Evaluation of the Impacts of ITS Using Traffic Simulation

Newswee Leaders
ANZ ITS Technical Leader
Director, ITS Australia

Presentation Outline
• Background & Objectives
• Methodology
  - Model development
  - Incident modelling
  - Modelling of incident management strategies
  - Results
• Summary and Directions for Future Research

Background
Incidents are any events that reduce the capacity of a road facility
- Roadway incidents impose a substantial cost to society when delays, congestion, secondary accidents and environmental emissions are taken into consideration
- Non-recurrent congestion accounts for 20-40 percent of congestion on motorways
- In Brisbane, the estimated avoidable cost of traffic congestion is $1.472 billion
  Congestion due to traffic incidents could be up to $700 million per year (BTRE)

Background
Incident impacts can be reduced through implementation of incident management (IM)
- Evaluation of incident impacts and benefits of IM strategies is important for justification of expenditure of public funds on ITS
- Ideally, evaluation should be based on field tests but the limited data on dynamic impacts restrict a comprehensive evaluation
- Traffic simulation provides an alternative approach for evaluating the impacts
Objectives
Quantify the impacts of incidents and selected incident management strategies using a traffic simulation approach

- Local and network-wide impacts
- Integrated motorway and arterial environment
- Traffic, fuel consumption, emissions, and operating costs impacts
- Incident management strategies evaluated:
  - Ramp metering
  - VMS information and route diversion
  - Variable speed limits
  - Dynamic traffic signal control

Model Development
Pacific Motorway (M1)
- 43 km strategic route
- 6–8 lanes
- more than 115,000 vpd
- speeds up to 110 kph
- 15 interchanges

M1 AIM SUN Model
- Area ∼ 122 square kilometres
- 85 km of arterial roads
- AM Peak (07:00–09:00)
- PM Peak (16:00–18:00)
- More than 90,000 vehicles inside network during peak periods

Model Calibration Results
Using traffic counts from loop detector stations on M1 and mid-block counts on arterials

<table>
<thead>
<tr>
<th></th>
<th>M1 AM</th>
<th>Arterials AM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration errors</td>
<td>6 percent</td>
<td>10 percent</td>
</tr>
</tbody>
</table>

Simulation of Incidents
Incident logs were retrieved to determine location of incidents, their duration and severity for incidents dating back to 2004

- Analysis of field data showed a number of locations that were over-represented in terms of their incident frequency
- Incidents were simulated at these locations with varying characteristics reflecting field conditions

54 incidents AM
66 incidents PM
Duration 1 to 1.5 hours
Blocking lane 3 or 4 or both
Local Impacts

All incidents were evaluated at the local and network levels

- An example of local impacts is demonstrated by the simulation of a major incident that occurred at 7:15 am, blocked 2 lanes (out of 4) on the northbound direction and lasted for 1.5 hours
- Section of freeway where localised impacts were measured was 600-m long

Network Impacts

<table>
<thead>
<tr>
<th>Time before incident</th>
<th>Time after incident</th>
<th>Flow (vph)</th>
<th>Speed (kph)</th>
<th>Travel time (sec)</th>
<th>Delays (sec)</th>
<th>Stopped time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>AM</td>
<td>3,931</td>
<td>95</td>
<td>19</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>PM</td>
<td>PM</td>
<td>1,783</td>
<td>60</td>
<td>145</td>
<td>127</td>
<td>111</td>
</tr>
</tbody>
</table>

Fuel Consumption/Emissions Impacts

Evaluation conducted using four-mode elemental model (Akcelik & Besley, 2003)

This model is based on drive cycles to estimate fuel consumption and emissions

Model was integrated with the traffic simulator using AIMSUN's Application Programming Interface (API)

AIMSUN tracks the movement of individual vehicles and generates speed, acceleration & deceleration estimates for use by the emissions model
Fuel Consumption & Emissions Impacts

<table>
<thead>
<tr>
<th>Time</th>
<th>Demand</th>
<th>Number of Vehicles</th>
<th>Cost Increase</th>
<th>Cost Increase</th>
<th>Cost Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM Peak</td>
<td></td>
<td>86,142 cars and 5,498 HV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM Peak</td>
<td></td>
<td>81,467 cars and 23,745 HV</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average increase of $21,000 in operating costs

Total Cost (based on average increase in operating costs) for peak hour incidents = $2,041,000

Evaluation of IM Strategies – Ramp Metering

Flow metering algorithm (based on minimum and maximum number of vehicles to be released per unit time)

Incident which caused major disruptions (closure of 2 lanes) was simulated

IM Strategies – VMS & Route Diversions

Incident simulated on arterial and VMS information provided on Motorway

Motorway traffic diverted at different proportions (30 to 80 percent)

Traffic flow variations suggest diversion rate of 30% produces best distribution of flows between the normal and alternative routes
**IM Strategies – VMS & Route Diversions**

Traffic impacts show that Case 3 (only incident signal timing plans without diversions) does not produce much benefits on normal route (Exit 66) compared to Case 4 (incident signal timing plans with diversions).

Comparison of scenario where the incident occurs and no action is taken (Case 2) with scenario where the two IM responses are implemented (Case 4) is shown below.

**IM Strategies – VMS & Route Diversions**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Route</th>
<th>Delay (s)</th>
<th>Speed (km/h)</th>
<th>Number of stops</th>
<th>TC (veh-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>Exit 66</td>
<td>117</td>
<td>50</td>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>Case 2</td>
<td>Exit 66</td>
<td>117</td>
<td>50</td>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>Case 3</td>
<td>Exit 66</td>
<td>202</td>
<td>50</td>
<td>9</td>
<td>5.0</td>
</tr>
<tr>
<td>Case 4</td>
<td>Exit 66</td>
<td>107</td>
<td>50</td>
<td>4</td>
<td>1.5</td>
</tr>
<tr>
<td>Case 5</td>
<td>Exit 66</td>
<td>117</td>
<td>50</td>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>Case 6</td>
<td>Exit 66</td>
<td>202</td>
<td>50</td>
<td>9</td>
<td>5.0</td>
</tr>
</tbody>
</table>

**Preliminary Investigation of Variable Speed Limit (VSL)**

- 8-km section of M1 was tested
- Some of the factors that affect performance of VSL include distances between signs, triggers for changing speed limits, speed limit increments, levels of congestion etc.
- Flow homogenisation (reduction in the variation of the speeds between vehicles, both within a lane and adjacent lanes) and reduction in decelerations at the back of queued vehicles were found.

**Preliminary Findings**

- VSL has potential to provide safety and efficiency benefits by homogenising the flow in higher speed regimes
- The number of stops per vehicle on the motorway reduced by 64 percent following the speed limit reduction from 110 kph to 70 kph as a result of the incident
- VSL was found to provide an 11 percent improvement in delays upstream of the incident

**Summary**

- Study demonstrated feasibility of using traffic simulation to evaluate the impacts of incidents and IM strategies
- Simulated incidents, based on characteristics of real-life incidents, were found to have substantial impacts on network performance, operating costs and emissions: e.g. AM Peak incidents resulted in:
  - 2.2% increase in travel time
  - 5.7% increase in delays
  - 1.5% increase in CO emissions
  - 5.0% increase in operating costs
- Selected IM strategies were explored:
  - Ramp metering
  - VMS information, route diversions and dynamic signal timing plans
- Results are network-dependent; will vary across networks, and are a function of existing levels of congestion, availability of alternative routes and congestion on these routes; driver route choice behaviour and compliance with traffic advice etc.