University of Southern Queensland
Faculty of Engineering and Surveying

Evaluating the effectiveness of Intelligent Transport Systems at reducing speeds through roadworks sites in Australia

A dissertation submitted by

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Abstract

Occupational health and safety hazards are present in all industries in Australia. However construction works on roads have higher exposure due to the proximity of moving vehicles. Traffic controllers and workers are consistently at risk. In recent years there has been increased media attention on road works and this can be attributed to an increasing community concern with traffic controller fatalities. To improve the safety of those working on the road, and the travelling public passing through these areas, opportunities need to be taken to upgrade both the practise and performance of existing traffic control measures. This includes improving the credibility of signage across roadworks sites and most importantly compliance, ensuring drivers conform to the devices. This dissertation therefore seeks to evaluate innovative signage options and in particular the effectiveness of Intelligent Transport Systems (ITS) for reducing speeds through roadworks sites in Australia.

The research work was conducted in four phases. The current "state of the art" in traffic management/control in Australia was collected through an in depth literature review. This included the analysis of current standards. One survey was developed to gain an understanding of the perception of road works through the eyes of the general public and the second intended for those at the forefront of traffic management in the civil construction industry. A selection was made on an appropriate ITS device to trial, a vehicle activated speed radar sign.

Field experiments assessed motorist's interaction and response to the sign. The field experiments were conducted within a work zone on the Bruce Highway in the Sunshine Coast region of Queensland. The data collected was divided into three classes; conventional signage only, ITS signage and police presence. Statistical analyses of the results were performed to determine the level of interaction between motorist's responses and the various signage arrangements.

Results showed that with the speed radar sign operational, drivers slowed by an average of up to 4km/h. More meaningfully the number of vehicles speeding improved by 85%, equating to a reduction of speeding vehicles in the region of 42,000 vehicles out of 49,200 vehicles in a typical week. The most effective outcome was with police presence, showing a 100% speed compliance and average speeds reduced by up to 13.43km/h.

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Certification of Dissertation

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

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Abbreviations

The following abbreviations have been used throughout the text:

ITS – Intelligent Transport Systems

TMP – Traffic Management Plan

TGS – Traffic Guidance Scheme

MUTCD – Manual of Uniform Traffic Control Devices

TCAW – Traffic Control at Worksites

TMAA – Traffic Management Association of Australia

TRUM – Traffic and Road Use Manual

AS1742.3 – Australian Standard 1742.3

CMS – Changeable Message Signs

VMS – Variable Message Signs

VSL – Variable Speed Limits

SLLOWS – Speed Limiting Locally Operating Warning Signs

LOS – Level of Service

HCM – Highway Capacity Manual

Chapter 1: Introduction

1.1 Introduction

Over 70 percent of all domestic passenger movements within Australia occur on roads. Every year millions of dollars are invested into building, upgrading and maintaining this infrastructure and for every project there is a significant need for traffic management and traffic control in order for the works to progress efficiently. There are standards and practises within Australia that govern how traffic management must be implemented however, the number of accidents, injuries and even fatalities at roadworks still remains a problem. As recent as September 2015 traffic controllers are still losing their lives on roadworks sites due to errant vehicles and this leads to the question of; is conventional traffic control out of date? Is there a more effective method of reducing speeds through roadworks sites? Is it in the interest for transport authorities to review current traffic management and traffic control practises at roadworks sites and ensure the devices being used are providing the highest level of safety for all worksite personnel?

One such component worthy of this consideration is the use of Intelligent Transport Systems (ITS) to control the flow of traffic and increase driver compliance and this research project seeks to evaluate the effectiveness of one such device, primarily a speed radar sign. Intelligent Transport Systems are becoming more apparent in our everyday transport system, on established roads and in permanent situations we are seeing variable speed signs being installed, real time travel times being displayed and other ITS devices such as electronic toll collection and interactive traffic signals being utilised.

Intelligent Transport Systems have been developed to increase the efficiency and safety of our roads in their permanent alignment and have the potential to be adapted on a smaller scale during the construction phase. There have been numerous incidents involving vehicle and human collisions causing serious injury or death to traffic controllers and workman on site and these can largely be attributed to excessive speed, but to mitigate these incidents there seems to be a push for more flashing lights, more signage, more spotters and more traffic controllers. Taking an alternative approach to traffic management and controlling or managing traffic with less people on the road, less distraction and more concise and accurate signage that has the ability to be controlled remotely is one viable solution.

Traffic management of road works in Queensland is essentially broken up into three broad categories. The Traffic Management Plan (TMP) is an overview of how traffic might be staged over the duration of a project. Traffic Guidance Schemes (TGS's) are then developed and are specific to individual jobs on site. TGS's are the plans that indicate how the travelling public will navigate their way through the job site and provide the blue print to personnel implementing the controls on site. The third category is the implementation and ongoing monitoring of the designed plans. The Manual of Uniform Traffic Control Devices (MUTCD), Part 3 – Works on Roads, sets out the minimum standards required for each of these categories and stipulates the exact signage and controls that must be used for various speed zones and various types of roads in Queensland. The primary focus of this dissertation is therefore evaluating the conventional signage currently being used and exploring the effectiveness of alternative control measures to those set out in the MUTCD.

Figure 1.1: Alternative approaches to traffic control. (Left: Conventional Signage. Right: ITS Signage with the ability to be controlled remotely.)

To progress further into this evaluation a clear and concise understanding of why reduced speed limits at roadworks are established needs to be clarified. Essentially when new roads are built they are either constructed in what is called a Greenfields job, where traffic is a non-issue, or a Brownfields job, where live traffic has some implication on the way the works are staged (ignoring detours). Since this dissertation focuses on vehicle/worker interaction and speed compliance, the elements of a Brownfields job is the most important and is explained below:

Simply put there are virtually only ever two methods of traffic management that can be employed on a brownfields job. That is, separating traffic from the work zone by means of protective devices such as temporary concrete barriers and constructing the works in stages or constructing the works under traffic where live lanes of vehicles are in very close proximity to the workers.

This understanding is essential, in that both cases alluded to above will require a reduction in speed from what is posted permanently, and gaining driver compliance with those speeds is necessary in both situations for the following reasons.

1. When works are constructed in stages and separated by protective devices it is often not the workers safety in jeopardy but the travelling public. The available space regularly becomes an issue for constructability purposes and in order to maximise that available space, temporary line marking (often a lesser standard to permanent works) is required and in turn the lane widths that vehicles travel in are also significantly reduced in certain instances. With the presence of roadworks and the increased amount of road furniture associated with it, sites can also appear quite cluttered or disorderly and lead to confusion amongst drivers, adding another valid reason for speed reduction, however the objectives of this research project is to evaluate the signage component of traffic management and therefore this is largely out of the scope of this dissertation.

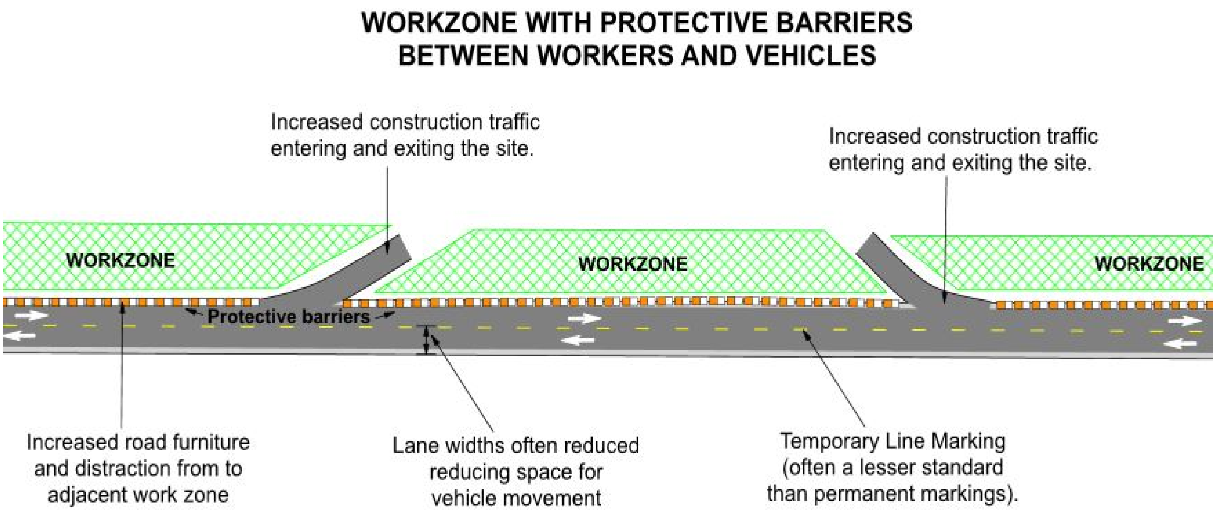

Figure 1.2: Work zone with protective barriers between workers and vehicles

2. When works are constructed under traffic where separation of workers and vehicles cannot be achieved a safe speed for vehicles to pass the site must be selected and this is often based on recognized standards (such as the MUTCD) or done on a risk assessment basis. When construction works are undertaken in this type of arrangement often lane closures need to be implemented which introduces another variable for drivers to contend with and also more resources are required on the roads. It is this type of situation where both the workers and drivers are at risk and the importance of complying with the reduce speed limits becomes even more critical.

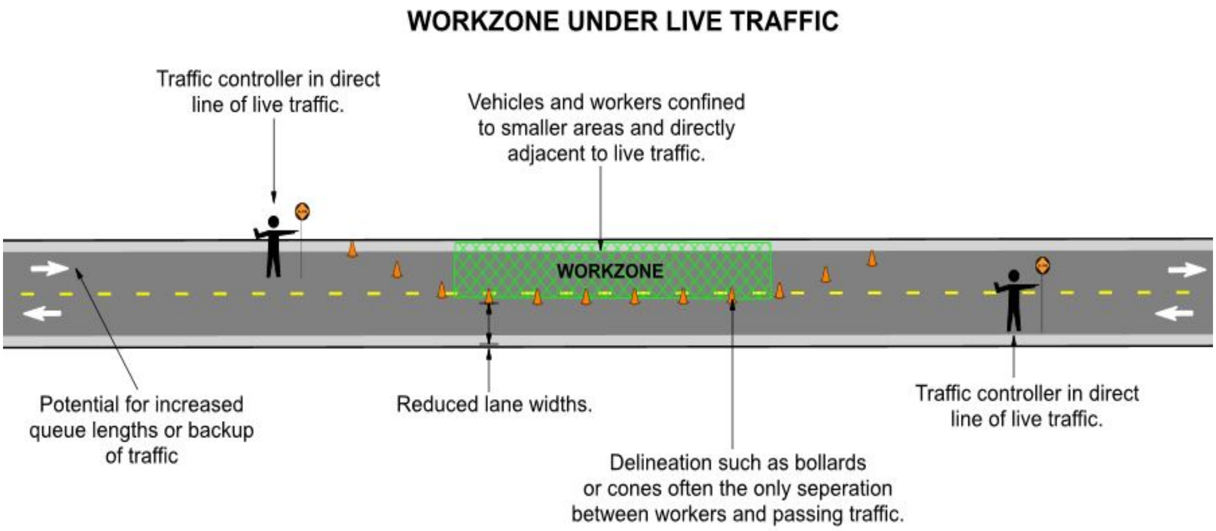

Figure 1.3: Work zone under live traffic arrangement

Having covered both characteristic work zone scenarios above it is evident that each brings its own risks, but in both circumstances the need for speed reductions is certainly required and the compliance with this speed is a necessity for the safety of all involved.

1.2 Driver awareness

Changing driver behaviour at roadworks sites is one of the greatest challenges faced and it is widely acknowledged that most drivers do not follow directions at roadworks sites, particularly the signage directing them to slow down. The primary purpose of any speed or information display on our roads is to have an immediate effect on the decisions that drivers make. It is therefore fundamental that the messages displayed are clear and concise, simple but eye catching and most importantly relevant to the situation - something conventional signage at roadworks does not currently seem to be achieving.

An understanding from drivers is also required, as to the consequences of inattention or lack of compliance with speeds, as even the slightest increase in speed can have dramatic effects - as demonstrated by numerous trials. A snapshot of one which is provided below (Department of Transport and Main Roads 2015)

Figure 1.4: A vehicles stopping distance travelling at 60km/h

Figure 1.5: A vehicle stopping distance travelling at 67km/h

As shown in figure 1.4 a vehicle travelling at the intended speed limit, in this case 60km/hr, had adequate time to react to the situation apply the brakes and stop prior to colliding with the dummy. At just 7km/hr more (Figure 1.5) the car collides with the dummy still travelling at 30km/hr, a speed that can still have fatal consequences.

This situation is relevant to roadworks situations as works are undertaken on a variety of roads with a variety of speed limits and often have personnel in the direct pathway of oncoming traffic. As the speed limit increases it becomes even more crucial to gain compliance and this concept is presented further in Figure 1.6 below.

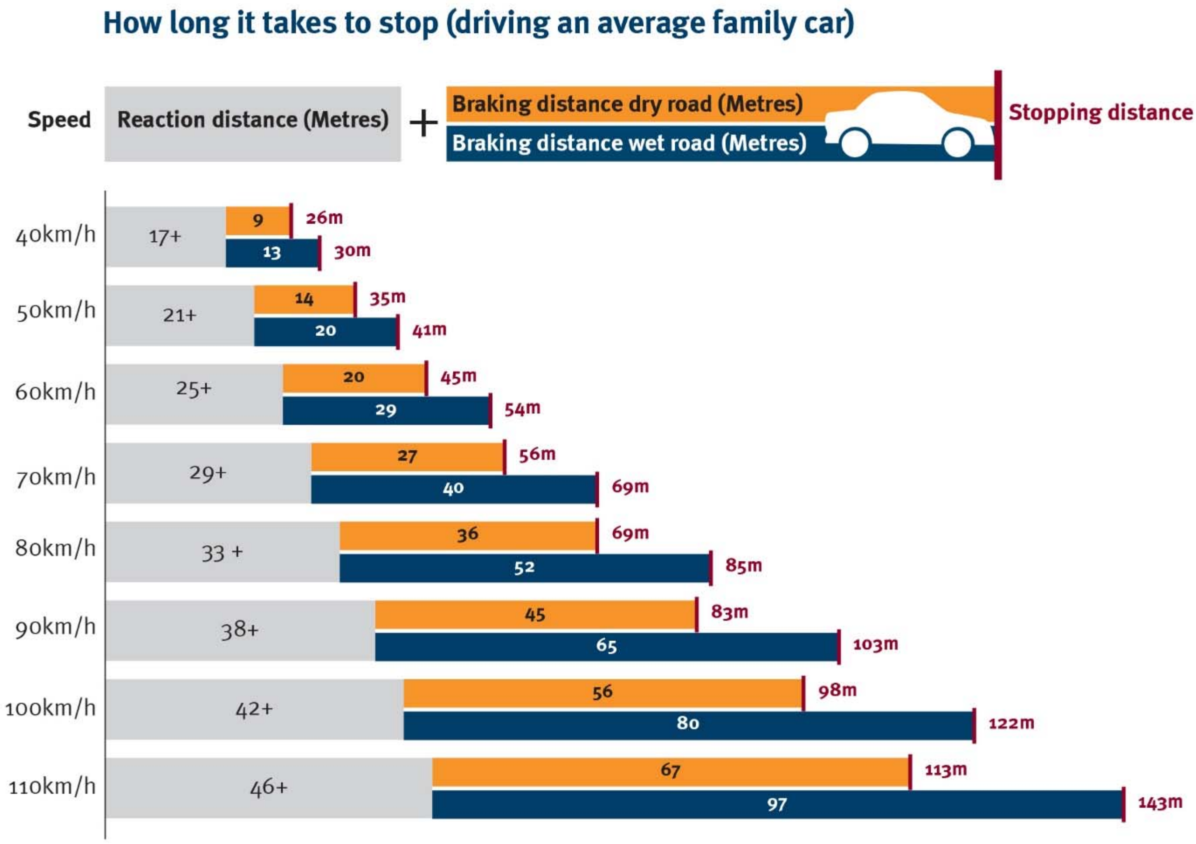

Figure 1.6: Stopping distances at various speeds (Department of Transport and Main Roads 2015)

1.3 Project Objectives

The following is the defined scope of the investigation into the effectiveness of Intelligent Transport Systems at reducing speeds through roadworks sites in Australia

I. Research the topic of traffic management and control. This includes gaining an understanding of the best practise in Australia.

II. Identify alternative traffic management or control methods such as ITS that have been trialled or are currently in use in Australia or other highly motorized countries and review their effectiveness.

III. Attain detailed statistics on roadworks traffic incidents to fill the current data gap in Australian research to gain a clearer understanding of the problem.

IV. Increase the understanding of the perception of road works sites through the eyes of the travelling public and from those at the fore-front of traffic management by developing appropriate surveys.

V. Identify and evaluate appropriate control measures to trial based on the information gained from the literature review and the developed surveys.

VI. Trial an appropriate innovative traffic control device and gather data on its effect on speed choices through road works sites.

VII. Produce results and evaluate all findings presenting them in appropriate legible and easy to understand formats.

VIII. Complete an academic dissertation providing conclusions, comparisons and recommendations on the effects of the selected innovative control device in regard to speed compliance and roadworks safety.

The literature review in Chapter 2 will provide comprehensive details to cover objectives I and II above. Discussions and Liaison with appropriate members of Safe Work Australia and Workplace Health and Safety will result in valuable statistics and ensure that objective III is met. This will similarly be presented in Chapter 2 – Literature Review. Chapter 3 – Methodology will provide the appropriate information to achieve all the project objectives while Chapter 4 – Survey Development explores objectives IV and V and summarises their results. Objective VI is addressed in Chapter 5 – Field Evaluation and Chapter 6 – Results, analyses and summarizes the findings while Chapter 7 and 8 discuss these results and clearly state the conclusions including a set of fitting recommendations.

1.4 Consequential Effects/Project Outcomes

Overall the vision of the project is to provide safer road works sites for the traffic controller, the workers on site and the road user passing through the site by gaining maximum compliance with the posted speed limits. There are both positive and negative consequential effects that may arise from the findings which have been detailed below:

Positive:

The vast majority of roadworks sites often appear cluttered and can often add to driver frustration when navigating through the site. This is one possible reason why many may fail to see and interpret road works signage. It is understood that the construction equipment and materials on site often cannot be removed and therefore the signage and controls used to manage traffic need to stand out, be clear, bold and concise. By reviewing the current signage and controls and developing innovative strategies, the first step of this puzzle may be completed and driver distraction be reduced. This alone will lead toward an increased safety for the traffic controllers, workers and the travelling public.

Other positive effects of controlling worksites with ITS may be to provide more effective and therefore time reduced travel through work zones. If new techniques are implemented and are consistent across work zones it may increase the reliability of signage from a driver's perspective and speed regulations followed more stringently. By using ITS in temporary situations it will ensure that the country is keeping up with advances in technology currently being used in permanent situation and bring a harmonization to the feel of the road network. The ability to control the devices remotely is another huge positive consequential effect.

Negative:

Many road authorities, contractors and standards regulators would be affected by a large change to current operating standards. There would be a significant roll out plan needed to be implemented and of course the approvals that come with it. Up-front costs for traffic management devices are likely to increase as could ongoing maintenance cost of the equipment. A change to an ITS based system would also enforce a change required to traffic control companies way of thinking and perhaps even their company structure. This may inflict negative responses across the industry and cause extended delays to its implementation.

At the worksites themselves confusion for drivers and workers alike may take time to dissipate and cause increased frustration during the interim phases. A substantial increase in training would be required to ensure traffic management personnel across the board are inline and implementing the schemes correctly, efficiently and safely.

Chapter 2 – Background/Literature Review

The following literature review was undertaken by asking a series of relevant questions to identify and understand the current "state of the art" in traffic management and control at roadworks in Australia. Once this knowledge base was established a further investigation into previous publications involving work zone speed control and driver compliance at roadworks was undertaken. This final phase looked specifically at the use of innovative traffic control devices such as ITS in Australia and overseas.

2.1 Conventional control

2.1.1 What is traffic management at roadworks and why do we need it?

In general (Austroads Inc. 2009) refers to traffic management as the organisation, arrangement, guidance and control of both stationary and moving traffic, including pedestrians, cyclists and all types of vehicles. Its aim is to provide for the safe, orderly and efficient movement of persons and goods, and to protect and where possible enhance the quality of the local environment on and adjacent to roads. Along similar lines (Safe Work Australia 2012) describes traffic management as the safe movement of vehicles (such as cars, trucks and buses), mobile powered plant (such as forklifts) and pedestrians within, through and around sites where work is carried out.

More specifically to roadworks situations the Manual of Uniform Transport Devices (MUTCD) a reference material widely used within Queensland and across Australia breaks traffic management into similar categories. Movement of traffic through the work area under closely controlled conditions, movement past the work area by mean of a delineated path alongside but clear of the work area and movement around the work area by means of a detour or closure of the road for short periods of time while work is carried out. (Kirschfink, Hernández & Boero 2000) break traffic management into two different classes: direct control measures using traffic lights and variable message signs and (Mattox III et al. 2007) Indirect control measures like recommendations for the drivers by means of VDS (variable direction signs and text panels), warning messages (via broadcast, RDS/TMC or handy-based services), pre-trip information (e.g. via Internet) and individual driver information systems.

Traffic management is required from small scale maintenance projects through to major construction projects mainly in the roadworks industry. In small scale projects the objectives of a traffic management plan may be to find the most simplified and effective means to complete the work whereas on the other end of the scale many more decisions need to be made such as selecting appropriate delineation and traffic staging. Considering the above points, the main purpose behind traffic management is to effectively control the interaction of roadworks personnel and the travelling public with a high regard to the safety of all. This dissertation will be specifically focused on movement of traffic through or past a worksite and how best to achieve speed compliance in these areas.

2.1.2 What standards govern traffic management implementation at roadworks in Australia?

Within Queensland traffic management at roadworks relies largely on the Manual of Uniform Traffic Control Devices (MUTCD) which is based on the Australian standard AS1742.3-2009, Traffic Control for Works on Roads. In other highly motorized states across Australia such as New South Wales and Victoria this same standard is adhered to but presented in manuals of their own such as the TCAW (Traffic Control at Worksites) manual in New South Wales. Other reference materials in Queensland include, the Traffic and Road Use Management Manual (TRUM) Volume 7: Roadworks and Traffic management for construction or maintenance work – Code of Practise 2008. The Department of Transport and Main Roads also include Technical Specifications such as MRTS02 – Provision for Traffic in their construction contracts which may include further information that is site specific such as minimum lane widths, minimum posted speeds and working hours. There are also equivalent documents to the MRTS02 in other states in Australia such as the Road and Maritime Services Specification G10 – Control of Traffic in New South Wales. Austroads publications are also prominent throughout Australia and the guidelines in these publications are adopted widely across Australia. The Austroads Guide to Traffic Management publication covers thirteen various aspects of traffic management, including Traffic Operations, Traffic Control and Communications and Road Environment Safety to name a few.

2.1.3 What are the problems that occur with current traffic management?

Within Queensland alone there is a lack of compliance with the current arrangements of temporary signage at work zones. (Aarts & Van Schagen 2006) report that poor compliance with reduced speed limits is a major contributor to the high risk and relatively high severity of roadwork crashes, which often involve public vehicles. There is growing support for that claim which is further confirmed with measurements of speeds at Queensland roadwork sites demonstrating high levels of noncompliance with reduced speed limits in typical situations (Blackman, Debnath & Haworth 2014a; Debnath, Blackman & Haworth 2014). This noncompliance issue may be a largely contributing factor to road works accidents with (Blackman, Debnath & Haworth 2014b) stating that Dozens of workers are killed or seriously injured by moving vehicles every year at Australian roadwork sites, while similar outcomes also befall many motorists involved in work zone crashes.

Further trials have also been undertaken on the effect of various traffic control treatments at roadworks sites using AS1742.3-2009 as the base standard. (Cordingley & Jarvis 1982) investigated six common traffic control treatments employed at roadwork sites with the effectiveness of the various treatments measured in terms of their ability to reduce speed past the roadworks. The major results showed that it was only control treatments which contained an element of driver surveillance (flagman or police) which resulted in significant reductions in vehicle speeds past the site. These trials further confirm what (Aarts & Van Schagen 2006) and (Blackman, Debnath & Haworth 2014b) have stated in regards to noncompliance of temporary signage.

While lack of compliance with speed signs seem to be one of the major problems at roadworks this could be due to sites becoming cluttered with signage and the mix of inadequate signage with the general untidiness that is associated around work zone causing confusion toward drivers. (Arrows, 1998) confirms that road work zones constitute traffic situations that are unexpected and unusual for the majority of drivers. The often inconsistent and sometimes inadequate implementation of road work zones can be a source of confusion, leading to driver error and accidents.

Figure 2.1 – A Cause for Confusion

2.1.4 What are the consequences associated with these problems in conventional traffic control?

In the United States the number of fatalities within work zones increased from less than 800 in 1995 to more than 1,050 in 2005 (Benekohal et al. 2010). However within Australia it is very difficult to identify roadwork zone incidents in official records (Haworth, Symmons & Mulvihill 2002) but based on New South data (RTA 2008) estimates that at least 50 deaths and 750 injuries result from traffic crashes annually in Australian roadwork zones. With only limited detail available in publications this research project emphasized a concerted effort to gaining statistics and details of road work incidents in Australia. In doing so, members of Workplace Health and Safety, Safe Work Australia and Department of Transport and Main Roads data analysis team were individually contacted and valuable statistics were gained with specific focus on roadworks.

In Queensland, police crash data (See Appendix B for full report) provided by the Transport and Main Roads data analysis team shows that between 2007 and 2011 a total of 203 casualties - resulting from motor vehicle crashes involving roadworks were recorded. These resulted in either minor injury, medical treatment, hospitalisation or in the worst case death. Of the 203 incidents 57 can be attributed to drivers either hitting an object or hitting a pedestrian and it is assumed but not confirmed that any injuries or fatalities to do with road workers (including traffic controllers) could be included in this figure however, no further evidence or detail within this set of data could be identified. Interestingly (and in contrast to statements from earlier literature provided) only 6.4% of crashes were attributed to speeding, however, a majority (60.1%) were still contributed to drivers disobeying road rules and this might include ignoring advanced warning signs or traffic controllers stop batons.

Casualty - Severity	2007	2008	2009	2010	2011	Total
Fatality	2	0	0	0	0	2
Hospitalised	17	15	10	6	8	56
Medically treated	16	11	16	14	27	84
Minor injury	15	12	11	12	11	61
Total Casualties	50	38	37	32	46	203

Table 2.1: Queensland Police Crash Data involving roadworks – Crash Severity

Casualty - Crash Nature	2007	2008	2009	2010	2011	Total
Hit object	11	3	7	1	8	30
Hit pedestrian	4	4	5	7	7	27
Head-on	0	7	4	0	0	11
Angle	4	9	1	6	3	23
Overturned	5	1	0	0	1	7
Rear-end	21	14	14	14	22	85
Fall from vehicle	2	0	0	1	2	5
Sideswipe	2	0	4	3	1	10
Hit parked vehicle	1	0	1	0	2	4
Other	0	0	1	0	0	1
Total Casualties	50	38	37	32	46	203

Table 2.2: Queensland Police Crash Data involving roadworks – Crash Nature

Safe work Australia produced a more promising report which included data between 2003 - 2013 and had a much more detailed structure. Of particular interest was the statistics acquired for work-related injuries and fatalities in construction across the whole of Australia. The document showed that a total of 401 fatalities across the construction industry occurred over the 10 year period. In narrowing these results further the fatalities by mechanism of incident were reviewed and indicated that 48 of these fatalities were due to being hit by moving objects (i.e. cars, trucks or plant). These statistics were also broken down further to show totals state by state and are included in Table 2.3 and Table 2.4 respectively.

Year	Mechanism of incident							Total
	Falls from a height	Vehicle collision	Contact with electricity	Being hit by moving objects	Being hit by falling objects	Trapped between or in equip-ment	Other	
2003	14	5	9	8	4	1	2	43
2004	11	7	6	4	3	3	1	35
2005	7	6	6	4	1	2	4	30
2006	16	7	7	3	6	2	2	43
2007	10	10	5	7	1	1	11	45
2008	11	4	5	7	5	2	4	38
2009	8	3	7	3	6	4	5	36
2010	9	9	4	4	5	6	4	41
2011	9	10	6	2	7	6	1	41
2012	12	3	3	4	4	2	2	30
2013	5	1	3	2	4	2	2	19
Total	**112**	**65**	**61**	**48**	**46**	**31**	**38**	**401**
% of Total	**28%**	**16%**	**15%**	**12%**	**11%**	**8%**	**9%**	**100%**

Table 2.3: Worker fatalities in the construction industry: number by mechanism of incident, 2003 to 2013 (Work-related Injuries and Fatalities in Construction, Australia, 2003 to 2013, p18)

Mechanism of incident	Number of fatalities						
	New South Wales	Victoria	Queens-land	Western Australia	South Australia	Tasmania	Australia
Falls from a height	42	23	23	9	7	3	112
Vehicle collision	19	15	19	2	4	4	65
Contact with electricity	20	9	20	5	2	1	61
Being hit by moving objects	8	9	15	9	4	3	48
Being hit by falling objects	14	9	14	5	1	2	46
Other mechanisms	16	14	20	7	9	1	69
Total	**119**	**79**	**111**	**37**	**27**	**14**	**401**

Table 2.4: Worker fatalities in the construction industry: number by mechanism of incident and state or territory of death, 2003 to 2013 (Work-related Injuries and Fatalities in Construction, Australia, 2003 to 2013, p19)

Having established a suitable set of data for analysis the next step was to refine the incidents occurring within the category (being hit by moving objects) in order to understand the occupation of workers involved. Of the 48 fatalities occurring due to being hit by moving objects 11 could be deemed with certainty to have an involvement with roadworks or traffic management/control situations, that is, those with a traffic control labourer occupation.

Occupation	Mechanism of incident						Total	% of total
	Falls from height	Contact with electricity	Vehicle collision	Being hit by moving objects	Being hit by falling objects	Other mech-anisms		
Technicians & trades workers	**68**	**49**	**19**	**9**	**16**	**23**	**184**	**46%**
Electricians	12	30	7	2	0	3	54	13%
Bricklayers, carpenters & joiners	17	5	3	2	6	6	39	10%
Glaziers, plasterers & tilers	13	2	1	1	2	2	21	5%
Plumbers	8	5	2	1	2	3	21	5%
Painting trades workers	12	2	1	1	0	3	19	5%
Electronics & telecommunications trades workers	3	4	2	1	0	2	12	3%
Labourers	**39**	**11**	**12**	**18**	**16**	**16**	**112**	**28%**
Building & plumbing labourers	18	4	3	3	9	4	41	10%
Structural steel construction workers	6	0	2	0	3	2	13	3%
Concreters	3	0	2	2	2	2	11	3%
Traffic control labourers	0	0	0	11	0	0	11	3%
Machinery operators & drivers	**2**	**1**	**22**	**18**	**11**	**29**	**83**	**21%**
Earthmoving plant operators	1	1	14	8	5	9	38	9%
Truck drivers	0	0	9	7	6	1	23	6%
Machine & stationary plant operators	1	1	2	2	2	6	14	3%
Managers	**2**	**0**	**7**	**3**	**3**	**0**	**15**	**4%**
Other occupations	**1**	**0**	**5**	**0**	**0**	**1**	**7**	**2%**
Total	**112**	**61**	**65**	**48**	**46**	**69**	**401**	**100%**

Table 2.5: Worker fatalities in the construction industry: number by occupation and mechanism of incident (Work-related Injuries and Fatalities in Construction, Australia, 2003 to 2013, p23)

Although part of the 11 traffic control fatalities could be attributed to onsite vehicles rather than errant vehicles from the travelling public it is largely known that crashes involving the interaction between public vehicles and traffic controllers do occur frequently as numerous media articles can support and this number is of relative accuracy.

2.1.5 How might we approach improving the situation?

As described in section 2.1.3 there is a common theme in that noncompliance with temporary signage is a major factor in work zone accidents. Whether due to excess speed or simply inattention on the driver's behalf it throws a challenge as to how the current operating systems can be improved and also, how we change driver behaviour. (Scriba & Atkinson 2014) produced an article on creating smarter work zones and present ideas that agencies can incorporate into their transportation management plans or TMP's. Of particular interest in this article was the work zone technologies table which includes potential ITS devices for creating safer and more efficient work zones. These technologies have been split into six categories which are devices for:

1. Managing Speeds
2. Reducing exposure
3. Monitoring performance and management
4. Identifying and preventing incidents
5. Managing traffic and,
6. Providing Travel information

Due to the extent of this table and the volume of information contained within, the document can be found in Appendix C.

Further to this (Benekohal et al. 2010) and (Fontaine, Schrock & Ullman 2002) both investigated the use of automated speed photo radar enforcement systems and their effectiveness of gaining driver compliance in work zones and summarized that automated speed enforcement has significantly reduced the mean speed and percent exceeding the speed limit in the locations it has been used. These results suggest that delivering activate enforcement is critical to improving the situation and could be combined with further innovative ITS solutions to improve work zone safety.

It appears that conventional regulatory signage does not currently influence the speed selection the majority of drivers take through a work zone and better communication of the risks need to be identified. Road users have also highlighted their frustrations with roadwork signage and it is understood that improved and consistent signage may well be one of the most significant issues to be addressed. Innovative and attention-grabbing messages were tested by (Wang, Dixon & Jared 2003) finding immediate speed reductions and accordingly (Brewer et al. 2006) and (Bai & Li 2006) showed VMS to be more effective than traditional traffic control devices in reducing the number of speeding vehicles. A combination of active speed enforcement and innovative communication is a promising process in meeting the projects objectives but further investigation into any previous ITS type control and driver compliance needs to be understood.

2.2 ITS Control

2.2.1 What is ITS and how is it currently being used?

Intelligent transportation systems are advanced applications which aim to provide innovative solutions relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. (EU directive 2010) defines ITS as systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport.

Some of the applications ITS is currently being used for in permanent situations include;

- Real time travel times
- Automatic road/speed enforcement
- Collision avoidance systems
- Dynamic traffic light sequencing, and most commonly in Australia;
- Variable Speed Limits

There appears to be a general consensus that the development and use of intelligent transport systems has improved and will continue to improve road safety and efficiency. ITS has been around since the 30's and has slowly been creeping into our everyday lives (Figueiredo et al. 2001) state that "the major developments on ITS were made in Europe, U.S. and Japan, and it has gone through three phases [1]: preparation (1930-1980), feasibility study (1980-1995) and product development (1995-present)". (Washimi, 2014) also mention the developments of signal controllers in Japan in the 1960's and implementation of electronic toll collection systems in the 1990's. Although the idea has been in the pipeline for quite some time, relatively speaking the technology is still fairly new. The advance in this technology described above relate to the use of ITS on final design or permanent works and have been developed to increase the efficiency and safety of our roads in their permanent alignment. In road works situation however, this technology needs to be adapted on a smaller scale and various options are discussed further on.

2.2.2 Do current traffic management standards allow for innovation?

In Queensland the manual of Uniform Traffic Control Devices allows the use of alternative device layouts using new and/or improved devices however, new or improved devices require approval by the Department of Transport and Main Roads. The TRUM manual however has a technical note for the use of supplementary devices at roadworks showing an acceptance for innovative processes surrounding traffic management and recently (April 2015) information on the use of other innovative supplementary devices at roadworks to reduce speed have been provided in the MUTCD Part 3 Supplement – Clause 3.5.5.

2.2.3 What type of ITS controls are currently being used or have been trialled at Roadworks in Australia and what effect have they had?

A reasonable amount of research has been undertaken in the past on the effectiveness of ITS measures in controlling speeds in work zones, however the majority of studies sourced in this literature review have originated in the United States and there appears to be a slight data gap in the information available for ITS control and Australian work zones.

The technological solutions used in the United States cover a vast array of innovations including drone radar, speed monitoring displays, changeable message signs (CMS) and vehicle activated signage and their effects have been positive in reducing overall speeds (Mattox III et al. 2007)

(Garber & Srinivasan 1998) showed that Changeable Message Signs (CMS) with radar is effective in reducing the speeds of speeding drivers in a work zone for short durations (one week or less) and even when used for prolonged periods of time (up to seven weeks) with a decrease in average speed of 4-5mph. Similarly (McCoy, Bonneson & Kollbaum 1995) evaluated the effectiveness of a vehicle speed warning system that used radar to detect vehicle speeds approaching the work zone and displayed these speeds on two portable displays. The results indicated that the speed monitoring displays reduced the mean speed of traffic by up to 4.7mph.

Still overseas (Lyles, Taylor & Grossklaus 2003) conducted a study in 2003 of a Michigan work zone and examined another variant of ITS signage, a prototype variable speed limit (VSL) system and evaluated the effectiveness of the system at improving speed limit compliance and the credibility of speed limits. As a result of using VSL, both the speed limits displayed by the VSL trailers and operating speeds generally increased, average speed was generally below the displayed speed for VSL, and drivers maintained more consistent speeds during non-peak periods, especially at night.

In Australia there is limited research material available that show the effectiveness of such devices in roadworks situations however, a conference paper by (Burke 2015) tells about Brisbane City Councils proactive approach to road safety and innovative speed control by installing 26 portable speed warning signs on local streets and roads. These portable speed warning signs have been operational since November 2013 and in the 17 months up to the end of the March 2015, have subsequently captured 25.1 Million motorists and advised them to slow down if driving over the posted speed limit. The data from each of these sites has shown a marked decrease in the number of motorists travelling over the speed limit as a consequence of being advised of their travelling speed.

Another Australian research paper (Mabbott et al. 2005) evaluated the effects of Speed Limiting Locally Operating Warning Signs (SLLOWS). The SLLOWS system is another Vehicle-activated sign that simply gives speeding motorists one message – 'Slow Down' and the results suggest that SLLOWS can be effective in reducing speeds on suburban roads. However it was noted that their optimum use is as a specific-purpose speed reduction tool over a limited period of time in a limited area. The same report takes that idea one step further and talks about the so-called 'halo effect', where driver behaviour remains changed for a period of time before reverting to pre-trial levels and researchers generally agree the 'halo effect' is very fleeting.

Considering the points discussed in this section it is noted that innovative ITS speed reduction techniques in work zones have been trialled with successful results, however the majority of results available are limited to work zones in the United States. There have been trials carried out in Australia but these seem to be limited to local roads or roads in their permanent alignment and a suitable set of data for work zone activity would be highly useful. Other interesting topics arising from the literature review is the effect police presence has on results and also the so called "Halo Effect", both of which would be suitable to test in further trials.

Chapter 3 – Methodology

3.1 Brief

The planning and procedures required to fulfil the projects objectives are detailed in the following Methodology Outline. The research will use a combination of qualitative and quantitative methodology in investigating the effectiveness of Intelligent Transport Systems in road works zones.

3.2 Methodology Outline

The research approach used was conducted in four stages: a literature review, the development and carrying out of two nationwide surveys, selection of a suitable traffic control device to trial based on the literature review and survey results and finally; field testing. The literature review was broken into two main focus areas, Conventional Traffic Control and ITS traffic control. To gain a further understanding of the topic a series of relevant questions were answered under each subsection and focused on defining what traffic management is and how it is currently being used. The literature review then focused on improvements to the current situation by reviewing innovative controls being used within Australia and in other highly motorized countries. Two nationwide surveys were then conducted. The initial survey was aimed at the general public to gain an appreciation of their perceptions of roadwork sites. The second survey was conducted to document the extent to which innovative traffic control devices have been or are being used from those at the forefront of traffic management in Australia. To complete this task, members of the Traffic Management Association of Australia (TMAA) were requested to complete the survey which was distributed through the Department of Transport and Main Roads. The TMAA comprises members from various traffic management and control departments such as civil contractors, traffic control companies, state transport departments, police departments and local transport authorities alike. Based on the survey results and a correlation to the literature review, a suitable innovative traffic control device was selected for field testing. The selected device was then trialled on an established road works sites on the Bruce Highway on the Sunshine Coast in Queensland and its effectiveness on traffic speeds and potential impact on the safety of drivers and work site personnel evaluated.

Chapter 4 – Survey Developments

Two surveys were developed for this research project. The first of which was aimed at the general public and sought their perspective on roadworks sites. The second survey included more technical questions and was aimed at those in the industry with a greater knowledge of traffic management and control than the layman. That is, people actively involved in the preparation and implementation of traffic management plans across Australia.

4.1 Survey 1: General Public

4.1.1 Survey Design

The general public survey was designed in a way that encouraged open participation and encouraged all opinions. The intent was to gain an understanding of motorists' perceptions in work zones as they may differ significantly from that of an engineer who prepares the traffic management plans or even differ from the current standards in place. An understanding from a driver's perspective may be useful and alter the thinking of those preparing the traffic guidance schemes. The survey included eight principal questions and was distributed through family, friends, colleagues and social media via https://www.surveymonkey.com/r/8JRBPFG

4.1.2 Survey 1 Results Summary

A total of 83 responses were returned for the general public survey. The responses are summarized by question below and indicate key observations. In addition, the original survey layout and all detailed responses have been included in Appendix D

1. Have you ever driven through a roadworks site in Queensland?

Of the 83 respondents, 82 answered the question and 1 participant skipped the question. Among the 82 participants 100% nominated that they had driven through a roadworks site in Queensland.

2. Why do you think speeds are reduced through road works?

78.31% of respondents agreed that the reason for reducing speeds through roadworks was for the safety of the workers and on site personnel while 19.28% said it was for the safety of the traveling public. The least important was to allow construction vehicles adequate time to enter and exit the work zone with only 2.41% selecting this at the most important reason for reducing speeds.

3. Do you as a driver/passenger traveling through roadworks sites feel at risk?

Of the 82 respondents who answered the question an overwhelmingly and interesting response was that 92.68% of participants did not feel at risk when traveling through road works sites. Through the literature presented earlier in the report we know that speeds are reduced for both workers and the general public but clearly the increase in road furniture, reduced lane widths and general clutter does not appear to have a significant effect on how the drivers/passenger view their own safety.

4. Have you ever sped through a roadworks site?

Again, 82 respondents answered this question and 59.76% said they have sped through roadworks sites leaving 40.24% claiming they have always abided by the reduced speed limits. So, close on 60% of people who responded to the survey have at some point sped through road works sites but based on the answers from Questions 2 – 4 this suggests that although the majority of people agree that speeds are reduced for the safety of onsite personnel and not themselves they are either unaware of the damage they could cause or have no regard for the safety of workers on site.

5. If yes to Question 4, what is the main reason why you find yourself speeding?

Of the 49 respondents who had sped through a roadworks site at some point in time all 49 gave reasons for why they find themselves speeding and this gives evidence as to why the answers from questions 2 and 3 may be skewed. The majority of answers suggested the reason for speeding is not because the signage wasn't clear or that they didn't see the reduced speeds but rather that far too often speed reductions were in place but no workers could be seen or there seemed to be no reason for the reduction. Others also felt comfortable with selecting a speed they thought was suitable for the time and place.

6. Have you ever received a speeding fine through a road works site?

Of the 82 respondents 4.88% had received a speeding fine through a roadworks site suggesting that some police enforcement is taking place in these areas but evidently (based on question 6 answers) is not having a tremendous effect on speed choices or speed compliance.

7. In your opinion, which of the following do you think would be MOST effective in reducing speeds through roadworks sites?

- *Enforcement (I.e. Fixed speed cameras or double demerit points through roadworks zones)*
- *More concise signage (I.e. Large flashing speed signs with variable speed limits, similar to those seen in school zones - when workers are on the road the sign might display 40km/hr, when there are no workers the sign might display 60km/hr)*
- *Radio blocking (I.e. Audible messages communicated through your radio when encroaching roadwork zones)*
- *Intelligent advanced warning signage (I.e. Vehicle activated signage informing drivers of their current speed or estimated travel time through a roadworks site.)*
- *Reduce available space (I.e. Narrower lane lines creating a sense of danger to the driver/passenger)*

The majority of participants agreed that more concise signage that has the ability to be controlled remotely and the ability to have variable speed limits depending on the conditions. This was closely followed by enforcement measures such as fixed speed cameras or double demerit points through road work zones. The use of intelligent advanced warning signage such as vehicle activated signage also rated highly among the respondents answers.

8. Can you provide any further ideas on traffic control measures that may improve safety through roadwork zones?

From the 83 respondents who undertook the survey, 28 provided further comment on their ideas for reducing speeds. As mentioned earlier the detailed responses have been included in Appendix D which is appropriate for the extent and variance in answers provided for this question.

4.2 Survey 2: Technical Survey

4.2.1 Survey Design

The second survey was aimed at those at the forefront of traffic management in Australia and sought to understand what innovative controls, if any had been used previously to reduce speeds at roadworks. This survey was distributed nationwide with the help from the department of main roads and reached members of the Traffic Management Association of Australia in five states. Being a more technical based survey it was expected that the number of respondents would be reduced as was the case with 27 people participating. This survey included seven principal questions, each which has been summarized below. The original layout and full extent of answers can be found in Appendix E. The web link used for distribution was (https://www.surveymonkey.com/r/ZD8M73K).

4.2.1 Survey 2 Results Summary

1. Please select your State or Territory:

Responses were received from participants across 5 states in Australia including:

- Queensland: 55.56%
- Victoria: 18.52%
- New South Wales: 14.81%
- Northern Territory: 7.41%
- South Australia: 3.7%

2. What standards, manuals or guidelines does your agency base their traffic management plans or traffic guidance schemes for controlling traffic at roadworks sites?

Queensland:
MUTCD Part 3 – Works on Roads (based on AS1742.3), Traffic and Road Use Manual (TRUM), Austroads Guides, Traffic Management for Construction or Maintenance Work Code of Practice 2008, MRTS02 – Provision for Traffic

Victoria:

AS1742.3, Road Management Act 2004, VIC Code of Practice for Worksite Safety 2010

New South Wales:

Road and Maritime (RMS) Traffic Control at Worksites (TCAWS) Manual Version 4 and AS1742.3

Northern Territory:

AS1742.3 and Northern Territory Permit to work

South Australia:

AS1742.3 and South Australian Code of Practice - Road Traffic Act

3. Have you or your agency used or trialled any innovative traffic control devices that are not included in the documents listed in Question 2?

62.96% of respondents in the technical field have trialled innovative traffic control techniques that differ from those set out in the manuals listed in Question 2.

4. If yes to Question 2, what types of devices have you trialled/used?
(E.g. this could be items such as portable rumble strips, intrusion warning devices, vehicle activated signage or any other device you believe differs from the documents listed in Question 2)

All respondents who answered yes to Question 3 provided examples of innovative traffic control techniques they have used or trialled that differ to the standards or manuals in their state. Examples of these device are provided below. A full list is also contained within Appendix E

- Drop deck trucks - Attenuator vehicles - Multi Message signage
- Mobile camera / recording / radar system.
- Frangible permanent sign cover-ups.
- Early Warning Systems
- Portable Rumble Strips
- Vehicle Mounted Speed Radar Signs.
- Portable Speed Humps
- Video Camera on Tripod
- Speed and Surveillance Camera

5. Please describe the most effective traffic control device/s used by you or your agency to reduce vehicle speeds through roadworks sites.
(You may include devices included in the documents described in Question 2 or any innovative devices used/trialled as described in Question 4.)

25 of the 27 respondents made comment on Question 5 with the majority stating that the most effective means of slowing traffic is to have police presence. A minority also stated the use of speed radar signage or variable messages signs had positive effects on reducing speeds.

6. In your opinion, which of the following do you think would be MOST effective in reducing speeds through roadworks sites?

- *Enforcement (I.e. Fixed speed cameras or double demerit points through roadworks zones)*
- *More concise signage (I.e. Large flashing speed signs with variable speed limits. Similar to those seen in school zones - when workers are on the road the sign might display 40km/hr, when there are no workers the sign might display 60km/hr)*
- *Radio blocking (I.e. Audible messages communicated through your radio when encroaching roadwork zones)*
- *Intelligent advanced warning signage (I.e. Vehicle activated signage informing drivers of their current speed or estimated travel time through a roadworks site)*
- *Reduce available space (I.e. Narrower lane lines creating a sense of danger to the driver/passengers)*

The answers provided differed slightly from that of the general public's response in that the majority of those involved in traffic management suggested enforcement is the most effective means of reducing speeds through roadworks sites. This when then followed by the use of intelligent advanced warning signage and more concise signage that has the ability to be controlled remotely and the ability to have variable speed limits depending on the conditions

7. Can you provide any further ideas on traffic control measures that may improve safety through roadwork zones?

The main message apparent in the additional responses suggest educational campaigns will benefit safety around roadworks.

Chapter 5 - Field evaluation

5.1 Device Selection

The selection of a suitable Intelligent Transport device to trial took into account the information gathered as part of the literature review along with the answers and feedback received in both surveys. The device needed to differ from conventional devices common at Australian worksites and also generate an interaction with drivers as per the intention of ITS. In both surveys it was suggested that more concise and accurate signage was required and that vehicle activated signage may be one of the most effective means of reducing speeds. Variable message boards with speed display were considered due to their immediate availability and minimal hire expense however similar looking devices are frequently used as message boards and may not have engaged the travelling public in the intended way.

It was decided that a vehicle activated speed radar sign would be appropriate to trial, based on the limited data that has been generated from such a device in Australian work zones. Another significant factor in selecting the speed radar sign was the guidance on its use which is included in a supplement to the MUTCD (MUTCD Part 3 Supplement April 2015). The final device selected was an EVOLIS Solution Speed display purchased through Artcraft Pty Ltd and gratefully funded by Bielby Holdings Pty Ltd.

5.2 Device Features

The speed radar device selected is capable of the following:

- The ability to display vehicle speeds and messages for a minimum period of five seconds.
- A 300 metre detection range and the ability to display a message every three seconds.
- Allows remote access via Bluetooth for the purpose of programming and data collection.
- Has internal storage capacity to store data for up to 6 months.
- Has the ability to obtain speed data and export the data to an excel file for graph preparation.
- Ability to switch off the device remotely.
- Operate through the use of solar power with battery backup.

- Complies with the requirements of MRTS218
- Has a three colour speed display (Red, Amber & Green)
- Has the ability to program custom messages

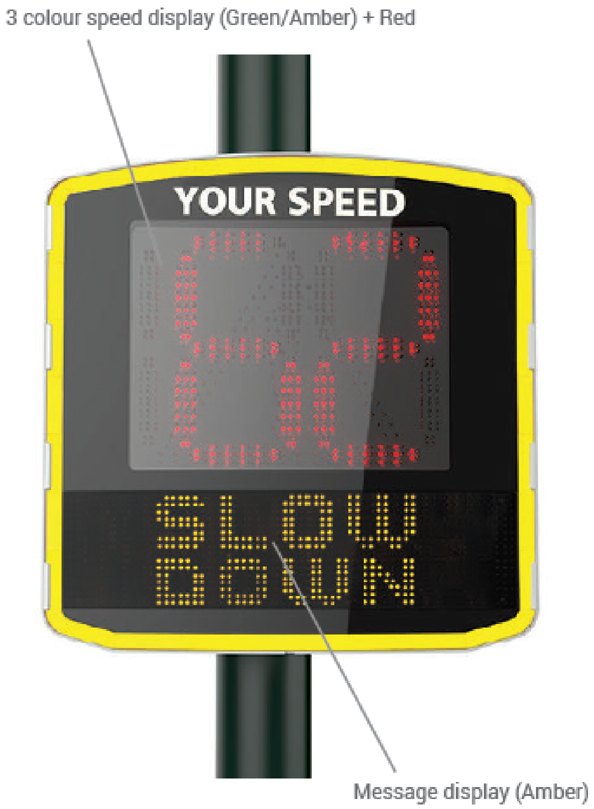

Figure 5.1: Vehicle activated speed radar sign

5.3 Device Installation

For best operating performances the speed radar sign was installed according to the following criteria:

- An open field of view at least 150m upstream of the sign
- A minimum of 70m away from any large road signs to avoid disturbance to the radar beam
- Away from area of cross traffic to avoid detecting vehicles on opposing roads
- Between 2.2m and 5m high (calculated from the bottom edge of the speed display) and,
- A maximum of 3m from the road edge and parallel to the road edge

.

5.4 Data Collection Site

With a suitable device selected an appropriate data collection site was required. Selecting potential sites was based on the need for the work zone to be operating at a high level of service and in free-flow condition with minimal speed influence from traffic congestion. In addition, it was important that the work zone be active and that activity during data collection periods be continuous. It was also appropriate to consider the approvals necessary to undertake these trials on an active site and based on these criteria it was required to involve the Department of Transport and Main Roads. With their approval the data collection site chosen was on a section of the Bruce Highway Upgrade between Cooroy and Curra in the Sunshine Coast region of Queensland.

Figure 5.1: Data Collection Site: Bruce Highway Upgrade – Cooroy to Curra, Pomona QLD – Perspective view

The data collection site shown in figure 5.1 is representative of a worksite where worker and vehicle separation is done so through the use more heavy duty road furniture such as concrete barriers, guardrail and end treatments. The lane widths at this particular site have been reduced and opposing traffic is separated only by a painted median island. The speed radar sign was positioned on the northbound side of the road (left hand side of figure 5.1) with clear visibility to the oncoming traffic and prior to a site access and a significant chicane in the road - an area where the importance of speed compliance was at its highest.

A top view of the site has also been included as is shown in Figure 5.2 below.

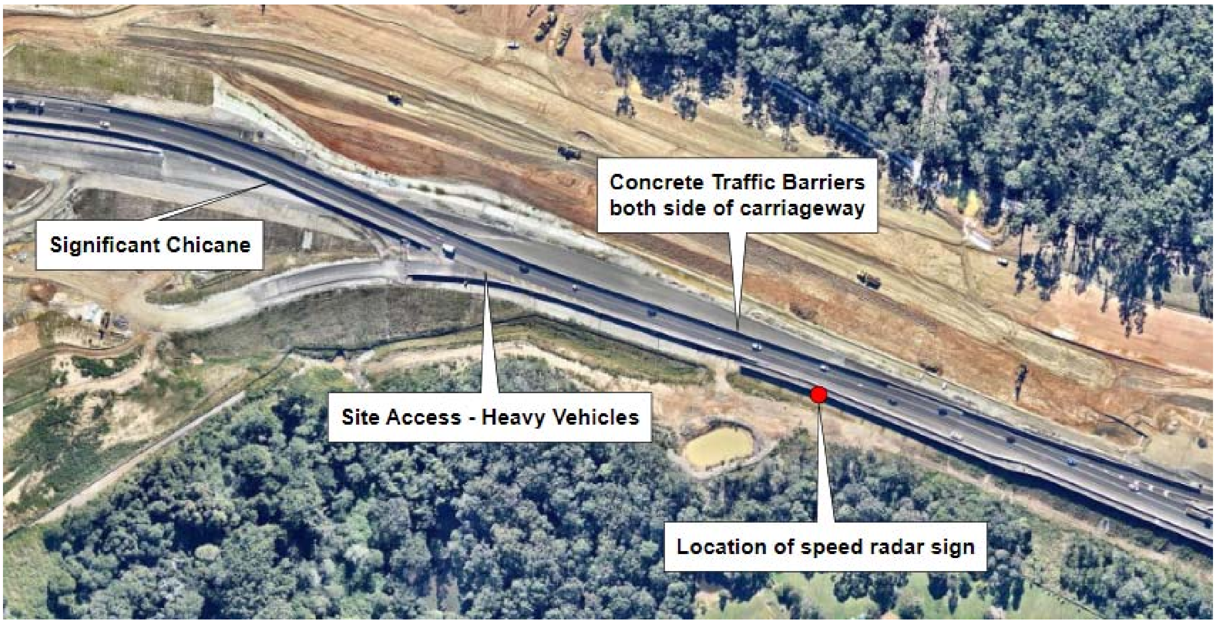

Figure 5.2: Data Collection Site: Bruce Highway Upgrade – Cooroy to Curra, Pomona QLD – Aerial view

As part of the site selection daily traffic counts were acquired to gain a further appreciation on the amount of vehicles passing through the site and also provided a reference point for comparison to vehicle counts during the data collection phase. The figures provided represented a week in 2013 and indicate a high level of service through this area with 24-hour counts ranging from a minimum of 14,443 vehicles per day (occurring on a Saturday) and a maximum of 18,502 vehicles per day (occurring on a Friday). During this week a total of 109,690 vehicles passed through the site. For reference, the original set of data is included in Appendix F.

5.5 Data Collection Procedure

Within the speed radar sign is an in built traffic statistics data logger which made for easy collection of vehicle speeds as they approached the sign – notably the incoming direction of traffic as well as the vehicles departing from the sign or the outgoing direction of traffic.

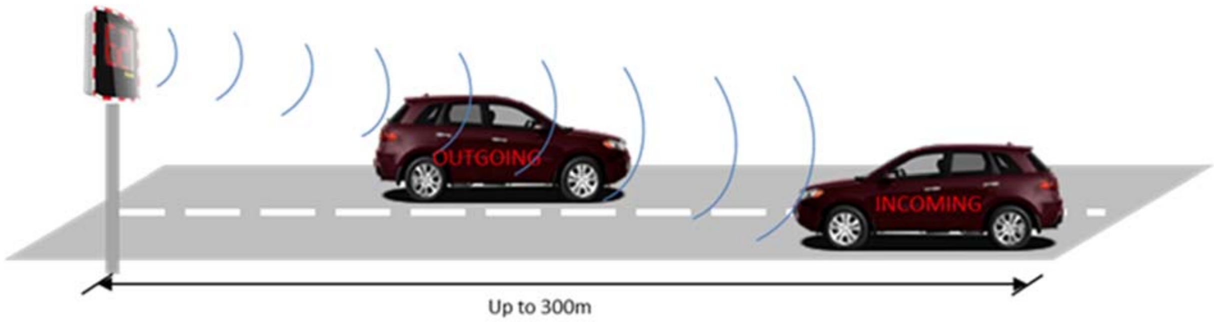

Figure 5.3: Data Collection illustration

As mentioned the sign was installed with clear visibility to the oncoming traffic and prior to a significant chicane in the road, an area where the importance of speed compliance was at its highest. The speed radar sign was run in a stealth or spy mode and actively collected traffic data without displaying any messages to the passing vehicles. This generated a base set of data on the current traffic flow with only conventional signage in place. This data set would be used for comparison purposes as to the effect the sign has when fully operational.

Figure 5.4: Speed Radar Sign (Spy Mode)

After a reliable set of base data was collected the sign was turned on into full operation and displayed a range of messages based on each vehicles speed. Each mode was run for one week and all vehicle speeds recorded. During the second week of trials a period of police presence was implemented and any changes in speeds during this time were recorded.

Figure 5.5: Police Presence

After identifying the potential for a 'Halo Effect' to occur as discussed in the literature review another week of data was analysed a full month after the initial installation and the data generated here would either confirm or contradict what other researcher state in regard to the continuing effect of new devices as time goes on.

5.5.1 Message display

The posted speed through this particular section of roadworks was set at 80km/h and the messages programmed into the sign were based on this number. The messages were broken into five categories based on incoming vehicle speeds and automatically changed based on the drivers actions, that is whether they slowed down, maintained their existing speed or in the unlikely case, sped up. The messages utilised are shown in Figure 5.5 below.

Figure 5.6: Message displays

Chapter 6 – Results

Upon completing the field evaluation, the raw data was downloaded from the speed radar sign, organised into appropriate formats within excel and examined for the any significant differences in - the change in average speed and the change in percent of vehicles exceeding the speed limit. It was decided to omit the change in average maximum speeds through the site due to the volatility associated with this data however a brief analysis on level of service and its effect on speeds was carried out and has also been presented.

Each set of results were broken into four categories, namely:

1. Conventional Signage Only (The Control set of data)
2. ITS Signage (Immediate effect of the device)
3. Police Presence
4. ITS Signage (Long term or Halo Effect of the device)

One week of speed data was analysed for each of the categories above with the exception of the effect of police presence due to the availability of these resources. For this category only two hours of data were collected however this was deemed appropriate for comparison purposes.

The dates and times of data collection for each category were:

1. Conventional Signage Only
   4th August 2015, 8am to 11th August 2015, 8am.

2. ITS Signage (Immediate effect)
   12th August 2015, 8am to 19th August 2015, 8am

3. Police Presence
   11th August 2015, 10am to 11th August 2015, 12pm

4. ITS Signage (Long Term or Halo effect)
   1st September 2015, 8am to 8th September 2015, 8am

6.1 Average Speeds

The average speeds for each category have been summarized and included in Table 6.1 below. Individual graphs for each category have also been included and are presented in Figures 6.1 to 6.8 further on. Although the data presented indicates both ingoing and outgoing results, the discussion will focus on the ingoing direction as this is the critical direction to determine the effectiveness of the device.

Summary of Average speeds for each category (km/h)				
	Conventional Signage (Control Data)	**ITS Signage (Immediate effect)**	**Police Presence**	**ITS Signage (Long Term or Halo Effect)**
Ingoing Direction	80.03	77.8	66.6	76.13
Outgoing Direction	79.86	78.47	70.2	77.5

Table 6.1: Average Speeds for each category

The biggest reduction in average speed of 13.43km/h during testing occurred while there was police presence, and the smallest reduction of 2.23 km/h occurred during the first week that the device was switched on. Interestingly, these average speeds reduced even further as time progressed and although the Halo effect often has a negative connotation, with the average speeds often returning to pre-trial levels, these results showed an improvement with a further reduction in average speed of 1.67km/h occurring. The outgoing direction was expected to have minimal variance throughout the trials due to the lack of interaction between the travelling public and the device however, reduction in average speed did occur and could most likely be contributed to the fact that drivers were aware that a radar device was in use through the area. The reduction in average speed for the outgoing direction during the time of police presence was also expected as the blue and red flashing lights were visible from both direction of travel.

6.1.1 Conventional Signage only

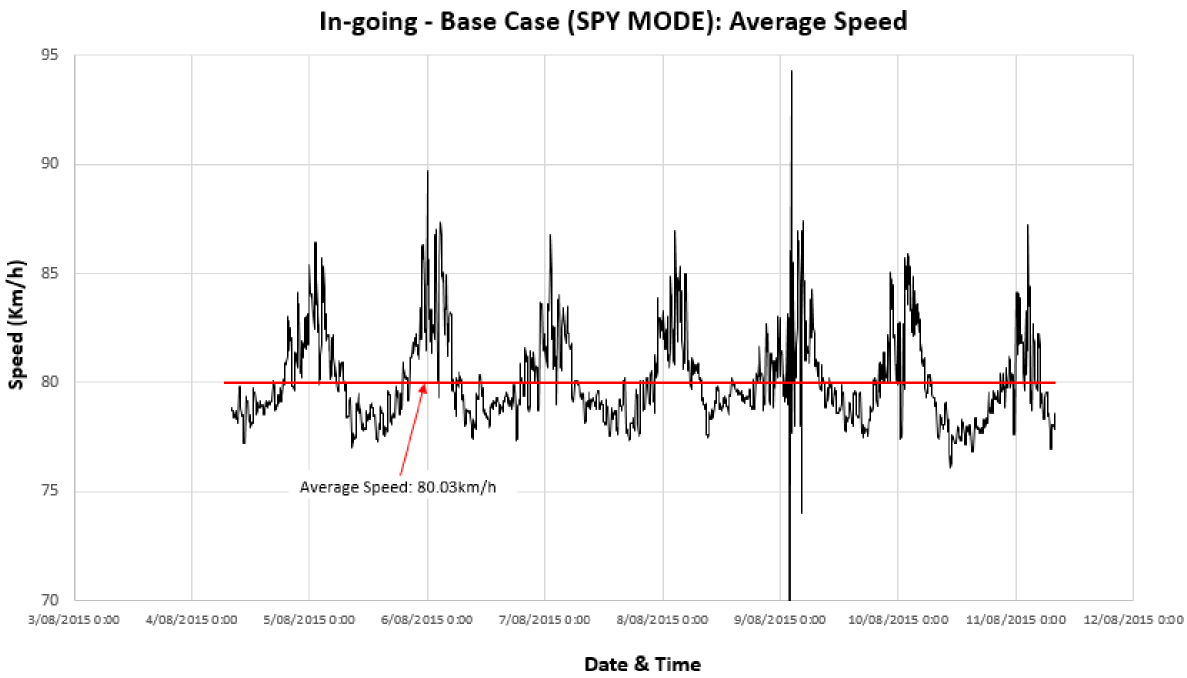

Figure 6.1: Ingoing Average Speed (Conventional Signage Only)

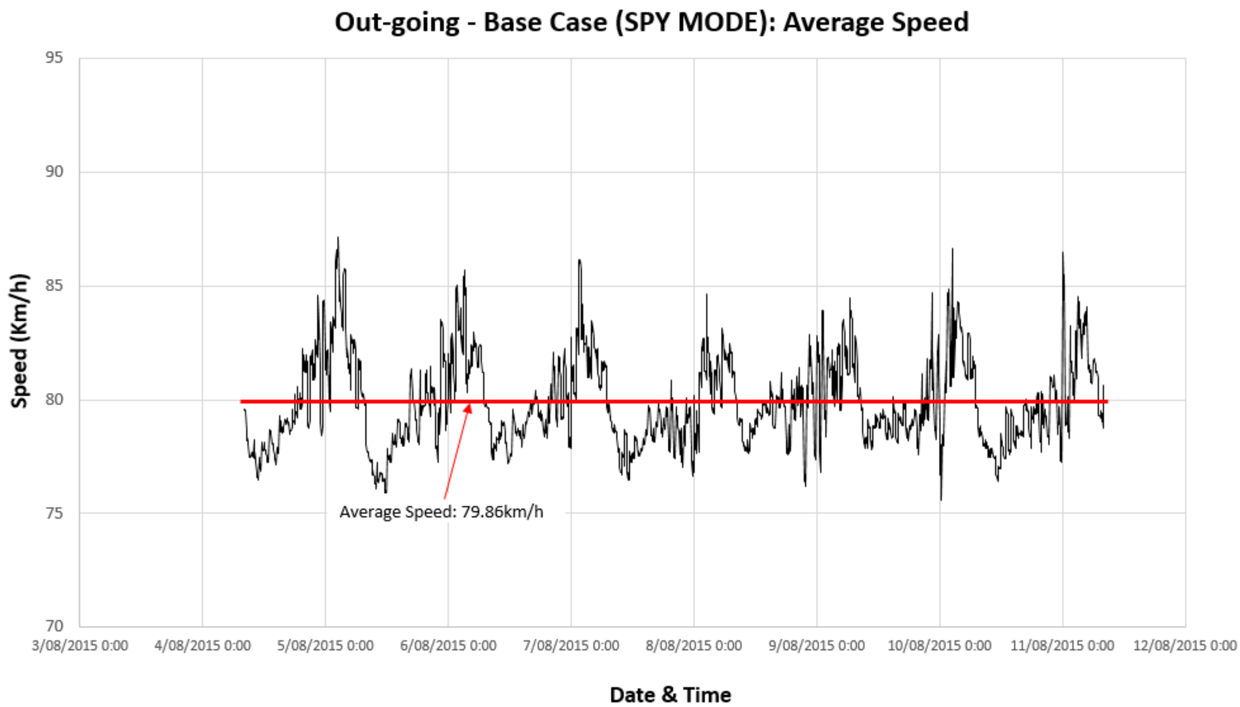

Figure 6.2: Outgoing Average Speed (Conventional Signage Only)

6.1.2 ITS Signage (Immediate effect)

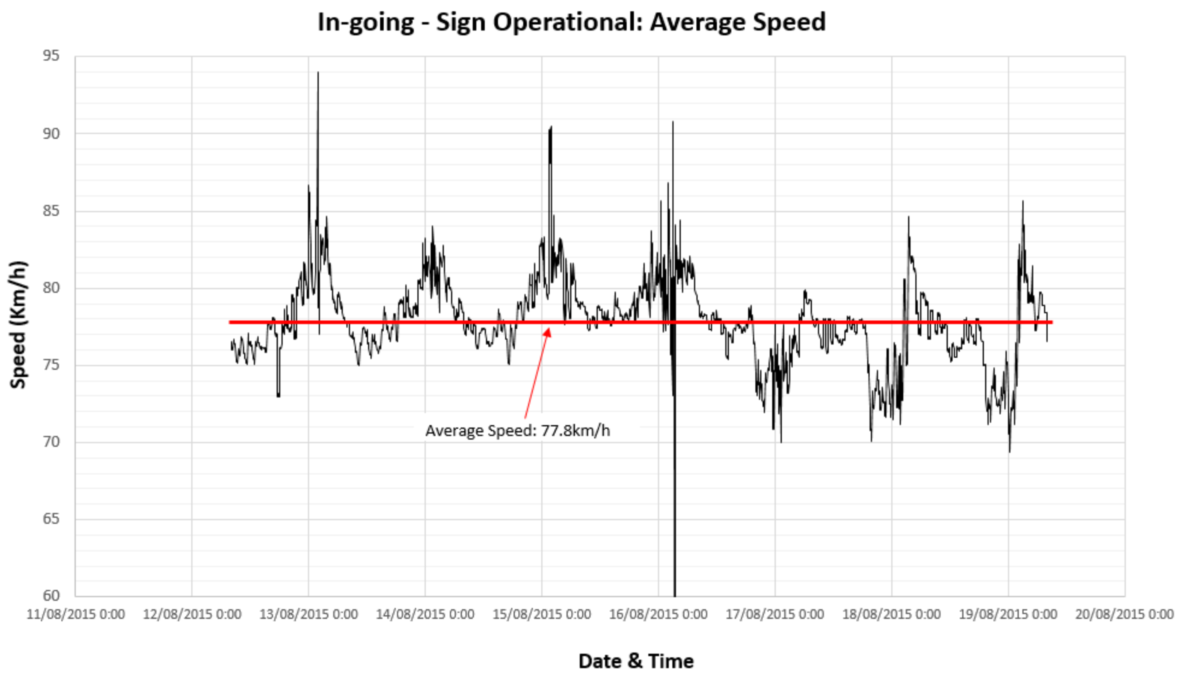

Figure 6.3: Ingoing Average Speed (ITS Signage – Immediate Effect)

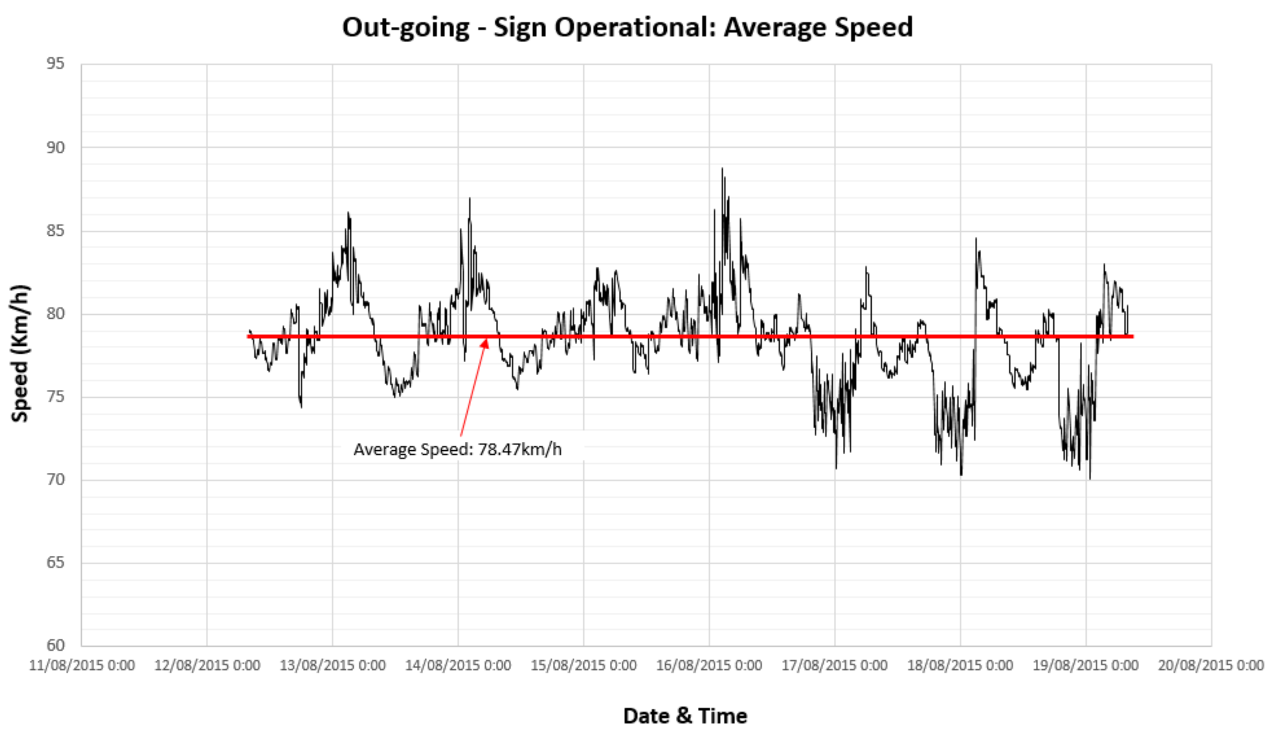

Figure 6.4: Outgoing Average Speed (ITS Signage – Immediate effect)

6.1.3 Police Presence

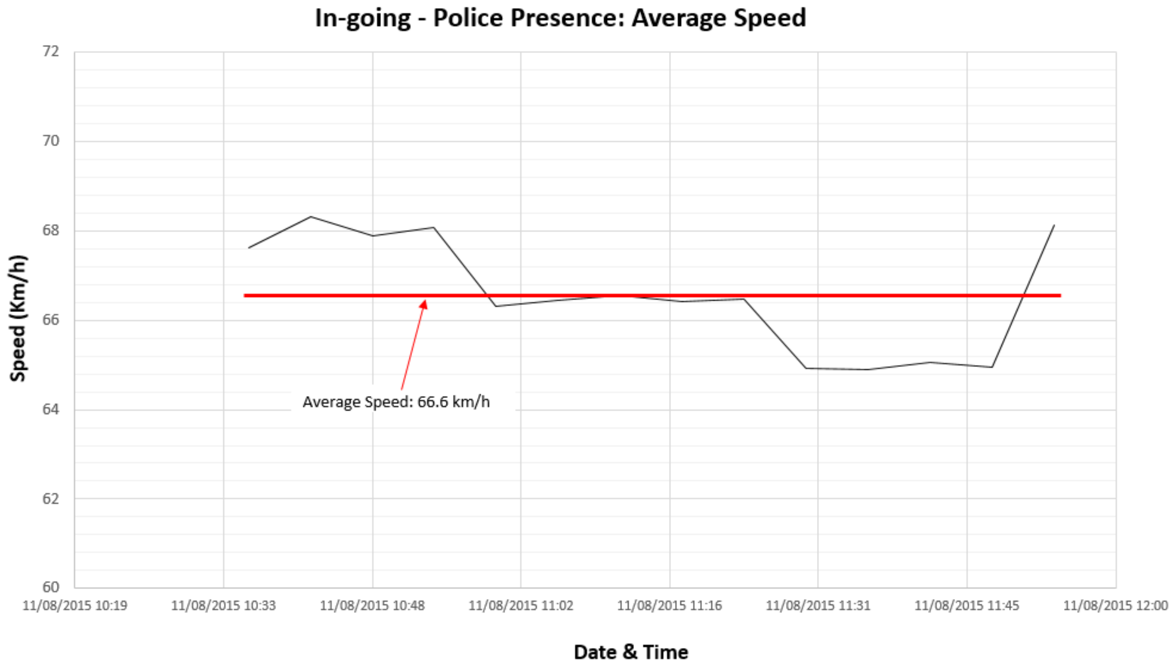

Figure 6.5: Ingoing Average Speed (Police Presence)

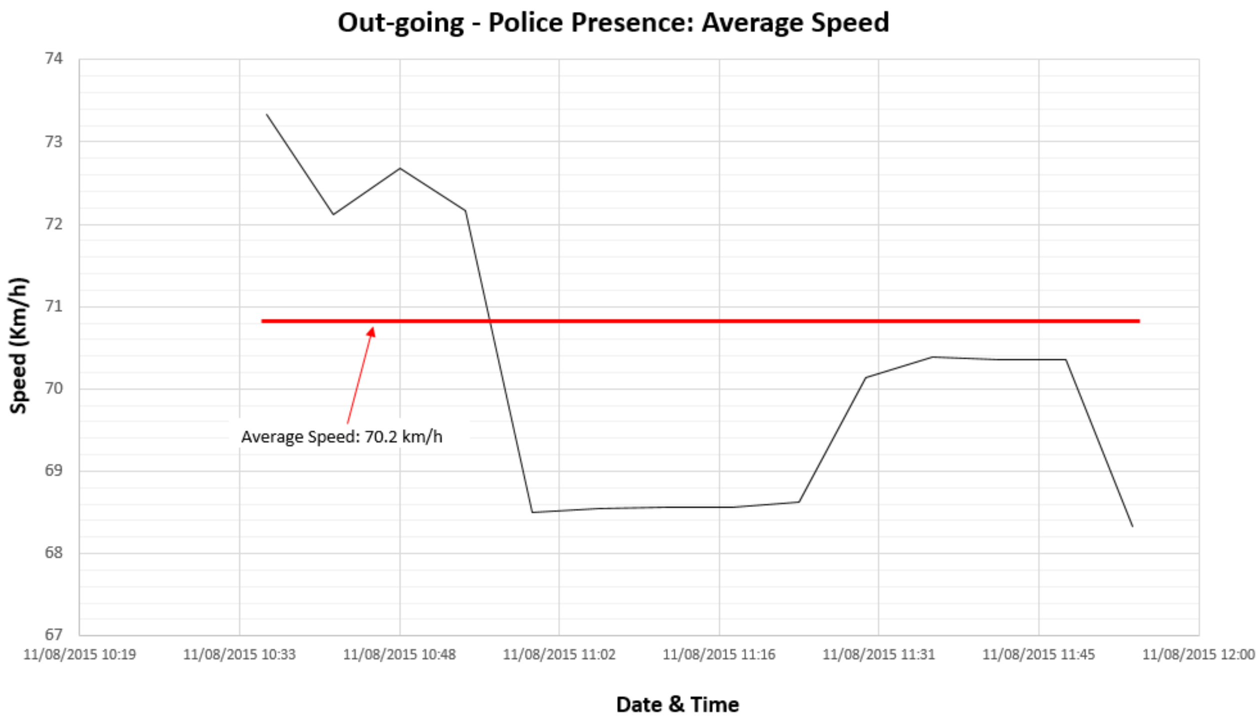

Figure 6.6: Outgoing Average Speed (Police Presence)

6.1.4 ITS Signage (Long term or "Halo effect")

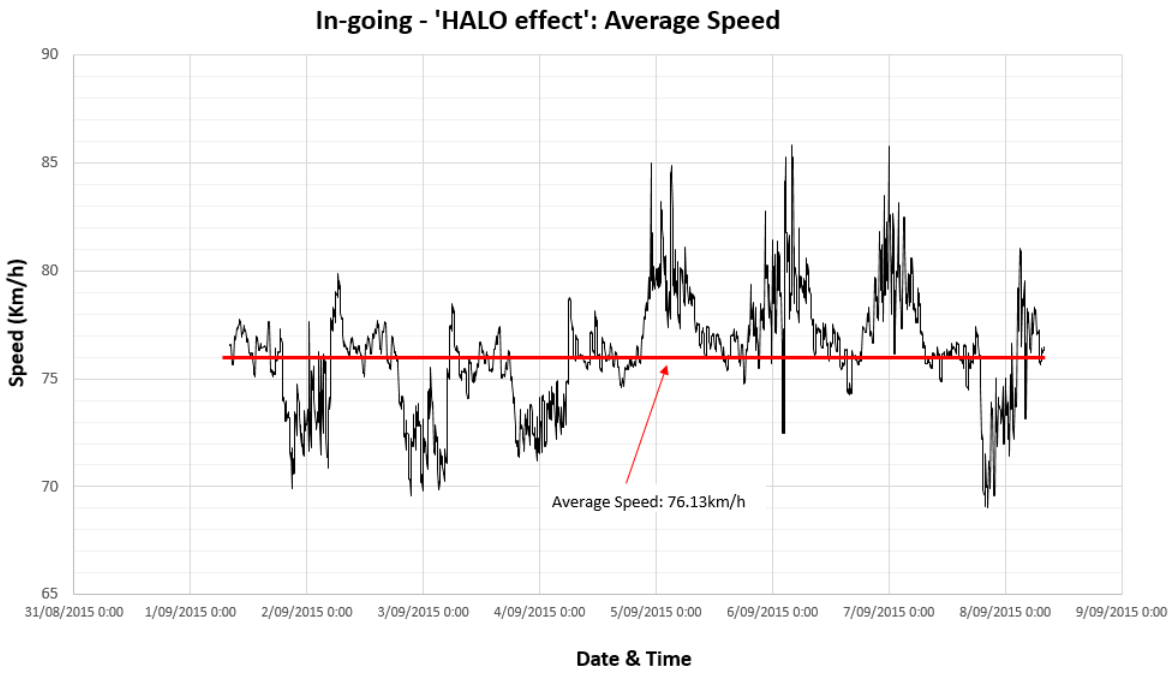

Figure 6.7: Ingoing Average Speed (ITS Signage – Long term or "Halo effect"

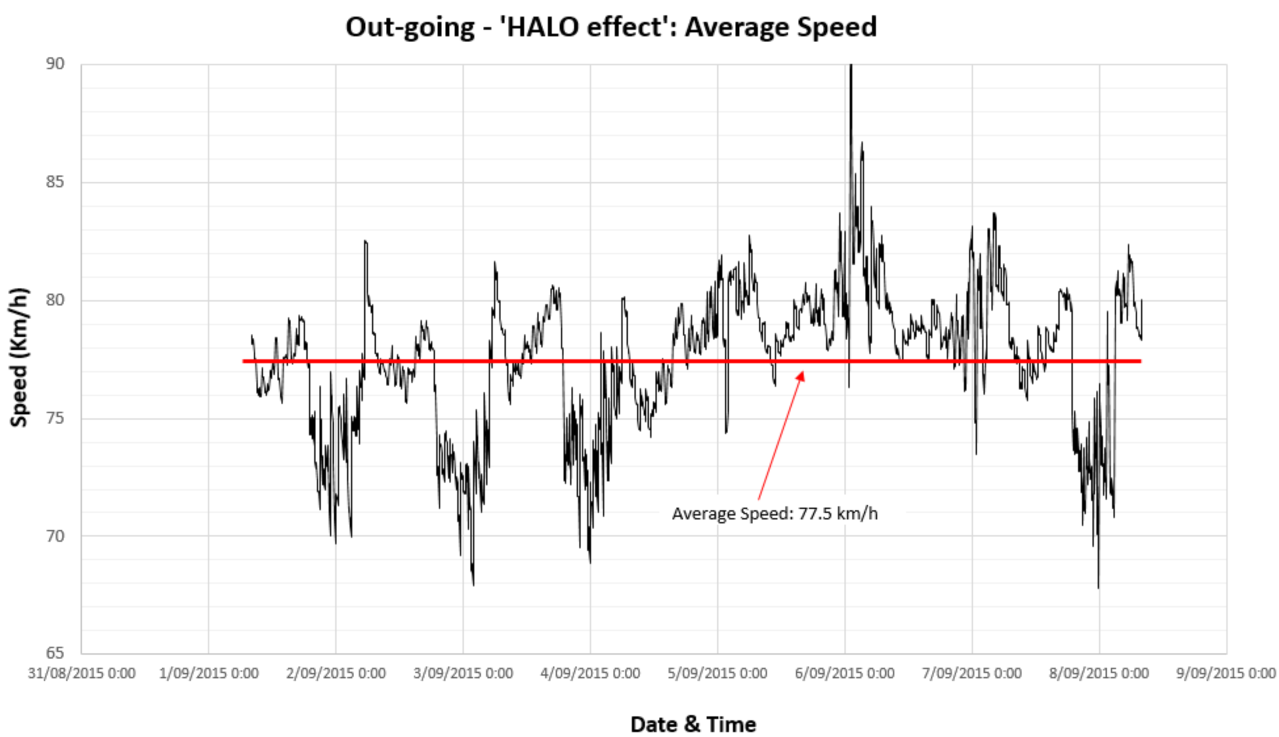

Figure 6.8: Outgoing Average Speed (Long term or "Halo Effect")

6.2 Percent exceeding the speed limit

The percent of vehicles exceeding the speed limit for each category have been summarized and included in Table 6.2 below. Individual graphs for each category have also been included and are presented in Figures 6.9 to 6.16 further on.

Summary of percent of vehicles exceeding the speed limit				
	Conventional Signage (Control Data)	**ITS Signage (Immediate effect)**	**Police Presence**	**ITS Signage (Long Term or Halo Effect)**
Ingoing Direction	41%	18%	0%	6%
Outgoing Direction	39%	29%	0%	17%

Table 6.2: Percent of vehicles exceeding the speed limit

The results from the data gathered on the percentage of vehicles exceeding the speed limit indicates that the speed radar sign has produced significant reductions in the amount of vehicles exceeding the speed limit. The concept behind showing the number of vehicles exceeding the speed limit rather than average speeds gives a greater depth of understanding as to the effectiveness of the chosen ITS device as it shows a distinct and more comprehendible number and for clarity this is presented further in table 6.3 below.

Summary of number of vehicles exceeding the speed limit				
	Conventional Signage (Control Data)	**ITS Signage (Immediate effect)**	**Police Presence**	**ITS Signage (Long Term or Halo Effect)**
Ingoing Direction	25,188	10,813	0	3,553
Outgoing Direction	32,276	23,463	0	13,388

Table 6.3: No. of vehicles exceeding the speed limit

It is clear that all data sets indicate a significant reduction in the number/percentage of vehicles exceeding the speed limit when the speed radar sign is active.

It appears that a positive reaction to the ITS device has been achieved with a significant increase in driver compliance shown by a 21,635 vehicle reduction to excessive speed. The effect of police presence also has a significant positive effect in reducing speeds with a 100% speed compliance being achieved during these trial periods.

To measure the severity of vehicles exceeding the speed limit a summary has also been included in table 6.3, 6.4 and 6.5 below which shows the number of vehicles travelling over the speed limit by between 0 to 3km/h, 3 to 7km/h and 7 to 13km/h respectively.

Summary of number of vehicles exceeding the speed limit by 0 – 3km/hr				
	Conventional Signage (Control Data)	**ITS Signage (Immediate effect)**	**Police Presence**	**ITS Signage (Long Term or Halo Effect)**
Ingoing Direction	18,430	9,010	0	2,960
Outgoing Direction	26,482	19,416	0	11,813

Table 6.4: Percent of vehicles exceeding the speed limit by 0 – 3km/h

Summary of number of vehicles exceeding the speed limit by 3 – 7km/hr				
	Conventional Signage (Control Data)	**ITS Signage (Immediate effect)**	**Police Presence**	**ITS Signage (Long Term or Halo Effect)**
Ingoing Direction	6,143	1,201	0	592
Outgoing Direction	5,793	3,236	0	1,575

Table 6.5: Percent of vehicles exceeding the speed limit by 3 – 7km/h

Summary of number of vehicles exceeding the speed limit by 7 – 13km/hr				
	Conventional Signage (Control Data)	**ITS Signage (Immediate effect)**	**Police Presence**	**ITS Signage (Long Term or Halo Effect)**
Ingoing Direction	614	600	0	0
Outgoing Direction	0	809	0	0

Table 6.6: Percent of vehicles exceeding the speed limit by 7 – 13km/h

6.2.1 Conventional Signage only

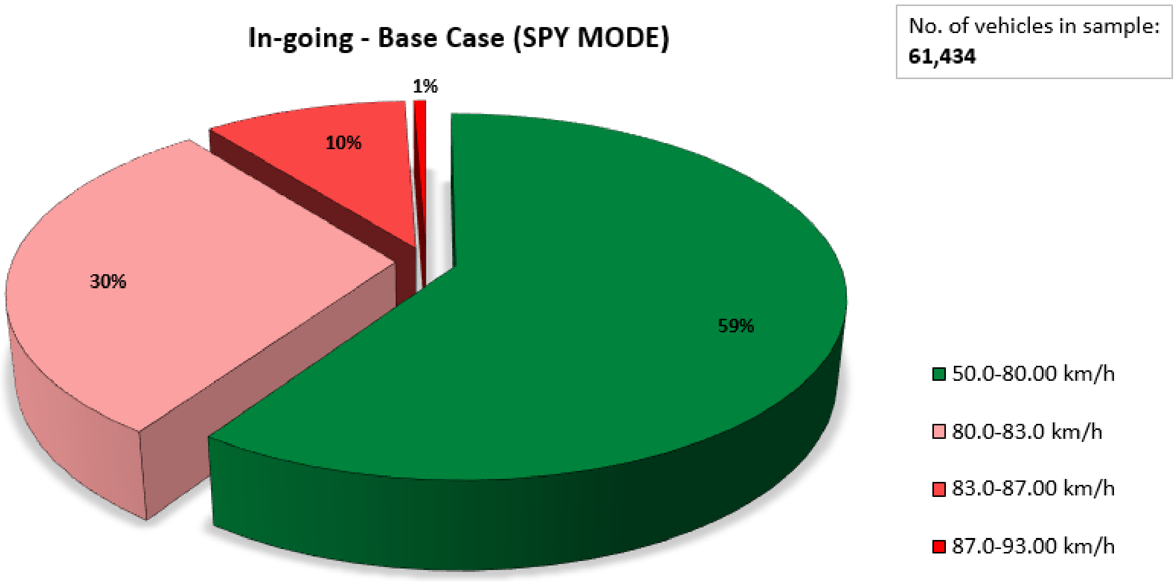

Figure 6.9: Ingoing percent of vehicles speeding (Spy mode)

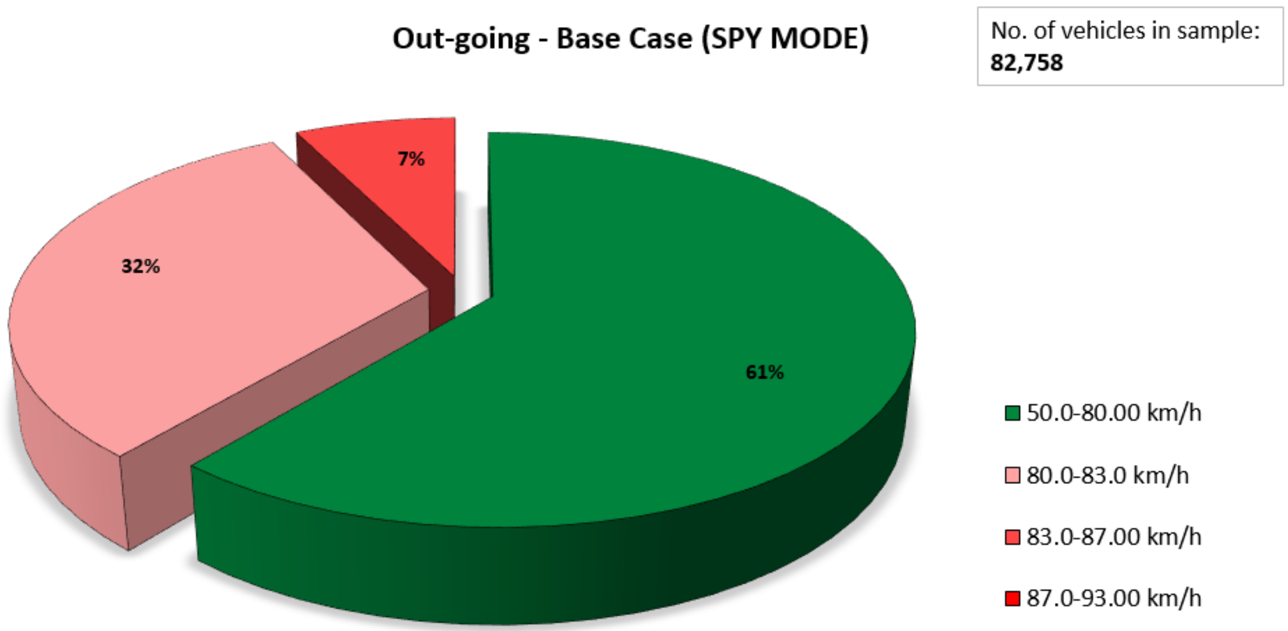

Figure 6.10: Outgoing percent of vehicles speeding (Spy mode)

6.2.2 ITS Signage (Immediate effect)

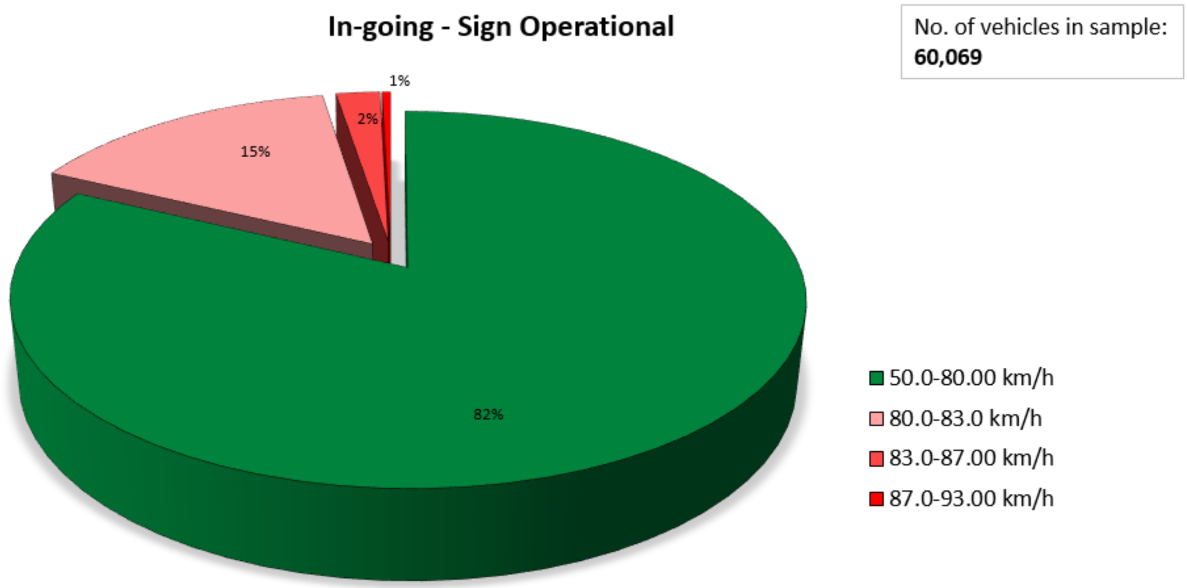

Figure 6.11: Ingoing percent of vehicles speeding (Immediate effect)

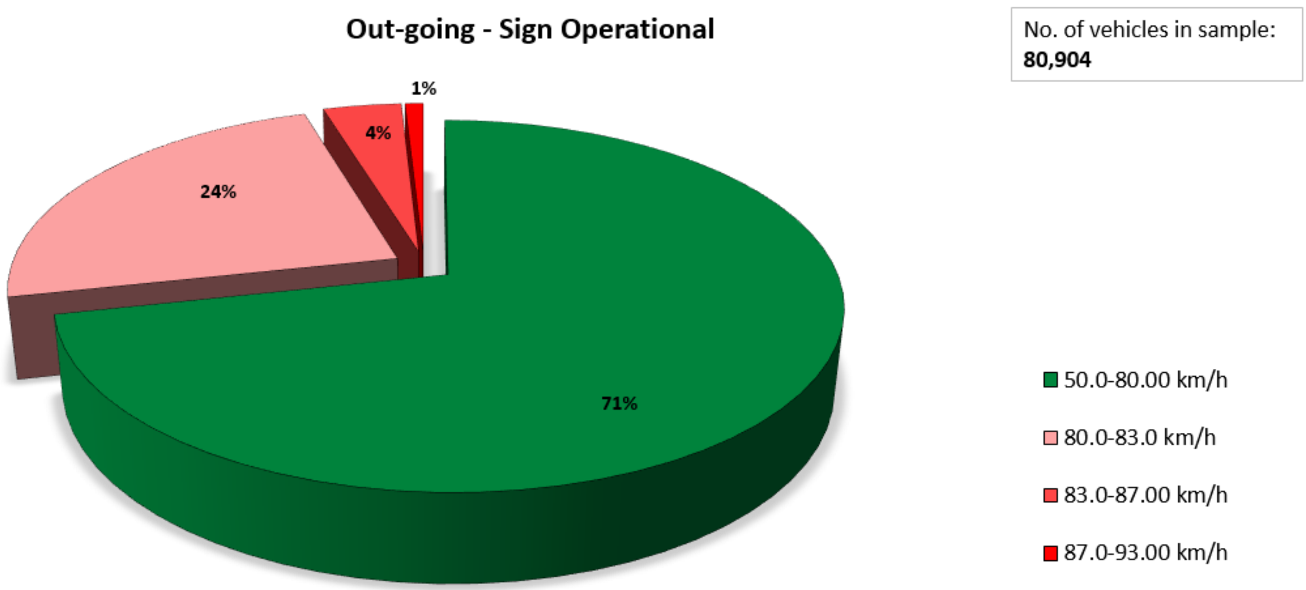

Figure 6.12: Outgoing percent of vehicles speeding (Immediate effect)

6.2.3 Police Presence

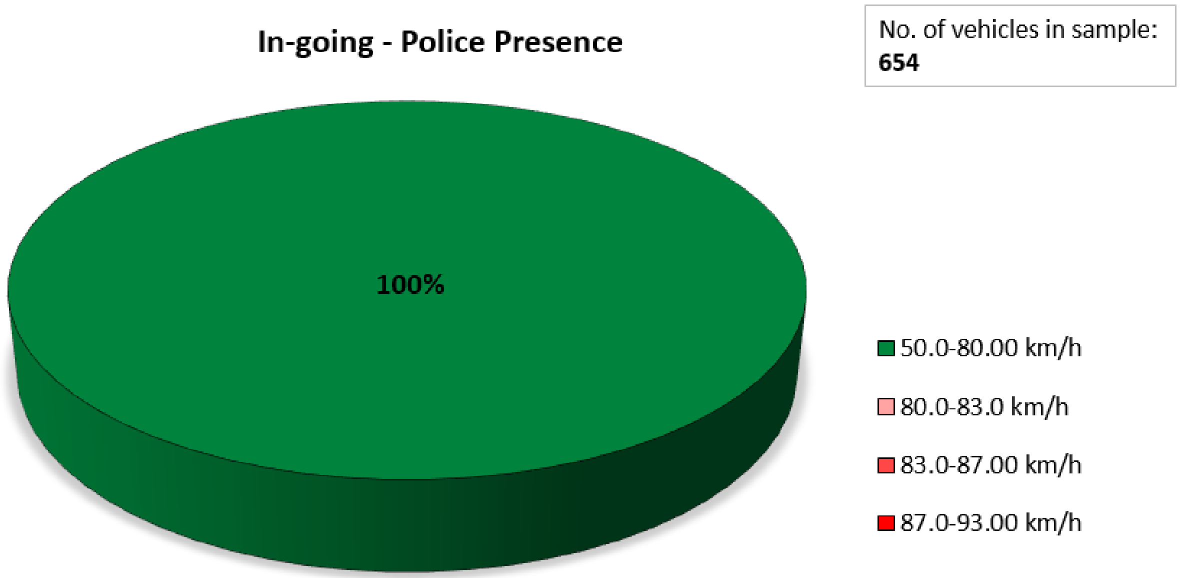

Figure 6.13: Ingoing percent of vehicles speeding (Police Presence)

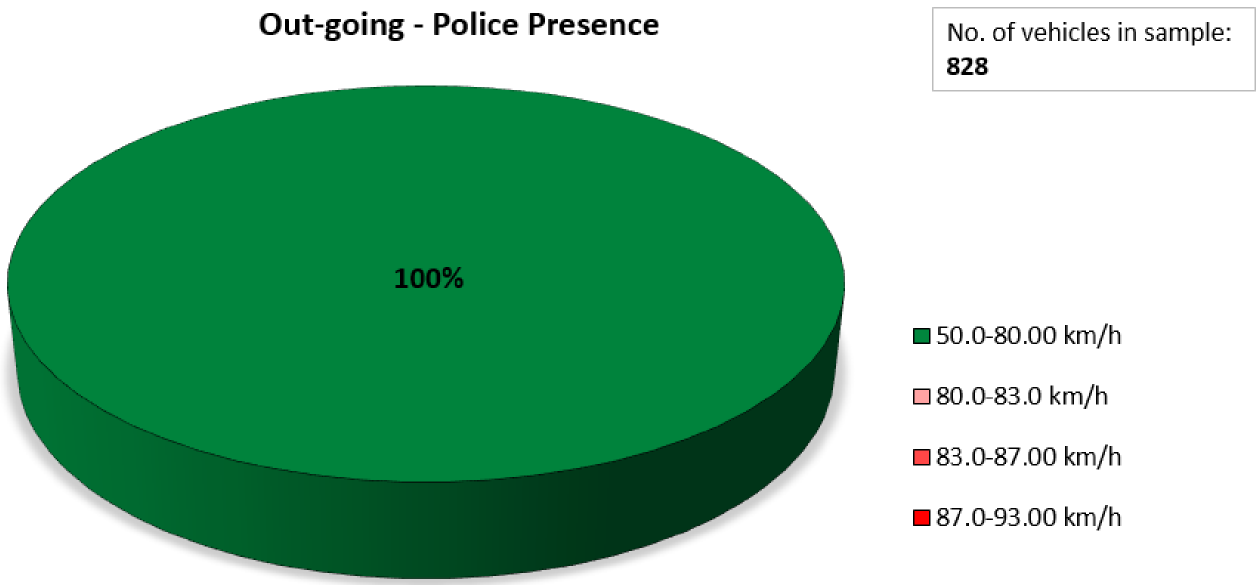

Figure 6.14: Outgoing percent of vehicles speeding (Police Presence)

6.2.4 ITS Signage (Halo effect)

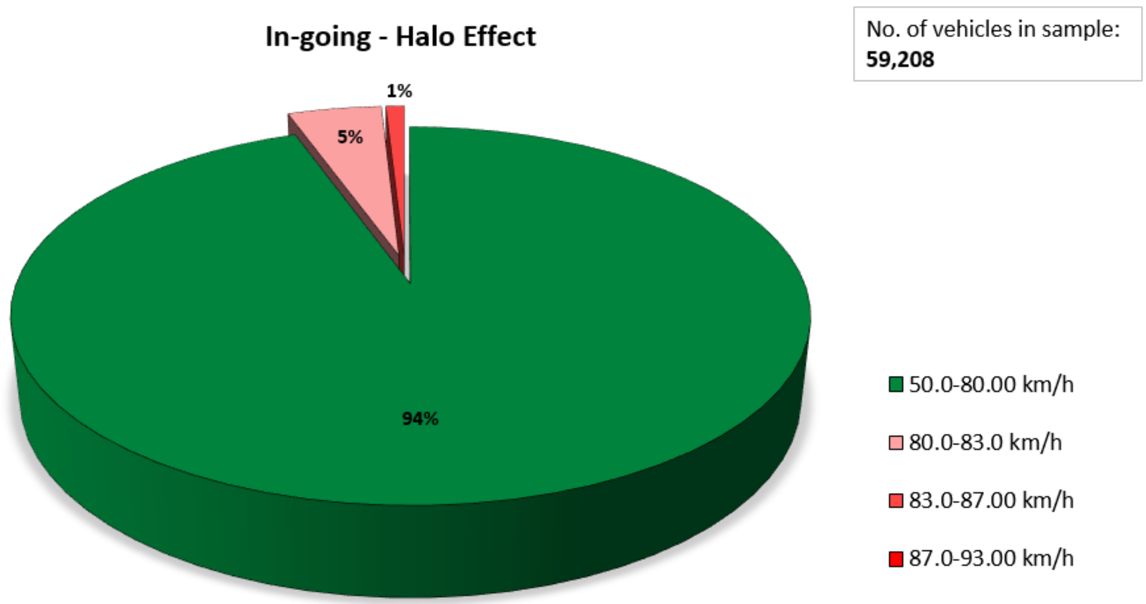

Figure 6.15: Outgoing percent of vehicles speeding (Long term of "Halo Effect")

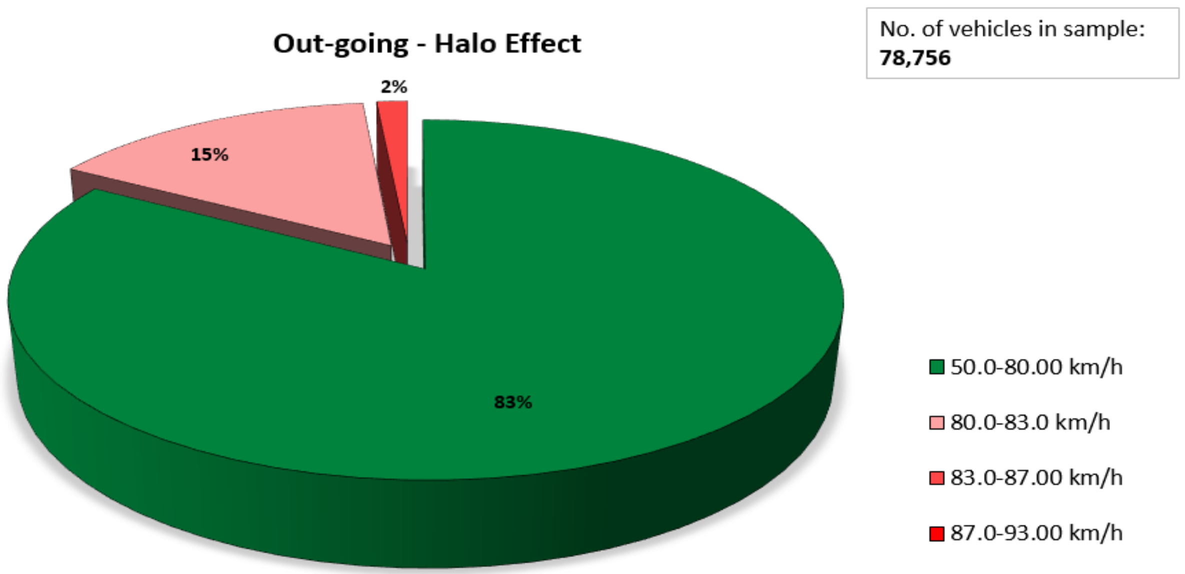

Figure 6.16: Outgoing percent of vehicles speeding (Long term of "Halo Effect")

6.3 Level of Service and effect on speed

Level of service (LOS) is a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers. A level of service definition generally describes these conditions in terms of factors such as speed and travel time, delay, density, freedom to manoeuvre, traffic interruptions, comfort and convenience, and safety. (Austroads Inc., 2009 #24)

There are six levels of service associated wirh uninterupted flow facilities which are described in the Highway Capacity Manual (HCM) 2010 and provided below:

Level of service A	A condition of free-flow in which individual drivers are virtually unaffected by the presence of others in the traffic stream. Freedom to select desired speeds and to manoeuvre within the traffic stream is extremely high, and the general level of comfort and convenience provided is excellent.
Level of service B	In the zone of stable flow where drivers still have reasonable freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is a little less than with level of service A.
Level of service C	Also in the zone of stable flow, but most drivers are restricted to some extent in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience declines noticeably at this level.
Level of service D	Close to the limit of stable flow and approaching unstable flow. All drivers are severely restricted in their freedom to select their desired speed and to manoeuvre within the traffic stream. The general level of comfort and convenience is poor, and small increases in traffic flow will generally cause operational problems.
Level of service E	Traffic volumes are at or close to capacity, and there is virtually no freedom to select desired speeds or to manoeuvre within the traffic stream. Flow is unstable and minor disturbances within the traffic stream will cause breakdown.

Level of service F	In the zone of forced flow, where the amount of traffic approaching the point under consideration exceeds that which can pass it. Flow breakdown occurs, and queuing and delays result.

Table 6.7: Level of Service Descriptions

Level of Service and its effect on speed is of high importance in work zones as the road furniture and feeling of confinement between barriers or other delineation may influence how drivers perceive the situation and accordingly their selected speed. The area may still be effectively operating at a LOS A but the perceived LOS by drivers may be closer to a LOS C where the general level of comfort and convenience declines noticeably.

Therefore as part of the field evaluation a set of data was also produced to gain an appreciation of how the level of service, which may vary throughout the day and night, effects the drivers speed choices and levels of comfort. To do this a plot of the number of vehicles and average speeds over time was produced and shows quite a uniform pattern (See Figure 6.17 below). As the number of vehicles increased (primarily throughout the day) the average vehicle speeds decreased and as night time approached and less vehicles were in the traffic stream it appears that drivers comfort levels increased and accordingly selected higher speeds to travel.

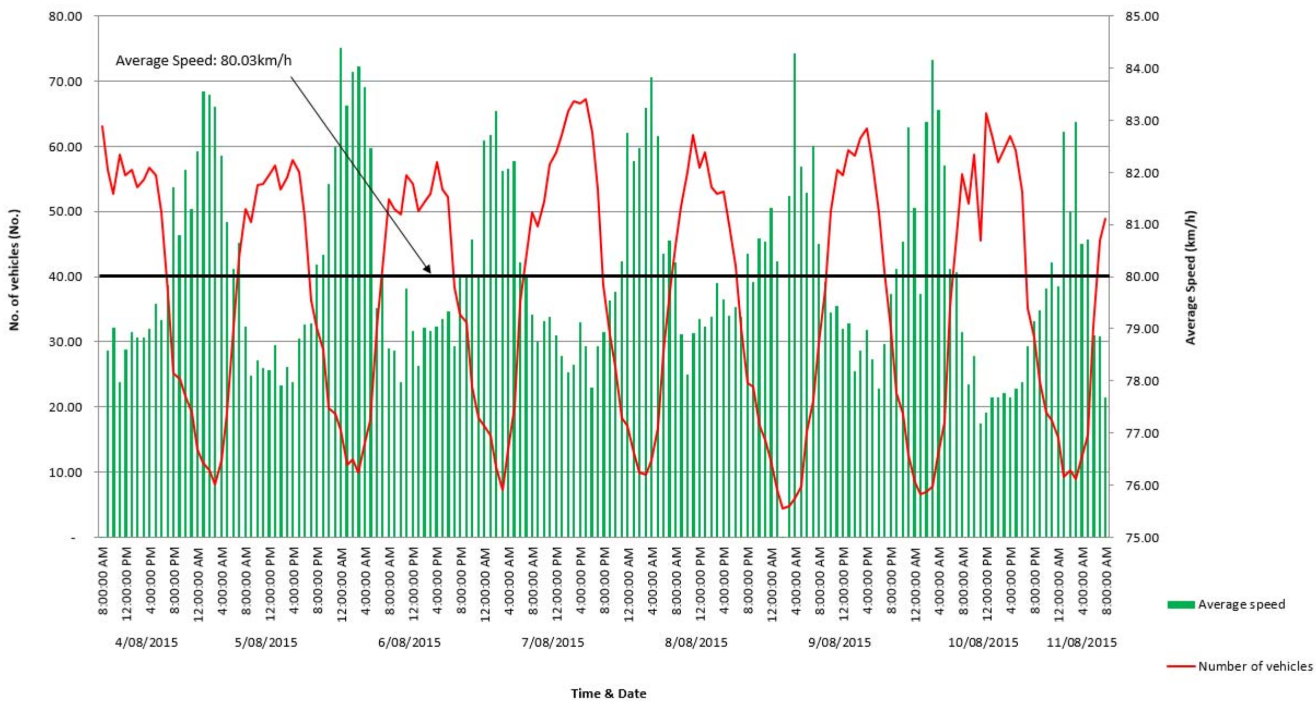

Figure 6.17: Level of service and effect on speed

Chapter 7 – Discussion

This research investigated the use of ITS devices for use in road work zones in Australia. In particular the impact on drivers selected travel speeds were analysed with the use of a speed radar sign installed on an active work site on the Bruce Highway in Queensland. Previous research conducted in the United States and Australia on devices in a similar category suggested that in the short term these signs may have a positive effect in reducing speeds, however this increased compliance may only last a few weeks.

From the findings in this project there is strong evidence to suggest that vehicle activated speed radar signs have a significant effect in reducing the overall average of speeds past the sign and more importantly shows a huge reduction in the number of speeding vehicles. Average speeds decreased by up to 4km/h with the percentage of vehicles speeding improving from 41% to 6% which is a significant reduction in terms of number of vehicles. This change is substantial and could definitely translate into safer road works zones for both workers and the travelling public.

The greatest impact on speed reduction however, was the period of police presence, showing a drop in average speeds of 13.43km/h and a 100% speed compliance in the area. These figures are noteworthy and could suggest that the use of police at work zones should be saved for important lane closures or high risk work only, where the importance of low speeds are at their greatest.

Following on from this, the level of service and its effect on speed choice showed that as the number of vehicles in the traffic flow decreased, the average speeds measured inherently increased. The times that these increases in speed occurred followed quite a uniform pattern with night time and weekend periods having the most effect on those higher speed choices.

Finally, while previous studies attach a negative connotation to the halo effect and suggest that generally speeds return to their pre-trial levels, the data in this investigation contradict that theory. The field evaluation undertaken to test this effect show that average speeds were in fact lower than the immediate effect of the device. The percentage of vehicles speeding also followed this same pattern with only 6% of vehicles passing the sign travelling above the posted speed.

7.1 Potential factors effecting the accuracy of the data

The results presented in this report have been taken on face value and have not been modified or changed to counteract any events that may have occurred during data collection however a list of potential factors effecting the accuracy or reliability of the results were analysed and are discussed below.

7.1.1 Rainfall

1. Conventional Signage Only
   4th August 2015, 8am to 11th August 2015, 8am.

Date:	Rainfall (mm)
4/08/2015	0.5
5/08/2015	0
6/08/2015	0
7/08/2015	0
8/08/2015	0
9/08/2015	0
10/08/2015	0.1
11/08/2015	0.2

Table 7.1: Rainfall Data (1st Trial week)

2. ITS Signage (Immediate effect)
   12th August 2015, 8am to 19th August 2015, 8am

Date:	Rainfall (mm)
12/08/2015	20.7
13/08/2015	0
14/08/2015	0
15/08/2015	0
16/08/2015	0.2
17/08/2015	0.2
18/08/2015	0.3
19/08/2015	0.1

Table 7.2: Rainfall Data (2nd Trial week)

3. Police Presence
   11th August 2015, 10am to 11th August 2015, 12pm

   None.

4. ITS Signage (Long Term or Halo effect)
   1st September 2015, 8am to 8th September 2015, 8am

Date:	Rainfall (mm)
1/09/2015	0
2/09/2015	0.1
3/09/2015	6
4/09/2015	0
5/09/2015	0
6/09/2015	0
7/09/2015	1.3
8/09/2015	2.8

Table 7.3: Rainfall Data (3rd Trial week)

Over the entire testing period only one day had a significant amount of rainfall. On the 12th August 2015 - 20.7mm was recorded on site. The average speeds and percent of vehicles speeding on this day could have been affected however the likeliness of this one day having an extreme influence is minimal.

7.1.2 Site Conditions

The purpose of this section was to investigate if any work or significant changes to the site had taken place during the trial periods. Through the contractors daily dairy it was confirmed that the site remained unchanged and no significant work in the area had taken place.

7.1.3 Odometer Readings

An exclusive Drive test has shown 93 per cent of new car speedometers are inaccurate with a five-month study of 60 new vehicles showing most speedos measured over the posted limit by an average of 5km/h at 100km/h. (Charlwood, 2014 #24)

This suggests that drivers speeds recorded at 80km/h on the speed radar sign are consciously doing 84km/h on their odometers.

The data presented in this report are the true values based on the speed radar sign however this shows driver's habits may be worse than they appear in the results.

7.1.4 Intentional Speeding

It is obvious that with such a device in place drivers may speed up or slow down to test the accuracy of their own odometer. There was no standout control to mitigate this type of response but from visual inspections the traffic flow did not appear to have this staggering type nature. The signs message display was also capped at a speed of 93km/h after which only a DANGER message was displayed. The purpose of this was to avoid the risk of drivers challenging to receive the highest speed display.

7.1.5 Radar Accuracy

The manufacturer of this particular device claims to have an accuracy of +/- 1%. To ensure the radar accuracy and confirm these limits of accuracy a highly calibrated police radar gun was used to confirm the speed displays on the sign and showed that speeds matched exactly.

Figure 7.1: Sign Calibration Check

7.2 Recommendations

- Consider the use of vehicle activated speed signage at reducing speeds through work zones in addition to conventional signage.

- With the ability to be controlled remotely, consider the use of ITS signage as a replacement for conventional traffic control signs. The use of ITS devices to indicate speed limits for variable speed zones may have a significant effect on driver compliance.

- If requiring substantial speed reductions for high risk activities consider the use of police presence however do this sparingly to ensure to impact of this control remains as effective.

- To encourage a holistic reduced speed environment consider the use of speed radar signage at multi locations through the work zone and for both directions of travel.

- Ensure the locations selected for such devices are appropriate to the situation and in areas where maximum compliance is required.

- Consider the use of speed radar for the duration of projects but be aware of the potential for drivers to return to old habits. Monitor this situation and attempt to vary the situation by moving the signage or displaying different messages to ensure the continued interaction with driver's remains.

- Utilise the in-built traffic statistics loggers to analyse the speed environment on a regular basis as this can assist in more targeted speed reduction operations.

- For larger sites or sites that may be constantly changing, consider the use of trailer mounted ITS devices. The mobility of these arrangements allows them to be used at numerous locations at various times of the day.

Chapter 8 – Conclusions and further work

Based on these early trials of speed radar signage within work zones in Australia it is apparent that Intelligent Transport System may have a place in changing driver behaviour and the speed choices they select through roadworks. Although this research only scratches the surface on the potential of these devices it has shown the positive effect they can have in contrast to the below par conventional signage current being implemented with average speed reduction of up to 4km/h and a reduction in the percent of speeding vehicles from 41% to 6% with active signage alone. With police presence up to 13.43km/h speed reductions can be achieved and a 100% compliance with the posted speed limits may occur.

There is quite clearly a more effective method of communicating the dangers of roadworks sites and ensuring that drivers comply with these regulations. Changing driver behaviour is not an easy challenge to overcome, however identifying new, smarter ways to communicate the dangers they face is essential to improving the safety of those in the roadworks environment.

Further research that may be of benefit include;

Speed Radar Sign effectiveness over distance – That is, how far past the device do vehicles return to pre-trial levels.

Speed Radar Sign effectiveness with multi signs – That is, devices like this used as advanced warning signs to reduce speeds from for instance 100km/h to 60km/h prior to a work zone.

Speed Radar Sign effectiveness over time – That is, analysing the effects again over a even longer durations such as three to twelve months

References

Aarts, L & Van Schagen, I 2006, *Driving speed and the risk of road crashes: A review*, Accident Analysis & Prevention, 0001-4575, viewed 13/08/2015, <http://www.sciencedirect.com/science/article/pii/S0001457505001247>.

Austroads Inc. 2009, 'Guide to Traffic Management Part 1: Introduction to Traffic Management', 2nd edn, pp. 7

Bai, Y & Li, Y 2006, *Determining major causes of highway work zone accidents in Kansas*, Kansas Department of Transportation, viewed 15/08/2015, <http://dmkd.cs.wayne.edu/Compendium/Compendium_Files/12/12-2385.pdf>.

Benekohal, RF, Hajbabaie, A, Medina, JC, Wang, M-h & Chitturi, MV 2010, *Speed photo-radar enforcement evaluation in Illinois work zones*, FHWA-ICT-10-064, viewed 15/08/2015, <https://www.ideals.illinois.edu/bitstream/handle/2142/45957/FHWA-ICT-10-064.pdf?sequence=2>.

Blackman, RA, Debnath, AK & Haworth, NL 2014b, 'Influence of visible work activity on drivers' speed choice at roadworks', in *Proceedings of the 2nd Occupational Safety in Transport Conference*, CARRS-Q, Queensland University of Technology, pp. 1-10.

Brewer, MA, Pesti, G, Schneider, I & William, H 2006, 'Effectiveness of Selected Measures to Improve Work Zone Speed Limit Compliance', in *2006 ITE Annual Meeting and Exhibit Compendium of Technical Papers*.

Burke, A 2015, 'Effectiveness of Portable Speed Warning Signs', in *AITPM National Traffic & Transport Conference*: *Proceedings of the AITPM National Traffic & Transport Conference* Brisbane Convention & Exhibition Centre, pp. 1-24.

Cordingley, R & Jarvis, J 1982, 'The effect of various traffic control treatments employed at roadworks sites', in *Proceedings of the Eleventh Australian Road Research Board Conference*, University of Melbourne.

Debnath, AK, Blackman, RA & Haworth, NL 2014, 'Making informed decisions on selecting promising Work Zone Safety Treatments', in *26th ARRB Conference*: *Proceedings of the 26th ARRB Conference* Sydney, NSW.

Department of Transport and Main Roads 2015, viewed 07/09/2015, <http://www.tmr.qld.gov.au/Safety/Driver-guide/Speeding/Stopping-distances.aspx>.

Figueiredo, L, Jesus, I, Machado, JT, Ferreira, J & De Carvalho, JM 2001, 'Towards the development of intelligent transportation systems', in *Intelligent transportation systems*, pp. 1206-11, viewed 12/07/2015, <http://www.universelle-automation.de/1984_Columbus.pdf>.

Fontaine, M, Schrock, S & Ullman, G 2001, 'Feasibility of real-time remote speed enforcement for work zones', in Transportation Research Record: Journal of the Transportation Research Board: Proceedings of the Transportation Research Record: Journal of the Transportation Research Board Washington D.C.

Garber, NJ & Srinivasan, S 1998, *Effectiveness Of Changeable Message Signs In Controlling Vehicle Speeds In Work Zones-Phase II*, viewed 09/09/2015, <http://www.virginiadot.org/vtrc/main/online_reports/pdf/98-r10.pdf>.

Haworth, N, Symmons, M & Mulvihill, C 2002, *Safety of small workgroups on roadways*, 195, Monash University Accident Research Centre, viewed 17/06/2015, <http://www.monash.edu.au/miri/research/reports/muarc195.pdf>.

Kirschfink, H, Hernández, J & Boero, M 2000, 'Intelligent traffic management models', in *Proccedings of the European Symposium on Intelligent Techniques (ESIT)*, pp. 36-45.

Lyles, R, Taylor, WC & Grossklaus, J 2003, *Field test of variable speed limits in work zones (in Michigan)*, Michigan state University, viewed 02/10/2015, <http://stsmo.transportation.org/Documents/TRB2004-001180.pdf>.

Mabbott, N, Lloyd, B, Poole, D & Roberts, P 2005, *Evaluation of speed limiting locally operating warning signs*, 1921139099, viewed 28/08/2015, <https://www.onlinepublications.austroads.com.au/items/AP-R278-05>.

Mattox III, J, Sarasua, W, Ogle, J, Eckenrode, R & Dunning, A 2007, *Development and evaluation of speed-activated sign to reduce speeds in work zones*, Transportation Research Record: Journal of the Transportation Research Board, 0361-1981, viewed 28/08/2015, <https://www.workzonesafety.org/files/documents/database_documents/07-0015.pdf>.

McCoy, PT, Bonneson, JA & Kollbaum, JA 1995, 'Speed reduction effects of speed monitoring displays with radar in work zones on interstate highways', *Transportation Research Record*, no. 1509, pp. 65-72.

RTA 2008, *Road traffic crashes in New South Wales. Statistical statement for the year ended 31 December 2007*.

Safe Work Australia 2012, *Traffic Management in Workplaces - Code of Practise*.

Scriba, T & Atkinson, J 2014, *Creating Smarter Work Zones*, viewed 18/04/2015, <https://www.fhwa.dot.gov/publications/publicroads/14marapr/06.cfm>.

Wang, C, Dixon, K & Jared, D 2002, *Evaluating speed-reduction strategies for highway work zones*, 0361-1981, viewed 01/08/2015 <http://www.ltrc.lsu.edu/TRB_82/TRB2003-002099.pdf>.

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Appendix A – Project Specification

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

PROJECT SPECIFCATION
ENG4111 / 4112 Research Project

FOR: Wade Davey (0050093007)

TOPIC: **Evaluating the effectiveness of Intelligent Transport Systems at reducing speeds through roadworks sites in Australia**

SUPERVISORS: USQ - Professor Ron Ayers

Work – Terry Cogill, Managing Director & Civil Engineer, Bielby Holdings Pty Ltd

PROJECT AIM: This project seeks to evaluate the effectiveness of Intelligent Transport Systems (ITS) at reducing speeds through roadworks sites in Australia

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PROGRAM: Issue B; Revised: 1st October 2015

1. Research road work site traffic management practices and standards currently being implemented in Australia and overseas, with specific focus on the utilisation of ITS.

2. Identify alternative traffic management practises or control methods that differ from the standards currently being used.

3. Gain an increased understanding of the perceptions of road works site through the eyes of the general public and those at the fore-front of traffic management by developing and distributing appropriate surveys.

4. Select a suitable geographic area and/or road network type for the study i.e. north Queensland, Townsville City; urban, rural, multilane, highway etc.

5. Select an appropriate ITS device to trial and implement these trials on the chosen geographic area.

6. Produce results, analyse data and evaluate all findings presenting them in appropriate and legible formats.

7. Write a dissertation in the required format

AGREED:

Student: Wade Davey
Date: 08/10/2015

Supervisor: Prof. Ron Ayers
Date: 08/10/2015

Appendix B – Road Crash Data

Department of Transport and Main Roads - Road Crash, Registration, Licensing and Infringement Data Request Form

*Please use **BLOCK LETTERS** if handwritten.*

Contact Details

Name:	Wade Davey
Email	wdavey@bielby.com.au
Phone:	0466 812 545
Alternate phone:	
Fax:	
Organisation	Bielby Holdings Pty Ltd

Office Use Only

Request Number: rq ……………………

Priority: ……………………………………

Link Number: rq ……………………………

Due Date: …………………………………

Checker Due Date: ………………………

Assigned To: ………………………………

Estimated Time: ……………………………

Please tick appropriate box(es): ☑ Road Crash Data ☐ Registration/Licensing/Infringement Data

Request Information

When do you require this data? *Note: Normal turnaround time is at least 5 working days; complex requests will take longer. If data is required before this time, please state the date (& time if appropriate) you require it. If your requested timeframe is not achievable we will contact you to negotiate a timeframe.*
requests marked as "URGENT" or "ASAP" will be automatically allocated a 5 working day turnaround

Is this **updating previous data supplied**? If possible, please provide the **request number** and/or approximate **date** that the previous data was supplied. Also, if available, please **attach** the data.

How do you plan to **use** this data? For example: *presentation, research paper, ministerial.*

Research paper

Time range

☑ Previous 5 full years of data ☐ Previous 12 full months of data ☐ Year to date

Other time range / comments, how would you like it broken down? *Example: year, month*

Yearly Statistics

Geographical area

☑ All of Queensland	☐ Police Region	☐ Queensland Transport Region	☐ Road/Hwy
☐ Local Government Area	☐ Police District	☐ Main Roads Region	☐ Road/Hwy section
	☐ Police Division		☐ Intersection

Geographic details and comments.

Statistical Data Required

Road Crash Data: *(examples of possible characteristics)*

Crashes	Casualties	Units	Unit controllers	Contributing circumstances
☐ Severity	☑ Severity	☐ Unit type	☐ Road user type	☑ Contributing circumstances
☑ Crash nature	☑ Road user type	☐ Intended action	☐ Age	☑ Contributing factors (circumstance groupings)
☐ Roadway feature	☐ Road user type – unit group	☐ Overall damage	☐ Gender	
☑ Traffic control	☐ Age	☐ Main damage point	☐ Licence type	
☑ Speed limit	☐ Gender	☐ Towing	☐ State licensed in	
☐ Roadway surface	☐ Helmet use	☐ Number of occupants		
☐ Atmospheric condition	☐ Restraint use	☐ Dangerous goods		
☐ Lighting	☐ Seating position	☐ Defective		
☐ Horizontal alignment		☐ Registration status		
☐ Vertical alignment		☐ Type of use (business or private)		
☐ DCA code				
☐ DCA group				
☐ Time of day				
☐ Day of week				

Registration Licensing and Infringement Data: *(examples of possible characteristics)*

Registration	Licensing	Infringement	Recreational Vessels
☐ New Business	☐ Age	☐ Category	☐ Length
☐ Transfers	☐ Gender	☐ Description	☐ Draft
☐ Vehicles by body type	☐ Class	☐ Code	☐ Body Type
☐ Make	☐ Level		☐ Registration Category
☐ Model			☐ Powered by
☐ Gross Vehicle Mass			
☐ Purpose Of Use			

Data request comments and details:

I am searching for some data that might help answer the following questions: (I am primarily focused on crash statistics surrounding ROADWORKS) Thanks in advance!
How many accident have occurred in roadworks sites across QLD or Australia in the last 5 years?
What sort of roads have a higher accident rate?
What speed zones have a higher accident rate?
How many fatalities have resulted from accidents involving the travelling public and site personnel at roadworks?
What (if identified) have been the root cause of these accidents

Please send this form to:

Data Analysis, Department of Transport and Main Roads

Email: DataAnalysis@tmr.qld.gov.au

Fax: (07) 3066 2410

The Department of Transport and Main Roads is collecting the information on this form for the purposes of providing you with road crash, registration, licensing and infringement data. Your personal details will not be disclosed to any other third party without your consent unless required or authorised to do so by law.

CRASH

Date extracted: 08-Sep-2015

Motor vehicle casualty crashes, involving roadworks, Queensland

01-Jan-2007 to 31-Dec-2011

Each column represents a 12 month period between January and December

Crash - Severity	2007	2008	2009	2010	2011	Total
Fatal	2	0	0	0	0	2
Hospitalisation	12	9	9	6	8	44
Medical treatment	13	10	12	11	23	69
Minor injury	9	11	6	5	8	39
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Nature	2007	2008	2009	2010	2011	Total
Hit object	9	3	5	1	6	24
Hit pedestrian	4	4	5	6	7	26
Head-on	0	4	2	0	0	6
Angle	3	6	1	4	3	17
Overturned	3	1	0	0	1	5
Rear-end	13	12	10	9	18	62
Fall from vehicle	1	0	0	1	2	4
Sideswipe	2	0	2	1	1	6
Hit parked vehicle	1	0	1	0	1	3
Other	0	0	1	0	0	1
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Type	2007	2008	2009	2010	2011	Total
Single Vehicle	14	4	6	2	10	36
Multi-Vehicle	18	22	15	14	22	91
Hit pedestrian	4	4	5	6	7	26
Other	0	0	1	0	0	1
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Contributing factors	2007	2008	2009	2010	2011	Total
Alcohol/drug related	0	2	2	1	3	8
Involving drink drivers/riders	0	0	0	0	1	1
Involving alcohol impaired pedestrians	0	0	0	0	0	0
Involving speeding drivers/riders	2	4	2	0	0	8
Fatigue related crashes involving motor vehicles	2	0	0	0	0	2
Involving drivers/riders who disobeyed road rules (all)	22	23	9	13	19	86
Involving drivers/riders who disobeyed road rules (tra	0	0	0	0	0	0
Involving drivers/riders who disobeyed road rules (fail	2	5	1	4	2	14
Involving drivers/riders who disobeyed road rules (oth	20	18	8	10	18	74
Involving driver/rider controller conditions	5	3	12	4	8	32
Involving young adult drivers/riders (aged 16 to 24 yea	12	7	3	3	7	32
Involving senior adult drivers/riders (aged 60 years or	6	4	5	7	14	36
Involving unlicensed drivers/riders	3	3	1	1	1	9
Involving unregistered motor vehicles	1	1	0	1	0	3
Involving vehicle defects	0	0	0	1	2	3
Involving heavy freight vehicles	2	5	6	5	8	26
Involving motorcycles/mopeds	5	4	5	4	3	21
Involving motorcycles	3	4	4	3	2	16
Involving mopeds	2	0	1	1	1	5
Involving buses	0	0	1	0	2	3
Involving atmospheric conditions	1	1	1	0	1	4
Involving rain/wet/slippery conditions	5	3	2	0	2	12
Involving road conditions	23	13	11	6	12	65

Involving lighting conditions	2	1	2	0	1	6
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - Police Region (known)	2007	2008	2009	2010	2011	Total
Northern	4	1	6	2	7	20
Central	11	11	7	3	11	43
Southern	6	6	3	2	8	25
South Eastern	7	6	2	4	7	26
Brisbane	8	6	9	11	6	40
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - Police District (known)	2007	2008	2009	2010	2011	Total
Far North	2	1	4	2	4	13
Mount Isa	0	0	0	0	1	1
Townsville	2	0	2	0	2	6
Capricornia	2	0	0	1	1	4
Mackay	0	1	3	0	3	7
Sunshine Coast	5	9	3	1	1	19
Wide Bay Burnett	4	1	1	1	6	13
Darling Downs	1	2	0	2	4	9
Ipswich	1	3	1	0	3	8
Moreton	4	1	2	0	0	7
South West	0	0	0	0	1	1
Gold Coast	2	4	0	2	5	13
Logan	5	2	2	2	2	13
North Brisbane	3	5	2	8	4	22
South Brisbane	5	1	7	3	2	18
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - Transport Region (known)	2007	2008	2009	2010	2011	Total
Central	2	1	3	1	4	11
Northern	4	1	6	2	7	20
SEQ North	12	14	7	9	5	47
SEQ South	13	10	10	7	12	52
Southern	5	4	1	3	11	24
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - Main Roads Region (known)	2007	2008	2009	2010	2011	Total
North Queensland	4	1	6	2	7	20
Central Queensland	2	1	3	1	4	11
North Coast and Wide Bay/Burnett	13	12	6	3	9	43
Downs South West	1	2	0	2	5	10
Metropolitan	9	9	10	10	5	43
South Coast	7	5	2	4	9	27
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - Main Roads District (known)	2007	2008	2009	2010	2011	Total
Far North	2	1	4	2	4	13
North West	0	0	0	0	1	1
Northern	2	0	2	0	2	6
Mackay/Whitsunday	0	1	3	0	3	7
Fitzroy	2	0	0	1	1	4
Wide Bay/Burnett	4	2	1	1	6	14
North Coast	9	10	5	2	3	29

	2007	2008	2009	2010	2011	Total
Darling Downs	1	2	0	2	5	10
Metropolitan	9	9	10	10	5	43
South Coast	7	5	2	4	9	27
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - ABS Remoteness Index (known)	2007	2008	2009	2010	2011	Total
Major cities	22	22	16	16	15	91
Inner regional	6	5	3	3	11	28
Outer regional	8	3	8	2	9	30
Remote	0	0	0	1	3	4
Very remote	0	0	0	0	1	1
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - ABS Statistical Area 4 (SA4) (known)	2007	2008	2009	2010	2011	Total
Brisbane - East	0	0	2	1	0	3
Brisbane - North	1	2	0	4	0	7
Brisbane - South	3	2	3	2	2	12
Brisbane - West	0	0	0	1	1	2
Brisbane Inner City	4	2	3	2	2	13
Cairns	2	1	4	2	4	13
Darling Downs - Maranoa	1	1	0	2	4	8
Fitzroy	2	0	0	1	1	4
Gold Coast	2	4	0	2	5	13
Ipswich	1	3	2	0	3	9
Logan - Beaudesert	5	1	2	2	1	11
Mackay	0	1	3	0	3	7
Moreton Bay - North	4	1	2	0	0	7
Moreton Bay - South	0	1	0	1	2	4
Queensland - Outback	0	0	0	0	1	1
Sunshine Coast	5	8	3	1	1	18
Toowoomba	0	1	0	0	1	2
Townsville	2	0	2	0	2	6
Wide Bay	4	2	1	1	6	14
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - ABS Statistical Area 3 (SA3) (known)	2007	2008	2009	2010	2011	Total
Bald Hills - Everton Park	0	0	0	1	0	1
Beenleigh	1	0	0	1	1	3
Bowen Basin - North	0	0	2	0	2	4
Brisbane Inner	2	0	1	0	0	3
Brisbane Inner - North	2	1	1	2	2	8
Brisbane Inner - West	0	1	1	0	0	2
Broadbeach - Burleigh	0	0	0	0	1	1
Browns Plains	1	1	1	0	0	3
Buderim	0	2	0	0	0	2
Bundaberg	0	0	0	0	5	5
Burnett	1	0	0	0	1	2
Caboolture	3	1	0	0	0	4
Caboolture Hinterland	1	0	0	0	0	1
Cairns - South	0	0	1	0	0	1
Caloundra	2	2	1	0	1	6
Carindale	1	1	1	0	0	3
Centenary	0	0	0	0	1	1
Chermside	0	0	0	3	0	3
Cleveland - Stradbroke	0	0	0	1	0	1
Darling Downs (west) - Maranoa	1	1	0	0	1	3
Darling Downs - East	0	0	0	0	3	3

Forest Lake - Oxley	0	0	1	0	0	1
Gladstone - Biloela	1	0	0	0	0	1
Gold Coast - North	1	0	0	1	0	2
Granite Belt	0	0	0	2	0	2
Gympie - Cooloola	1	1	0	0	0	2
Hervey Bay	1	1	1	0	0	3
Hills District	0	1	0	0	1	2
Holland Park - Yeronga	0	0	1	2	0	3
Innisfail - Cassowary Coast	1	1	2	2	2	8
Ipswich Hinterland	0	0	0	0	2	2
Ipswich Inner	1	2	0	0	0	3
Jimboomba	2	0	0	0	0	2
Kenmore - Brookfield - Moggill	0	0	0	1	0	1
Loganlea - Carbrook	0	0	0	1	0	1
Mackay	0	0	1	0	1	2
Maroochy	1	0	1	0	0	2
Maryborough	1	0	0	1	0	2
Mt Gravatt	0	0	0	0	1	1
Mudgeeraba - Tallebudgera	1	1	0	0	0	2
Nambour - Pomona	1	3	0	0	0	4
Narangba - Burpengary	0	0	2	0	0	2
Nathan	1	0	0	0	0	1
Nerang	0	0	0	0	1	1
Noosa	0	0	0	1	0	1
North Lakes	0	0	0	0	1	1
Ormeau - Oxenford	0	1	0	1	0	2
Outback - North	0	0	0	0	1	1
Robina	0	2	0	0	1	3
Rockhampton	1	0	0	1	1	3
Rocklea - Acacia Ridge	0	1	1	0	1	3
Sandgate	1	2	0	0	0	3
Southport	0	0	0	0	2	2
Springfield - Redbank	0	1	1	0	1	3
Springwood - Kingston	1	0	1	0	0	2
Strathpine	0	0	0	1	0	1
Sunnybank	1	0	0	0	0	1
Sunshine Coast Hinterland	1	1	1	0	0	3
Tablelands (east) - Kuranda	1	0	1	0	2	4
Toowoomba	0	1	0	0	1	2
Townsville	2	0	2	0	2	6
Whitsunday	0	1	0	0	0	1
Wynnum - Manly	0	0	2	0	0	2
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - Local Government Area (known)	2007	2008	2009	2010	2011	Total
Banana Shire	1	0	0	0	0	1
Brisbane City	8	6	9	9	4	36
Bundaberg Region	0	0	0	0	5	5
Cairns Region	1	1	2	1	0	5
Carpentaria Shire	0	0	0	0	1	1
Cassowary Coast Region	0	0	1	1	2	4
Fraser Coast Region	2	1	1	1	0	5
Gold Coast City	2	4	0	2	5	13
Goondiwindi Region	1	1	0	0	1	3
Gympie Region	1	1	0	0	0	2
Ipswich City	1	3	1	0	1	6
Livingstone Shire	0	0	0	1	0	1
Logan City	5	1	2	2	2	12
Mackay Region	0	0	1	0	1	2
Mareeba Shire	0	0	1	0	1	2

Moreton Bay Region	3	2	2	1	2	10
Noosa Shire	0	0	0	1	0	1
North Burnett Region	1	0	0	0	1	2
Redland City	0	0	0	1	0	1
Rockhampton Region	1	0	0	0	1	2
Scenic Rim Region	0	0	0	0	2	2
Somerset Region	1	0	0	0	0	1
Southern Downs Region	0	0	0	1	0	1
Sunshine Coast Region	5	8	3	0	1	17
Tablelands Region	1	0	0	0	1	2
Toowoomba Region	0	1	0	1	3	5
Townsville City	2	0	2	0	2	6
Western Downs Region	0	0	0	0	1	1
Whitsunday Region	0	1	2	0	2	5
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - State Electorate (known)	2007	2008	2009	2010	2011	Total
Albert	1	0	0	1	1	3
Algester	0	2	0	0	0	2
Aspley	0	0	0	2	0	2
Barron River	0	0	1	0	0	1
Beaudesert	1	0	0	0	2	3
Brisbane Central	1	1	1	1	2	6
Broadwater	1	0	0	1	0	2
Buderim	1	3	0	0	0	4
Bundaberg	0	0	0	0	1	1
Bundamba	0	0	1	0	1	2
Burdekin	0	0	2	0	3	5
Burnett	0	0	0	0	4	4
Cairns	0	0	1	0	0	1
Callide	2	0	0	0	1	3
Caloundra	2	2	1	0	1	6
Chatsworth	1	1	1	0	0	3
Clayfield	0	0	0	1	0	1
Condamine	0	0	0	1	3	4
Cook	0	0	0	0	1	1
Coomera	0	1	0	1	0	2
Dalrymple	1	0	0	0	1	2
Everton	0	0	0	0	1	1
Gaven	0	0	0	0	1	1
Glass House	2	0	1	0	0	3
Greenslopes	0	0	0	2	0	2
Gympie	1	1	0	0	0	2
Hervey Bay	1	1	1	0	0	3
Hinchinbrook	0	0	1	1	2	4
Inala	0	0	1	0	0	1
Ipswich	0	1	0	0	0	1
Ipswich West	1	1	0	0	0	2
Kallangur	0	0	0	1	1	2
Kawana	0	1	0	0	0	1
Logan	1	1	1	0	0	3
Lytton	0	0	2	0	0	2
Mackay	0	0	1	0	1	2
Mansfield	0	0	0	0	1	1
Maroochydore	1	0	1	0	0	2
Maryborough	1	0	0	1	0	2
Mermaid Beach	0	1	0	0	0	1
Mirani	1	0	0	1	1	3
Moggill	0	0	0	1	0	1
Morayfield	0	0	2	0	0	2

Mount Coot-tha	0	1	1	0	0	2
Mount Isa	0	0	0	0	1	1
Mount Ommaney	0	0	0	0	1	1
Mudgeeraba	1	2	0	0	1	4
Mulgrave	1	1	1	1	0	4
Mundingburra	0	0	1	0	0	1
Nanango	1	0	0	0	0	1
Nicklin	0	2	0	0	0	2
Noosa	0	0	0	1	0	1
Nudgee	1	1	0	1	0	3
Pine Rivers	0	1	0	0	0	1
Pumicestone	2	1	0	0	0	3
Redlands	0	0	0	1	0	1
Sandgate	0	1	0	0	0	1
South Brisbane	2	0	2	0	0	4
Southern Downs	1	1	0	1	1	4
Southport	0	0	0	0	1	1
Stafford	1	0	0	1	0	2
Sunnybank	1	0	1	0	0	2
Surfers Paradise	0	0	0	0	2	2
Thuringowa	1	0	0	0	0	1
Toowoomba North	0	1	0	0	0	1
Townsville	1	0	1	0	1	3
Warrego	0	0	0	0	1	1
Waterford	1	0	1	1	0	3
Whitsunday	0	1	0	0	0	1
Woodridge	1	0	0	0	1	2
Yeerongpilly	1	0	0	0	0	1
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash Location - Federal Electorate (known)	2007	2008	2009	2010	2011	Total
Blair	1	2	0	0	2	5
Bonner	1	1	3	0	1	6
Bowman	0	0	0	1	0	1
Brisbane	2	2	2	1	2	9
Capricornia	1	0	0	1	1	3
Dawson	0	1	3	0	3	7
Dickson	0	1	0	1	2	4
Fadden	1	1	0	2	0	4
Fairfax	2	5	1	0	0	8
Fisher	5	3	2	0	1	11
Flynn	1	0	0	0	3	4
Forde	3	0	0	2	1	6
Griffith	2	0	2	2	0	6
Groom	0	1	0	0	3	4
Herbert	2	0	2	0	1	5
Hinkler	2	1	1	0	4	8
Kennedy	2	1	2	2	5	12
Leichhardt	0	0	2	0	0	2
Lilley	1	2	0	3	0	6
Longman	2	1	2	0	0	5
Maranoa	1	1	0	2	2	6
Mcpherson	1	3	0	0	1	5
Moncrieff	0	0	0	0	4	4
Moreton	2	0	0	0	1	3
Oxley	0	2	3	0	2	7
Petrie	0	0	0	2	0	2
Rankin	2	1	2	0	0	5
Ryan	0	0	0	1	0	1
Wide Bay	2	1	0	2	0	5

Total Crashes	36	30	27	22	39	154

Crash - Time of day (2 hourly)	2007	2008	2009	2010	2011	Total
Midnight - 2am	0	1	0	0	0	1
2am - 4am	3	1	0	0	0	4
4am - 6am	1	0	1	0	6	8
6am - 8am	3	3	5	1	1	13
8am - 10am	6	5	1	7	5	24
10am - noon	4	6	3	2	9	24
Noon - 2pm	4	4	2	5	5	20
2pm - 4pm	6	5	6	5	4	26
4pm - 6pm	1	1	4	0	2	8
6pm - 8pm	4	1	2	1	4	12
8pm - 10pm	2	2	1	0	3	8
10pm - midnight	2	1	2	1	0	6
Total Crashes	36	30	27	22	39	154

Crash - Time of day	2007	2008	2009	2010	2011	Total
1am - 2am	0	1	0	0	0	1
2am - 3am	1	0	0	0	0	1
3am - 4am	2	1	0	0	0	3
4am - 5am	1	0	0	0	1	2
5am - 6am	0	0	1	0	5	6
6am - 7am	1	3	1	1	0	6
7am - 8am	2	0	4	0	1	7
8am - 9am	3	3	1	3	2	12
9am - 10am	3	2	0	4	3	12
10am - 11am	2	3	1	2	4	12
11am - Noon	2	3	2	0	5	12
Noon - 1pm	3	1	1	3	2	10
1pm - 2pm	1	3	1	2	3	10
2pm - 3pm	4	1	3	2	2	12
3pm - 4pm	2	4	3	3	2	14
4pm - 5pm	1	0	2	0	2	5
5pm - 6pm	0	1	2	0	0	3
6pm - 7pm	2	0	1	0	2	5
7pm - 8pm	2	1	1	1	2	7
8pm - 9pm	1	2	1	0	1	5
9pm - 10pm	1	0	0	0	2	3
10pm - 11pm	0	1	2	1	0	4
11pm - Midnight	2	0	0	0	0	2
Total Crashes	36	30	27	22	39	154

Crash - Day of Week	2007	2008	2009	2010	2011	Total
Monday	5	6	6	8	7	32
Tuesday	11	5	4	2	8	30
Wednesday	6	3	6	3	7	25
Thursday	3	5	6	1	8	23
Friday	6	4	1	5	3	19
Saturday	3	6	2	2	2	15
Sunday	2	1	2	1	4	10
Total Crashes	36	30	27	22	39	154

Crash - Weekend or weekday	2007	2008	2009	2010	2011	Total
Weekday	31	23	23	19	33	129
Weekend	5	7	4	3	6	25

Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Month	2007	2008	2009	2010	2011	Total
January	0	1	3	1	3	8
February	3	4	2	3	3	15
March	3	0	5	2	2	12
April	0	9	3	1	1	14
May	5	3	3	1	5	17
June	2	0	2	1	5	10
July	5	2	2	1	4	14
August	3	3	2	2	1	11
September	4	2	1	0	4	11
October	5	3	1	4	0	13
November	3	2	2	5	6	18
December	3	1	1	1	5	11
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Quarter	2007	2008	2009	2010	2011	Total
Jan-Mar	6	5	10	6	8	35
Apr-Jun	7	12	8	3	11	41
Jul-Sep	12	7	5	3	9	36
Oct-Dec	11	6	4	10	11	42
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crashes - Road Authority	2007	2008	2009	2010	2011	Total
State controlled	15	15	11	13	24	78
Locally controlled	21	15	16	9	15	76
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Speed Limit	2007	2008	2009	2010	2011	Total
0 - 50 km/h	16	17	10	13	18	74
60 km/h	12	9	14	5	18	58
70 km/h	0	1	0	1	0	2
80 - 90 km/h	5	3	2	1	3	14
100 - 110 km/h	3	0	1	2	0	6
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Intersection	2007	2008	2009	2010	2011	Total
Intersection	9	10	8	7	7	41
Non-Intersection	27	20	19	15	32	113
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Roadway Feature	2007	2008	2009	2010	2011	Total
Intersection - Cross	2	2	1	2	0	7
Intersection - T Junction	7	4	5	4	5	25
Intersection - Interchange	0	1	2	1	2	6
Intersection - Roundabout	0	3	0	0	0	3
Bridge, Causeway	0	1	0	0	1	2
Median Opening	0	1	0	0	0	1
Bikeway	0	0	1	0	0	1
No Roadway Feature	27	18	18	15	31	109
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Traffic Control	2007	2008	2009	2010	2011	Total
Road/Rail worker	15	17	17	16	27	92
Operating traffic lights	2	0	0	0	0	2
Flashing amber lights	0	0	1	0	0	1
Stop sign	0	1	0	1	1	3
Give way sign	0	3	0	1	0	4
No traffic control	19	9	9	4	11	52
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Atmospheric Condition (known)	2007	2008	2009	2010	2011	Total
Clear	31	29	26	19	36	141
Fog	1	0	0	0	0	1
Raining	4	1	1	3	2	11
Smoke/Dust	0	0	0	0	1	1
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Lighting Condition (known)	2007	2008	2009	2010	2011	Total
Darkness - Lighted	6	4	1	2	5	18
Darkness - Not Lighted	6	3	3	0	4	16
Dawn/Dusk	1	0	2	0	1	4
Daylight	23	23	21	20	29	116
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Horizontal Road Alignment (known)	2007	2008	2009	2010	2011	Total
Curved, view obscured	3	4	2	0	3	12
Curved, view open	8	8	4	0	7	27
Straight	25	18	21	22	29	115
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Vertical Road Alignment (known)	2007	2008	2009	2010	2011	Total
Crest	2	0	1	2	2	7
Dip	1	1	0	0	2	4
Grade	7	7	4	5	7	30
Level	26	22	22	15	28	113
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Road Surface (known)	2007	2008	2009	2010	2011	Total
Sealed - dry	24	25	23	15	32	119
Sealed - wet	4	2	2	6	3	17
Unsealed - dry	6	2	2	1	3	14
Unsealed - wet	2	1	0	0	1	4
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Impact Location (known)	2007	2008	2009	2010	2011	Total
On Road	25	26	21	22	36	130
On road-related area	11	4	6	0	3	24
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - DCA Group (Definition for Coding Accidents)	2007	2008	2009	2010	2011	Total
Intersection, from adjacent approaches	1	3	1	1	1	7
Head-on	2	4	2	0	0	8

Opposing vehicles, turning	1	1	0	3	1	6
Rear-end	13	12	10	9	18	62
Lane changes	1	0	1	1	1	4
Vehicle leaving driveway	0	1	0	0	1	2
Hit parked vehicle	1	0	0	0	0	1
Pedestrian	3	4	3	4	7	21
Off carriageway, on straight	2	0	0	0	0	2
Off carriageway, on straight, hit object	2	0	2	0	1	5
Out of control, on straight	2	0	0	0	2	4
Off carriageway, on curve	2	1	0	0	1	4
Off carriageway, on curve, hit object	2	2	0	0	1	5
Out of control, on curve	0	1	0	0	0	1
Other	4	1	8	4	5	22
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - LOW Speed DCA Group (Definition for Coding	2007	2008	2009	2010	2011	Total
Intersection, from adjacent approaches	1	3	1	1	1	7
Head-on	1	3	2	0	0	6
Opposing vehicles, turning	1	1	0	3	1	6
Rear-end	11	11	9	6	17	54
Lane changes	1	0	0	1	1	3
Vehicle leaving driveway	0	1	0	0	1	2
Hit parked vehicle	1	0	0	0	0	1
Pedestrian	3	4	3	4	6	20
Off carriageway, on straight	2	0	0	0	0	2
Off carriageway, on straight, hit object	1	0	1	0	1	3
Out of control, on straight	1	0	0	0	2	3
Off carriageway, on curve	0	1	0	0	1	2
Off carriageway, on curve, hit object	2	2	0	0	1	5
Other	3	1	8	4	4	20
Total Crashes	**28**	**27**	**24**	**19**	**36**	**134**

Crash - HIGH Speed DCA Group (Definition for Coding	2007	2008	2009	2010	2011	Total
Head-on	1	1	0	0	0	2
Rear-end	2	1	1	3	1	8
Lane changes	0	0	1	0	0	1
Pedestrian	0	0	0	0	1	1
Off carriageway, on straight, hit object	1	0	1	0	0	2
Out of control, on straight	1	0	0	0	0	1
Off carriageway, on curve	2	0	0	0	0	2
Out of control, on curve	0	1	0	0	0	1
Other	1	0	0	0	1	2
Total Crashes	**8**	**3**	**3**	**3**	**3**	**20**

Crash - DCA (Definition for Coding Accidents)	2007	2008	2009	2010	2011	Total
000-PED'N: HIT OTHER	2	0	2	2	0	6
003-PED'N: FAR SIDE VEHICLE HIT FROM LEFT	0	0	0	0	1	1
004-PED'N: PLAY; WORK; STAND; LIE ON C'WAY	3	4	3	4	6	20
100-VEH'S ADJACENT APPROACH: OTHER	0	1	0	0	0	1
101-VEH'S ADJACENT APPROACH: THRU-THRU	0	0	1	1	0	2
102-VEH'S ADJACENT APPROACH: RIGHT-THRU	0	1	0	0	0	1
104-VEH'S ADJACENT APPROACH: THRU-RIGHT	1	1	0	0	0	2
107-VEH'S ADJACANT APPROACH: THRU-LEFT	0	0	0	0	1	1
201-VEH'S OPPOSITE APPROACH: HEAD ON	2	4	2	0	0	8
202-VEH'S OPPOSITE APPROACH: THRU-RIGHT	1	1	0	3	1	6
301-VEH'S SAME DIRECTION: REAR END	13	10	10	9	18	60
302-VEH'S SAME DIRECTION: LEFT REAR	0	1	0	0	0	1

303-VEH'S SAME DIRECTION: RIGHT REAR	0	1	0	0	0	1
305-VEH'S SAME DIRECTION: LANE SIDE SWIPE	0	0	1	1	0	2
306-VEH'S SAME DIRECTION: LANE CHANGE RIGHT	0	0	0	0	1	1
307-VEH'S SAME DIRECTION: LANE CHANGE LEFT	1	0	0	0	0	1
400-VEH'S MANOEUVRING: OTHER	0	1	2	0	0	3
403-VEH'S MANOEUVRING: PARKING VEH'S ONLY	0	0	1	0	0	1
405-VEH'S MANOEUVRING: REV INTO FIXED OBJECT	0	0	1	0	0	1
406-VEH'S MANOEUVRING: LEAVING DRIVEWAY	0	1	0	0	0	1
408-VEH'S MANOEUVRING: ENTERING FROM FOOTW	0	0	0	0	1	1
601-VEH'S ON PATH: PARKED	1	0	0	0	0	1
606-VEH'S ON PATH: TEMPORARY ROADWORKS	1	0	0	1	5	7
607-VEH'S ON PATH: TEMPORARY OBJECT ON C'WA	0	0	1	0	0	1
702-OFF PATH-STRAIGHT: RIGHT OFF CWAY	1	0	0	0	0	1
703-OFF PATH-STRAIGHT: LEFT OFF CWAY HIT OBJ	1	0	1	0	1	3
704-OFF PATH-STRAIGHT:RIGHT OFF CWAY HIT OBJ	1	0	1	0	0	2
705-OFF PATH-STRAIGHT:OUT OF CONTROL ON CW/	2	0	0	0	2	4
707-OFF PATH-STRAIGHT: RIGHT TURN	1	0	0	0	0	1
800-OFF PATH-CURVE: OTHER	1	0	0	0	0	1
801-OFF PATH-CURVE: OFF CWAY RIGHT BEND	0	1	0	0	0	1
802-OFF PATH-CURVE: OFF CWAY LEFT BEND	2	0	0	0	1	3
803-OFF PATH-CURVE: OFF CWAY RT BEND HIT OBJ	2	1	0	0	1	4
805-OFF PATH-CURVE: OUT OF CONTROL ON CWAY	0	1	0	0	0	1
808-OFF PATH-CURVE: MOUNTS TRAFFIC ISLAND	0	1	0	0	0	1
901-PASS & MISC: FELL IN/FROM VEHICLE	0	0	1	1	0	2
Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Crash - Contributing circumstances	2007	2008	2009	2010	2011	Total
ANIMAL UNCONTROLLED-ON ROAD	1	0	0	0	0	1
ATMOSPHERIC-HEAVY RAIN	0	0	1	0	1	2
ATMOSPHERIC-RAIN	0	1	0	0	0	1
ATMOSPHERIC-SMOKE	1	0	0	0	0	1
CONDITION-UNDER INFLUENCE OF LIQUOR/DRUG (N	0	2	2	1	2	7
DRIVER-DISTRACTED	1	0	0	0	0	1
DRIVER-FATIGUE RELATED BY DEFINITION	1	0	0	0	0	1
DRIVER-FATIGUE/FELL ASLEEP	1	0	0	0	0	1
DRIVER-TAKING AVOIDING ACTION TO MISS ANOTHI	0	1	0	0	0	1
DRIVER-UNDERAGE (INEXPERIENCE)	0	1	0	0	0	1
EXCESSIVE SPEED FOR CIRCUMSTANCES	1	2	2	0	0	5
LIGHTING-NO STREET LIGHTING	2	0	2	0	0	4
LIGHTING-SUNLIGHT GLARE (DAWN/DUSK/REFLECT	0	0	0	0	1	1
LIGHTING CONDITIONS-MISCELLANEOUS	0	1	0	0	0	1
ROAD-ROADWORKS	23	13	11	6	12	65
ROAD-ROUGH SURFACE	1	0	0	0	0	1
ROAD-STEEP GRADE	0	1	0	0	0	1
ROAD-WET/SLIPPERY	5	2	1	0	1	9
ROAD CONDITIONS-MISCELLANEOUS	1	1	1	0	0	3
VEHICLE-BRAKES	0	0	0	1	1	2
VEHICLE-TYRES (I.E. LOW TREAD, PUNCTURE/BLOW	0	0	0	0	1	1
VEHICLE ENTERING DRIVEWAY	0	2	0	0	0	2
VIOLATION-CROSS DOUBLE LINES	0	0	1	0	0	1
VIOLATION-DANGEROUS DRIVING	1	0	0	0	0	1
VIOLATION-DISOBEY GIVE WAY SIGN	0	3	0	1	0	4
VIOLATION-DISOBEY STOP SIGN	1	2	1	3	1	8
VIOLATION-EXCEEDING SPEED LIMIT	1	2	0	0	0	3
VIOLATION-FAIL TO GIVE WAY	1	0	0	0	1	2
VIOLATION-FAIL TO KEEP LEFT	1	2	1	0	2	6
VIOLATION-FOLLOW TOO CLOSELY	2	0	2	3	5	12
VIOLATION-OVER PRESCRIBED CONCENTRATION OI	0	0	0	0	1	1
VIOLATION-TURN IN FACE OF ONCOMING TRAFFIC	0	0	0	1	1	2
VIOLATION-UNSAFE LANE CHANGE	0	0	0	0	1	1

Total Crashes	**36**	**30**	**27**	**22**	**39**	**154**

Appendix C – Creating Smarter Work zones

Work Zone Technologies			
Technology	**Description**	**Work Zone Issue Addressed**	**Potential Benefits and Outcomes**
Managing Speeds			
Automated Speed Enforcement	Mobile units used in automated speed enforcement record when a vehicle's speed exceeds a specified maximum and document the date and time of the violation. The mobile units are equipped with onboard cameras that capture images of the vehicle's license plate and possibly the driver.	• Crashes associated with speed and involving road workers • Speeding in work zones • Speed differentials	• May significantly reduce fatal and severe crashes • Increases speed limit compliance and may reduce average speeds
Speed Feedback Signs	Speed feedback signs inform approaching drivers of their current speeds and encourage them to slow down if they are traveling above the speed limit. The signs typically are portable and can be installed upstream of the work zone or within the work area when driver speed compliance is an issue.	• Speeding in work zones	• Can be moved to new locations as needed • Require minimal maintenance • Encourage drivers to comply with the posted speed limit
Reducing Exposure			
Automated System to Install Raised Pavement Markers	Automated placement of raised pavement markers reduces the need for personnel and vehicles for manual installation, while minimizing exposure to workers. A typical placement operation includes four vehicles and a six-person crew, but the Georgia Department of Transportation's automated system requires one vehicle and only two staffers.	• Worker exposure during installation of pavement markers	• Reduces worker and road user exposure and increases safety • Reduces the need for multiple fleet vehicles to a single-vehicle operation • Lessens the wear and tear on vehicles associated with stop-and-go operations • Improves the installation rate versus traditional methods
Automated Cone Deployment System	An automated machine for deployment places and retrieves traffic cones during roadway lane closures. This system can be operated by a single worker to open and close busy lanes for construction or maintenance work zones.	• Worker exposure during setup and removal of traffic cones	• Reduces worker and road user exposure • Can be operated by a single worker
Moveable and Mobile Barriers	This technology allows quick barrier adjustments to create protected work spaces or to reallocate travel lanes in a work zone to match fluctuations in traffic flow. Unlike traditional barriers, which are difficult and time consuming to reposition,	• Worker safety, particularly on highways with high speeds	• Can be moved to accommodate peak traffic flow • Provide positive protection in situations where a barrier might not otherwise be used

	movable and mobile barriers are designed to be quickly moved as a unit.	• Number, duration, and impact of needed lane closures	• Can improve worker safety and efficiency
Remotely Operated Lane Closure System	Installing temporary traffic control devices requires significant resources. And, as a work area changes, the locations of the temporary traffic control devices must also change, which requires personnel to enter the active roadway. A lane closure system that is remotely operated can reduce the interruption to traffic by deploying the temporary traffic control devices needed for lane closures one time and by modifying the setup from a remote location.	• Workers in close proximity to traffic • Worker and traffic exposure as vehicle fleets set up signing packages • Impact on traffic flows associated with the installation and removal of signing	• Can be easily installed and relocated • Is operated remotely • Uses solar power • Decreases the downtime associated with multiple installations of signing, which may increase the time available for construction
Work Space Intrusion Warning	A work space intrusion system alerts workers when a vehicle has entered the area closed for roadwork. The system also alerts the driver.	• Vehicles inadvertently entering the work area	• Reduces the potential for vehicle collisions with construction equipment • Increases construction worker safety
Automated Flagger Assistance Device	Automated flagger assistance devices are mechanically operated devices that function under the same operational principles as traditional flagging. Crews can operate the devices from a distance, which removes human flaggers from close proximity to traffic.	• Flaggers being exposed to traffic hazards	• Increases the safety of flaggers by removing them from the traffic lane or shoulder
Monitoring Performance and Management			
Portable Traffic Monitoring Devices	These devices use radar, cellular, microwave, and satellite technologies to monitor traffic conditions without a large investment of infrastructure or staff resources. The devices can detect queues and measure the average travel speed in key areas, such as in advance of and within work zone transition areas. They also store data for analysis purposes.	• Traffic condition data in work zones to monitor and assess performance, provide traveler information, and manage traffic	• Maximize resources by enabling easy relocation when areas experiencing issues change • Support policy decisions • Have data warehousing capabilities • Can facilitate data collection in locations where permanent collection devices are disabled or not feasible

Identifying and Preventing Incidents			
Notification of Construction Equipment Entering and Exiting the Traffic Stream	Detection technologies help to identify construction equipment entering or exiting the work area and notify motorists by changing message signage to provide an alert.	• Vehicle collisions with construction equipment entering or exiting the traffic stream • Vehicles inadvertently following construction equipment into the work area	• Reduces vehicle collisions with construction equipment • Increases safety of construction workers
Identifying Traffic Incidents Through Traffic Monitoring and Invehicle GPS	An agency can detect when incidents have occurred by monitoring travel speeds or ITS camera images. Technologies that are primarily GPS-based and located within vehicles, such as airbag activation detection, motion sensors, navigation/GPS receivers, and other in-car control devices, provide sufficient information for identifying general traffic patterns. Such realtime information may be able to infer the occurrence of a crash. These capabilities will increase as connected vehicle technology becomes more widely deployed.	• Delayed incident detection leading to congestion, queuing, and secondary incidents	• May improve emergency detection and response times to the incident location • May enable more appropriate response equipment to be sent because of camera images • Reduces the likelihood of secondary crashes • Improves travel times through work zones • May be able to provide immediate incident notification through automated alerts
Managing Traffic			
Use of Sequential Warning Lights to Improve Recognition of Nighttime Traffic Control	Nighttime lane closures for work zones require motorists to shift into another lane despite reduced visibility. Sequential warning lights affixed on temporarily deployed cones or barrels at the work zone taper can improve driver recognition of the lane closure by clearly delineating the lane taper area.	• Crashes and queuing resulting from delayed driver recognition of traffic patterns in work zones at night	• Increases safety in nighttime work zones by clearly defining lane taper • Increases early merging • Can reduce average speeds
Dynamic Lane Merge	Dynamic lane merge is the broad term used to describe several types of merges that agencies can use at lane closure and merge locations. The system may include traffic sensors, trailers with solar-powered flashers, equipment and batteries, dynamic message signs, and communication devices. Types of merges include the following.	• Queuing associated with lane drop • Aggressive driving at the merge point and associated crashes	• Improves road user safety by reducing the number of aggressive merges • Improves travel times through the work zone associated with normalized speeds and minimizes queuing

	• Lane-based signal merge: A strategy that employs a signal at the proper merging point to assign the right-of-way for traffic in each lane if the approaching volume exceeds 800 vehicles per hour per lane. • Dynamic early merge: When traffic congestion is low, signs encourage early merging to the through lane to avoid traffic disruptions from merges at the lane drop. • Dynamic late merge: When traffic congestion is moderate to high, signs encourage using all lanes to the merge point to reduce queue lengths.	• Delay associated with incident response at the merge point and congestion through the work zone • Right-of-way confusion	• Lane-based signal merge increases vehicle throughput and, as a result, reduces the average vehicle delay, stopped vehicle delay, and the number of vehicle stops under congested traffic conditions
Providing Traveler Information			
Dynamic Stopped Traffic Advisory	Because queue lengths can vary greatly, identifying a suitable location for advanced warning signage is sometimes difficult without regularly altering the placement. The dynamic stopped traffic advisory system can be activated only when queues exist for determined lengths or sections of roadway, which may help to reduce travel times, decrease work zone congestion, and reduce the likelihood of back-of-queue crashes. The system also can be used to warn motorists about stopped traffic in situations where sight distance is impeded by roadway geometry, such as near horizontal or vertical curves.	• Back-of-queue crashes related to little or no warning about queuing	• Collects realtime or near-realtime traffic data • Provides motorists with information about queues and delays • Reduces rear-end crashes
Over-Dimension Warning	Work zones may cause temporary minimal width or height clearances for large vehicles using the roadway. Efforts made on behalf of the transportation agency to reroute the affected vehicles may not be effective, so over-dimension warnings give compliance notifications as large vehicles approach the work zone.	• Congestion and traffic mobility • Safety	• Alerts drivers that their vehicle is over dimension and they need to use an alternate or escape route • Warns drivers about their inability to continue through the work zone, providing sufficient time to use an alternate or escape route • Tells drivers to stop when they fail to use the designated alternate or escape route
Portable Changeable Message Signs	Portable changeable message signs are useful in situations that require advance notice, such as ramp or lane closures, narrow	• Significant queuing and delays	• Provide travelers with realtime information on work zone conditions • Reduce speed variance

	lanes, changing geometric conditions, or realtime travel information.	• Changing travel conditions within the work zone • Work zone speed variability • Changes in roadway alignment and surface conditions	• Increase effectiveness at night and during inclement weather
Work Zone Realtime Information System	Portable queue detectors include video cameras mounted on poles in advance of work zones. System detectors collect lane occupancy and traffic speed data and send them to a computer connected to changeable message signage. The computer processes the data and, when it determines that backups are forming, it automatically displays warning messages on the changeable message signage.	• Variability in travel time leading to traveler uncertainty • Potential for increased delay	• Reduces congestion associated with lane closures • Reduces rear-end crashes and fatal crashes due to excessive queuing • Improves communication with the motoring public • Provides realtime, credible information resulting in better compliance with suggested actions for travelers

Appendix D – General Public Survey & Detailed Response

Research Project - Traffic management and control at roadworks

No. of Questions: Eight (8)
Estimated time: 2 - 5 minutes

The following survey has been developed with the aim of gaining insight into reducing speeds and improving traffic flow with the goal of increasing safety at road works sites. The survey results will be utilized for my final level project at the University of Southern Queensland and the information made available to traffic control authorities and local industry. The survey is an anonymous response survey and no personal information is gained from your participation.

Thank-you for your time and input into the topic

1. Have you ever driven through a roadworks site in Queensland?

- [ ] Yes
- [ ] No

2. Why do you think speeds are reduced through road works?

(Please rank from 1 - 3, 1 being MOST important and 3 being LEAST important)

[▾] Safety of the traveling public.

[▾] Safety of the workers and on site personnel.

[▾] To allow construction vehicles time to enter and exit the work zone.

3. Do you as a driver/passenger traveling through roadworks sites feel at risk?

- [ ] Yes
- [ ] No

4. Have you ever sped through a roadworks site?

- [ ] Yes
- [ ] No

5. If yes to Question 4, what is the main reason why you find yourself speeding?

[ ]

6. Have you ever received a speeding fine through a road works site?

- [ ] Yes
- [ ] No

7. In your opinion, which of the following do you think would be MOST effective in reducing speeds through roadworks sites?

(Please rank from 1 to 5. 1 being the MOST EFFECTIVE and 5 being the LEAST EFFECTIVE)

Enforcement (I.e. Fixed speed cameras or double demerit points through roadworks zones)

More concise signage (I.e. Large flashing speed signs with variable speed limits, similar to those seen in school zones - when workers are on the road the sign might display 40km/hr, when there are no workers the sign might display 60km/hr)

Radio blocking (I.e. Audible messages communicated through your radio when encroaching roadwork zones)

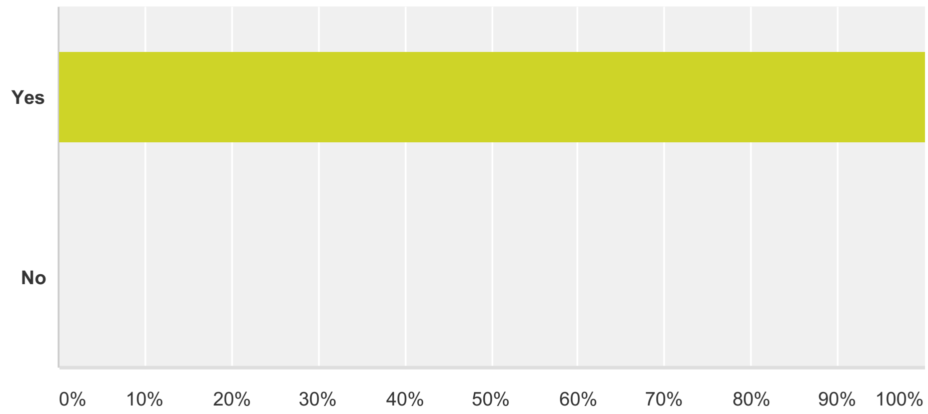
Intelligent advanced warning signage (I.e. Vehicle activated signage informing drivers of their current speed or estimated travel time through a roadworks site.)

Reduce available space (I.e. Narrower lane lines creating a sense of danger to the driver/passenger)

8. Can you provide any further ideas on traffic control measures that may improve safety through roadwork zones?

Q1 Have you ever driven through a roadworks site in Queensland?

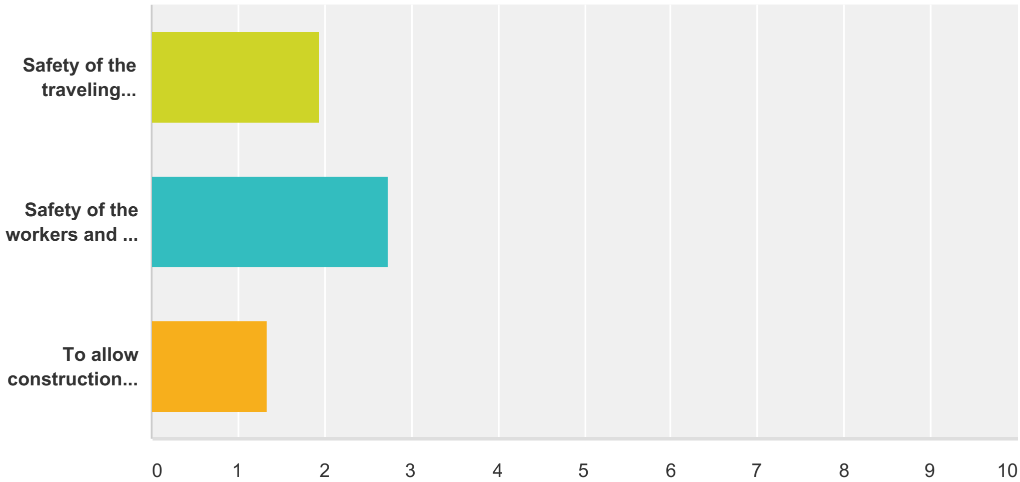
Answered: 82 Skipped: 1



Answer Choices	Responses	
Yes	**100.00%**	82
No	**0.00%**	0
Total		**82**

Q2 Why do you think speeds are reduced through road works? (Please rank from 1 - 3, 1 being MOST important and 3 being LEAST important)

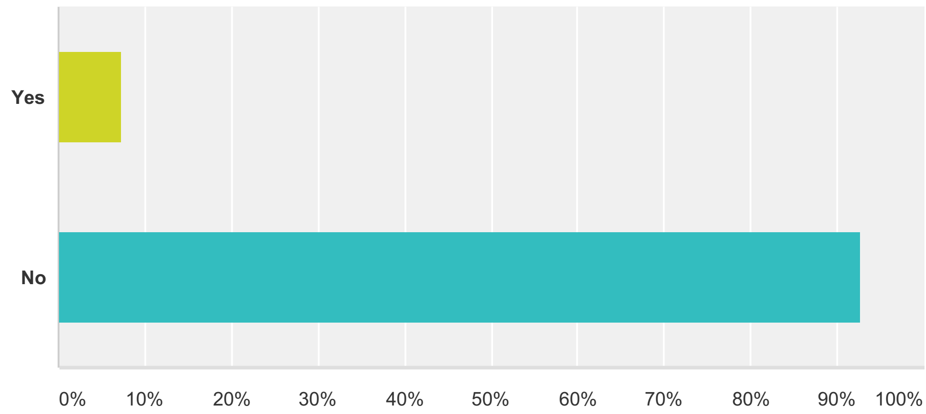
Answered: 83 Skipped: 0



	1	2	3	Total	Score
Safety of the traveling public.	**19.28%** 16	**55.42%** 46	**25.30%** 21	83	1.94
Safety of the workers and on site personnel.	**78.31%** 65	**16.87%** 14	**4.82%** 4	83	2.73
To allow construction vehicles time to enter and exit the work zone.	**2.41%** 2	**27.71%** 23	**69.88%** 58	83	1.33

Q3 Do you as a driver/passenger traveling through roadworks sites feel at risk?

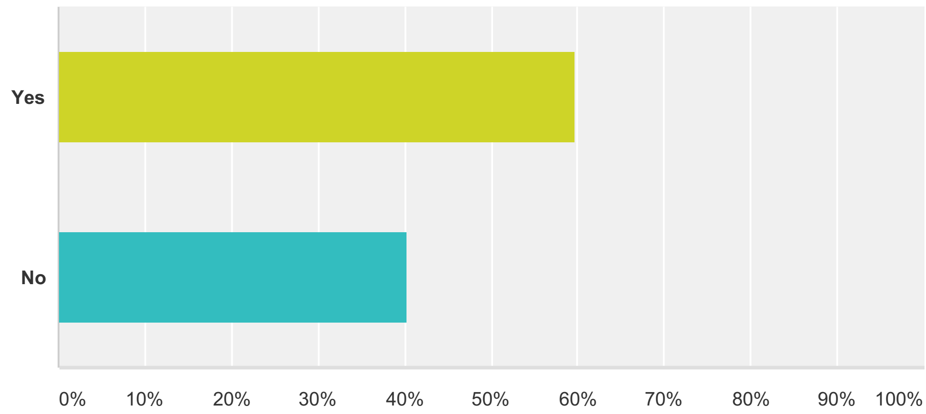
Answered: 82 Skipped: 1



Answer Choices	Responses	
Yes	**7.32%**	6
No	**92.68%**	76
Total		**82**

Q4 Have you ever sped through a roadworks site?

Answered: 82 Skipped: 1



Answer Choices	Responses	
Yes	**59.76%**	49
No	**40.24%**	33
Total		**82**

Q5 If yes to Question 4, what is the main reason why you find yourself speeding?

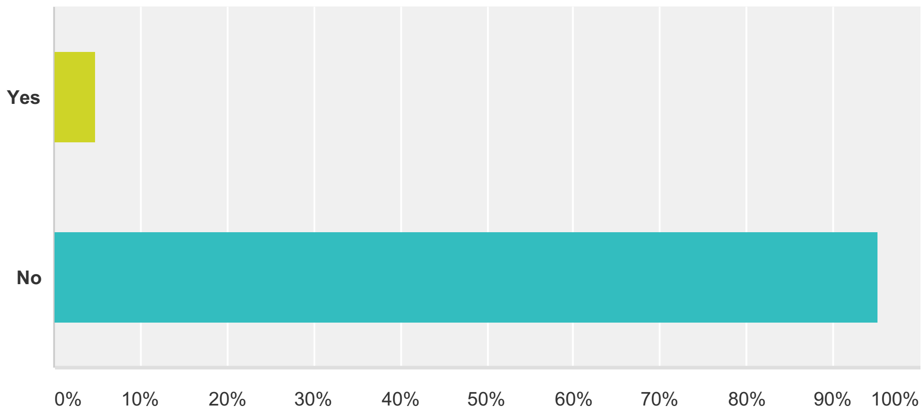
Answered: 49 Skipped: 34

#	Responses	Date
1	N/A	7/17/2015 10:42 PM
2	Haven't seen the REDUCE SPEED signs	7/10/2015 2:00 AM
3	Speed are often reduced by so much so it is difficult to adjust. Normally appears safe and controlled so reason for 40km is not needed.	7/8/2015 9:59 AM
4	Slightly higher speed than the designated 40 when there was clearly no work happening and no workers	7/8/2015 9:50 AM
5	Usually if its after hours and there isn't any work going on. Provided there is no obvious hazard. I also find road works signed incorrectly. They often never have an "end" sign or it tells you to slow down to the already set speed limit etc.	7/7/2015 2:43 PM
6	When no one is working - after hours /weekend	7/7/2015 11:34 AM
7	Pressure from surrounding vehicles	7/7/2015 10:08 AM
8	The reduced speed zone is extended too far in terms of distance.	7/6/2015 9:22 PM
9	If there is no work being done at the time.	7/6/2015 4:22 PM
10	NA	7/6/2015 4:05 PM
11	I didn't see the road signs until it was too late.	7/6/2015 3:19 PM
12	No works actually taking place at the time, site was closed.	7/6/2015 2:27 PM
13	Signs are in place but it is obvious no work is taking place	7/6/2015 2:17 PM
14	To keep up with the traffic. When there is no roadworks happening at the time (i.e. at night) or when there are no workers on site.	7/6/2015 2:15 PM
15	I, like many others, tend to drive a speed that I consider safe/reasonable in the circumstances, unless I am consciously changing my speed to reflect a posted speed limit to ensure I do not break the law. It often seems reasonable to drive at say 50 (rather than the posted 40km/h) speed limit if it feels safe, especially if the road usually has a posted speed limit of say 80 or 100km/h, and there appears to be only marginal changes due to road works. For that reason, I may slip into driving at speed higher than the post speed limit at road works.	7/6/2015 2:07 PM
16	Either didn't realise the speed changed until already in the zone (signs not too far in advance). or the speed signs are still up with works obviously completed and no works or signs of works around.	7/6/2015 1:38 PM
17	Appears to be no impact to the road section i'm travelling. i.e. weekend and no work occuring	7/6/2015 12:12 PM
18	no work occurring	7/6/2015 10:59 AM
19	Exceeding the limit a minimal amount when the roadworks area is much larger than the works being done.	7/6/2015 10:08 AM
20	Because there was no workers there,yet speed limits and work signs were still in place.	7/5/2015 7:46 PM
21	lack of attention	7/4/2015 10:25 PM
22	sometimes its very slow and there are no other cars or workers on the road.	7/4/2015 7:58 PM
23	Didn't see the signs for a construction site	7/4/2015 1:54 PM
24	Inappropriate speed for that road works site. Speed seemed to slow	7/4/2015 10:44 AM
25	unable to slow given conditions	7/3/2015 9:42 PM
26	There were no roadworks taking place, only signs.	7/3/2015 6:25 PM
27	Aware of construction site unaware of speed limit. Usually not signed or badly signed (mostly small temporary sites)	7/3/2015 5:11 PM
28	Normally because it's on a weekend where there are no works going on	7/3/2015 4:06 PM
29	Site was deserted and risk to me travelling at normal speed.	7/3/2015 4:04 PM
30	Often no one working and site totally unattended	7/3/2015 3:11 PM
31	No reason to slow down, can travel easily through site at usual speed.	7/3/2015 2:57 PM

32	Impatience and sometimes looks like no roadworks or construction being undertaken.	7/3/2015 2:08 PM
33	I'm not sure why I speed in work zones	7/3/2015 1:38 PM
34	Highway roadworks - Generally enough temporary safety controls (ie barriers, lights etc) have been installed, with significant spacing (and wide lanes) between the controls and the traffic to reduce the risk without the need of significant speed reduction (ie 100kmh to 40kmh). Other times, roadworks signs have been erected in areas where there is no road works, or end of roadworks signs are too far away from the actual roadworks and therefore there is no reason for the reduced speed.	7/3/2015 1:27 PM
35	Too many changes in speed limits. 60, 40, 60, 80, 60, 40.	7/3/2015 12:54 PM
36	No work happening	7/3/2015 12:48 PM
37	sometimes speed is unnecessarily too slow.	7/3/2015 12:44 PM
38	Speed limit is too low for the actual work being done.	7/3/2015 12:35 PM
39	being careless	7/3/2015 12:32 PM
40	Often the reduced speed sign is there, however no road works are happening (i.e. I'm driving through at night or on the weekend) so I continue to drive at the un-reduced speed. Having other cars speed also increases my chances of speeding	7/3/2015 12:31 PM
41	Because noone has been working on the site/ the signs have been left up when the work has resumed	7/3/2015 12:30 PM
42	Roadwork signs are there but there are no roadworks!	7/3/2015 12:27 PM
43	I might drive 10k over the speed limit hard to reduce speed in time without slamming on breaks	7/3/2015 12:27 PM
44	Can't see anyone working	7/3/2015 12:26 PM
45	BECAUSE IT IS CLEAR THAT THERE IS NO DANGER (EG. WORKS ARE NOT BEING CARRIED OUT) ALSO SIGNAGE IS NOT ALWAYS CLEAR.	7/3/2015 12:17 PM
46	Because most of the time when I travel through 'road works' I can't actually see any workers and therefore If I was to have an accident then it wouldn't seriously impact on any other personnel. When I can see that there are employees working in roadwork sites then I am much more careful and stick to the advised speed.	7/3/2015 12:15 PM
47	On open roads where it is clear no roadwork is occurring for example over weekends	7/3/2015 12:13 PM
48	Not concentrating, felt the limit was too slow, no one on site	7/3/2015 12:11 PM
49	90% of the time there is no one around who may be at risk to justify the heavily reduced speed limit. 100% of the time the people who are at risk are standing there doing nothing so I get frustrated.	7/3/2015 12:11 PM

Q6 Have you ever received a speeding fine through a road works site?

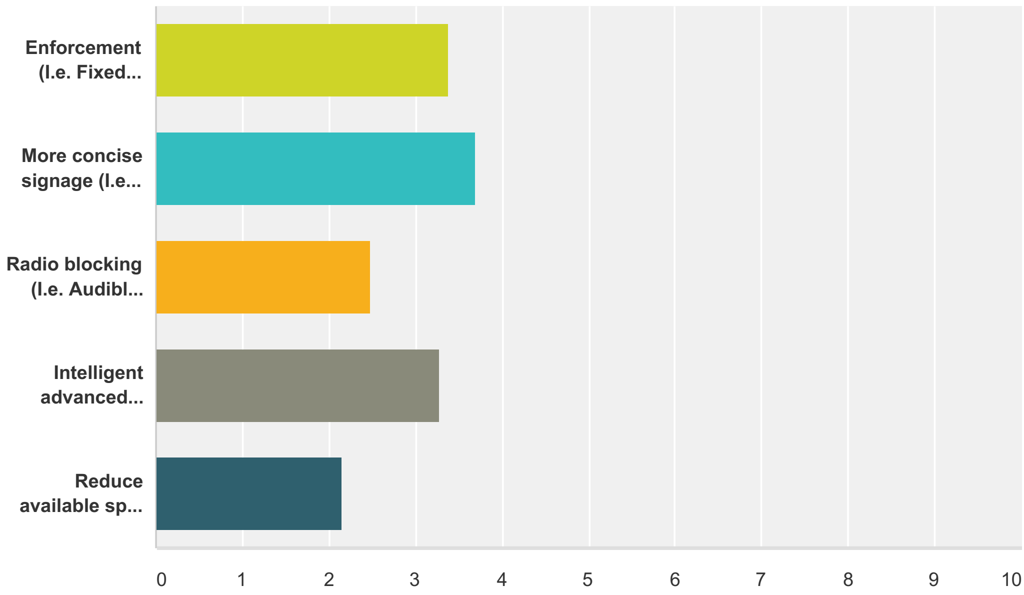
Answered: 82 Skipped: 1



Answer Choices	Responses	
Yes	**4.88%**	4
No	**95.12%**	78
Total		**82**

Q7 In your opinion, which of the following do you think would be MOST effective in reducing speeds through roadworks sites? (Please rank from 1 to 5. 1 being the MOST EFFECTIVE and 5 being the LEAST EFFECTIVE)

Answered: 83 Skipped: 0



	1	2	3	4	5	Total	Score
Enforcement (I.e. Fixed speed cameras or double demerit points through roadworks zones)	**32.53%** 27	**19.28%** 16	**19.28%** 16	**12.05%** 10	**16.87%** 14	83	3.39
More concise signage (I.e. Large flashing speed signs with variable speed limits, similar to those seen in school zones - when workers are on the road the sign might display 40km/hr, when there are no workers the sign might display 60km/hr)	**36.14%** 30	**27.71%** 23	**15.66%** 13	**10.84%** 9	**9.64%** 8	83	3.70
Radio blocking (I.e. Audible messages communicated through your radio when encroaching roadwork zones)	**8.43%** 7	**10.84%** 9	**26.51%** 22	**30.12%** 25	**24.10%** 20	83	2.49
Intelligent advanced warning signage (I.e. Vehicle activated signage informing drivers of their current speed or estimated travel time through a roadworks site.)	**19.28%** 16	**28.92%** 24	**19.28%** 16	**25.30%** 21	**7.23%** 6	83	3.28
Reduce available space (I.e. Narrower lane lines creating a sense of danger to the driver/passenger)	**3.61%** 3	**13.25%** 11	**19.28%** 16	**21.69%** 18	**42.17%** 35	83	2.14

Q8 Can you provide any further ideas on traffic control measures that may improve safety through roadwork zones?

Answered: 28 Skipped: 55

#	Responses	Date
1	Signs must be blocked or removed on weekends or when no work is taking place, very irritating driving at 40kmh when everyone has already gone home !!!	7/17/2015 10:42 PM
2	no	7/10/2015 2:00 AM
3	Roadwork signs are only used when work is currently underway and the road is affected. People are more likely to take the signs seriously and obey the speed limit.	7/8/2015 2:00 PM
4	When workers are visible there is a greater desire to avoid speed or to cause harm. The use of people to control traffic always seems to work best. Ensure that speed limits are accurate - i.e if they are actually not required (no work occurring) - don't use them. Over use or inaccurate use causes people to react adversely to the restrictions. In the end people tend to drive at a speed they think is safe - physical restrictions will always work best because they reduce the perceived safety margin.	7/8/2015 9:50 AM
5	More accurate signage. I don't have a problem with slowing down for road works but when they aren't signed properly in the first place (or at all) it gets frustrating.	7/7/2015 2:43 PM
6	Better timing control to reduce road rage induced by long waits.	7/7/2015 1:13 PM
7	At night there is always the potential for confusion when there are lots of flashing signs, bollards, etc. This aids the slowing process but when there is a diversion or something to navigate it is difficult to sometimes know what is required.	7/7/2015 12:17 PM
8	No	7/7/2015 11:34 AM
9	Have a smaller distance of reduced speed. People loose their patience or either neglect to consistently watch their speed.	7/6/2015 9:22 PM
10	No	7/6/2015 4:05 PM
11	I think the most cost effective way of reducing speed at road works would be to create a road enviornment that requries slow speed to be navigated safely for the driver, regardless of how much spaced is needed for the road works e.g. restric the lane widths to such a degree that a person can only not hit markes/road signs etc if they slow down to the desired speed limit. This is based on my observation/assumption that people drive to what they feel is safe for them, not others.	7/6/2015 2:07 PM
12	Signs advising speed enfringements enforced	7/6/2015 12:12 PM
13	Those responsible for roadworks to pre-inform communities affected by promoting a website link showing roads to be affected and dates: commencement and (expected) completion. This could be available along with digital roadside signage. The link could be included on roadside signage.	7/6/2015 11:32 AM
14	I find signage is helpful but also additional lighting at night could potentially be helpful.	7/6/2015 10:08 AM
15	As above	7/5/2015 7:46 PM
16	• Higher quality staff training and assessment to provide consistent implementation of roadwork signage. More concise signage is a nice idea but traffic control staff currently are mostly incapable of using the signage they have to useful effect and what they have already seems fairly concise. Drivers need clear instruction not confusion. • Adopting the school zone system for roadwork zones will only make it ubiquitous and therefore less important. To use the system used at schools will only diminish the effectiveness of the school traffic system, which appears to have a high level of success. Either a unique system for traffic control signage needs to be developed for roadwork sites or the existing signage needs to be implemented correctly and consistently across all roadwork zones. More signage does not mean more safety. Better consistent signage and implementation, monitoring and enforcement of the sign system might.	7/5/2015 11:37 AM
17	Clear signs when work finishes so people take signs seiously.	7/5/2015 9:39 AM
18	Police car with flashing lights parked at start of zone	7/4/2015 10:55 PM
19	Most annoying road work problem. When they block off lanes for roadworks and nothing is happening. Most often times I speed.	7/4/2015 1:54 PM
20	I would like to see more education material emailed to learner drivers during the licensing process.	7/4/2015 9:57 AM
21	do road works after hours low traffic conditions	7/3/2015 9:42 PM

22	Timeous signs about the roadworks that allow a driver to decide to take another route.	7/3/2015 4:41 PM
23	Cover up permanent signs when nobody is working on a site over the weekend and there are no barriers/traffic cones in sight.	7/3/2015 4:04 PM
24	Having a police car sitting there with the lights flashing always seems effective in slowing the traffic down	7/3/2015 1:38 PM
25	Comment for question 7 - believe the last three measures would be equally effective	7/3/2015 12:25 PM
26	When work is not currently being done during road work sites make sure the signs are taken away or the 40km/h speed limit is increased ie nights, weekends etc. This will mean that when I do come across a road work zone and the signs are up and the speed limits are enforced I know for absolute certain that there are workers in the near vicinity therefore I must slow down to avoid a possible accident.	7/3/2015 12:15 PM
27	removing restrictions when work is not occurring	7/3/2015 12:13 PM
28	no	7/3/2015 12:11 PM

Appendix E – Technical Survey & Detailed Response

Research Project - Traffic management and control at roadworks using innovative techniques

No. of Questions: Seven (7)
Estimated time: 2 - 5 minutes

The following survey has been developed with the aim of gaining insight into reducing speeds and improving traffic flow with the goal of increasing safety at road works sites. The survey results will be utilized for my final level project at the University of Southern Queensland and the information made available to traffic control authorities and local industry. The survey is an anonymous response survey and no personal information is gained from your participation.

Thank-you for your time and input into the topic.

1. Please select your State or Territory:

(If outside of Australia, please select other and comment on your location)

Other (please specify)

2. What standards, manuals or guidelines does your agency base their traffic management plans or traffic guidance schemes for controlling traffic at roadworks sites?

3. Have you or your agency used or trialled any innovative traffic control devices that are not included in the documents listed in Question 2?

- Yes
- No

4. If yes to Question 2, what types of devices have you trialled/used?

(E.g. This could be items such as portable rumble strips, intrusion warning devices, vehicle activated signage or any other device you believe differs from the documents listed in Question 2)

5. Please describe the most effective traffic control device/s used by you or your agency to reduce vehicle speeds through roadworks sites.

(You may include devices included in the documents described in Question 2 or any innovative devices used/trialled as described in Question 4.)

6. In your opinion, which of the following do you think would be MOST effective in reducing speeds through roadworks sites?

(Please rank from 1 to 5. 1 being the MOST EFFECTIVE and 5 being the LEAST EFFECTIVE)

Enforcement (I.e. Fixed speed cameras or double demerit points through roadworks zones)

More concise signage (I.e. Large flashing speed signs with variable speed limits. Similar to those seen in school zones - when workers are on the road the sign might display 40km/hr, when there are no workers the sign might display 60km/hr)

Radio blocking (I.e. Audible messages communicated through your radio when encroaching roadwork zones)

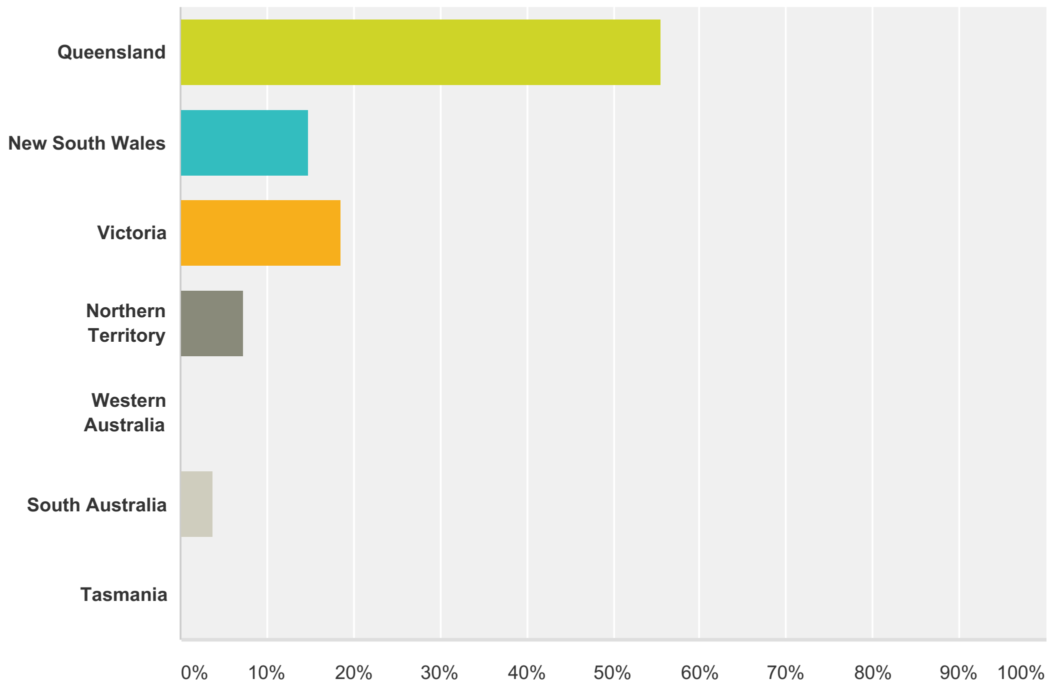
Intelligent advanced warning signage (I.e. Vehicle activated signage informing drivers of their current speed or estimated travel time through a roadworks site)

Reduce available space (I.e. Narrower lane lines creating a sense of danger to the driver/passengers)

7. Can you provide any further ideas on traffic control measures that may improve safety through roadwork zones?

Q1 Please select your State or Territory:(If outside of Australia, please select other and comment on your location)

Answered: 27 Skipped: 0



Answer Choices	Responses	
Queensland	55.56%	15
New South Wales	14.81%	4
Victoria	18.52%	5
Northern Territory	7.41%	2
Western Australia	0.00%	0
South Australia	3.70%	1
Tasmania	0.00%	0
Total		27

#	Other (please specify)	Date
	There are no responses.	

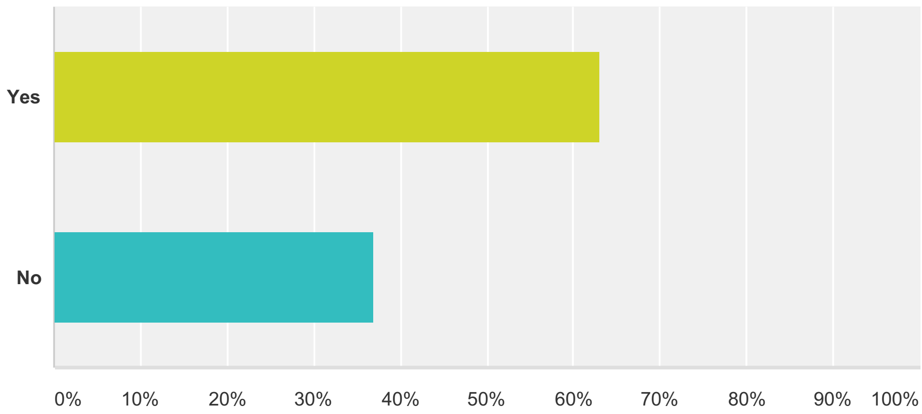
Q2 What standards, manuals or guidelines does your agency base their traffic management plans or traffic guidance schemes for controlling traffic at roadworks sites?

Answered: 27 Skipped: 0

#	Responses	Date
1	MUTCD, TRUM, AUSTRoads	8/10/2015 5:26 PM
2	1742.3 - SA code of practice - Road traffic act	7/9/2015 12:06 PM
3	TCAWS Mannual and Australian Standard	7/8/2015 11:31 AM
4	TCAWM V4 AND Australian Standards AS1742	7/7/2015 12:05 PM
5	Traffic Management for construction or Maintenance Work Code of Practice 2008 & Manual of Uniform Traffic Control Devices	7/6/2015 4:14 PM
6	MUTCD	7/6/2015 3:47 PM
7	MUTCD	7/6/2015 3:31 PM
8	MUTCD Part 3; TC signs; MRTS	7/6/2015 3:23 PM
9	MUTCD Part 3	7/6/2015 3:07 PM
10	MUTCD Part 3 2014	7/6/2015 1:19 PM
11	AS1742.3-2009	7/6/2015 12:34 PM
12	MUTCD	7/6/2015 11:58 AM
13	MUTCD	7/6/2015 11:57 AM
14	RTA TCAWS and Standards Australia	7/6/2015 11:31 AM
15	as 1742.3 and the code	7/6/2015 11:24 AM
16	MUTCD	7/6/2015 10:51 AM
17	RMS TCAWS Manual, AS 1742.1	7/6/2015 10:37 AM
18	1742.3-2009, NT permit to work	7/6/2015 10:21 AM
19	As-1742.-2009 & Road Management Act 2004	7/6/2015 10:19 AM
20	AS1742.3 and VIC Code of Practice for Worksite Safety 2010	7/6/2015 10:16 AM
21	Aus Standards and Code of Practice	7/6/2015 9:52 AM
22	Road management act code of practice 2010 and AS 1742.3	7/4/2015 9:56 AM
23	MUTCD	7/1/2015 2:11 PM
24	MUTCD and TRUM	7/1/2015 2:09 PM
25	MUTCD	7/1/2015 12:29 PM
26	MUTCD	7/1/2015 11:00 AM
27	MUTCD	7/1/2015 9:30 AM

Q3 Have you or your agency used or trialled any innovative traffic control devices that are not included in the documents listed in Question 2?

Answered: 27 Skipped: 0



Answer Choices	Responses	
Yes	**62.96%**	17
No	**37.04%**	10
Total		**27**

Q4 If yes to Question 2, what types of devices have you trialled/used? (E.g. This could be items such as portable rumble strips, intrusion warning devices, vehicle activated signage or any other device you believe differs from the documents listed in Question 2)

Answered: 17 Skipped: 10

#	Responses	Date
1	drop deck trucks - Attenuator vehicles - Multi Message signage	7/9/2015 12:06 PM
2	VMS boards on vehicle. There is no mention of these for this application in either. There area range of products available with many misleading claims made regarding what is and isnt allowed by certain manufacturers.	7/8/2015 11:31 AM
3	Solar lighting at crash terminals.	7/6/2015 4:14 PM
4	Mobile camera / recording / radar system.	7/6/2015 3:47 PM
5	solar lighting	7/6/2015 3:31 PM
6	Multi-message sign leg adjusters (to place signs level on roadway verge); frangible permanent sign cover-ups.	7/6/2015 3:23 PM
7	Early Warning Systems	7/6/2015 3:07 PM
8	A form of portable rumble strip, a hose. A hose stretched across the active traffic lane seems to dramatically reduce traffic speed past the work area.	7/6/2015 12:34 PM
9	Additional warning prior to end treatments, such as mini guide posts (150mm height) installed on shoulder between face of barrier and edge line.	7/6/2015 11:58 AM
10	portable rumble strips and signage that can be used on freeways when there is no shoulder	7/6/2015 11:24 AM
11	Truck Mounted Attenuators, Cone Deployment Trucks, Rumble Strips, Vehicle Mounted VMS Boards, Vehicle Mounted Speed Radar Signs.	7/6/2015 10:37 AM
12	Portable Speed Humps	7/6/2015 10:19 AM
13	Drop deck trucks, Portable rumble strips, Traffic Data logging	7/6/2015 10:16 AM
14	Rumble strips	7/6/2015 9:52 AM
15	Temporary speed humps	7/4/2015 9:56 AM
16	A traffic onctrol in 2006 set-up a video camera on a tripod near to the road; this resulted in cars slowing down.	7/1/2015 11:00 AM
17	VMS signs to display speed and lane stats. Police. Speed & Surveillance Camera.	7/1/2015 9:30 AM

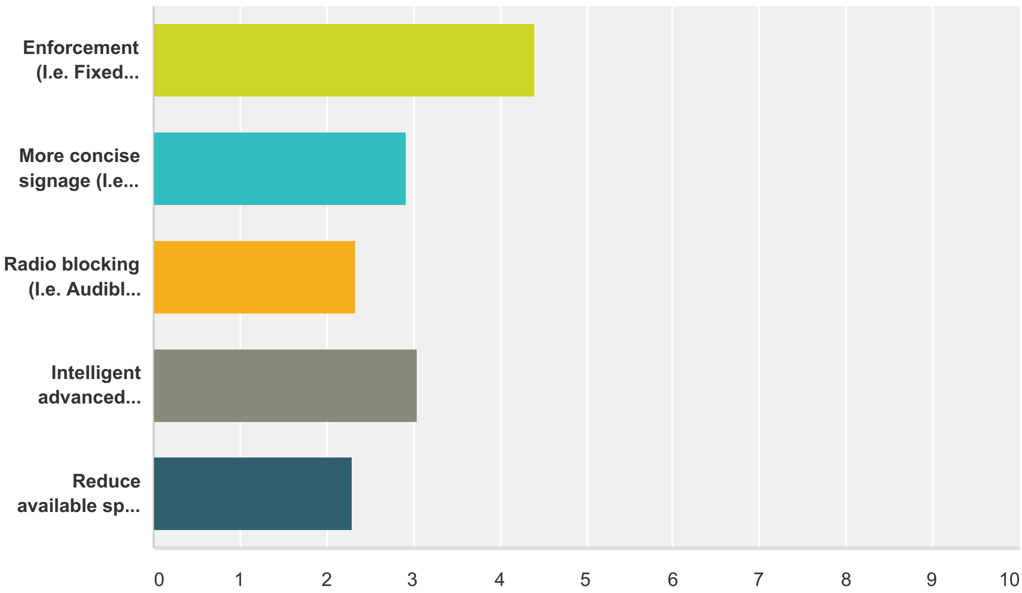
Q5 Please describe the most effective traffic control device/s used by you or your agency to reduce vehicle speeds through roadworks sites. (You may include devices included in the documents described in Question 2 or any innovative devices used/trialled as described in Question 4.)

Answered: 25 Skipped: 2

#	Responses	Date
1	Police, Traffic controlers, VMS Boards	8/10/2015 5:26 PM
2	Road closure	7/9/2015 12:06 PM
3	TRAFFIC CONES AND SPEED SIGNAGE	7/7/2015 12:05 PM
4	Variable message signs warning reduced speed Large speed signs both sides of carrigeway	7/6/2015 4:14 PM
5	Mobile Camera / radar equipment	7/6/2015 3:47 PM
6	police	7/6/2015 3:31 PM
7	Wig Wams on Traffic Controller Ahead Sign	7/6/2015 3:23 PM
8	Speed displayed Radar VMS	7/6/2015 3:07 PM
9	VMS Board	7/6/2015 1:19 PM
10	When used correctly by a competent traffic controller, a slow paddle can reduce traffic speed past the work area. Also, a form of portable rumble strip, a hose. A hose stretched across the active traffic lane seems to dramatically reduce traffic speed past the work area.	7/6/2015 12:34 PM
11	Police, works every time.	7/6/2015 11:58 AM
12	VMS & Other regulatory Signage Actual Speed of Vehicles Display Boards Traffic Controllers	7/6/2015 11:57 AM
13	Police	7/6/2015 11:31 AM
14	correct signage and warning beacons	7/6/2015 11:24 AM
15	Police presence	7/6/2015 10:51 AM
16	Vehicle mounted speed radars (Full Colour), Rumble Strips.	7/6/2015 10:37 AM
17	VMB radars	7/6/2015 10:21 AM
18	VMS Boards	7/6/2015 10:19 AM
19	VMS boards and speed display units	7/6/2015 10:16 AM
20	Radar Trailers	7/6/2015 9:52 AM
21	As above, temporary speed humps. Trailer speed detection devises	7/4/2015 9:56 AM
22	Police with speed guns/cameras	7/1/2015 2:11 PM
23	Police Officers	7/1/2015 12:29 PM
24	Most effective is when Police actively patrol with speed radar within the construction zone	7/1/2015 11:00 AM
25	Using cones to narrow lanes and introduce "dog legs" to make the drivers slow down. The use of VMS boards when doing big traffic control set ups. The flashing speed limit alerts drivers to expect a change in traffic conditions.	7/1/2015 9:30 AM

Q6 In your opinion, which of the following do you think would be MOST effective in reducing speeds through roadworks sites? (Please rank from 1 to 5. 1 being the MOST EFFECTIVE and 5 being the LEAST EFFECTIVE)

Answered: 27 Skipped: 0



	1	2	3	4	5	Total	Score
Enforcement (I.e. Fixed speed cameras or double demerit points through roadworks zones)	**74.07%** 20	**11.11%** 3	**3.70%** 1	**3.70%** 1	**7.41%** 2	27	4.41
More concise signage (I.e. Large flashing speed signs with variable speed limits. Similar to those seen in school zones - when workers are on the road the sign might display 40km/hr, when there are no workers the sign might display 60km/hr)	**3.70%** 1	**33.33%** 9	**29.63%** 8	**18.52%** 5	**14.81%** 4	27	2.93
Radio blocking (I.e. Audible messages communicated through your radio when encroaching roadwork zones)	**0.00%** 0	**25.93%** 7	**18.52%** 5	**18.52%** 5	**37.04%** 10	27	2.33
Intelligent advanced warning signage (I.e. Vehicle activated signage informing drivers of their current speed or estimated travel time through a roadworks site)	**14.81%** 4	**18.52%** 5	**25.93%** 7	**37.04%** 10	**3.70%** 1	27	3.04
Reduce available space (I.e. Narrower lane lines creating a sense of danger to the driver/passengers)	**7.41%** 2	**11.11%** 3	**22.22%** 6	**22.22%** 6	**37.04%** 10	27	2.30

Q7 Can you provide any further ideas on traffic control measures that may improve safety through roadwork zones?

Answered: 15 Skipped: 12

#	Responses	Date
1	Speed Raders & Camera's; VIASYS/ITCD or similar real time vehicle speed display, Public Safety campaigns.	8/10/2015 5:26 PM
2	Education and awareness campaign for road users. Attitudes toward the responsibility required to actually drive a vehicle are somewhat low. Larger visible presence of police/enforcement within worksites. When police are on site for an hour then all motorists obey the speed signage for that hour.	7/9/2015 12:06 PM
3	Police presence is always the best form of speed deterrent.	7/8/2015 11:31 AM
4	Love the idea of the radio blocking option!!!	7/7/2015 12:05 PM
5	Build side tracks to remove traffic from work zone.	7/6/2015 4:14 PM
6	Education and enforcement. All works area should have visible work being performed, public get frastrated when driving thru a work area when no work appears to be goin on.	7/6/2015 3:47 PM
7	stingers for misbehaving traffic	7/6/2015 3:31 PM
8	Have learner drivers travel through virtual road work sites as part of their learner driver program and be tested on it.	7/6/2015 3:23 PM
9	Keep the distance with reduced speed limit to include the work zone only and not the entire project. Only reduce speed where and while workers are exposed	7/6/2015 1:19 PM
10	Question, how does the driverless cars travel through roadwork sites, and are they travelling at the correct speed? No doubt this will be an issue for the future.	7/6/2015 11:58 AM
11	Police presence (Blue & Red flashing lights) Speed Bumps Single lanes	7/6/2015 11:57 AM
12	make sure the police are onsite and there will be no issues	7/6/2015 11:24 AM
13	Harmonised signage across boarders (particularly the east coast) where a lot of freight moves between Melbourne and Brisbane via Sydney. Standardised use of Full Colour Speed awareness devices and radars.	7/6/2015 10:37 AM
14	Advertisement through Media, especially in regards to the stationery TMA,s within the setup of work zones and what the they are designed for.	7/6/2015 10:19 AM
15	Awareness campaign. Drivers do not understand their responsibilities when travelling through worksites	7/4/2015 9:56 AM

Appendix F – Traffic Counts

Traffic Analysis and Reporting System

Weekly Volume Report

Week 2013-W12

Hour	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		Average Week Day		Average Weekend Day		Average Day	
00-01	58	0.4%	75	0.5%	95	0.6%	80	0.5%	111	0.6%	125	0.9%	93	0.6%	84	0.5%	109	0.7%	91	0.6%
01-02	50	0.3%	64	0.4%	78	0.5%	71	0.5%	81	0.4%	74	0.5%	52	0.3%	69	0.4%	63	0.4%	67	0.4%
02-03	78	0.5%	82	0.6%	90	0.6%	77	0.5%	101	0.5%	82	0.6%	51	0.3%	86	0.5%	67	0.5%	80	0.5%
03-04	112	0.7%	103	0.7%	117	0.8%	131	0.8%	98	0.5%	93	0.6%	69	0.5%	112	0.7%	81	0.5%	103	0.7%
04-05	267	1.7%	178	1.2%	218	1.4%	207	1.3%	181	1.0%	142	1.0%	98	0.6%	210	1.3%	120	0.8%	184	1.2%
05-06	556	3.5%	458	3.1%	454	3.0%	420	2.7%	428	2.3%	254	1.8%	184	1.2%	463	2.9%	219	1.5%	393	2.5%
06-07	858	5.4%	753	5.1%	747	4.9%	761	4.8%	688	3.7%	509	3.5%	298	2.0%	761	4.8%	404	2.7%	659	4.2%
07-08	1,199	7.5%	1,050	7.1%	1,032	6.8%	1,000	6.4%	982	5.3%	757	5.2%	506	3.3%	1,053	6.6%	632	4.3%	932	5.9%
08-09	1,142	7.2%	1,124	7.6%	1,077	7.1%	1,057	6.7%	1,112	6.0%	1,079	7.5%	748	4.9%	1,102	6.9%	914	6.2%	1,048	6.7%
09-10	1,113	7.0%	998	6.8%	1,013	6.7%	1,008	6.4%	1,151	6.2%	1,229	8.5%	984	6.5%	1,057	6.6%	1,107	7.5%	1,071	6.8%
10-11	1,135	7.1%	1,019	6.9%	1,008	6.6%	1,053	6.7%	1,092	5.9%	1,266	8.8%	1,186	7.8%	1,061	6.6%	1,226	8.3%	1,108	7.1%
11-12	1,166	7.3%	1,078	7.3%	989	6.5%	1,041	6.6%	1,275	6.9%	1,271	8.8%	1,328	8.7%	1,110	6.9%	1,300	8.8%	1,164	7.4%
12-13	1,184	7.4%	983	6.7%	994	6.6%	1,023	6.5%	1,271	6.9%	1,118	7.7%	1,217	8.0%	1,091	6.8%	1,168	7.9%	1,113	7.1%
13-14	1,073	6.7%	932	6.3%	1,021	6.7%	1,036	6.6%	1,383	7.5%	1,038	7.2%	1,286	8.4%	1,089	6.8%	1,162	7.8%	1,110	7.1%
14-15	1,099	6.9%	1,028	7.0%	1,144	7.5%	1,111	7.1%	1,463	7.9%	1,041	7.2%	1,371	9.0%	1,169	7.3%	1,206	8.1%	1,180	7.5%
15-16	1,138	7.2%	1,072	7.3%	1,190	7.8%	1,252	8.0%	1,527	8.3%	1,011	7.0%	1,512	9.9%	1,236	7.7%	1,262	8.5%	1,243	7.9%
16-17	1,061	6.7%	1,114	7.6%	1,130	7.4%	1,233	7.8%	1,454	7.9%	933	6.5%	1,259	8.3%	1,198	7.5%	1,096	7.4%	1,169	7.5%
17-18	975	6.1%	912	6.2%	1,019	6.7%	1,009	6.4%	1,322	7.1%	760	5.3%	1,046	6.9%	1,047	6.5%	903	6.1%	1,006	6.4%
18-19	517	3.3%	567	3.9%	607	4.0%	686	4.4%	975	5.3%	496	3.4%	698	4.6%	670	4.2%	597	4.0%	649	4.1%
19-20	344	2.2%	348	2.4%	327	2.2%	477	3.0%	647	3.5%	355	2.5%	504	3.3%	429	2.7%	430	2.9%	429	2.7%
20-21	303	1.9%	281	1.9%	306	2.0%	374	2.4%	451	2.4%	250	1.7%	306	2.0%	343	2.1%	278	1.9%	324	2.1%
21-22	192	1.2%	212	1.4%	222	1.5%	270	1.7%	326	1.8%	202	1.4%	197	1.3%	244	1.5%	200	1.3%	232	1.5%
22-23	162	1.0%	141	1.0%	180	1.2%	192	1.2%	213	1.2%	226	1.6%	156	1.0%	178	1.1%	191	1.3%	181	1.2%
23-24	121	0.8%	152	1.0%	110	0.7%	144	0.9%	170	0.9%	132	0.9%	88	0.6%	139	0.9%	110	0.7%	131	0.8%
Peaks	Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count		Hour End & Count	
AM	08:30	1,262	08:15	1,136	08:15	1,103	08:45	1,086	12:00	1,275	11:45	1,301	12:00	1,328	08:30	1,128	11:45	1,311	12:00	1,162
PM	13:00	1,184	15:15	1,119	16:15	1,204	16:15	1,268	16:00	1,527	13:00	1,118	16:00	1,512	16:00	1,235	16:00	1,261	16:00	1,242
12-Hour	12,802	80.5%	11,877	80.7%	12,224	80.6%	12,509	79.6%	15,007	81.1%	11,999	83.1%	13,141	86.2%	12,883	80.5%	12,573	84.7%	12,793	81.7%
16-Hour	14,499	91.2%	13,471	91.5%	13,826	91.2%	14,391	91.6%	17,119	92.5%	13,315	92.2%	14,446	94.8%	14,660	91.6%	13,885	93.5%	14,437	92.1%
18-Hour	14,782	93.0%	13,764	93.5%	14,116	93.1%	14,727	93.7%	17,502	94.6%	13,673	94.7%	14,690	96.4%	14,977	93.6%	14,186	95.6%	14,749	94.1%
24-Hour	15,903	100.0%	14,724	100.0%	15,168	100.0%	15,713	100.0%	18,502	100.0%	14,443	100.0%	15,237	100.0%	16,001	100.0%	14,845	100.0%	15,667	100.0%
Avg Week Day		99.4%		92.0%		94.8%		98.2%		115.6%						100.0%		92.8%		97.9%
Avg Weekend Day												97.3%		102.6%		107.8%		100.0%		105.5%
Avg Day		101.5%		94.0%		96.8%		100.3%		118.1%		92.2%		97.3%		102.1%		94.8%		100.0%