Incident Management Modelling Using Microsimulation with Adaptive Signal Control

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***Abstract*—This paper demonstrates the use of microsimulation modelling as a test-bed to evaluate various incident management strategies using adaptive signal control. S-Paramics is the microsimulation tool used and is linked to SCATS, which provides the adaptive signal control in the model. The results of the modelling indicate that SCATS can be modified in an incident scenario to provide better network performance.**

***Index Terms*—Incident management, microsimulation, traffic signal control systems.**

I. Introduction

Incident management is a key area of concern for road authorities throughout New Zealand (NZ). Unplanned incidents, such as vehicle crashes or breakdowns, often occur during peak periods when traffic networks are already at or over capacity. The type and timing of incident response is crucial to minimising the impact of incidents on the traffic network. Non-infrastructure solutions for handling the effects of traffic congestion, by using Intelligent Transport Systems (ITS), are becoming increasingly important to monitor traffic conditions, detect any incidents, and implement appropriate remedies such as modified traffic signal plans or driver information signage.

The effects of proposed ITS measures such as adaptive signal control and incident management strategies can be difficult to predict and evaluate using traffic flow theories, but can be modelled using microsimulation models. Microsimulation models, such as S-Paramics, can provide an excellent test-bed for evaluating various incident management techniques without affecting real road users. Travel times can change dramatically during an incident and can also take a long period of time to return to normal, even after an incident has cleared. Stochastic, dynamic, assignment techniques used in microsimulation models can show how drivers divert to different routes during incidents.

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. SCATS is now used extensively in Australia and NZ and is also used in Asia and North America. Nineteen Local Authorities in NZ use SCATS and 90% of all signals in NZ are under SCATS control [1].

The benefits of SCATS signal control versus fixed time and isolated vehicle actuated control are demonstrated in the literature. The results demonstrate significant traffic benefits can be obtained from SCATS. As traffic demand increases, the benefits of SCATS control also increase, in terms of reduced delay and stops, compared to fixed and actuated control [2].

By default, fixed signal phase times are specified in most microsimulation models. It is common practice to model SCATS controlled intersections in microsimulation models by using the average signal timings from SCATS. For options testing, the splits, phasing, cycle length and offsets can be optimised in an external signal optimisation package for input into a microsimulation model. However, in reality, the modelled signals are actually likely to be controlled by SCATS. It is difficult to effectively model SCATS controlled signals using fixed-time signal plans [3].

This problem can be compounded when modelling incidents, as fixed-time signals are unable to react to the change in demand resulting from incidents. Therefore, linking a microsimulation model directly to SCATS, instead of using fixed-time or actuated control, produces more consistent, stable, reliable and realistic results [1].

The RTA has worked with developers of microsimulation tools to develop interfaces between SCATS and microsimulation models including Q-Paramics, S-Paramics, AIMSUN and VISSIM [4]. "FUSE" has recently been developed by baseplus Ltd in Christchurch, NZ, to link SCATS to S-Paramics [5]. The signals in S-Paramics use SCATS control and not fixed times. This allows S-Paramics to be used to determine how SCATS will adapt in real time to the change in traffic demand related to incidents.

II. Methodology For Incident Modelling

Incidents can be modelled in S-Paramics using the incident editor [6]. During a modelled incident, vehicles will slow down and/or stop for the duration of the modelled incident. The information input into S-Paramics to model an incident includes: the duration of the incident, the speed of the vehicles (zero for stopped), turn delay experienced by affected vehicles

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(seconds), lane(s) affected, and the incident rate (the percentage of vehicles using the specified lane that will incur the incident). If "feedback" is turned on, vehicles will re-route to avoid additional delay caused by the incident.

ITS measures can also be modelled including VMS signs and transmitters (vehicles receive information about the incident when they are in a defined area). The incident information can include speed restrictions, lane restrictions, delay warnings, diversion routing and car-park availability advice. Drivers' aggression, awareness (which affects knowledge of route alternatives) and headways (for a specified area such as a ramp) can also be modified during the incident. The ITS messages can be applied to all vehicles, or to specific vehicle types.

In normal "on-street" applications, SCATS uses information from vehicle detectors, predetermined operation boundaries and historical data to determine cycle times, phase splits, phase sequences and coordination offsets. FUSE enables the actual on-street operation of SCATS-controlled intersections to be replicated in S-Paramics. It is relatively simple to code intersections in S-Paramics to be linked to SCATS through FUSE. Allowed and banned movements and vehicle detector locations are coded in S-Paramics and the signal controller settings and SCATS settings are loaded into WinTraff, which emulates the signal controllers. S-Paramics, WinTraff and SCATSim (software that replicates SCATS when connected to a traffic model) can all be run on the same computer.

Theoretically, microsimulation models could be linked directly to a live traffic situation, to enable "on-the-fly" assessment of incidents, modelling and performance evaluation of possible treatment measures (or of no treatment) and resolution of an appropriate strategy. The key to this would be faster-than-real-time modelling speed (and possibly parallel systems testing different scenarios), so that evaluation can be done in a timely manner to give useful information.

For practical purposes, it has to be assumed that any incident to be modelled occurs within the model area and that its effects are also sufficiently captured within this area. Technically this may be difficult to achieve unless an exceptionally large network is modelled. A mesoscopic model (such as SATURN) could be used to develop a model of a larger area to capture any wider changes in demand resulting from an incident. At the very least, the traffic demand should be consistent across all scenarios. It is important to make sure that all of the demand is loaded onto the network and trips are not queued into zones at the end of the simulation run. This is achieved by simulating a sufficiently long "after" period to make sure that the incident and its effects clear up during the simulation run.

Microsimulation has a variability in demand (due to the stochastic nature of the simulation), which affects predicted travel times. Microsimulation linked to SCATS will cause even greater variability. Multiple simulation runs therefore become important, using different "random seeds" to reflect day-to-day variations typically observed. The results can then be collated and performance measure statistics derived. Ten model runs were used and averaged for each of the scenarios presented here.

III. Performance Measures

The effectiveness of an incident management plan is dependent on the response time to incidents and what response is actually applied. The impact the incident has on the traffic network is also dependent on the location, type and severity of the incident as well as the level of congestion on the network at the time of the incident. If the network is operating near capacity, any reduction in capacity caused by an incident can have a large impact on the network.

The network performance during an incident can be determined by looking at measures such as:

- the change in vehicle travel times,
- the amount of re-routing that takes place,
- the level of service (volume/capacity ratios) at key locations of the network, and
- the time for the network to recover.

Good incident management strategies can provide more reliability to the network in terms of travel time. This may be important from a road user perspective. For example, motorists in Auckland, NZ, view the importance of reducing the standard deviation of travel time similarly to reducing average travel time [7].

IV. Modelling Results

A calibrated model of a small region of Auckland's North Shore was used for this research [8]. This model included a portion of Auckland's Northern Motorway as well as a parallel route using the urban arterial network along Wairau and Taharoto Roads (Fig.1). Auckland Harbour Bridge lies just to the South of the study area with Auckland's CBD just South of the bridge. The Northern Motorway is part of State Highway 1 (SH 1) which is not only a key part of Auckland's traffic network, but also the main North/South route on NZ's North Island.

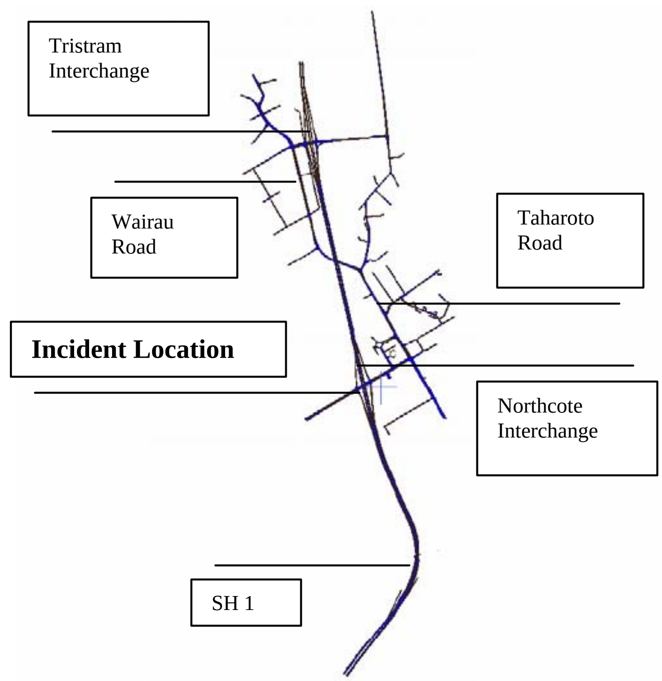

Fig. 1 Layout of Network Modelled and location of Tested Incident

The following features were modelled:

• One time period 3:15pm-4:30pm (before evening peak)

• Incidents on Motorway SH1 northbound (3 lane section between Tristram and Northcote interchanges)

• Closure of kerb lane from 3:30pm to 4:00pm and closure of centre lane from 3:30pm to 3:45pm were modelled as simultaneous incidents.

This scenario was used as the incidents cause enough congestion on the Motorway so that some motorists divert away from the motorway onto alternate routes. The pre-peak demand allowed for some spare capacity in the network during the base condition. This allowed SCATS an opportunity to make changes as the demand changed due to the incidents. When the network is already fully congested, SCATS cannot adapt well to the change in demand as phase times and cycle lengths may already be at their maximums.

The following treatments were tested against these scenarios:

- "Base" condition without any incidents on the motorway and SCATS adapting as usual

• Incident with SCATS configuration in the base condition, i.e. SCATS adapting as usual (Original SCATS)

• Incident with SCATS configuration optimised for re-routing from the Motorway, giving priority to the diversion route (Modified SCATS)

Two diversion routes were analysed. The first diversion route is shown in Fig. 2 – Taharoto diversion. This shows vehicles travelling Northbound with destinations North on the Motorway (SH 1). These motorists have the option of travelling to the motorway (black line), or diverting by avoiding the motorway (grey line). The results of this diversion are shown in Fig. 3 and demonstrate a small improvement in travel time on the diversion route when SCATS is modified for this incident condition.

The second diversion route is shown in Fig. 4 – Northcote diversion. This shows vehicles travelling northbound on the Motorway (SH 1) with destinations North on the Motorway. These motorists have the option of staying on the Motorway or diverting along Northcote Road (grey line). The results for this diversion are shown in Fig. 5 and also show an improvement in travel time on the diversion route when SCATS is modified for this incident condition. Note that the Base travel time is not given on this route as vehicles did not travel this diversion route during the Base condition.

The modelling work shows that an improvement in travel time traffic for diverted traffic due to incidents can be achieved with modifications to SCATS. The modifications made were minor and similar to the modifications a SCATS operator at the traffic control centre would make when such an incident is detected on the Motorway. The changes were made only for the duration of the incident after which SCATS reverted to the original settings. Although the improvement in travel times was small, if specific incident plans for particular incidents are developed, it is likely that the optimisation of the detour route could be improved.

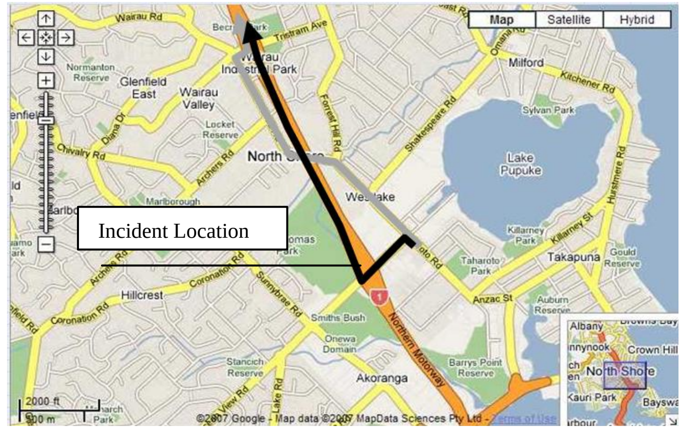

Fig. 2 Taharoto diversion route. This route shows trips Northbound on Taharoto Road heading Northbound on SH 1. The blue line shows the route on SH 1. The purple line shows the diversion route along Taharoto and Wairau Road and back on SH 1 at the Tristram Interchange.

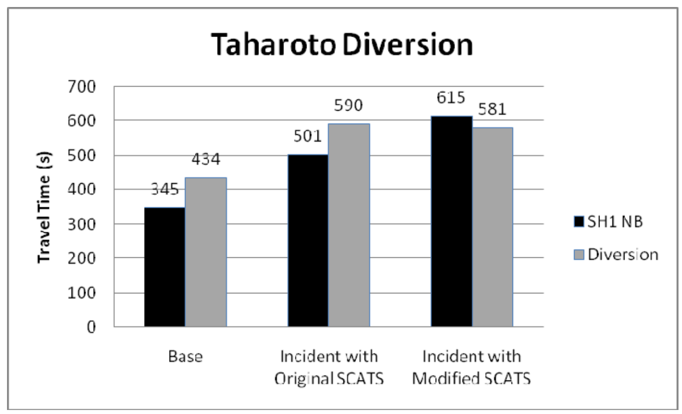

Fig. 3 Taharoto diversion results. The results show a small improvement in travel time along the diversion route with SCATS modified to accommodate the diverted traffic on this route.

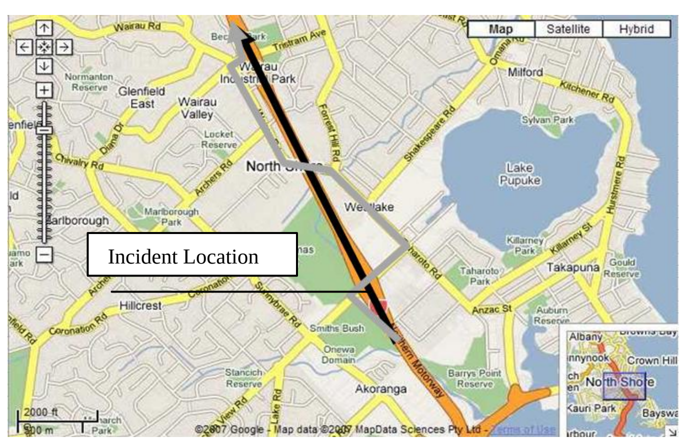

Fig. 4 Northcote diversion route. This shows trips heading Northbound on SH 1. The purple line is the diversion route. The diverted trips exit the SH 1 at

the Northcote Interchange and travel Northbound on Taharoto Road and Wairau Road and get back on SH 1 at the Tristram Interchange.

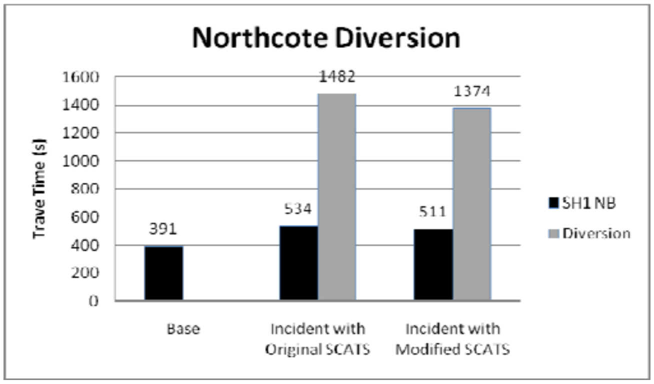

Fig. 5 Northcote diversion results. The results show a small improvement in travel time along the diversion route with SCATS modified to accommodate the diverted traffic on this route.

V. Conclusion

This paper shows the results of using microsimulation as a test bed for evaluating signal control incident management strategies. There are significant benefits from using microsimulation to test incident management strategies as real roadway users are not impacted by the testing done in the model. This allows a variety of different incident management strategies to be tested, until a desirable strategy is achieved. Using FUSE and S-Paramics, various types of incidents can be modelled and the impact of various SCATS scenarios can be tested and evaluated.

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