevant road Authority.

6.4 Power

Two charging systems - solar and wind power - have been used for the Trailer Mounted EVSLS.

The systems design has considered the power consumption, the hours of operation and the average amount of sunlight or wind available.

The following general requirements have applied on the solar system:

- solar panel size shall not exceed the trailer footprint
- solar panel mounting that is capable of an automated tilt of 45 degrees and rotation of 350 degrees
- solar supply capacity of 24 hours operation per two hour of sunlight (Melbourne condition) and a battery redundancy of 8 days, 50% DoD (Depth of Discharge)
- sealed gel type battery
- regulator system for features, communications and monitoring
- system voltage of 12 or 24 volt.

The wind system requirements include a wind turbine vertical axis and supply capacity for continuous 24 hour operation.

In order to extend the battery life the sign automatic dimming is not recommended.

7.0 EVSLS IMPLEMENTATION AND OPERATION

The M80 Ring Road Upgrade EVSLS Strategy includes the following rules for the implementation and operation of the signs:

- Installation of Trailer Mounted EVSLS's on both sides of the main carriageway with two or more lanes.
- Installation of Trailer Mounted EVSLS's on one side of the main carriageway considering spacing and its feasibility on a 'case by case' basis.
- Installation of Trailer Mounted EVSLS on the left hand side of any single lane entry ramp.
- Buffer zones (e.g. 100 – 80 – 60 – 40) at start of commencement of EVSLSs on main carriageway.
- Buffer zones (e.g. 100 – 80 – 60 – 40) at freeway to freeway connections.
- The length of buffer zones should be at least 300m for 80km/h and 150m for 60km/h (where possible).
- Trailer Mounted EVSLS's should be placed a minimum distance of 400m apart to provide a minimum length of speed zone and to provide a buffer zone as required.
- Trailer Mounted EVSLS display should be at least Size 'C'.
- Uniform speed must be maintained across each EVSLS site. Ramp sites will always display the same speed as the mainline site directly upstream from the ramp.
- Maximum speed reduction is no greater than 30km/h.

8.0 TRAILER MOUNTED EVSLS BENEFITS /CHALLENGES

8.1 Reduction of crash rates and traffic capacity

Riffkin et al (2088), Han et al. (2010) and Bevrani et al (2011) investigate and discuss benefits of EVSLS's in improving speed compliance and reducing crashes (in particular rear end crashes) and variations in traffic flow.

Although it is considered that there are many factors that influence the crash rates along the M80 Ring Road, the implementation of the permanent EVSLS's between the Western Highway and Tullamarine Freeway has contributed to lower crash rates when compared to statistics recorded prior to their installation.

8.2 Legible speed limits

An EVSLS uses light emitting technologies to create the display that is mounted on a purposely built trailer. Each display is made up from a series of spaced elements as opposed to continuous solid lines, used for displaying regulatory speed limits.

The signs have been designed to provide (as a minimum) legible speed limits of 40, 50, 60, 80 and 100km/h to drivers during any time of the day or night.

8.3 Visibility

An EVSLS is located on one or both sides of a freeway carriageway, such that it is clearly visible from each lane of the carriageway. The signs are more conspicuous (compared to static signs) from a greater distance, particularly in inclement weather conditions and at night.

8.4 Economic benefits

As already explained Trailer Mounted EVSLS's can be programmed remotely at any time to change displayed speed limits. This provides basis for the following benefits:

- greater window of opportunity for works on road resulting from the reduced time required to setup static speed signs
- reduced safety risks associated with being able to program displayed speed limits remotely
- flexibility in the management of incidents.

Currently, to change over static speed limit signs within a section of roadway, usually a three person team is required, including a truck mounted crash attenuator and a lead driver at a cost of approximately $3,500/event. Ideally, flip signs are used, still requiring deployment of a crash attenuator truck at a cost of approximately $2,000/event. On a typical ten hour shift, lost time to change over the static speed limit signs is approximately one hour. Lost productivity is dependent on machinery and personnel on site at any given shift. These costs may vary (e.g. a crane on site at a cost of $15,000 per shift = $1,500 lost in equipment hire alone). Therefore, per shift, operational loses may vary from a minimum of $3,500.

The real cost to a contractor is safety to work personnel. This cost may be intangible in nature; however, if an incident involving injury to a person/s were to occur, the result (in a worst case scenario) may be catastrophic. Contractors would prefer not to have personnel on the freeway and therefore, devices that ensure work personnel are not put into high risk situations are preferred. The cost of a serious and / or a fatal injury may be anywhere in excess of $1 million. There are also other adverse impacts such as reputation, safety record, operational costs, legal costs etc.

8.5 Challenges/further improvements

Regular monitoring of the EVSLS concept and operation has identified the following areas for further investigation and possible improvement:

- Timing at the start / completion of traffic management in relation to altering speed limits using EVSLS's and the impact on compliance by motorists
- Trailer Mounted EVSLS's placement / location, including spacing and impacts on compliance and credibility
- EVSLS's displaying 'blank' screen when communication system failure occurs
- Long term Trailer Mounted EVSLS reliability if regular maintenance is not undertaken, resulting in safety and compliance issues
- Limitations with existing forms of communication with signs (ie. 3G versus radio control). Currently permanent EVSLS are checked through Streams every 200 milliseconds, whereas Trailer Mounted EVSLS's checks are performed every 8 seconds.

9.0 CONCLUSION

Trailer mounted EVSLS's have been installed with due consideration of the requirements set out in the Australian Standard AS 5156: *Electronic Speed Limit Signs* and detailed technical requirements in the M80 Ring Road Upgrade Contract specification. The signs display worksite speed limits during traffic management activities and are planned to be used in transition between completed segments of works.

Trailer Mounted EVSLS's have been designed to operate and be compatible with the VicRoads operating platform with an option for other alternative platforms to be adopted.

Since the significant change from the traditional static speed limit signs, these are the main principles considered prior to Trailer Mounted EVSLS's deployment:

- consistent spacing and placement of Trailer Mounted EVSLS's, to improve compliance of the speed limit and minimise the need for enforcement
- placement of signs in relation to other traffic management/construction devices such as roadwork safety barriers, gawk screens and trailer mounted Variable Message Signs.

Fixed speed limit signs or permanent EVSLS's within road works have been relocated or decommissioned prior to the use of Trailer Mounted EVSLS's to ensure consistency of speed limits.

The M80 Upgrade current evaluation of the Trailer Mounted EVSLS's has shown major benefits in both road safety and traffic operation. The Project will continue to monitor these benefits, challenges and opportunities for further improvements.

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