Roundabout Design and Capacity Analysis in Australia and New Zealand

International Roundabout Design and Capacity Seminar
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The objective of presentation

This presentation highlights various aspects of roundabouts in AUSTRALIA and NEW ZEALAND in response to the following objective of the International Roundabout Design and Capacity Seminar:

*Present an overview of typical roundabout designs in urban and rural environment and treatments of bicycles and pedestrians, capacity and level-of-service methods used, and recent research on capacity and level-of-service.*

This is by no means a complete account of the subject. For more detailed information, please see the publications referred to in the presentation as well as other papers and presentations available for download from:

www.sidrasolutions.com/software_downloads_articles.aspx

Also refer to related guidelines used in Australia and New Zealand.
ACKNOWLEDGEMENTS

AUSTRALIA
VicRoads: Douglas Harley, Matthew Hall
Queensland Department of Transport and Main Roads: Owen Arndt, David Stewart, Robyn Davies, Mark McDonald

NEW ZEALAND
ViaStrada: Axel Wilke
Traffic Engineering Solutions: Ivan Jurisich
Australia And New Zealand

- We drive on the left-hand side of the road.
- Private car ownership is very high.
- Road use by commercial vehicles is substantial.
- Traffic congestion due to limited road space is a problem in large cities.
- Roundabouts are common and there are many high-capacity roundabouts.
All-Way Stop Control is rare
Two-Way Give Way (Yield) Control is common

This is likely to affect capacity of roundabouts

Australia & UK

USA
Roundabout design
A significant change from the Guide to Traffic Engineering Practice – Part 6: Roundabouts

A most significant change in this guide compared to the previous Austroads guide is that deflection is no longer used as a fundamental parameter in achieving control of the speed of vehicles at roundabouts. The method in this guide controls the speed of traffic entering roundabouts through the geometry of the roundabout entry, rather than within the roundabout where restriction through deflection requirements is essentially too late in the process of the driver negotiating the roundabout.
Roundabout examples – lane markings
Roundabout examples – lane markings
Roundabout examples – lane markings
Roundabout examples – lane markings
Roundabout examples
Roundabout examples
Roundabout examples – bus bypass lanes
Roundabout lane markings

Replacing signals with roundabouts or roundabouts with signals?

- Overall trend is to replace roundabouts with signals rather than the other way round. The reasons given include:
  - roundabout capacity limitations
  - unbalanced flow situations
  - better allowance for road users such as pedestrians and cyclists.
Roundabouts in Australia – a survey of Australian professionals

- A respondent commented: “Some see roundabouts as an evolutionary step before signals. A saturated signalised intersection is often treated through the construction of extra lanes, slip lanes and so on, rather than considering the option of a roundabout.”

- Replacing a roundabout with signals due to capacity reasons applies particularly to two-lane roundabouts since it is not common to expand them to three-lane roundabouts to improve capacity (although it occasionally happens).
Bicycle and pedestrian treatment examples
Bicycle and pedestrian treatments


The official New Zealand Transport Agency guidance is not to use cycle lane markings within the roundabout. Refer to the New Zealand training material “Planning and Design for Cycling, Module 4, Section 4 – Roundabouts”: http://vi astrada.co.nz/sites/vi astrada.co.nz/files/Module4-section4.pdf
Bicycle treatment examples

Australia
Bicycle treatment examples

Australia
Bicycle treatment examples

New Zealand
Bicycle treatment examples

New Zealand
New Zealand – The C-Roundabout

Paper by Ivan Jurisich presented at the TRB Roundabout Conference, Carmel, IN, USA, May 2011. For further information contact: Ivan.jurisich@tes.net.nz

VIDEOS are available.

Also refer to:

www.nzta.govt.nz/resources/research/reports/287
New Zealand – The C-Roundabout
Capacity and Level of Service Methods
In Australia and New Zealand practice, SIDRA INTERSECTION software is the main method used for capacity, performance and level of service.

Information about the roundabout capacity model used in SIDRA INTERSECTION is given in the following slides.
Features of SIDRA INTERSECTION

Model CONSISTENCY in evaluating alternative intersection treatments (e.g. Definition of delay, back of queue, stops, etc).

Total intersection analysis tool
SIDRA INTERSECTION provides facilities to calibrate the traffic model for local traffic conditions:

- **Standard models** with various options are available for different countries.
- **Customised Models** can be prepared by users.
- **Various options** and **key input parameters** can be used for detailed calibration.
- **HCM 2010 roundabout capacity model** is fully integrated into the software.
Features of SIDRA INTERSECTION

Power-based fuel and emission model

Four-mode elemental model (drive cycles)
- Emissions - CO2, CO, HC, NOx
- Fuel consumption
- Operating COST
Features of SIDRA INTERSECTION

Approach-based models such as the UK (TRL) linear regression (“empirical”) model for roundabouts are not adequate for intersection analysis.

<table>
<thead>
<tr>
<th>Individual vehicles</th>
<th>Drive cycles</th>
<th>Traffic flows</th>
<th>Speed-flow functions</th>
<th>Approaches</th>
<th>Lane groups</th>
<th>Individual Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsimulation models</td>
<td>SIDRA INTERSECTION</td>
<td>RODEL, ARCADY</td>
<td>TRANSYT, SYNCHRO US Highway Capacity Software</td>
<td>Most transport planning and economic analysis models</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LEVEL OF ANALYSIS DETAIL

more detailed model of road geometry

more detailed model of traffic stream
Some common and differing aspects of alternative models for roundabout capacity and performance estimation

An Assessment of the Highway Capacity Manual 2010 Roundabout Capacity Model

Table comparing the features three well-known analytical models of roundabout capacity:

USA: HCM 2010 (Highway Capacity Manual 2010) model

Australia: SIDRA INTERSECTION model, and

UK: TRL (linear regression) model (RODEL /ARCADY).

These models have some common features as well as significant differences.
LANE – BASED method

- Lane flows
- Unequal lane use
- De facto exclusive lanes
- Approach short lanes
- Exit short lanes (lane use effects)
- Roundabout circulating lane use

These cannot be modelled using an APPROACH-BASED method

Effectiveness of flaring (short lanes) depends on flow conditions
Observed at UK Roundabouts

Lane use at flared approaches (short lanes) depends on flows

Unequal lane utilisation

These cannot be modelled using an APPROACH-BASED method
Continuous lane without island causing lane underutilisation on another approach

This cannot be modelled using an APPROACH-BASED method
Observed at UK Roundabouts

Mini roundabouts operate effectively as all-way give-way control
Follow-up Headway and Critical Gap values decrease with increased flow rates, and depend on roundabout geometry.

More capacity

- $D_i = 30, n_e = 1$
- $D_i = 50, n_e = 2$
- $D_i = 80, n_e = 3$
SIDRA INTERSECTION features

GEOMETRY parameters that affect capacity

• inscribed diameter
• number of entry lanes
• average entry lane width
• number of circulating lanes
• entry radius
• entry angle
• “flaring” as short lanes
• bypass (slip and continuous) lanes
FLOW parameters that affect capacity

• circulating flow rate: increased values decrease the follow-up headway and critical gap
• circulating stream bunching characteristics (circulating lane flows)
• origin-destination flow patterns and queuing on approach lanes (for modelling unbalanced flow conditions)
• ratio of arrival flow to circulating flow
• ratio of dominant lane flow rate to subdominant lane flow rate
• heavy vehicles in the entry lane and circulating lane
• Environment Factor (general calibration parameter)
Roundabout model – LOW DEMAND

SIDRA INTERSECTION models negotiation radius, speed and distance allowing for path smoothing by drivers.
SIDRA INTERSECTION features

Roundabout model – HIGH DEMAND
SIDRA INTERSECTION identifies congestion caused by heavy circulating flows especially with **UNBALANCED** flow patterns.
• First released in 1984
• SIDRA INTERSECTION 5.1 released two months ago
• Backward spread of congestion (queue blockage)
• Capacity constraint
SIDRA interlinking with major software packages

Transoft Solutions

VISUM

VISSIM
SIDRA INTERSECTION Users

Over 1200 Organisations in 67 Countries
Latest Version 5.1, 5.0, 4.0 and 3.x Users Only (23 June 2011)

USA: 407
Australia: 284
South Africa: 197
Canada: 120
Arabian Peninsula: 77
New Zealand: 48
Malaysia: 40
Slovenia: 31
Spain: 19
Singapore: 18
Norway: 16
Italy: 15
Chile: 10
Turkey: 6
Other Asia and Africa: 44
Other Europe: 45
Other Latin America: 23

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Singapore: 171
Norway: 165
Italy: 31
Chile: 58
Turkey: 411
Other Asia and Africa: 133
Other Europe: 134
Other Latin America: 87
New Research
**Entry Radius and Entry Angle in SIDRA Standard model (SIDRA INTERSECTION 5.1)**

- \( f_r = 0.95 + 1 / r_e \)
- \( f_a = 0.94 + 0.00026 / \phi_e^{1.6} \)
- \( r_e \) is the entry radius (m)
- \( \phi_e \) is the entry angle (degrees)

**Customary units:**
- \( f_r = 0.95 + 3.28 / r_e \)
- \( r_e \) is the entry radius (ft)

<table>
<thead>
<tr>
<th>( r_e ) (m)</th>
<th>( r_e ) (ft)</th>
<th>( \phi_e ) (degrees)</th>
<th>UK TRL</th>
<th>SIDRA Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>16</td>
<td>70</td>
<td>1.40</td>
<td>1.35</td>
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<tr>
<td>10</td>
<td>33</td>
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<tr>
<td>100</td>
<td>328</td>
<td>0</td>
<td>0.87</td>
<td>0.90</td>
</tr>
</tbody>
</table>
Roundabout Size: Inscribed Diameter

SIDRA Standard model

Capacity drops for very large roundabouts

UK TRL model (RODEL, ARCADY)

Capacity does not drop
A “fatal flaw”: when the y-intercept is fixed:
Capacity decreases with improved geometry (increased entry radius, decreased entry angle, etc) if the capacity at zero circulating flow (y intercept) is fixed.

Roundabout Metering Signals CASE STUDY: Nepean Hwy – McDonald St, Melbourne, Australia, AM Peak

A major project was undertaken by Akcelik & Associates for VIC ROADS, 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.

Twenty roundabouts with metering signals were considered as candidates for the project. 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.
Metering Signals Project - A&A for VIC ROADS: Surveys

- Automatic traffic counter for circulating traffic
- Manual turning volume counts
- Floating car with GPS unit
- Signal timings

Video trailer

Video
Metering Signals Project - A&A for VIC ROADS

The roundabouts covered by the VIC ROADS project are shown in following slides.

For further information:

www.sidrasolutions.com/software_downloads_articles.aspx
# Metering Signals Project - A&A for VIC ROADS: Findings

<table>
<thead>
<tr>
<th></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>Flow Rate (veh/h)</td>
<td>Critical Gap (s)</td>
<td>Critical Gap (s)</td>
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<tr>
<td></td>
<td>HVs</td>
<td>HVs</td>
<td>Follow-up Headway (s)</td>
<td>Follow-up Headway (s)</td>
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<tr>
<td>Metered and controlling approaches together</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Minimum</td>
<td>134</td>
<td>174</td>
<td>2.13</td>
<td>2.17</td>
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<tr>
<td>15th percentile</td>
<td>356</td>
<td>288</td>
<td>2.79</td>
<td>2.54</td>
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<tr>
<td>Mean</td>
<td>674</td>
<td>677</td>
<td>3.20</td>
<td>3.37</td>
</tr>
<tr>
<td>85th percentile</td>
<td>984</td>
<td>985</td>
<td>3.60</td>
<td>3.98</td>
</tr>
<tr>
<td>Maximum</td>
<td>1365</td>
<td>1130</td>
<td>4.31</td>
<td>4.83</td>
</tr>
</tbody>
</table>

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Unbalanced flows and metering signals:
Mickleham Rd - Broadmeadows Rd, AM Peak

Controlling Approach: Mickleham Rd North

Metered Approach: Mickleham Rd South
Boundary Road / Governor Road, PM Peak

Controlling approach: Boundary Rd South

Metered approach: Governor Rd
Greensborough Bypass / Diamond Creek Rd, AM Peak

Controlling approach: Diamond Creek Rd

Metered approach: Civic Dve
South Gippsland Hwy / Pound Rd, PM Peak

Controlling approach: South Gippsland Hwy North

Metered approach: South Gippsland Hwy South
South Gippsland Hwy / Pound Rd, PM Peak

Fully signalised treatment
http://vicroads.vic.gov.au/Home/RoadProjects/MelbourneRoadProjects/SouthEasternSuburbs/PoundRoadDandenongSouth.htm
Thank you ...