Roundabout Design and Capacity Analysis in Australia and New Zealand

International Roundabout Design and Capacity Seminar
6th International Symposium on Highway Capacity and Quality of Service, Stockholm, Sweden, 1 July 2011

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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.

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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

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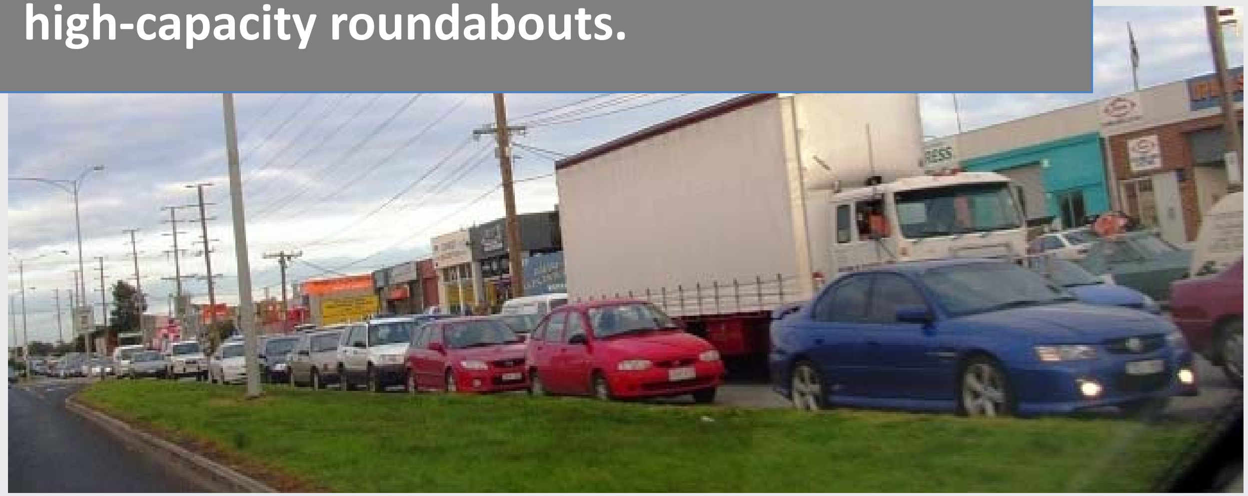
Australia And New Zealand

- 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

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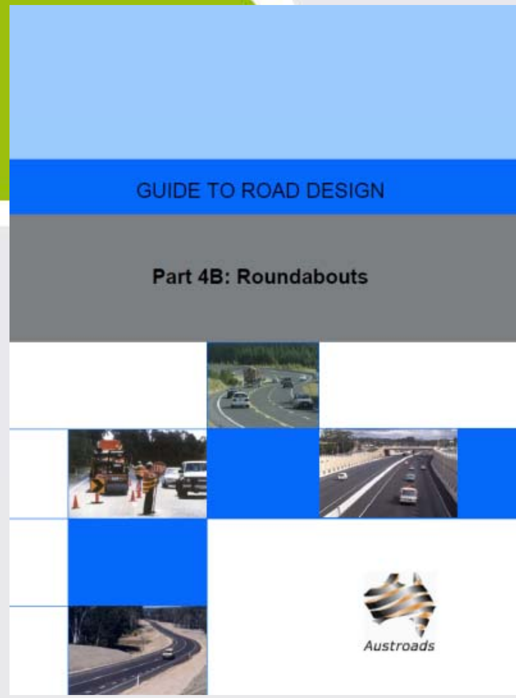
Roundabout design

AUSTROADS (2009) Guide to Road Design Part 4B - ROUNDABOUTS



New Roundabout Guide

(replaces the 1993 AUSTROADS Guide to Traffic Engineering, Part 6)

1.9 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

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Roundabout examples – lane markings

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Roundabout examples – lane markings

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Roundabout examples – lane markings

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Roundabout examples

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Roundabout examples

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Roundabout examples – bus bypass lanes

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Roundabout lane markings

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Roundabouts in Australia – a survey of Australian professionals

Akçelik, R. (2008). Roundabouts in Australia. Paper presented at the National Roundabout Conference, Transportation Research Board, Kansas City, MO, USA, 18-21 May 2008.

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.

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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).

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Bicycle and pedestrian treatment examples

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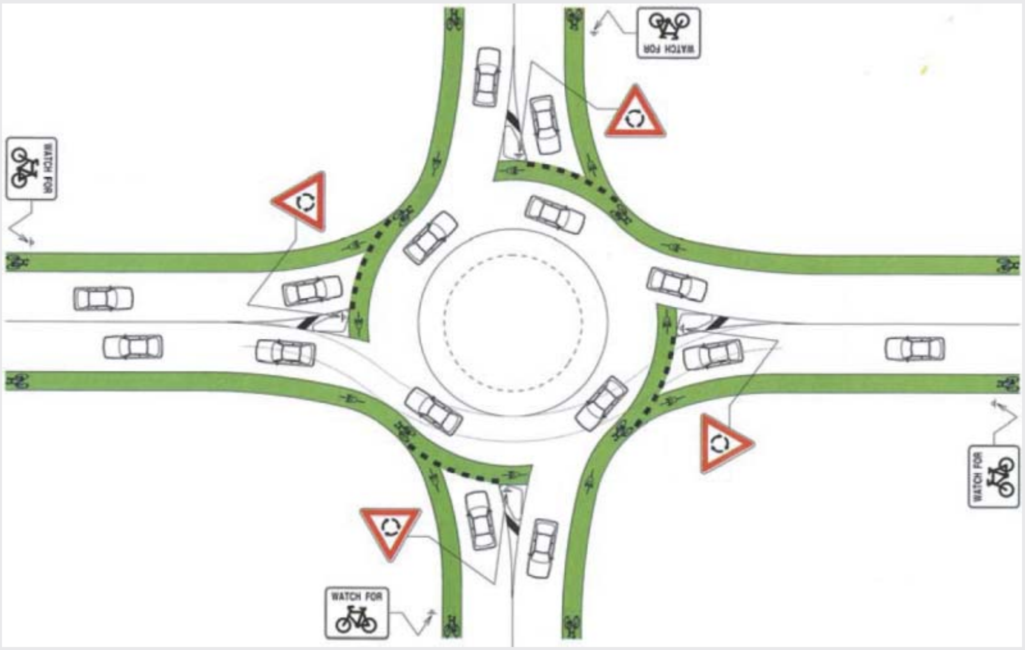
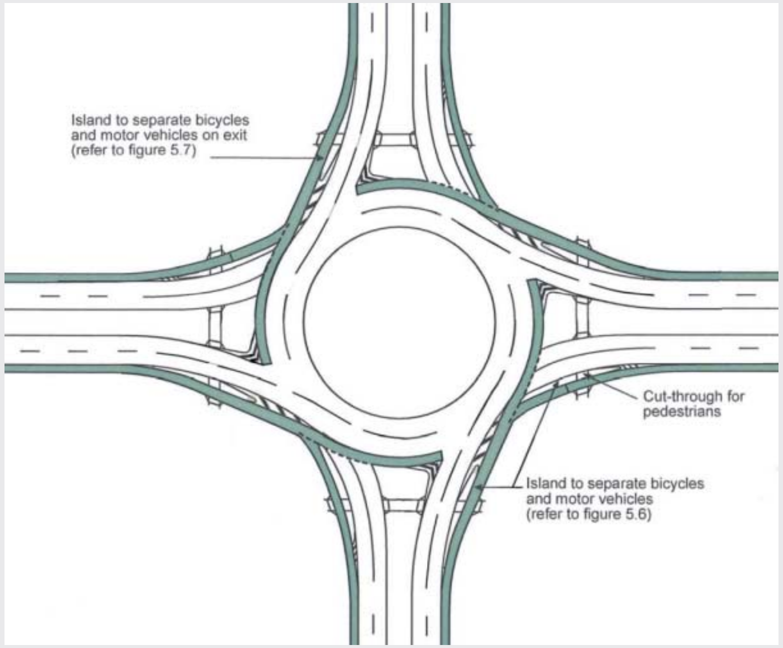
Bicycle and pedestrian treatments

Refer to: AUSTROADS (2009) Guide to Road Design, Part 4B – ROUNDABOUTS, Section 5.
This guide carries many warnings about possible 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://viastrada.co.nz/sites/viastrada.co.nz/files/Module4-section4.pdf





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Bicyle treatment examples

Australia

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Bicyle treatment examples

Australia

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Bicycle treatment examples

New Zealand

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Bicycle treatment examples

New Zealand

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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:
Multi-lane roundabout designs for cyclists. New Zealand Transport Agency, Research Report 287. Wellington, New Zealand, 2006.
www.nzta.govt.nz/resources/research/reports/287

New Zealand – The C-Roundabout

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Capacity and Level of Service Methods

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Capacity and Level of Service Methods

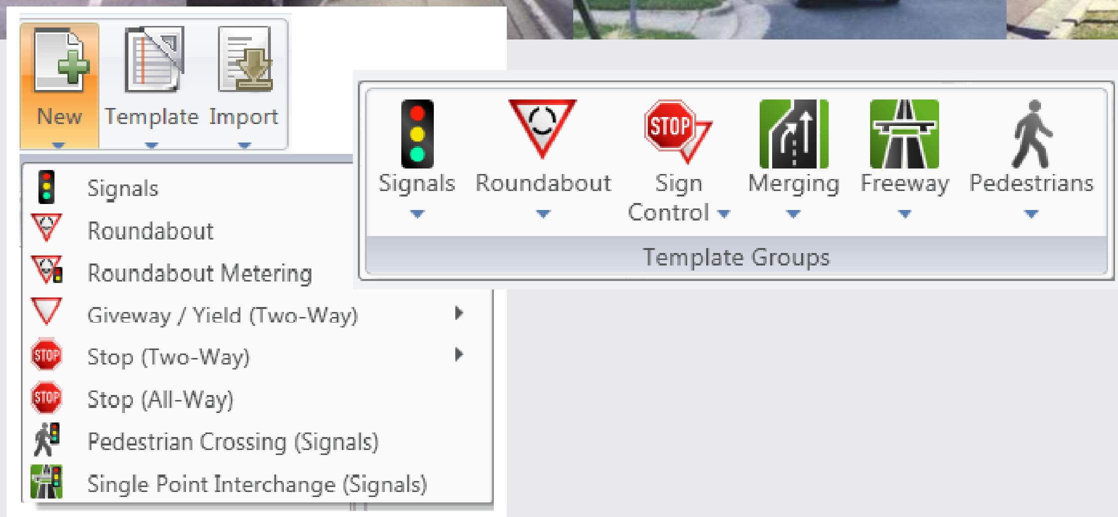
In Australia and New Zealand practice, SIDRA INTERSECTION software is the main method used for capacity, performance and level of service.

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



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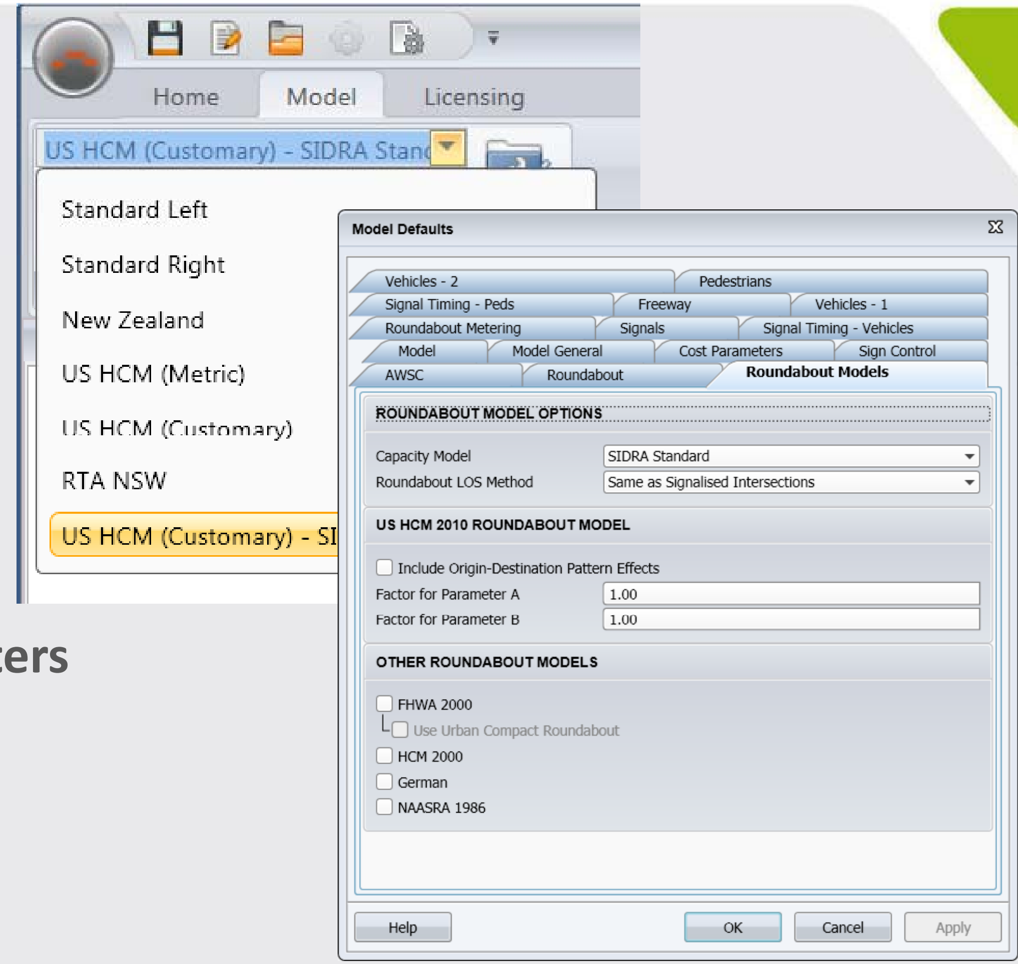
SIDRA models for LOCAL CONDITIONS

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.

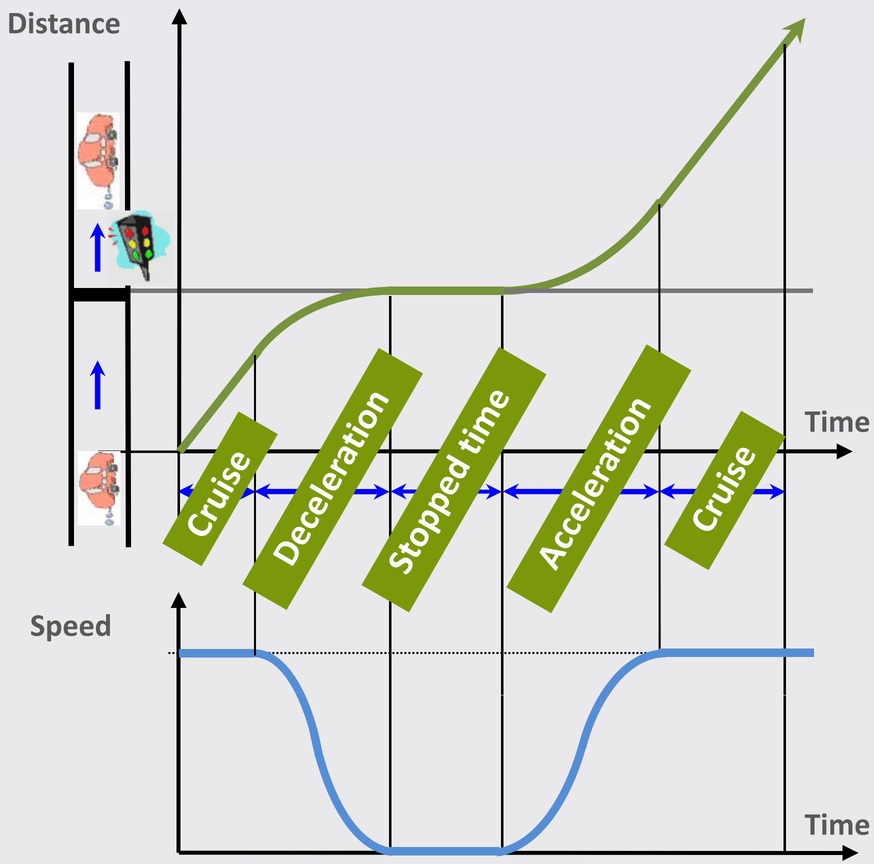


Features of SIDRA INTERSECTION

Power-based fuel and emission model

Four-mode elemental model (drive cycles)

- Emissions - CO_2, CO, HC, NOx
- Fuel consumption
- Operating COST



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Features of SIDRA INTERSECTION

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

more detailed model of traffic stream

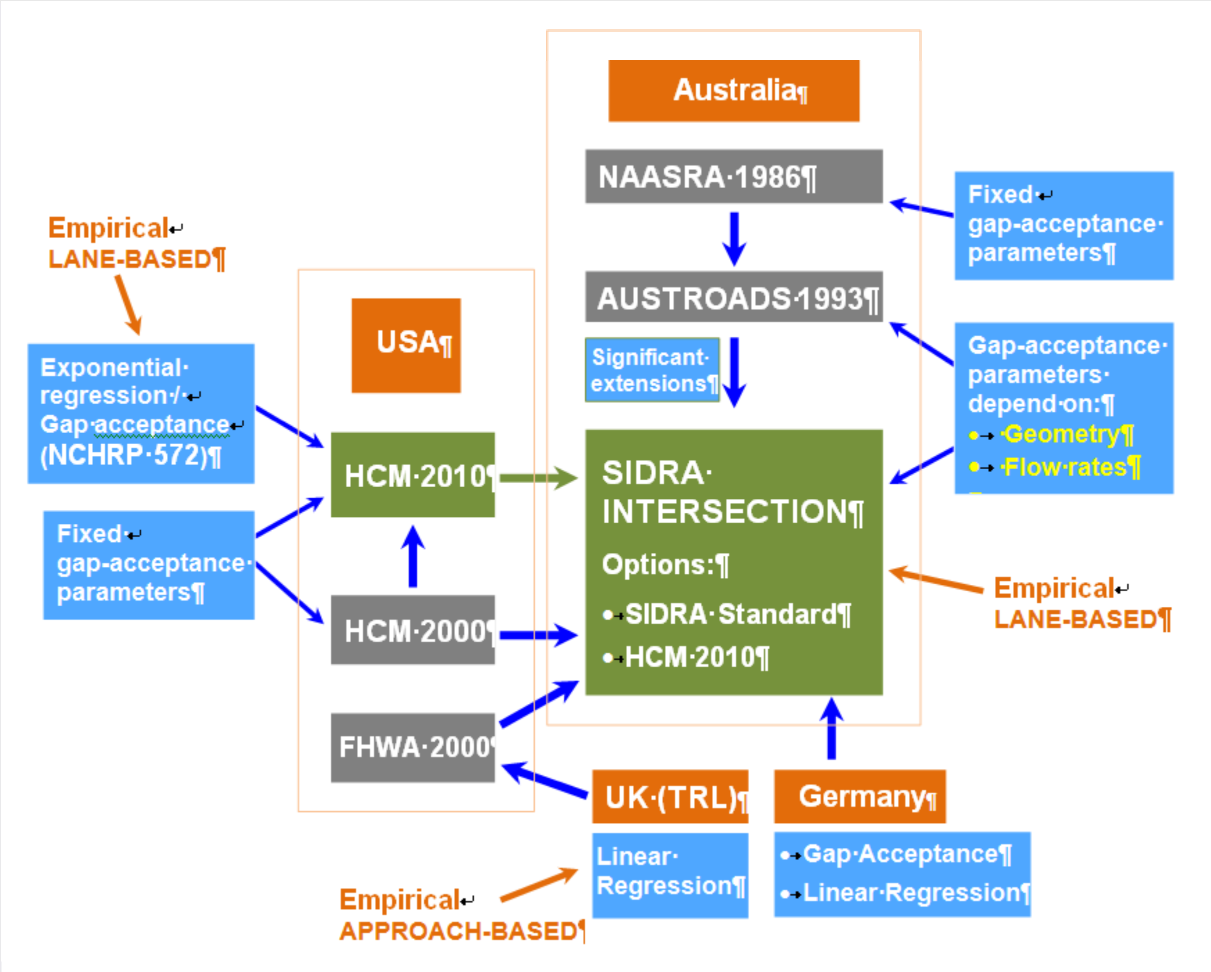
Individual vehicles			Microsimulation models
Drive cycles			SIDRA INTERSECTION
Traffic flows	RODEL, ARCADY	TRANSYT, SYNCHRO US Highway Capacity Software	
Speed-flow functions	Most transport planning and economic analysis models		
	Approaches	Lane groups	Individual LANES

Micro-analytical model

LEVEL OF ANALYSIS DETAIL

more detailed model of road geometry

ROUNDABOUT MODELS in SIDRA INTERSECTION



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Papers presented at the International Roundabout Conference, Transportation Research Board, Carmel, Indiana, USA, May 2011

- 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:

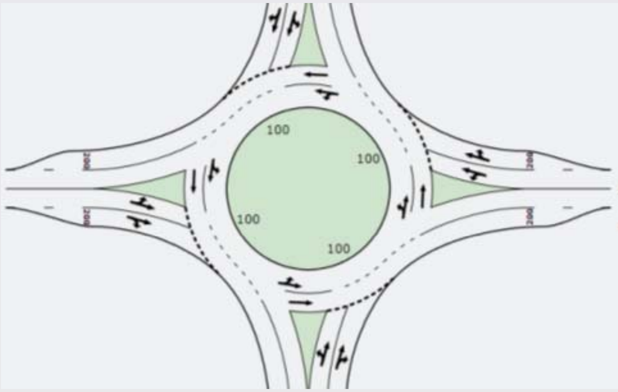
USA: HCM 2010 (Highway Capacity Manual 2010) model

Australia: SIDRA INTERSECTION model, and

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

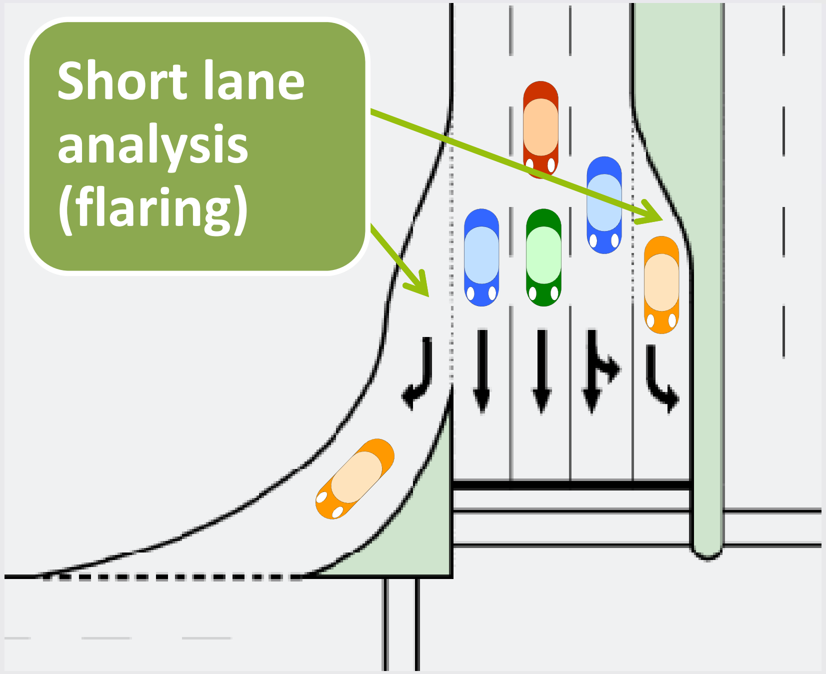
These models have some common features as well as significant differences.

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

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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

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Observed at UK Roundabouts

Continuous lane without island causing lane underutilisation on another approach

This cannot be modelled using an APPROACH-BASED method

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Observed at UK Roundabouts

Mini roundabouts operate effectively as all-way give-way control

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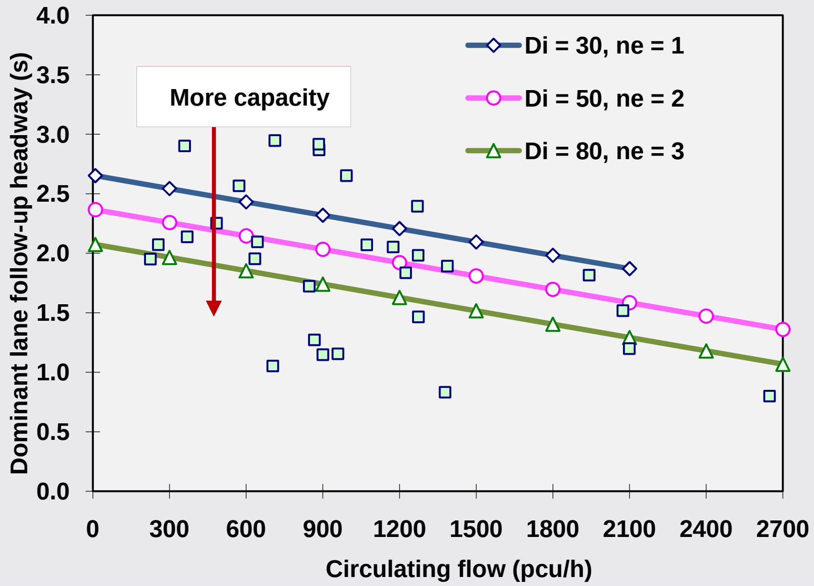
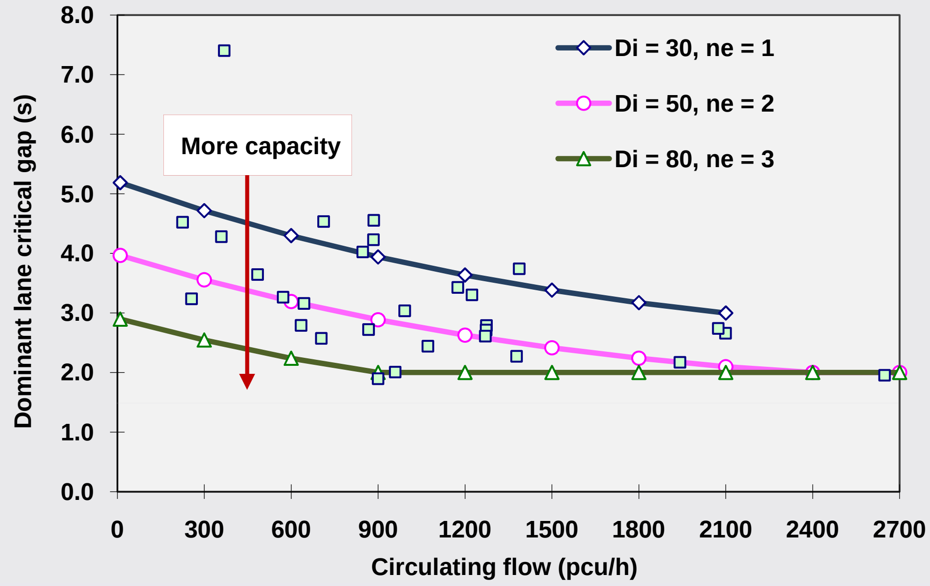
SIDRA INTERSECTION features

GEOMETRY and DRIVER BEHAVIOUR

Follow-up Headway and Critical Gap values decrease with increased flow rates, and depend on roundabout geometry





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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

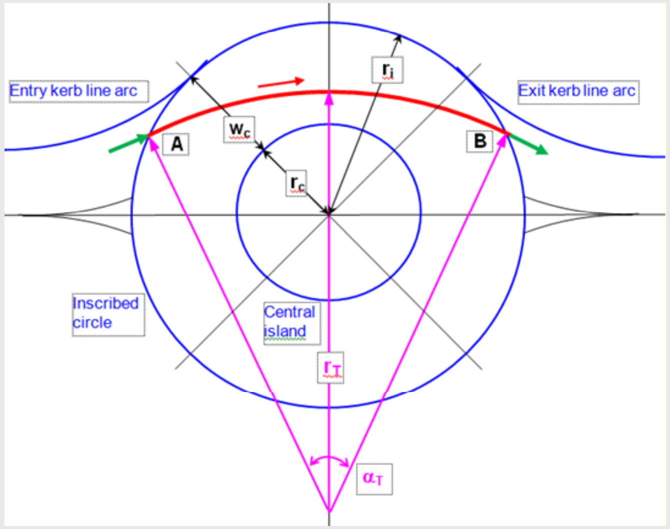
SIDRA INTERSECTION features

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



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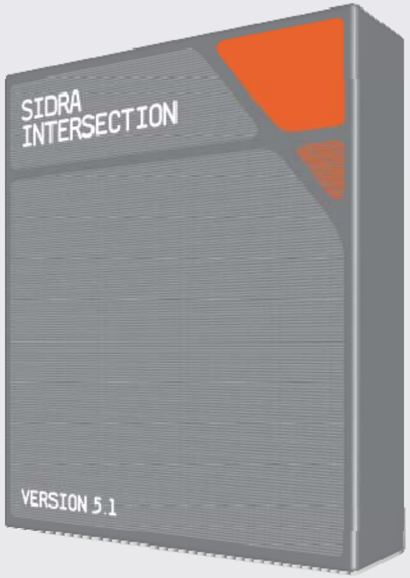
SIDRA INTERSECTION features

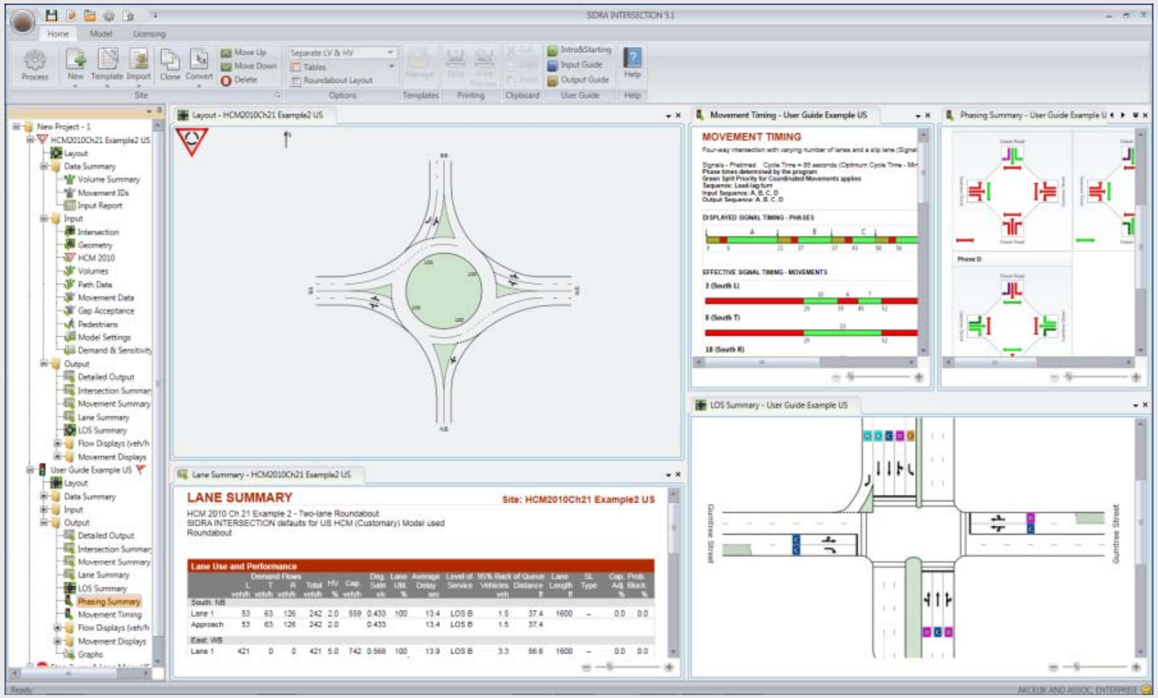
Roundabout model – HIGH DEMAND

SIDRA INTERSECTION identifies congestion caused by heavy circulating flows especially with UNBALANCED flow patterns

SIDRA ⇨ aaSIDRA ⇨ SIDRA INTERSECTION



- **First released in 1984**
- **SIDRA INTERSECTION 5.1 released two months ago**



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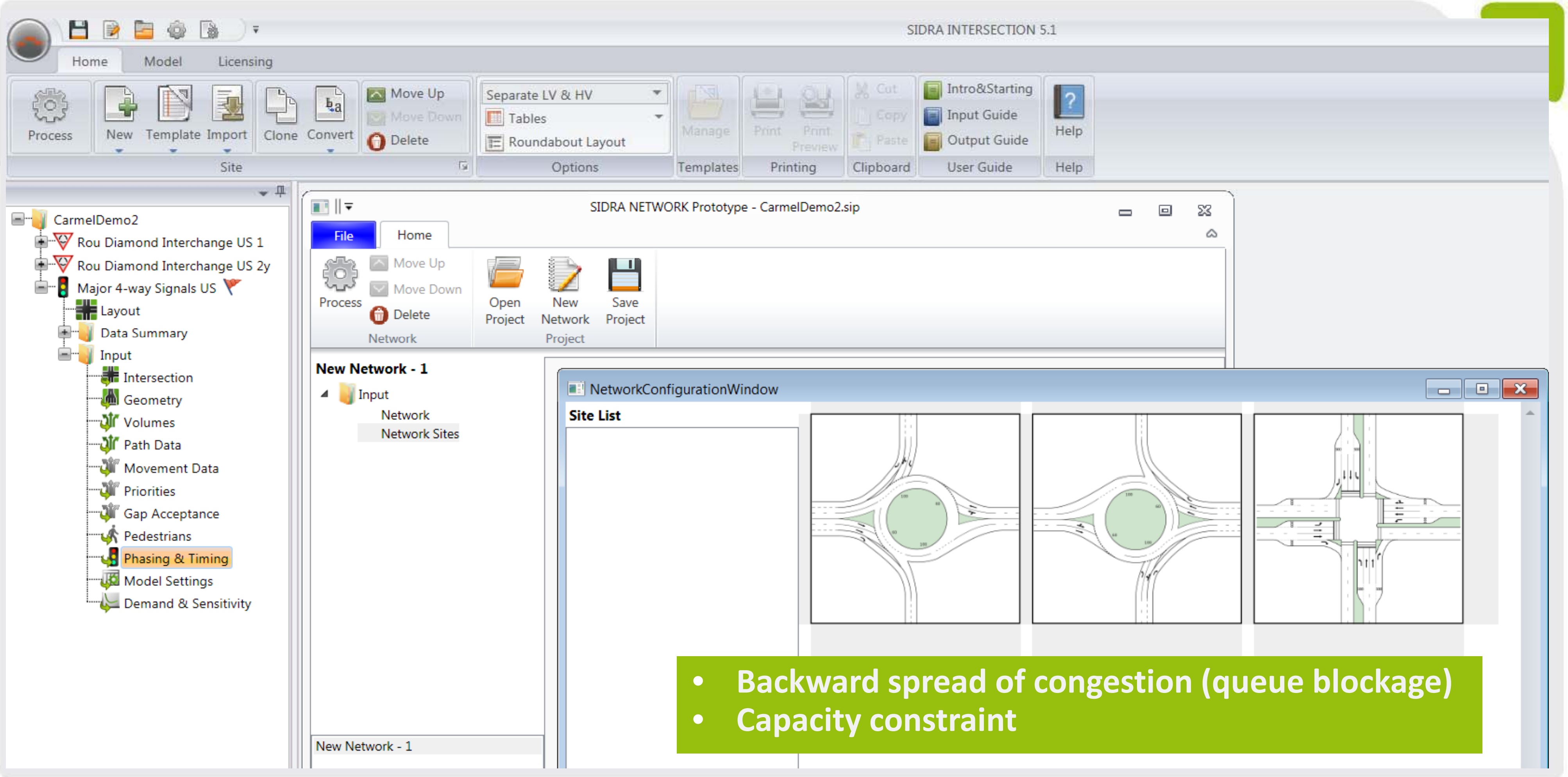
SIDRA NETWORK >> SIDRA INTERSECTION 6.0



- Backward spread of congestion (queue blockage)
- Capacity constraint

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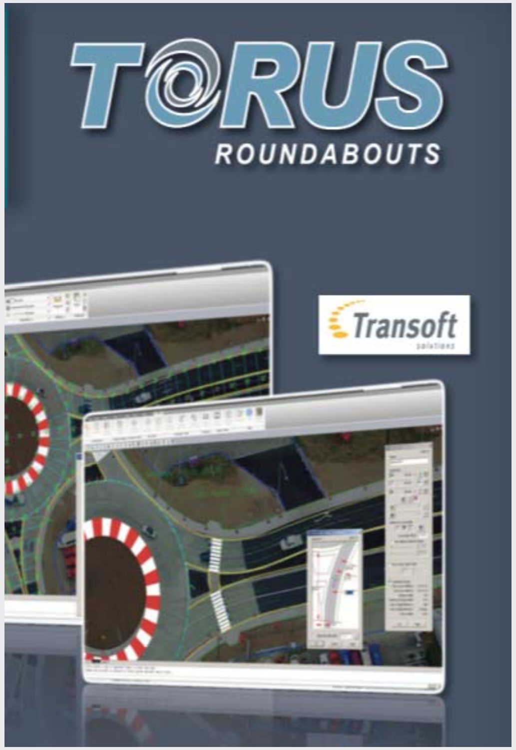
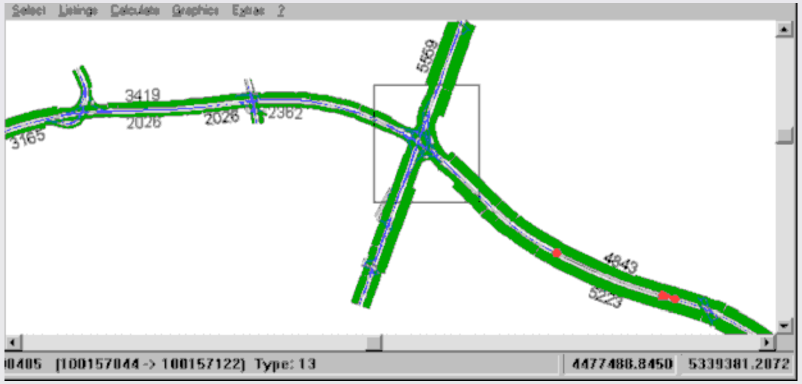
SIDRA interlinking with major software packages

Transoft Solutions



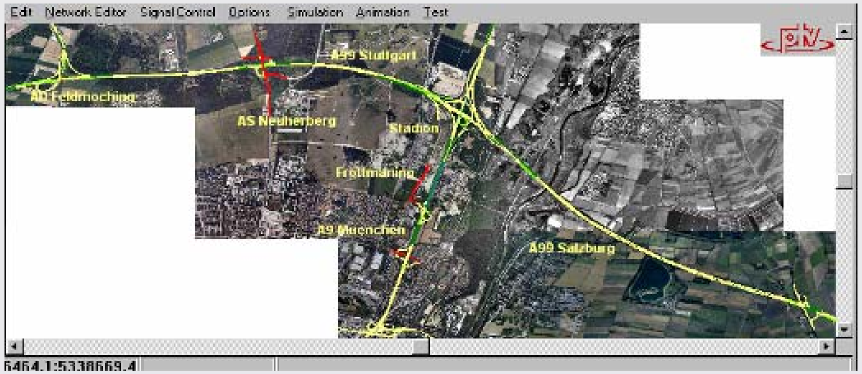
VISUM



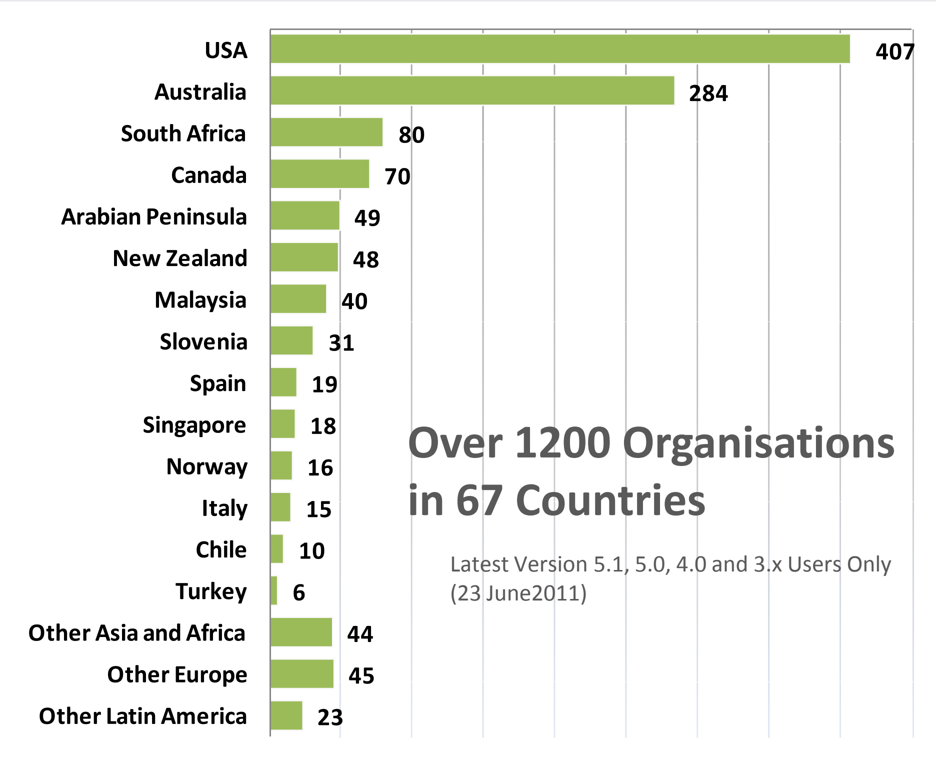
ptv vision

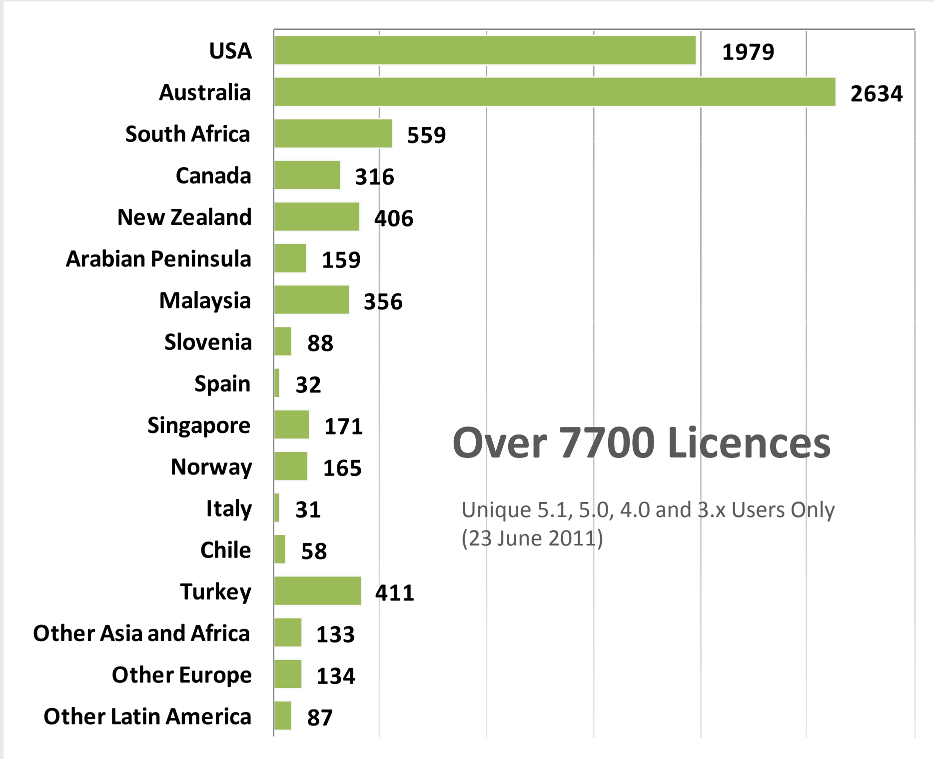
ptv
traffic mobility logistics.

VISSIM



SIDRA INTERSECTION Users





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New Research

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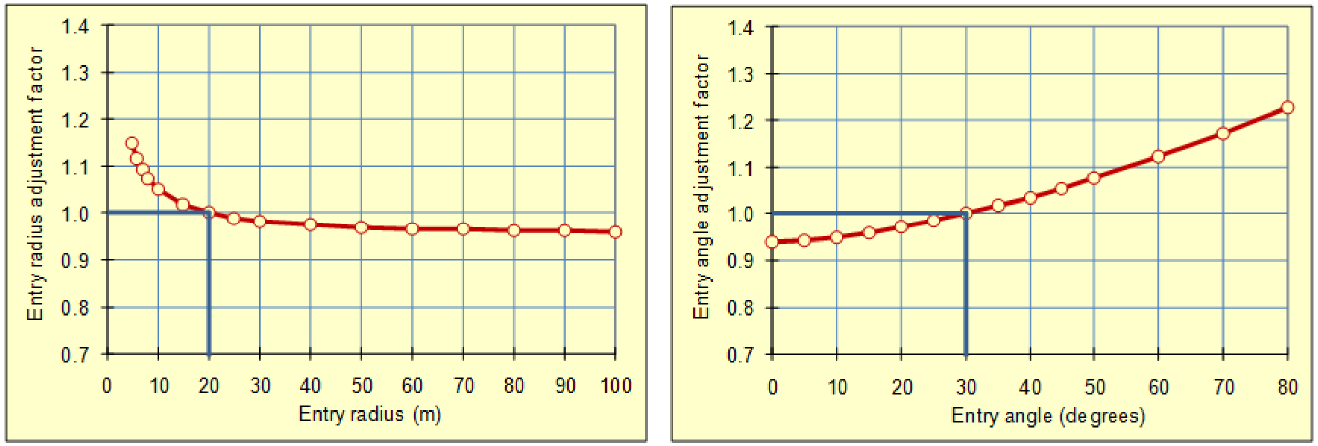
Entry Radius and Entry Angle in *SIDRA Standard* model (SIDRA INTERSECTION 5.1)



$f_r = 0.95 + 1 / r_e$

$f_a = 0.94 + 0.00026 / \phi_e^{1.6}$

r_e is the entry radius (m)

ϕ_e is the entry angle (degrees)

Customary units:

$f_r = 0.95 + 3.28 / r_e$

r_e is the entry radius (ft)

The entry radius and entry angle factors in *SIDRA Standard* and *UK TRL* models

r_e (m)	r_e (ft)	ϕ_e (degrees)	*UK TRL*	*SIDRA Standard*
5	16	70	1.40	1.35
10	33	60	1.18	1.18
20	66	45	1.05	1.05
30	98	35	1.00	1.00
40	131	**30**	0.98	0.98
60	197	15	0.92	0.93
80	262	5	0.89	0.91
100	328	0	0.87	0.90

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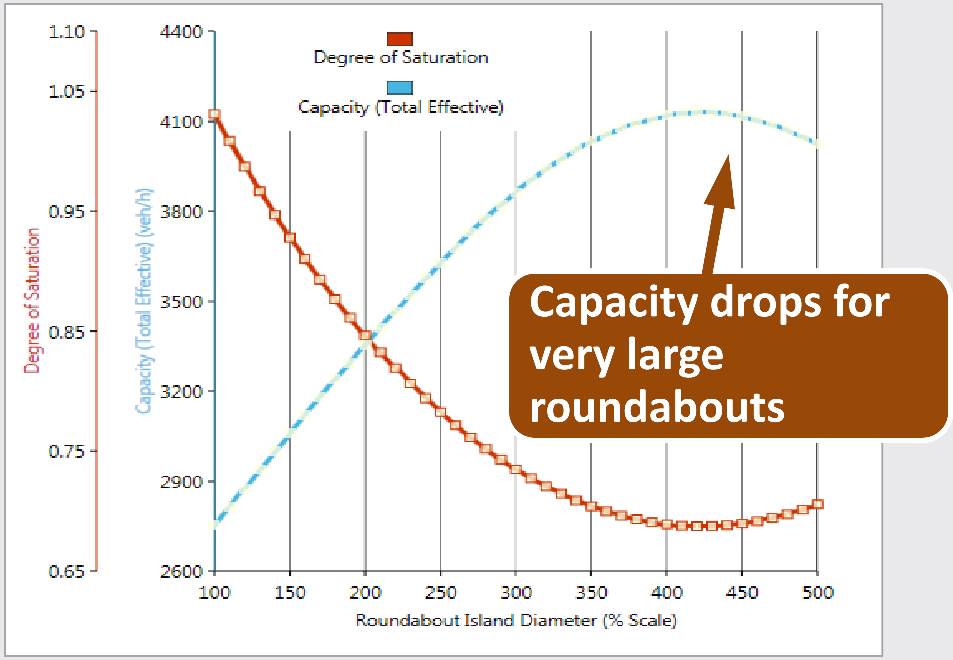
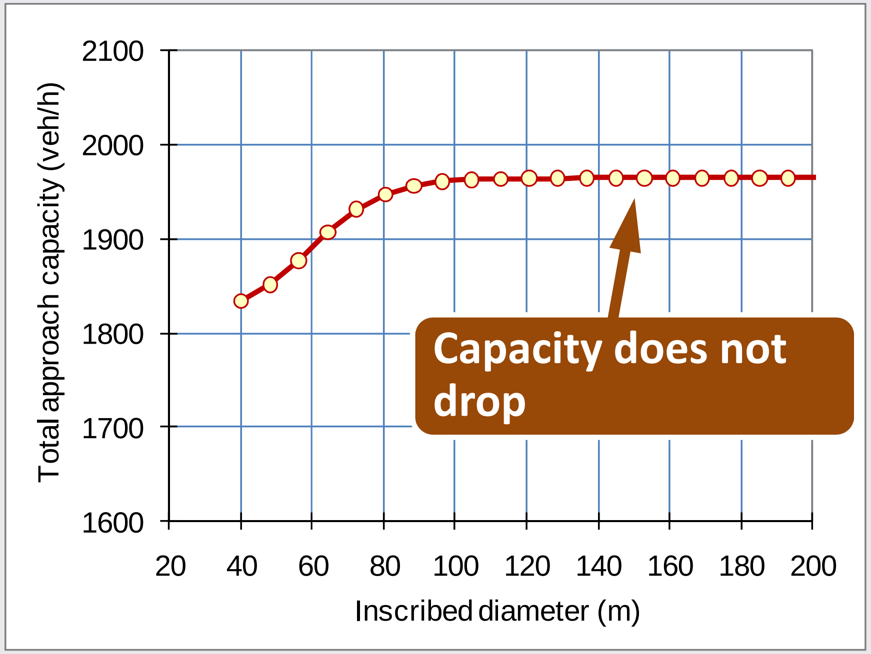
Roundabout Size: Inscribed Diameter

SIDRA Standard model



UK TRL model (RODEL, ARCADY)



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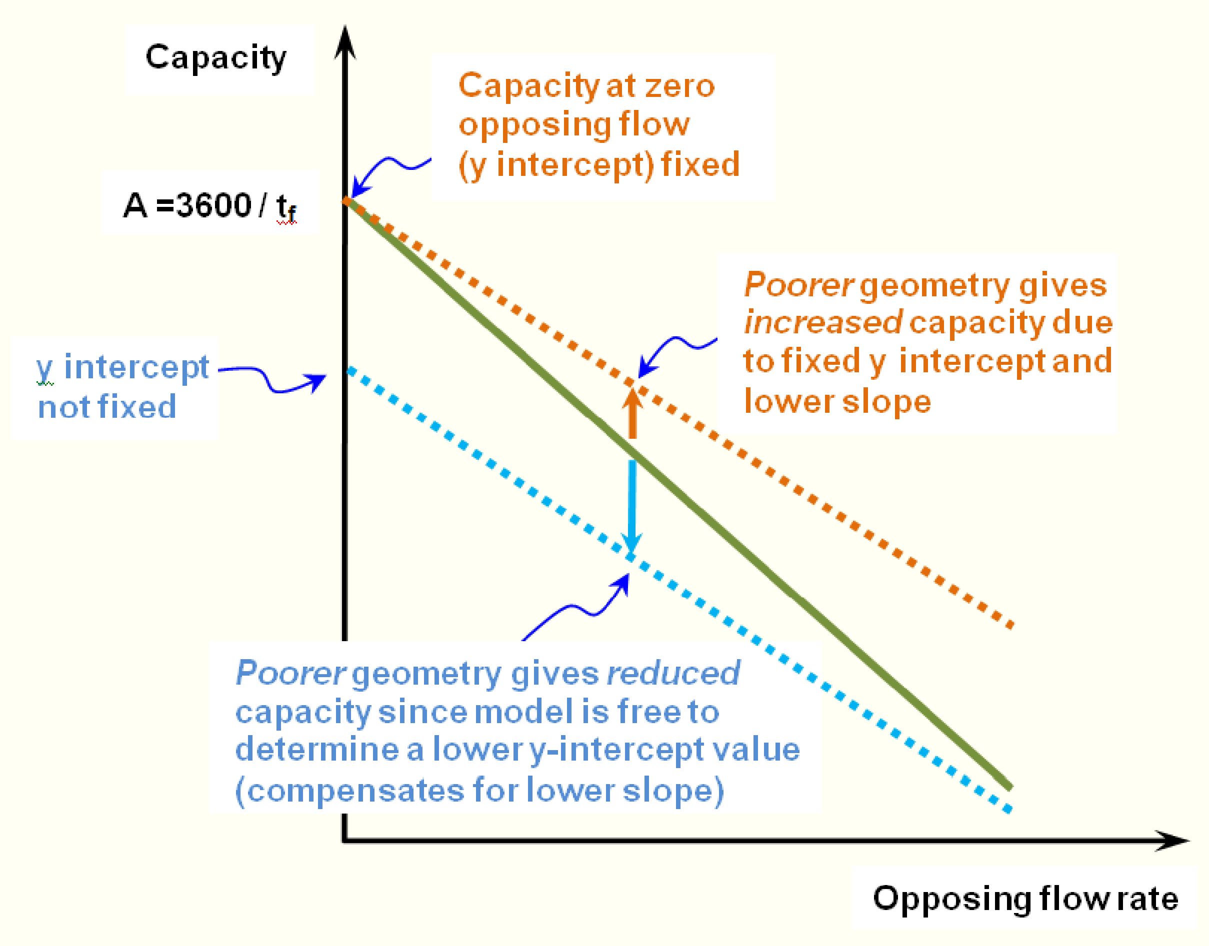
Model calibration issue with the TRL model (RODEL, ARCADY)



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.

Refer to: LENTERS, M. and RUDY, C. (2010). HCM Roundabout Capacity Methods and Alternative Capacity Models. ITE Journal, 80 (7), pp. 22-27.

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

AKÇELIK, R. (2011). Roundabout metering signals: capacity, performance and timing. Paper presented at the 6th International Symposium on Highway Capacity and Quality of Service, Transportation Research Board, Stockholm, Sweden.

Metering Signals Project : Akcelik & Associates for VIC ROADS

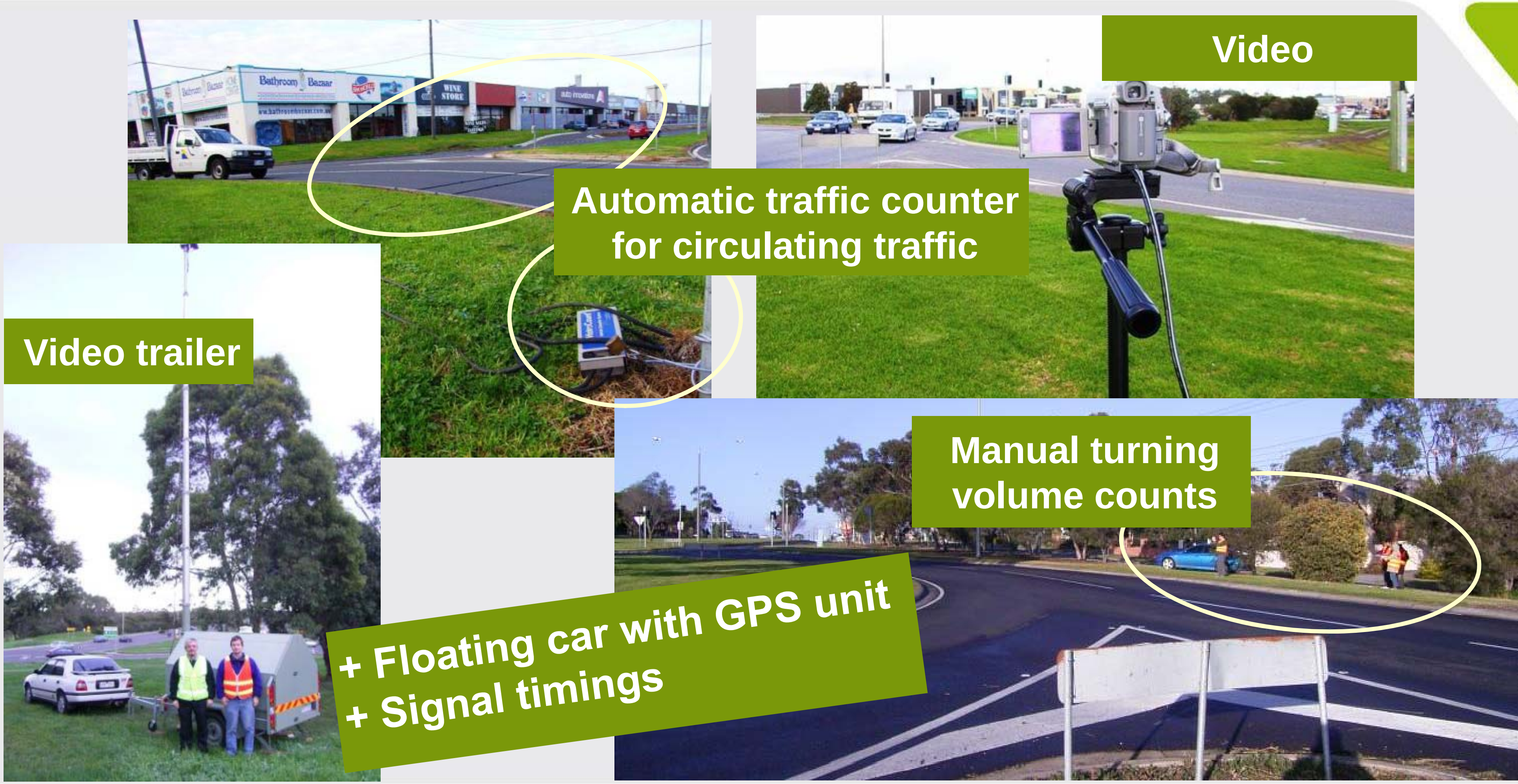
A major project was undertaken by Akcelik & Associates for **VIC ROADS**, the state transport authority in Victoria, to investigate the performance of **roundabouts with metering signals** in Melbourne, Australia.

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



Video

Automatic traffic counter for circulating traffic

Video trailer

Manual turning volume counts

+ Floating car with GPS unit
+ Signal timings

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Metering Signals Project - A&A for VIC ROADS

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

For further information:

AKÇELIK, R. (2008). An investigation of the performance of roundabouts with metering signals. Paper presented at the National Roundabout Conference, Transportation Research Board, Kansas City, MO, USA.

www.sidrasolutions.com/software_downloads_articles.aspx

Metering Signals Project - A&A for VIC ROADS: Findings

	Circulating Traffic		Entry Lane Traffic		Measured		Estimated	
	Flow Rate (veh/h)	HVs	Flow Rate (veh/h)	HVs	Critical Gap (s)	Follow-up Headway (s)	Critical Gap (s)	Follow-up Headway (s)
Metered and controlling approaches together								
Minimum	134	0.0%	174	0.0%	2.13	1.44	2.17	1.43
15th percentile	356	1.1%	288	0.7%	2.79	2.02	2.54	1.84
Mean	674	4.6%	677	3.4%	3.20	2.30	3.37	2.10
85th percentile	984	8.6%	985	6.7%	3.60	2.59	3.98	2.38
Maximum	1365	14.5%	1130	12.5%	4.31	3.25	4.83	3.11

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

Boundary Road / Governor Road, PM Peak

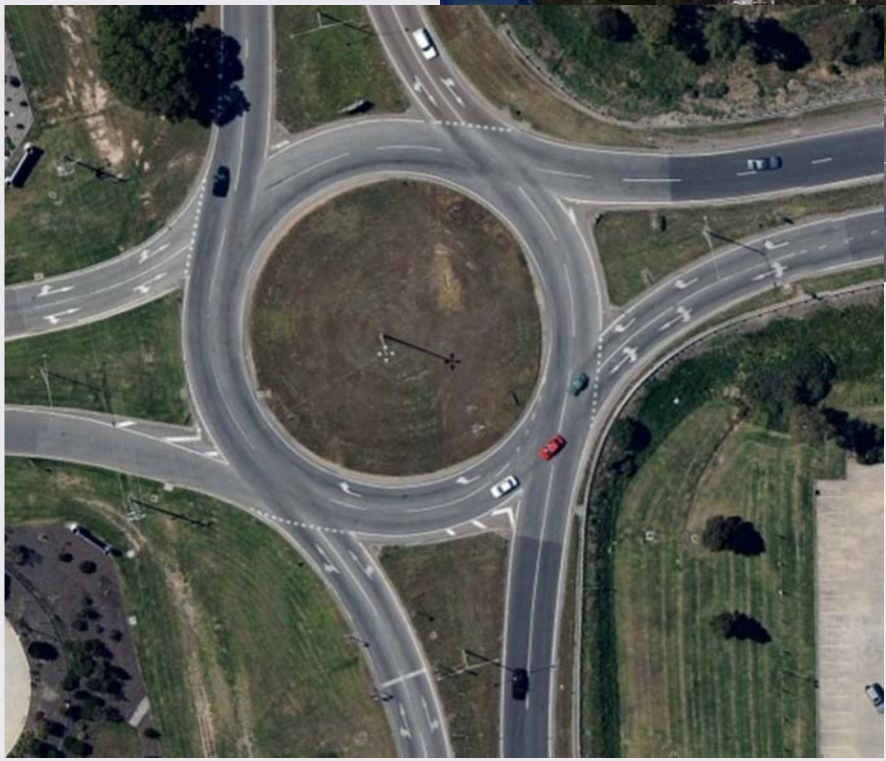
**Controlling approach:
Boundary Rd South**

**Metered approach:
Governor Rd**

Greensborough Bypass / Diamond Creek Rd, AM Peak

South Gippsland Hwy / Pound Rd, PM Peak

Controlling approach:
South Gippsland Hwy North



Metered approach:
South Gippsland Hwy South

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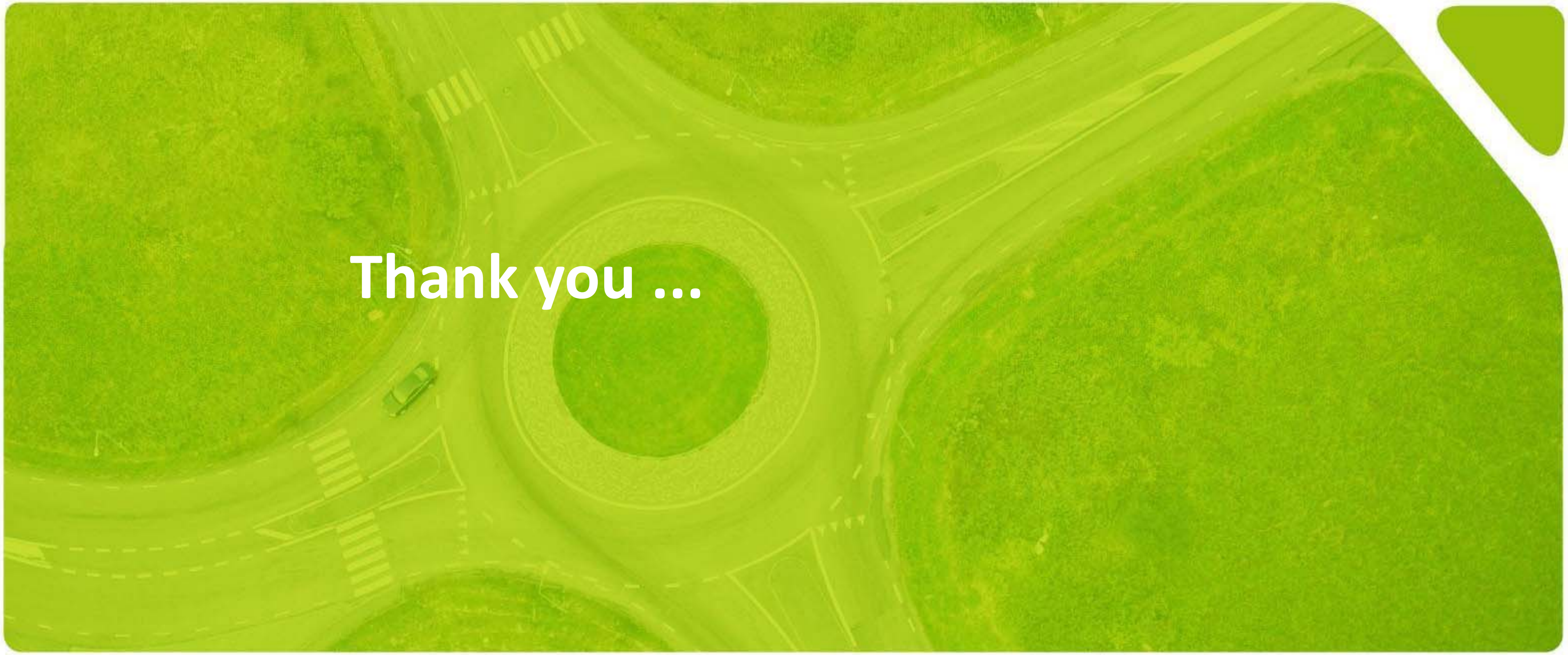
South Gippsland Hwy / Pound Rd, PM Peak

Fully signalised treatment

http://vicroads.vic.gov.au/Home/RoadProjects/MelbourneRoadProjects/SouthEasternSuburbs/PoundRoadDandenongSouth.htm

END OF PRESENTATION



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