Getting More from Our Roads: Evaluation of Managed Lanes on Arterial Roads

Tim Brown (GHD) and Richard Paling (Richard Paling Consulting)
Introduction

- NZTA (LTNZ) Research Project
- NZTA Managed Lanes Project
- Two part presentation:
  - Issues and effects
  - Simple modelling techniques
Research objectives

• Review local and international experience
• Examine behavioural response
• Understand measures of effectiveness
• Develop simple modelling tools for evaluating managed lanes
Managed lanes

- Pressure to make better use of road space
- Managed lane = special vehicle lane (New Zealand context)
- Allocate road space to different user classes
- Typically bus lanes or HOV lanes on arterials (no freight)
- Can be add-a-lane or convert-a-lane (much better acceptance for add-a-lane projects)
Issues

- Can be many “losers” with projects reallocating existing capacity
- Differential speed in lanes reduces effective capacity
- Scheme prioritisation
- Political pressure
- Lack of real world reporting of previous experience but even this is mainly on freeways
- Ineffective evaluation tools
Impacts

- Lane performance due to user class allocation
- Behavioural response (mode shift)
- Compliance
Allocation effects

- Little evidence on effects on performance of introducing managed lanes
  - Traffic theory
  - Limited real world data
- Difficult to get user benefits from reallocation given typical Auckland traffic mixes
  - Needs precise allocations of traffic
  - Do not fit easily with groups in existing traffic
- Effect generally negative if physical capacity unchanged
  - Typically increase in cost of total travel time
Behavioural response

- No generally accepted guidelines or even theory to assist
- Problems of measurement over time
- Response depends on site specific factors
- Very limited information on arterial roads
- Assembled information from a variety of sources to try to get general position
- Enforcement/compliance
Observed

Change in AVO - all vehicles

Savings in Total Journey Time with HOV Lane (minutes)

AM Peak  PM Peak
Observed

2% change in AVO per minute saved
Behavioural response

• With behavioural response, managed lanes look more attractive
• Higher average occupancy = less vehicles (without reassignment)
• With reductions in vehicle flows conditions can improve for all travellers
• Benefits will fall in total value of user time
• Key part of evaluation
• More robust data needed
Measures of effectiveness

• Vehicle travel time (LoS)
• Person travel time (LoS)
• Eligibility and compliance rate (is it likely to carry more people?)
• Bus/HOV journey time reliability (QTN)
• Economic impact/benefit
• Enforceability
• Public/political acceptance
• Support of policy or legislation e.g. LTMA/GPS
Quantitative evaluation

- Simple question – will it carry more people?
- Urban corridor performance
  - Intersection treatments, performance and spacing
  - Merging and lane changing (not yet considered)
  - Access, bus stops and parking
  - Link capacity
Quantitative evaluation

• Simple spreadsheet model
• Generic model applicable NZ wide
• Flexible (guide for user inputs, link or intersection based)
• Allows the user to select intersection treatments
• Uses HCM methodology (Urban Streets)
• Uses Akcelik function for mid-block speeds
• Uses TQSM/HCM for bus service analysis (under development)
• Provides graphical outputs
Limitations

• Only a single elasticity considered
• Merging and bottleneck delay not yet incorporated
• Does not accurately consider a “through-right” lane
• Model applies only for signalised intersections
## Inputs

### Corridor Assessment Models - Traffic Inputs

**General Information**
- **Date of Investigation:** 26/06/2003
- **Design Year:** 2008
- **Vehicle occupancy elasticity:** 0.93%
- **Bus patronage elasticity:** 4.00%
- **Level of illegal usage:** 10%
- **Turning Volumes Available:** Yes
- **Design year forecasts available:** Yes

**Composition of People and Traffic**

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus patronage</td>
<td>600</td>
<td></td>
<td></td>
<td>600</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of ALL STOPS bus services using the route</td>
<td>12</td>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of EXPRESS bus services using the route</td>
<td>13</td>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of 40 seat buses required to serve seated patronage</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Light Vehicles (includes cars, WD, SUV, box and panel vans)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of light vehicles with driven alone (SOV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of light vehicles with 2 occupants (HOV2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of light vehicles with 3+ occupants (HOV3+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average vehicle occupancy for HOV3+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy Vehicles (includes trucks &gt; 3.5t)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Heavy Vehicles (includes rigid and articulated)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Motorcycles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of total traffic in motorcycles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyclists</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of cyclists that use the corridor</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tbody>
</table>

### 2006 Turning Volumes

<table>
<thead>
<tr>
<th>Int No.</th>
<th>Side Road</th>
<th>Left Turn Volume</th>
<th>Through Movement Volume</th>
<th>Right Turn Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oakway Drive</td>
<td>56</td>
<td>592</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Appleby Road</td>
<td>43</td>
<td>525</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Road</td>
<td>18</td>
<td>195</td>
<td>164</td>
</tr>
<tr>
<td>4</td>
<td>Bass Road</td>
<td>99</td>
<td>894</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Wheat Road</td>
<td>69</td>
<td>786</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>Uni 1</td>
<td>1</td>
<td>885</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Collisum Drive</td>
<td>1</td>
<td>885</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>SH:7</td>
<td>16</td>
<td>473</td>
<td>220</td>
</tr>
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</table>

### 2007 Turning Volumes

<table>
<thead>
<tr>
<th>Int No.</th>
<th>Side Road</th>
<th>Left Turn Volume</th>
<th>Through Movement Volume</th>
<th>Right Turn Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oakway Drive</td>
<td>126</td>
<td>1147</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Appleby Road</td>
<td>100</td>
<td>1219</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Road</td>
<td>100</td>
<td>1046</td>
<td>337</td>
</tr>
<tr>
<td>4</td>
<td>Bass Road</td>
<td>100</td>
<td>1500</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Wheat Road</td>
<td>100</td>
<td>1482</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>Uni 1</td>
<td>1</td>
<td>1423</td>
<td>94</td>
</tr>
<tr>
<td>7</td>
<td>Collisum Drive</td>
<td>1</td>
<td>1314</td>
<td>325</td>
</tr>
<tr>
<td>8</td>
<td>SH:7</td>
<td>316</td>
<td>818</td>
<td>377</td>
</tr>
</tbody>
</table>
CORRIDOR ASSESSMENT MODELS - MID BLOCK

Inputs

CORRIDOR ASSESSMENT MODELS - SIGNALISED INTERSECTION TREATMENTS

INTERSECTION TREATMENTS

Number of mid-block lanes does not matter for these inputs.

If there is a clearway in one or more periods, then select the layout with a continuous kerbside lane (Type 1 or Type 3) as the lane length.

Treat a slip lane as a short left lane and specify the "free queue" as the lane length.

INTERSECTION LAYOUTS WITHOUT SHORT LANE

TYPE 1: NO SHORT LANE

TYPE 2: SHORT LANE ON LEFT

TYPE 3: SHORT LANE ON RIGHT

TYPE 4: SHORT LANE BOTH SIDES

INTERSECTION LAYOUTS WITH SHORT LANE

TYPE 1C: Priority lane thru intersection

TYPE 2C: General lane after priority lane

TYPE 3C: General lane after priority lane

TYPE 4C: Continuous lane through

<table>
<thead>
<tr>
<th>Int No.</th>
<th>Side Road</th>
<th>Layout without priority lane</th>
<th>Left Lane Movement/s</th>
<th>Right Lane Movement/s</th>
<th>Left Turn Protection</th>
<th>% Green Time for &quot;Priority&quot; Movement</th>
<th>Short left lane length</th>
<th>Kerbside Through Lane Utilisation</th>
<th>Layout WITH PRIORITY LANE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gateway Drive</td>
<td>2L</td>
<td>Thru</td>
<td>Thru</td>
<td>Partial (6s delay)</td>
<td>60%</td>
<td></td>
<td>1L</td>
<td>1L</td>
</tr>
<tr>
<td>2</td>
<td>Appleby Road</td>
<td>2L</td>
<td>Thru</td>
<td>Thru</td>
<td>Partial (6s delay)</td>
<td>60%</td>
<td></td>
<td>1L</td>
<td>1L</td>
</tr>
<tr>
<td>3</td>
<td>Rosebank Road</td>
<td>3X</td>
<td>Left-Thu</td>
<td>Right</td>
<td>Partial (15s delay)</td>
<td>40%</td>
<td></td>
<td>3X</td>
<td>3X</td>
</tr>
<tr>
<td>4</td>
<td>Grass Road</td>
<td>3X</td>
<td>Left-Thu</td>
<td>Right</td>
<td>Partial (6s delay)</td>
<td>50%</td>
<td></td>
<td>3X</td>
<td>3X</td>
</tr>
<tr>
<td>5</td>
<td>Vehild Road</td>
<td>3X</td>
<td>Left-Thu</td>
<td>Right</td>
<td>Partial (6s delay)</td>
<td>50%</td>
<td></td>
<td>3X</td>
<td>3X</td>
</tr>
<tr>
<td>6</td>
<td>Unie I</td>
<td>4X</td>
<td>Left</td>
<td>Right</td>
<td>Partial (6s delay)</td>
<td>50%</td>
<td></td>
<td>4C</td>
<td>4C</td>
</tr>
<tr>
<td>7</td>
<td>Callisium Drive</td>
<td>4X</td>
<td>Left</td>
<td>Right</td>
<td>None or SCRAMBLE</td>
<td>40%</td>
<td></td>
<td>4C</td>
<td>4C</td>
</tr>
<tr>
<td>8</td>
<td>SH17</td>
<td>4X</td>
<td>Left</td>
<td>Right</td>
<td>None or SCRAMBLE</td>
<td>40%</td>
<td></td>
<td>4C</td>
<td>4C</td>
</tr>
</tbody>
</table>
Outputs – Vehicle speeds

Estimated Vehicle Speeds on Albany Highway

- Lane adj to Bus Lane
- Lane adj to T2 Lane
- No priority lane
- Lane adj to T3 lane
- Bus Lane TT
- T2 Lane TT
- T3 Lane TT

Year: Year 1, Year 2, Year 3, Year 4, Year 5, Year 6, Year 7, Year 8, Year 9, Year 10, Year 11, Year 12, Year 13, Year 14, Year 15, Year 16, Year 17, Year 18, Year 19, Year 20, Year 21, Year 22, Year 23, Year 24, Year 25, Year 26, Year 27, Year 28, Year 29, Year 30

Vehicle speeds (kph): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45
Outputs – Level of Service

Estimated Level of Service on Albany Highway

- Lane adj to Bus Lane
- Lane adj to T2 Lane
- No priority lane
- Lane adj to T3 lane

Travel time [mins]

Year 1, Year 2, Year 3, Year 4, Year 5, Year 6, Year 7, Year 8, Year 9, Year 10, Year 11, Year 12, Year 13, Year 14, Year 15, Year 16, Year 17, Year 18, Year 19, Year 20, Year 21, Year 22, Year 23, Year 24, Year 25, Year 26, Year 27, Year 28, Year 29, Year 30
Outputs – Person travel time

Total Person Travel Time

- With Bus Lane
- With T2 Lane
- General lanes only
- With T3 lane

Year
Enhancements

- Daytime profiles for clearway assessment
- Inclusion of bus stopping times into assessment
- Estimates of bus journey time reliability as an output
- Economic assessment of benefits
- Sensitivity analysis of elasticity
- Allow freight in the managed lanes.
Summary

- Research project due mid-year
- Simple spreadsheet for “quick” assessment
- Effective method for assessment, and quantitative
- Long term behavioural response – more robust data needed
- Allocation effect needs to be considered
- Enforceability and compliance need to be considered.
- Judge each project on its merits.
Supplementary info

• AVO = 1.2 to 1.25 (Ramp meter)
• 20-30% eligible, 10% violation rate (Ramp meter)
• A lot of data in Sydney but mixed results (RTA regular monitoring program)
• ARR308 (Get this info)
## Supplementary info

### Table 1: HOV Facility Performance

<table>
<thead>
<tr>
<th>HOV facility</th>
<th>Period</th>
<th>Length</th>
<th>Person throughput on HOV lane (persons / hour)</th>
<th>Person throughput on normal adjacent lane (persons / hour)</th>
<th>% difference in person throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>Military Rd – T3</td>
<td>a.m. (inbound)</td>
<td>7.99 km</td>
<td>3,953</td>
<td>1,500</td>
<td>164%</td>
</tr>
<tr>
<td>Military Rd – T3</td>
<td>p.m. (outbound)</td>
<td>2.33 km</td>
<td>4,539</td>
<td>1,400</td>
<td>224%</td>
</tr>
<tr>
<td>Epping Rd – T3 / T2</td>
<td>a.m. (inbound)</td>
<td>8.13 km</td>
<td>3,096</td>
<td>1,000</td>
<td>209%</td>
</tr>
<tr>
<td>Epping Rd – T3</td>
<td>p.m. (outbound)</td>
<td>4.34 km</td>
<td>1,037</td>
<td>1,082</td>
<td>-4%</td>
</tr>
<tr>
<td>Pacific Hwy – T3</td>
<td>p.m. (outbound)</td>
<td>4.71 km</td>
<td>692</td>
<td>1,213</td>
<td>-43%</td>
</tr>
<tr>
<td>Great Western – T2</td>
<td>a.m. (inbound)</td>
<td>9.47 km</td>
<td>860</td>
<td>1,136</td>
<td>-24%</td>
</tr>
</tbody>
</table>

### Table 2: HOV Facility Travel Time Changes

<table>
<thead>
<tr>
<th>HOV facility</th>
<th>Period</th>
<th>Length</th>
<th>Travel time changes</th>
<th>Travel time saving (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Military Rd – T3</td>
<td>a.m. (inbound)</td>
<td>7.99 km</td>
<td>-15.10 min</td>
<td>-41%</td>
</tr>
<tr>
<td>Victoria Rd – T3</td>
<td>a.m. (inbound)</td>
<td>9.57 km</td>
<td>-12.67 min</td>
<td>-31%</td>
</tr>
<tr>
<td>Great Western Hwy – T2</td>
<td>a.m. (inbound)</td>
<td>9.47 km</td>
<td>-2.72 min</td>
<td>-18%</td>
</tr>
<tr>
<td>Pacific Hwy – T3/T2</td>
<td>p.m. (outbound)</td>
<td>4.71 km</td>
<td>+1.77 min</td>
<td>+18%</td>
</tr>
<tr>
<td>William St – T2</td>
<td>a.m. (inbound)</td>
<td>0.73 km</td>
<td>+1.79 min</td>
<td>+97%</td>
</tr>
</tbody>
</table>

### Table 3: Average Car Occupancies

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Transit lane</th>
<th>General purpose lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Victoria Rd T3 – a.m. inbound</td>
<td>1.83</td>
<td>1.59</td>
</tr>
<tr>
<td>Military Rd T3 – a.m. inbound</td>
<td>2.66</td>
<td>2.25</td>
</tr>
<tr>
<td>Epping Rd T3/T2 – a.m. inbound</td>
<td>1.90</td>
<td>1.47</td>
</tr>
<tr>
<td>Great Western Hwy T2 – a.m. inbound</td>
<td>-</td>
<td>1.50</td>
</tr>
<tr>
<td>Great Western Hwy T2 – p.m. outbound</td>
<td>-</td>
<td>1.55</td>
</tr>
</tbody>
</table>
Akcelik link function

Link Speed Flow Curves

- Akcelik Ja=0.4
- Akcelik Ja=1
- Akcelik JA=1.6
- Australian Transport Council