TECHNICAL PAPER

TECHNIQUES FOR USING SCATS AS AN INCIDENT MANAGEMENT TOOL

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ABSTRACT:

This paper will discuss how SCATS (Sydney Co-ordinated Adaptive Traffic System), used widely throughout New Zealand, can be used to manage the sudden change in traffic demand resulting from incidents on the transport network. SCATS is an adaptive traffic signal control system that uses real time traffic information (loop detectors) to adjust phase splits, cycle times and offsets to optimise a signalised traffic network, resulting in reduced delays to motorists. This paper will focus on how SCATS can be modified to detect and respond to incidents.

Various tools are available within SCATS to handle unique traffic situations, such as those resulting from incidents. These include action plans, variation routines, using the unusual congestion monitor and the ITS port. The benefits of using these tools will be shown using a an S-Paramics traffic model linked to SCATS with FUSE. This allows various incidents to be modelled in a microsimulation model with the signals operating under SCATS control. The model used includes the Northern Motorway on Auckland's North Shore with various diversion routes off of the motorway. Various incidents will be modelled on and off of the motorway, showing traffic diversions on the arterial network. This case study will show how travel time on diversion routes used during incidents, can be decreased by using the SCATS as in incident management tool

This paper will discuss incident management strategies, the various SCATS tools available to handle incident scenarios, and present the benifits of these SCATS tools using a case study.

INTRODUCTION

Traffic congestion on New Zealand's roads continues to increase and traffic incidents, such as crashes and breakdowns, are a large contributor to congestion. Managing this congestion due to incidents requires innovative solutions.

Developing successful incident management is a key area of concern for dealing with congestion in large urban centres such as Auckland. The reduction in capacity on a traffic network due to incidents can cause huge delays, particularly if the network is already operating at or near capacity. ITS (intelligent transport systems) based solutions can play a key role in regaining capacity.

This paper presents how SCATS can be used as in incident management tool by adding capacity to diversion routes during incidents. A case study is presented to show how travel time can be reduced on diversion routes using SCATS as an incident management tool.

CONGESTION

Traffic congestion in New Zealand is estimated to cost nearly NZ$ 1 billion per year (Sankaren et al 2005). The Auckland traffic network is particularly congested and Auckland's motorways operate at or above capacity during peak hours. Figure 1 shows how traffic delay has increased in the Auckland region.

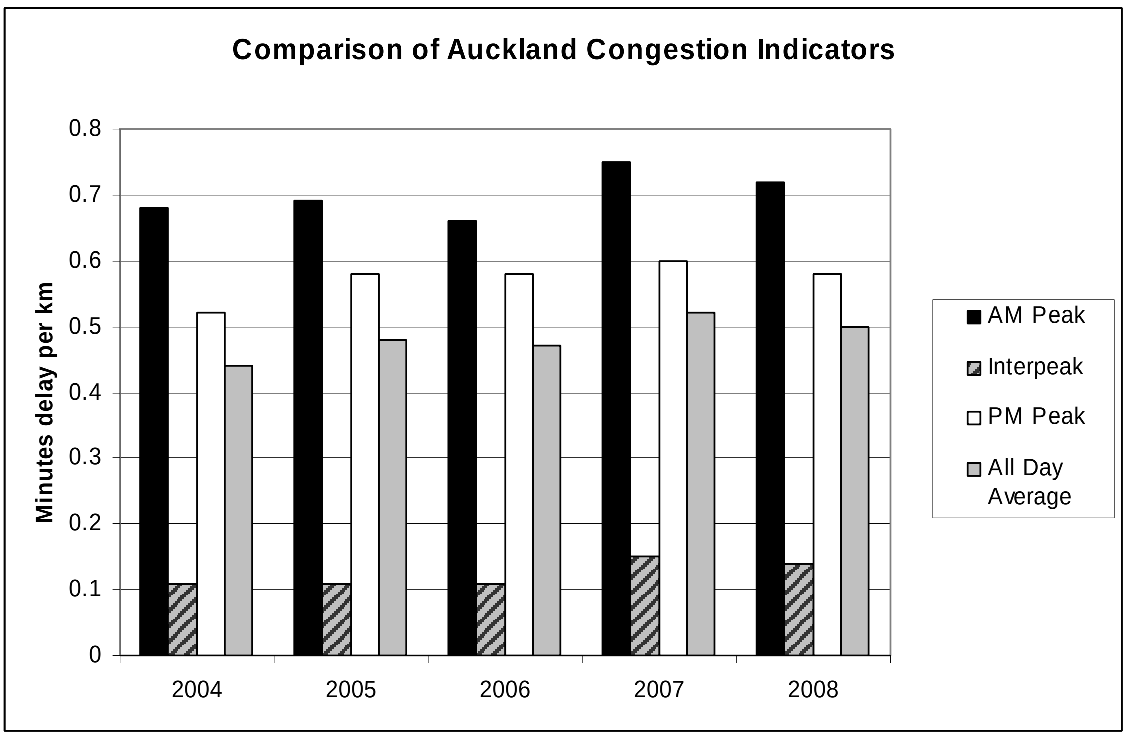


Figure 1: Auckland Congestion Indicators (Austroads 2009)

When a network is operating at or near capacity, even a small reduction in capacity can cause large delays. This can result in large variability in terms of travel times. Figure 2 shows how the variability in travel time in the Auckland region has changed over time. The AM and Interpeak show some increases but the PM peak and all day average, shows an increasing trend over time.

There are two basic types of congestion, recurring and non recurring congestion. Recurring congestion typically occurs on an average day, for example due to peak period traffic demand. Non recurring congestion is unusual or unexpected congestion resulting, for example, from incidents, weather, road works, that cause a sudden unexpected increase in demand or reduction in capacity.

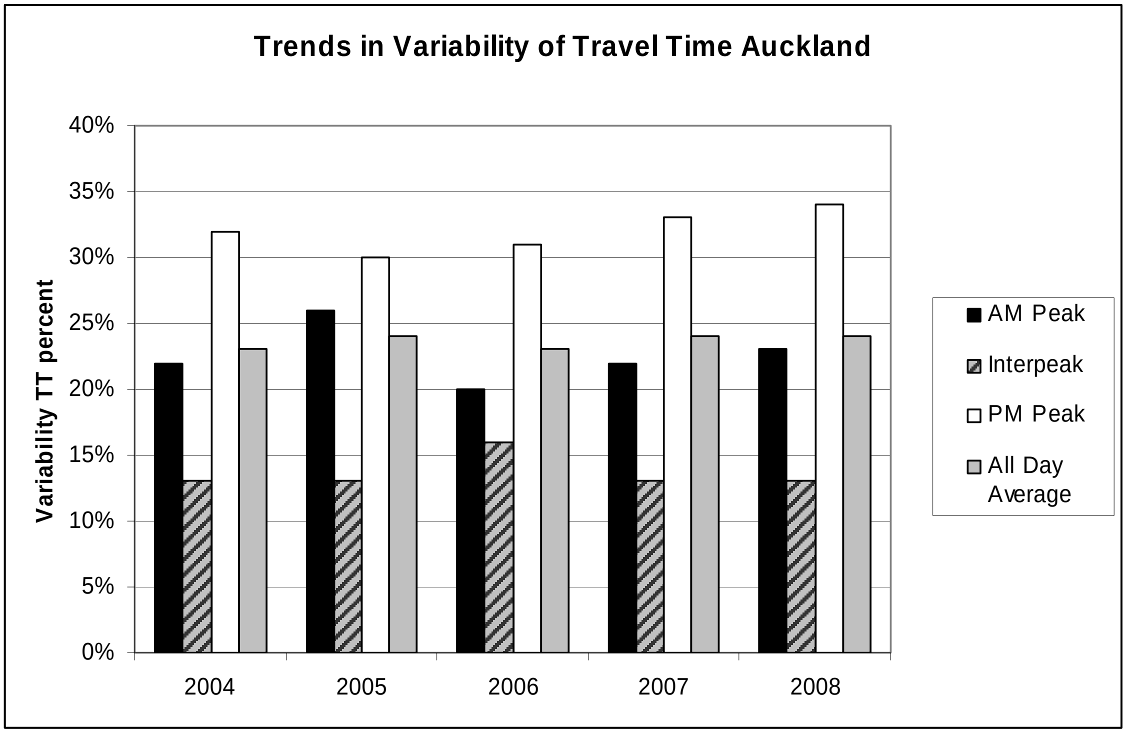


Figure 2: Auckland Travel Time Variability (Austroads 2009)

INCIDENT MANAGEMENT

Incidents can account for a large proportion of delay that motorists experience. The Urban Mobility Report estimates that 52-58% of total motorist delay in urban areas is caused by crashes and breakdowns (Shrank and Lomax 2009). Various types of incidents can lead to congestion problems on the traffic network by reducing available capacity. If there is available capacity on the traffic network, it may be possible to cope with an incident. However, when the network is operating at or near capacity (for example, during peak periods in Auckland) dealing with incident congestion becomes more challenging.

Various factors can affect the amount and duration of delay motorists face during incidents. These factors include:

- Time to detect and respond to incident
- Duration of incident
- Time of day (level of congestion on network)
- Severity of incident (reduction in capacity)
- Availability of spare capacity on parallel routes
- Secondary incidents. Approximately 14-18% of all incidents are secondary incidents (FHWA 2009)
- How quickly capacity is restored to the traffic network

Traffic incident management plans have been developed In order to reduce the impact of incidents on the traffic network. A typical incident management plan includes the following steps (FHWA 2009):

- Detection and verification (CCTV, loop detection)
- Traveller information (website, VMS)
- Response
- Scene management and traffic control
- Clearance and recovery

INCIDENT MANAGEMENT STRATEGIES

Various ITS treatments can be used to develop effective incident management plans. These can include:

- Loop detectors to detect incidents using automated incident detection algorithms.
- CCTV cameras used to detect and verify incidents.
- VMS signs to alert motorists to incidents and direct them to diversion routes.
- Adaptive signal control to provide additional capacity along diversion routes.
- Traffic signals can also provide “green waves” to give priority to emergency vehicles.

ADAPTIVE SIGNAL CONTROL

SCATS (Sydney Coordinated Adaptive Traffic System) is an adaptive signal control system developed by Roads and Traffic Authority (RTA) of New South Wales, Australia. SCATS is a real time adaptive traffic system that uses stop line vehicle detectors to detect changes in traffic demand and adapts the signals accordingly. Split plans are used to determine the phase sequence and phase times as well as special features, such as gapping off. Cycle plans are used to determine the cycle time as well as set maximum and minimum cycle times. Link plans are used to specify various offsets between adjacent intersections. Stop line loop detectors measure flow and occupancy to calculate SCATS degree of saturation (DS), which is a measure of the proportion of the green time that is being used by vehicles. Split plans are selected and adjusted to balance DS on competing strategic approaches. Cycle plans are adjusted to maintain the DS on the worst strategic approach. Link plans and when intersections are linked is also determined in real time using stop line detector data.

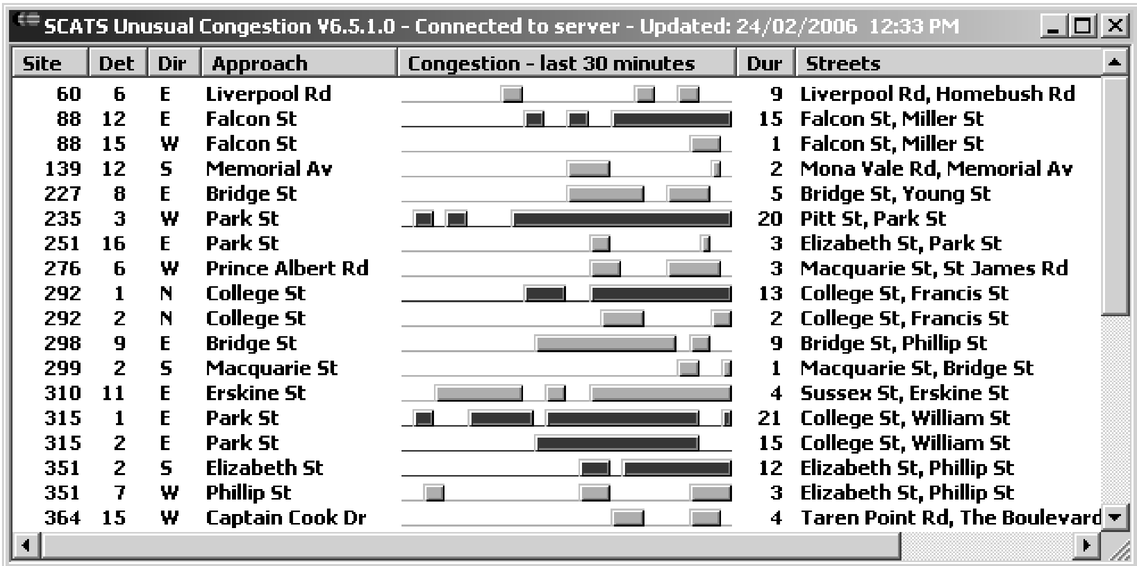
As SCATS adapts in real time to changes in traffic demand, it can, to some extent, cope with a change in demand resulting from incidents. One of the limitations SCATS has is that it will always try to balance DS on all approaches. Incident management strategies may call for priority to be given along a diversion route, even if the adjacent side streets experience additional delay. Also SCATS adapts gradually to a change in traffic demand. While this may be desirable during non-incident conditions, if an incident is detected, operator intervention can make changes to SCATS in anticipation of the change in demand.

INCIDENT MANAGEMENT WITH SCATS

SCATS has various features that can be used to detect and respond to incidents.

Unusual Congestion Monitor

The unusual congestion monitor can be configured to detect when flow over detectors is not what is expected. SCATS considers a lane to be unusually congested if the DS is high and the flow over the detector is a lot lower than would be expected. SCATS does not detect queues as the detectors are at the stop line. Instead, this unusual congestion is due to downstream queues blocking back. SCATS monitors how many minutes a lane is unusually congested. Thresholds for minutes of unusual congestion are set in the unusual congestion monitor and if those thresholds are met, the intersection affected will appear in the unusual congestion monitor (see Figure 3). The different shading in Figure 3 is a measure of how long the usual congestion has occurred. The unusual congestion monitor can therefore be used to detect the congestion resulting from an incident.


SCATS Unusual Congestion V6.5.1.0 - Connected to server - Updated: 24/02/2006 12:33 PM

Site	Det	Dir	Approach	Congestion - last 30 minutes	Dur	Streets
60	6	E	Liverpool Rd		9	Liverpool Rd, Homebush Rd
88	12	E	Falcon St		15	Falcon St, Miller St
88	15	W	Falcon St		1	Falcon St, Miller St
139	12	S	Memorial Av		2	Mona Vale Rd, Memorial Av
227	8	E	Bridge St		5	Bridge St, Young St
235	3	W	Park St		20	Pitt St, Park St
251	16	E	Park St		3	Elizabeth St, Park St
276	6	W	Prince Albert Rd		3	Macquarie St, St James Rd
292	1	N	College St		13	College St, Francis St
292	2	N	College St		2	College St, Francis St
298	9	E	Bridge St		9	Bridge St, Phillip St
299	2	S	Macquarie St		1	Macquarie St, Bridge St
310	11	E	Erskine St		4	Sussex St, Erskine St
315	1	E	Park St		21	College St, William St
315	2	E	Park St		15	College St, William St
351	2	S	Elizabeth St		12	Elizabeth St, Phillip St
351	7	W	Phillip St		3	Elizabeth St, Phillip St
364	15	W	Captain Cook Dr		4	Taren Point Rd, The Boulevard

Figure 3: SCATS Unusual Congestion Monitor (RTA 2006)

Variation Routines
SCATS has many built in variation routines that can be used to modify the signal operation at an intersection if certain conditions are met. The following variation routines are based on the same calculations used to detect unusual congestion:

- Test detectors for congestion
- Test strategic approach (group of detectors in specified phase) for congestion

An intersection can be configured to do the above tests and if true, then the signal operation can be modified to accommodate the congestion. For example, another variation routine could be used to bring in a particular split plan, cycle plan or link plan.

Action Lists
Action lists are another feature of SCATS that can be used to make specific changes to an intersection operation. For example, changes can be made to the cycle time, split plan or intersections can be linked. Action lists can be implemented by time of day through the SCATS Scheduler, or can be called through variation routines. A series of actions could be created to provide priority for a diversion route. These actions could be implemented manually when an incident is detected, or could be set to come in through a variation routine that is used to detect unusual congestion.

These techniques could be used together to detect unusual congestion through the unusual congestion monitor and then, when confirmed, use variation routines or action lists to provide priority along the complete diversion route.

CASE STUDY

To investigate how SCATS can be used as an incident management tool, incidents were modelled using a microsimulation model. It can be difficult to evaluate the effects of incidents and management techniques on a transportation network in the real world.

Microsimulation offers a test bed for evaluating the impacts of incidents on a transportation network as well as testing and evaluating various incident management strategies.

A calibrated Paramics model of a portion of the North Shore City was used to model various incidents. The study area is shown in Figure 4. This model was linked to SCATS (using SCATSIM) and all of the signals in the network were under SCATS control. Incidents were modelled on the Northern Motorway and some vehicles diverted to the arterial network.

Diversion 1 involved northbound vehicles on the motorway leaving at the Northcote interchange and shifting to the arterial route. Diversion 2 involved northbound vehicles on the Taharoto Road remaining on the arterial route rather than joining the motorway at the Northcote interchange.

Three different scenarios were modelled:

1. Base scenario with no incident
2. Incident on the motorway with traffic diverting to the arterial route. SCATS was left to adapt as per normal (incident with original SCATS)
3. Incident on the motorway with traffic diverting to the arterial route. Changes were made to SCATS at all ten signalised intersections along the diversion route to give priority along the diversion route (incident with modified SCATS).

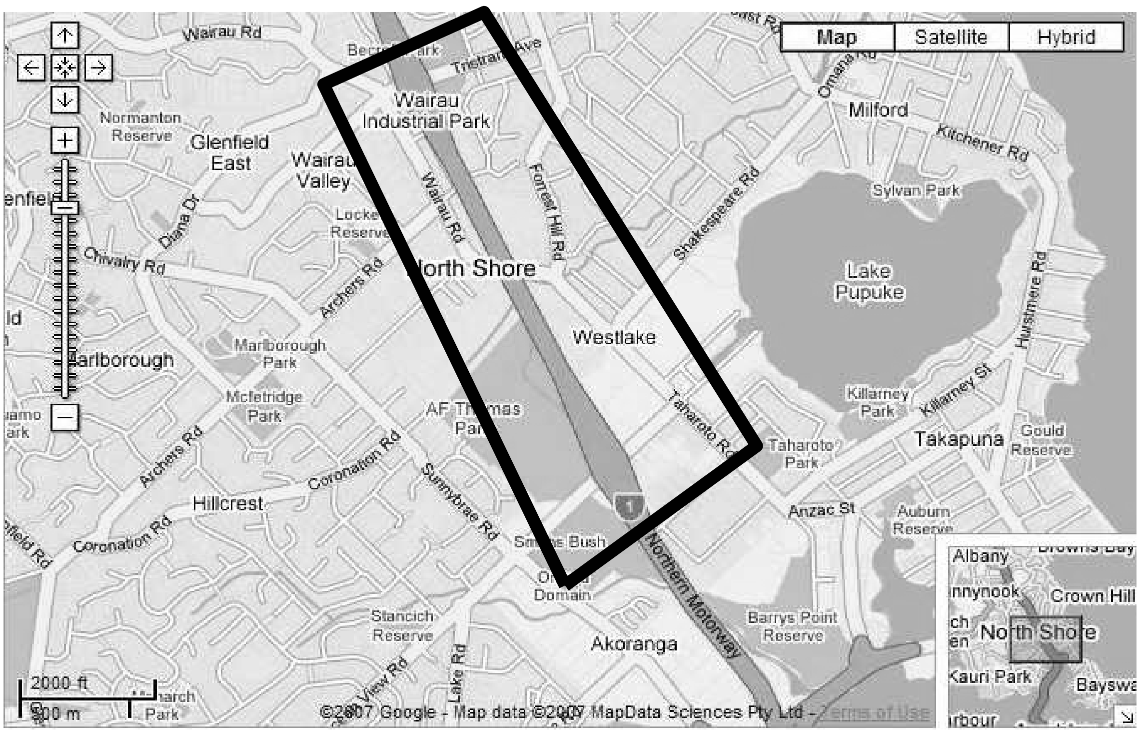


Figure 4: Study area

Manual changes were made to SCATS for the duration of the incident to prioritise the diversion route. The SCATS changes included:

- Changes to split plans to provide more green time along the diversion route
- Increased cycle times
- Linked intersections along the diversion route in the direction of the diversion

The results of the modelling are presented in the NZTA research report (Koorey et al 2007). In summary, two separate diversion routes were monitored in the model. A decrease in travel time was shown along the diversion routes when SCATS was modified to prioritise the diversion route (see Figure 5 and Figure 6). Figure 5 shows that the travel time on the motorway increased considerably in the incident scenario in Diversion 1 and the travel time on the diversion route also increased during the incident scenario. However, the travel time on the diversion route decreased when SCATS was modified to give priority to the diversion route. Figure 6 shows similar results, with a decrease in travel time along the diversion routes when SCATS was modified, even though the overall travel time on Diversion 2 remained higher than the motorway route. The decrease in travel time on the diversion routes was relatively small, however the SCATS changes made were relatively minor. It is anticipated that if more advanced techniques are used, such as those outlined in the "Incident Management with SCATS" section, a larger benefit may be seen. Stage 2 of the NZTA research report is underway, which is investigating these advanced techniques as well as additional performance measures such as overall network performance, not just along the diversion routes.

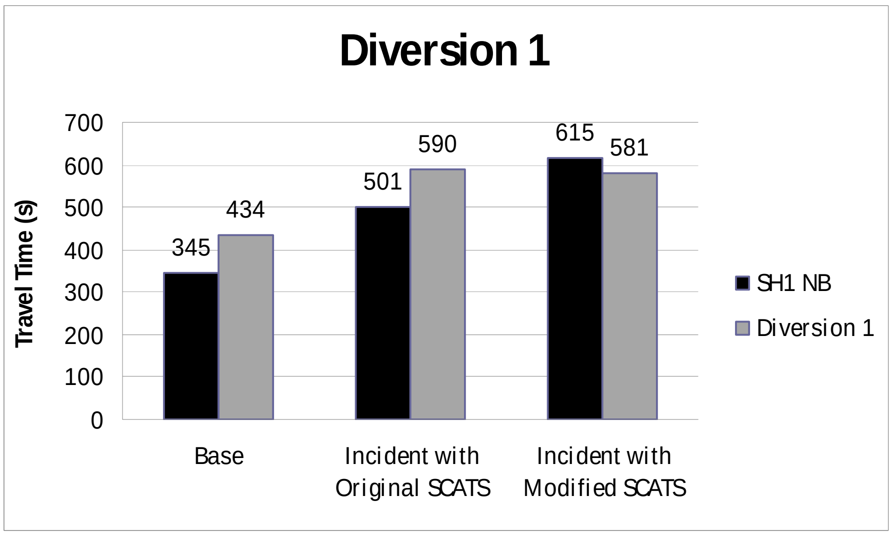


Figure 5: Travel time on Diversion Route 1

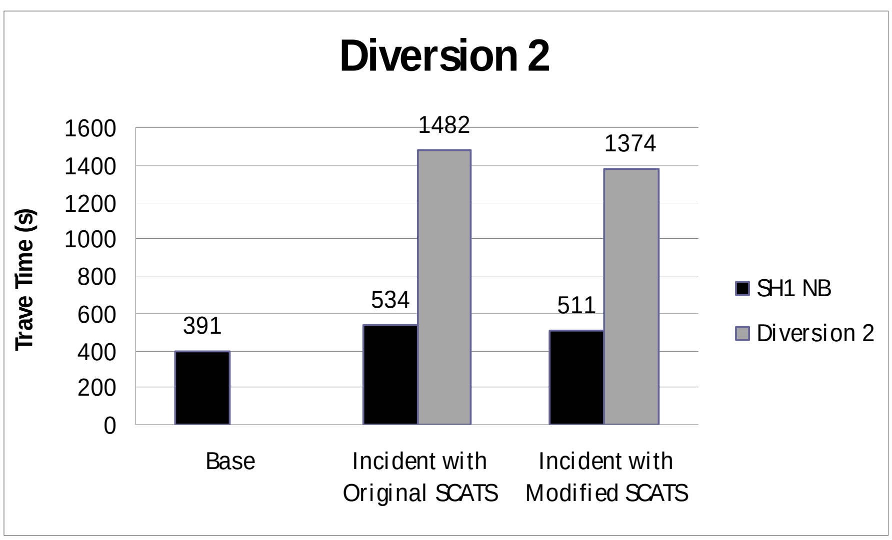


Figure 6: Travel time on Diversion Route 2

CONCLUSION

Traffic congestion in New Zealand's urban centres is increasing and causing a serious impact to the travelling public. The congestion resulting from traffic incidents can account for a large proportion of congestion delay and account for large variability in travel times, especially when a traffic network is already operating at or near capacity. Incident management strategies can help mitigate the congestion caused by incidents. Adaptive signal control, such as SCATS, can be used as an effective incident management strategy. Although normal SCATS operation can adapt in real time to the change in demand resulting from incidents, additional features of SCATS can be used to provide a targeted approach to increasing capacity on a traffic network.

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