An Investigation of the Performance of Roundabouts with Metering Signals

Presenter: Rahmi Akçelik

A major project was undertaken for VicRoads, the state transport authority in Victoria, to investigate the performance of roundabouts with metering signals in Melbourne, Australia.

The project included comprehensive surveys of traffic and driver behaviour at roundabouts with metering signals.
The research objectives included further development of analytical techniques to assess the performance of roundabouts with metering signals, and calibration and validation of these techniques for incorporation into the SIDRA INTERSECTION software.

Unbalanced flows at roundabouts

There are many examples of roundabouts with unbalanced flow patterns in Australia, where part-time roundabout metering signals are used to create gaps in the circulating stream in order to solve the problem of excessive queuing and delays at approaches affected by highly directional flows.
Roundabouts with Metering Signals

Metering Signals

The use of metering signals is a cost-effective measure to avoid the need for a fully-signalized intersection treatment.

Roundabout metering signals are often installed on selected approaches and used on a part-time basis since they are required only during peak demand periods.

The Australian (AUSTROADS) roundabout and traffic signal guides acknowledge the problem and discuss the use of metering signals.

Typical arrangements for roundabout metering signals

**Metered approach:** the approach stopped by red signals (approach causing problems for a downstream approach).

**Controlling approach:** the approach with the queue detector (approach helped by metering signals).
**Operation of metering signals**

When the queue on the controlling approach extends back to the queue detector, the metered approach signals display red so as to create a gap in the circulating flow.

When the red display is terminated on the metered approach (blank display), the roundabout reverts to normal operation.

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**Metering signals: Nepean Hwy - McDonald St**

(a case study published previously in this paper)

**Controlling approach:** Nepean Highway Southeast

**Metered approach:** McDonald Street
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**Surveys**

Twenty roundabouts with metering signals were considered as candidates for the project. Following site visits, five multi-lane roundabout sites were chosen for surveys (1 to 3 circulating lanes).

The peak 15-min intersection volumes at these sites were in the range approximately **3300 to 6000 veh/h**.

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**Survey Data**

- Video recordings of driver gap acceptance behaviour
- Turning movement volume counts
- Automated counting of circulating traffic
- GPS-equipped floating car surveys
- Metering signal timings
Roundabouts with Metering Signals

**Automatic traffic counter**

**Video**

**Video trailer**

+ Floating cars with GPS units

**Manual volume counts**

**Roundabouts with Metering Signals**

**Mickleham Rd / Broadmeadows Rd, AM Peak**

**Controlling approach:**
Mickleham Rd North

**Metered approach:**
Mickleham Rd South
Roundabouts with Metering Signals

Greensborough Bypass / Diamond Creek Rd, AM Peak

Controlling approach: Diamond Creek Rd

Metered approach: Civic Drive

Boundary Road / Governor Road, PM Peak

Controlling approach: Boundary Rd

Metered approach: Governor Rd
Roundabouts with Metering Signals

South Gippsland Hwy / Pound Rd, PM Peak

Controlling approach: South Gippsland Hwy North

Metered approach: South Gippsland Hwy South

Video view

Video Presentation
Roundabouts with Metering Signals

Characteristics of entering traffic:
Queue length and delay from GPS data

Survey vehicle reaches the back of queue 187 s, or 430 m (1410 ft), before crossing the roundabout give-way (yield) line.

Speed = 22 km/h (14 mph)

Time = 0 at the roundabout give-way (yield) line.

<table>
<thead>
<tr>
<th>Site</th>
<th>Approach</th>
<th>Number of Runs</th>
<th>Average Queue Length (ft)</th>
<th>Average Time In Queue (s)</th>
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</thead>
<tbody>
<tr>
<td>Mickleham Rd - Broadmeadows Rd Deviation</td>
<td>Controlling</td>
<td>27</td>
<td>75</td>
<td>6</td>
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<tr>
<td></td>
<td>Metered</td>
<td>28</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>Greensborough Bypass - Diamond Creek Rd (Morning)</td>
<td>Controlling</td>
<td>31</td>
<td>331</td>
<td>37</td>
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<tr>
<td></td>
<td>Metered</td>
<td>30</td>
<td>135</td>
<td>40</td>
</tr>
<tr>
<td>Greensborough Bypass - Diamond Creek Rd (Afternoon)</td>
<td>Controlling</td>
<td>21</td>
<td>328</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Metered</td>
<td>29</td>
<td>312</td>
<td>103</td>
</tr>
<tr>
<td>Boundary Rd - Governor Rd</td>
<td>Controlling</td>
<td>25</td>
<td>1201</td>
<td>119</td>
</tr>
<tr>
<td></td>
<td>Metered</td>
<td>23</td>
<td>469</td>
<td>72</td>
</tr>
<tr>
<td>South Gippsland Hwy - Pound Rd</td>
<td>Controlling</td>
<td>15</td>
<td>2031</td>
<td>181</td>
</tr>
<tr>
<td></td>
<td>Metered</td>
<td>14</td>
<td>1050</td>
<td>377</td>
</tr>
</tbody>
</table>
### Characteristics of entering traffic:
**Measured and estimated (SIDRA INTERSECTION) critical gap and follow-up headway values**

<table>
<thead>
<tr>
<th>Metered and controlling approaches together</th>
<th>Circulating Traffic</th>
<th>Entry Lane Traffic</th>
<th>Measured</th>
<th>Estimated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Flow Rate (veh/h)</td>
<td>HVs</td>
<td>Flow Rate (veh/h)</td>
<td>HVs</td>
</tr>
<tr>
<td>Minimum</td>
<td>134</td>
<td>0.0%</td>
<td>174</td>
<td>0.0%</td>
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<tr>
<td>15th percentile</td>
<td>356</td>
<td>1.1%</td>
<td>288</td>
<td>0.7%</td>
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<tr>
<td>Mean</td>
<td>674</td>
<td>4.6%</td>
<td>677</td>
<td>3.4%</td>
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<tr>
<td>85th percentile</td>
<td>984</td>
<td>8.6%</td>
<td>985</td>
<td>6.7%</td>
</tr>
<tr>
<td>Maximum</td>
<td>1365</td>
<td>14.5%</td>
<td>1130</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

### Characteristics of entering traffic:
**Measured critical gap values for controlling and metered approaches**

![Graph showing critical acceptance gaps vs circulating flow]
Characteristics of entering traffic:
Measured follow-up headway values for controlling and metered approaches

Trend lines are affected by a large number of points occurring at high circulating flows at metered approaches without corresponding points for controlling approaches.

Other findings
- The critical gap and follow-up headway values measured at the survey sites showed negligible difference in these entry traffic gap-acceptance parameters between dominant and subdominant lanes. This finding differs from the earlier research findings of Troutbeck based on data collected on Australian roundabouts more than 20 years ago.
Roundabouts with Metering Signals

Survey data indicated lower proportion of bunched vehicles for circulating traffic compared with the models based on data reported by Troutbeck (different methods used). Based on the survey data, it did not appear to be possible to attribute the higher levels of proportion free at the survey sites to the effect of metering signals.

Comparisons of measured delay and queue values with those estimated by the SIDRA INTERSECTION confirmed an important issue to be taken into account in the design of roundabouts. Demand volumes at oversaturated approaches will be underestimated as a result of the use of turning movement volumes counted at the give-way (yield) lines rather than demand volumes measured beyond the back of queues. This will result in underestimation of benefits from roundabout metering signals and other intersection improvements, and may result in inadequate design.
Survey data collected during this project indicated that the average queue spacing on approach roads is about **10 m (33 ft) per vehicle** (for light vehicles). This is larger than the average queue spacing observed at signalised intersections (for light vehicles, SIDRA INTERSECTION uses a default value of **7 m (23 ft)** for the standard left-hand version, and **7.6 m (25 ft)** for the US version. This is due to the continual flow discharge from the front of the **moving queue**.

Further research is recommended to establish whether these findings are specific to relatively large roundabouts with metering signals, or to all roundabouts generally (e.g. because driver behaviour may have changed after increased familiarity with roundabouts and increased saturation levels at roundabouts). Surveys of smaller single-lane and multi-lane roundabouts that carry moderate demand volumes with no metering signals should be undertaken for this purpose.