Roundabouts in Australia: the state of the art on models and applications

Seminar Presentation

One-day International Meeting on Roundabouts
Università di Pisa - Corso di TECNICA del TRAFFICO,
Livorno, 28 May 2015

Presenter:
Rahmi Akçelik

PRESENTATION OBJECTIVES

Discuss various aspects of roundabouts in Australia

Describe the roundabout models in the SIDRA INTERSECTION software developed in Australia

Roundabouts in AUSTRALIA and NEW ZEALAND

This section highlights various aspects of roundabouts in **AUSTRALIA and NEW ZEALAND** as presented at the International Roundabout Design and Capacity Seminar:

> AKÇELIK, R. (2011) **Roundabout Design and Capacity Analysis in Australia and New Zealand**. Presentation at the International Roundabout Design and Capacity Seminar, 6th International Symposium on Highway Capacity and Quality of Service, Stockholm, Sweden, July 2011.

The full presentation is available for download from:

www.sidrasolutions.com/software_downloads_articles.aspx

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.

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Driver Behaviour

All-Way Stop Control is rare and Two-Way Give Way (Yield) Control is common in Australia & New Zealand (opposite to North America).

This is likely to affect capacity of roundabouts.

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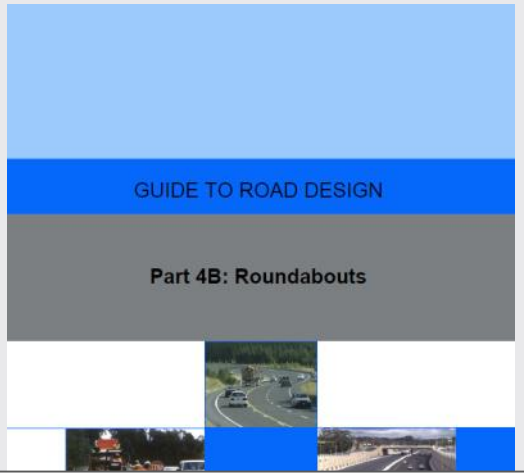
Roundabout Design

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



An important change in design principles

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.

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Roundabout examples – lane markings

Fitzsimons Lane - Porter St Roundabout, Melbourne

Paper available for download from:
sidrasolutions.com/Resources/Articles

Roundabout lane markings

Roundabout examples – lane markings

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Roundabout examples – lane markings

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Roundabout examples

Roundabout examples

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Roundabout examples – bus bypass lanes

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.

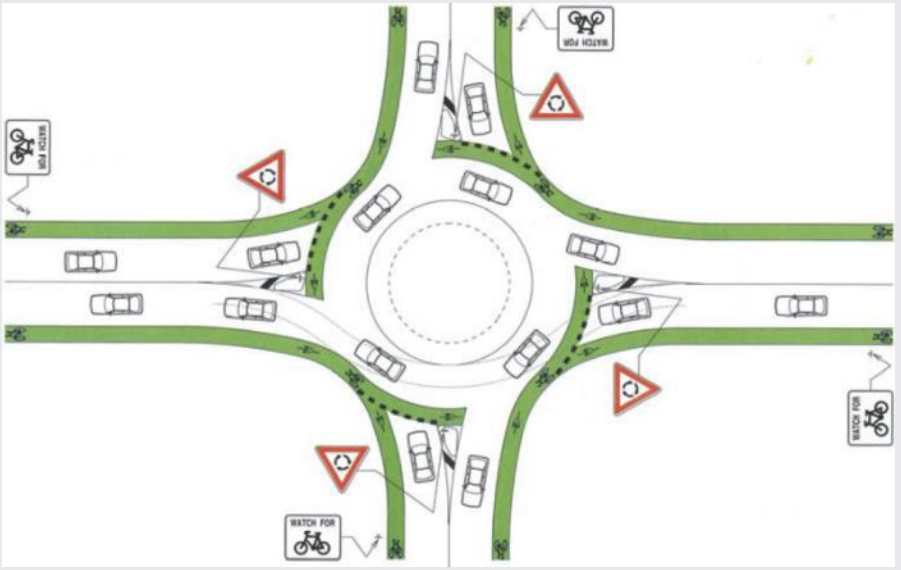
Roundabouts in Australia – a survey of Australian professionals

- 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 treatments

AUSTROADS (2009) Guide to Road Design, Part 4B – ROUNDABOUTS, Section 5 carries many warnings about possible treatments.

The official New Zealand Transport Agency guidance is not to use cycle lane markings within the roundabout: "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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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

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

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Capacity and Level of Service Methods

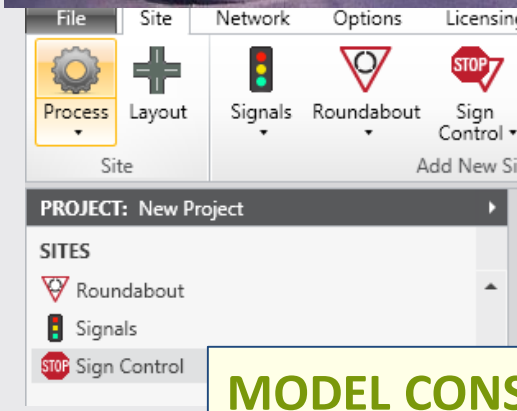
In Australian and New Zealand practice, the SIDRA INTERSECTION software is the main method used for capacity, performance and level of service estimation.

Information about the roundabout capacity and performance models used in SIDRA INTERSECTION is given in the following slides.

SIDRA INTERSECTION Roundabout Capacity and Performance Models

- Lane-based model
- Back of queue model
- Geometry configurations and parameters
- Templates
- Roundabout Capacity Model
- Unbalanced flows and roundabout metering signals

A traffic engineering tool for all intersection types - not just a roundabout software package !



MODEL CONSISTENCY
in evaluating alternative intersection treatments

Micro-analytical method for evaluating alternative treatments for INTERSECTIONS AND NETWORKS in one package:

- Roundabouts
- Signals
- Sign Control
- Pedestrian Crossings

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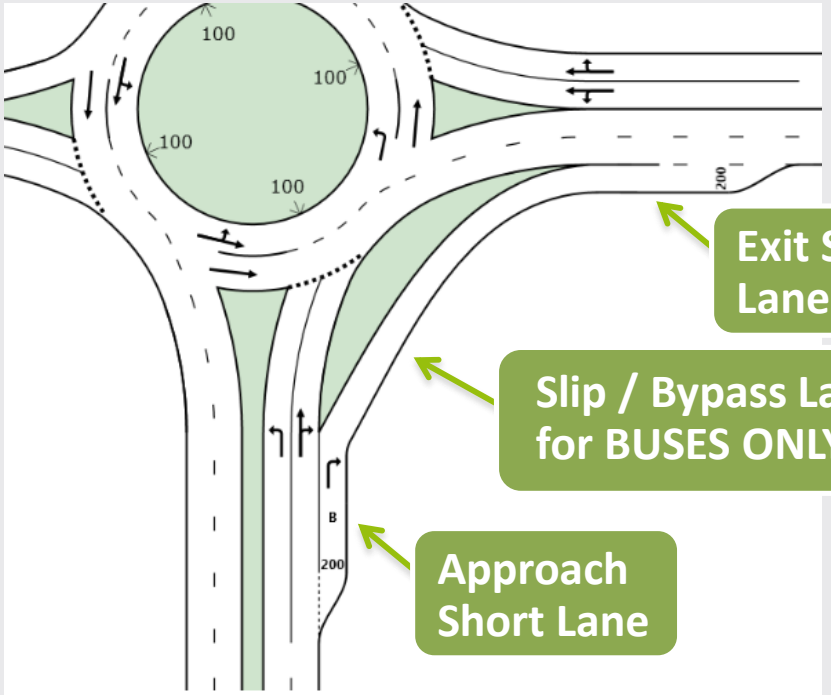
LANE-BASED MODEL

More realistic and reliable analysis compared with approach-based (UK) and lane group-based (US HCM) :

- General: Unequal lane flows, De facto exclusive lanes, Short lanes, Slip / Bypass lanes
- Roundabouts (Circulating lane use; Dominant and subdominant lanes)
- NETWORK Model (lane queues, lane blockage, signal platoon arrival and departure patterns)



Individual approach, exit and circulating lanes have different characteristics

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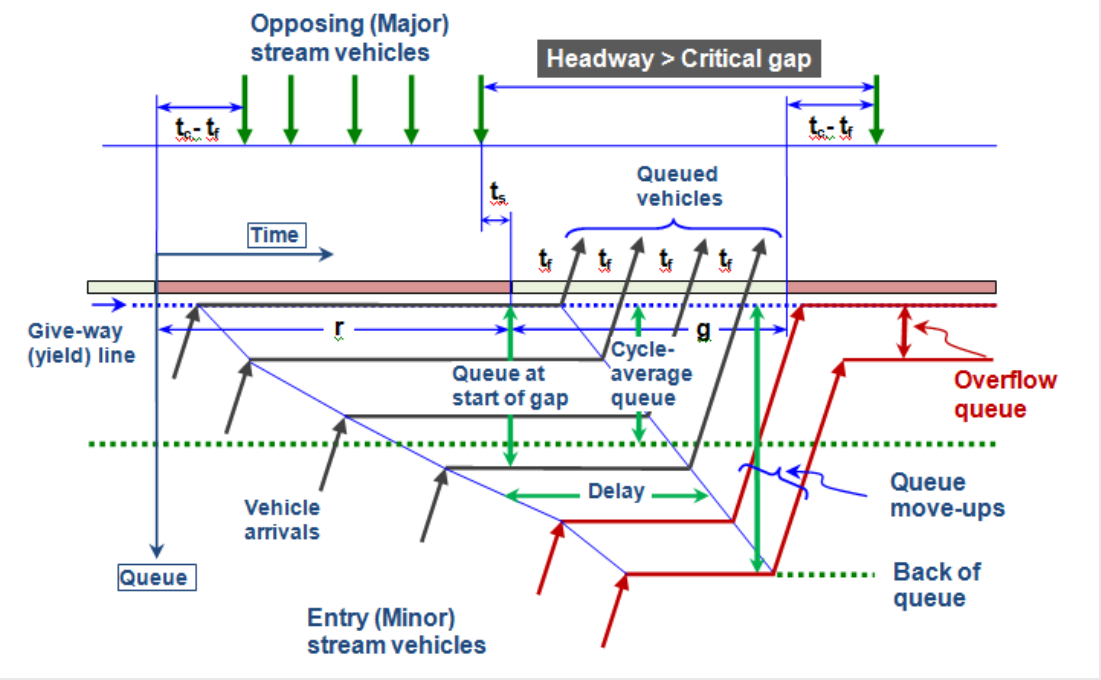
BACK OF QUEUE modelling by GAP ACCEPTANCE CYCLES

Unique method in SIDRA INTERSECTION to estimate **gap-acceptance cycles** helps to model **back of queue** and **stops** for Roundabouts and Sign control



BACK OF QUEUE important for **SHORT LANE** and **NETWORK** Modelling

Not in US Highway Capacity Manual or other methodologies …

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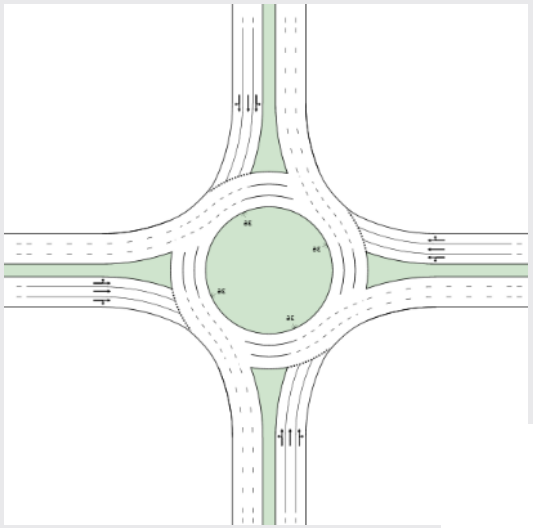
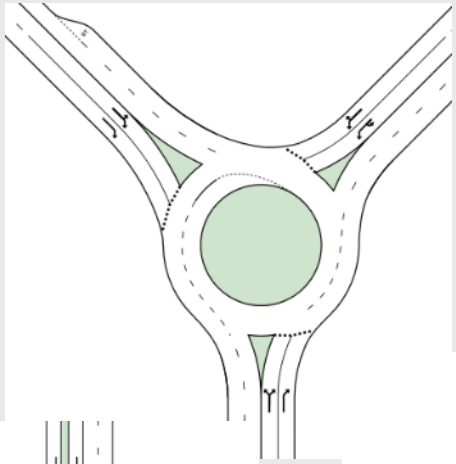
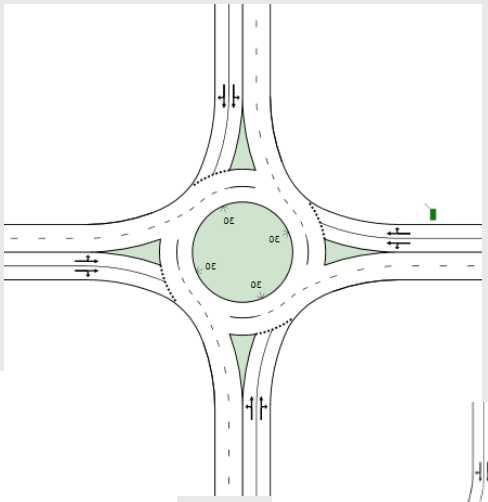
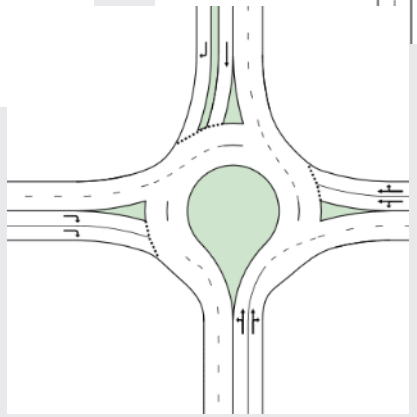
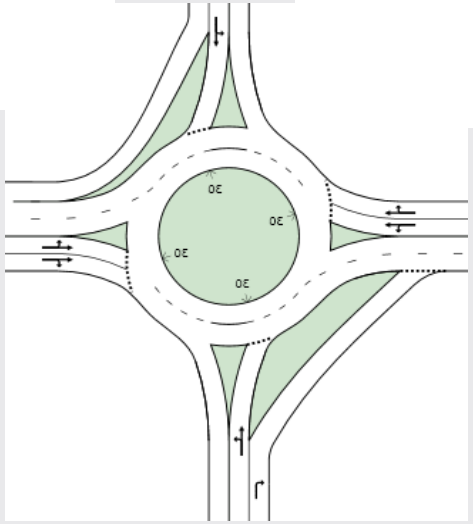
Roundabout Analysis – SIDRA INTERSECTION allows diverse GEOMETRY configurations

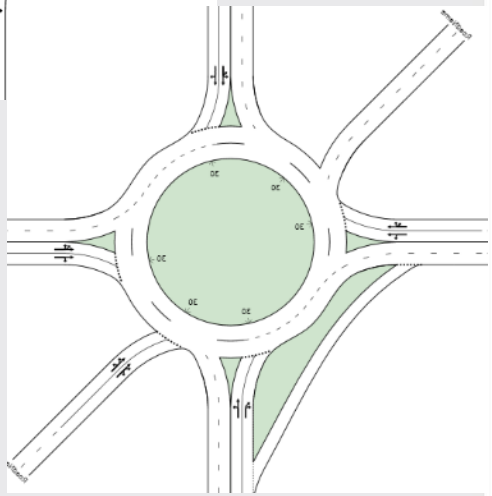












These and similar figures in this presentation are not design drawings

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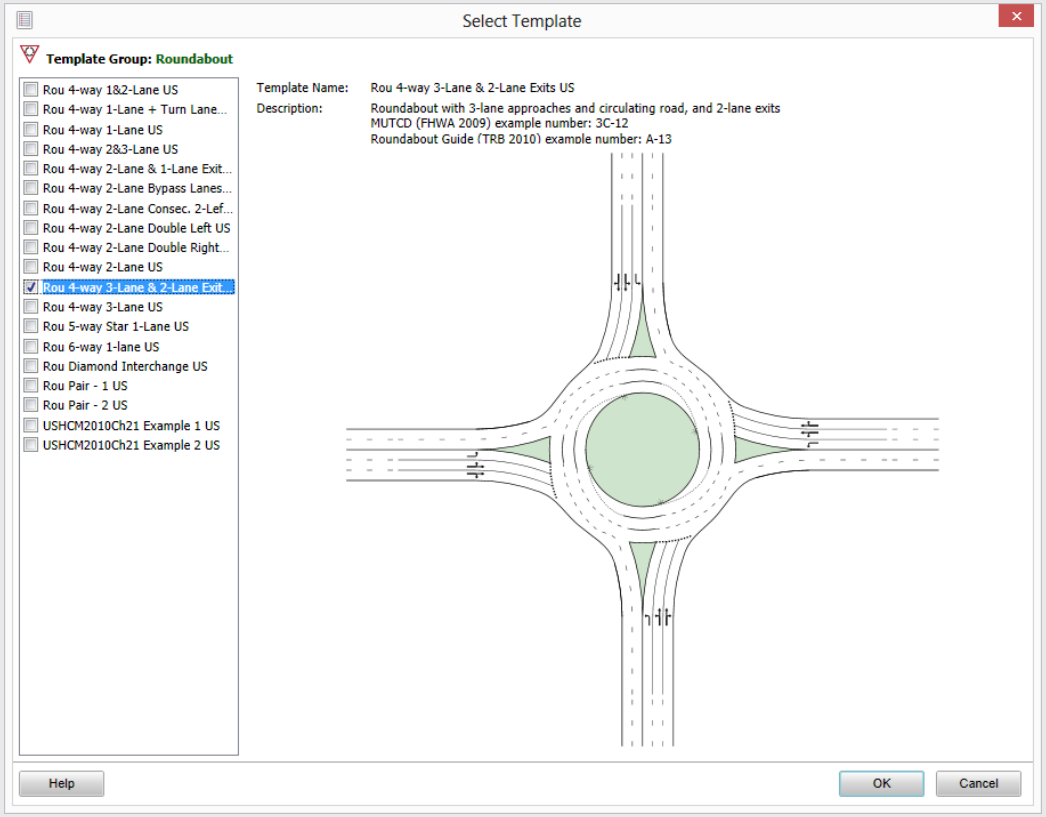
Roundabout Templates

SIDRA INTERSECTION provides a large number of templates for different 1-lane, 2-lane and 3-lane roundabout geometry configurations for easy setup including all MUTCD 2009 / TRB Roundabout Informational Guide design examples.



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Roundabout Capacity Model Options in SIDRA INTERSECTION

SIDRA INTERSECTION includes two main Roundabout Capacity Models

- SIDRA Standard (calibrated for US driving conditions)
- HCM 2010

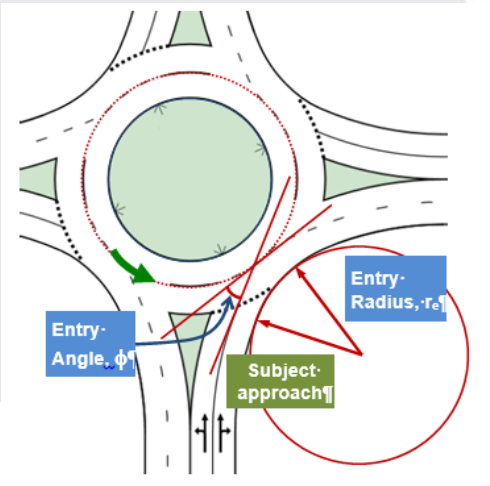
Common fundamental features of these two models:

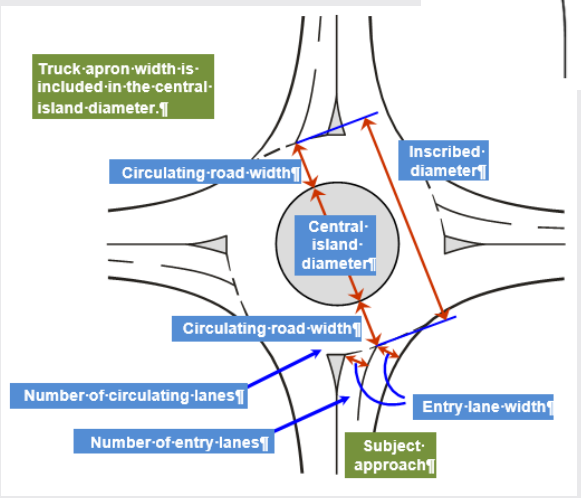
- Lane-based method
- Geometry and Driver Behavior (Gap Acceptance) effects combined
- Empirical and theoretical methods combined
- Non-linear form
- Back of queue estimation for queue spillback in short lane and network modelling (SIDRA model applied to HCM)

GEOMETRY parameters in the SIDRA Standard Roundabout Capacity Model

The SIDRA Standard Roundabout Capacity Model includes the largest number of roundabout GEOMETRY parameters for any analytical model:

- Number of entry lanes
- Average entry lane width
- Approach lane disciplines and configuration including bypass lanes (by Movement Class)
- Number of circulating (conflicting) lanes
- Central Island Diameter
- Circulating Road Width
- Inscribed Diameter
- Entry radius, Entry Angle
- Approach short lanes
- Number of exit lanes
- Exit short lanes





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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)

Observed at UK Roundabouts

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

These cannot be modelled using an APPROACH-BASED method

Driving on the left-hand side of the road

Lane underutilisation caused by a continuous lane without island on another approach

Unequal lane utilisation

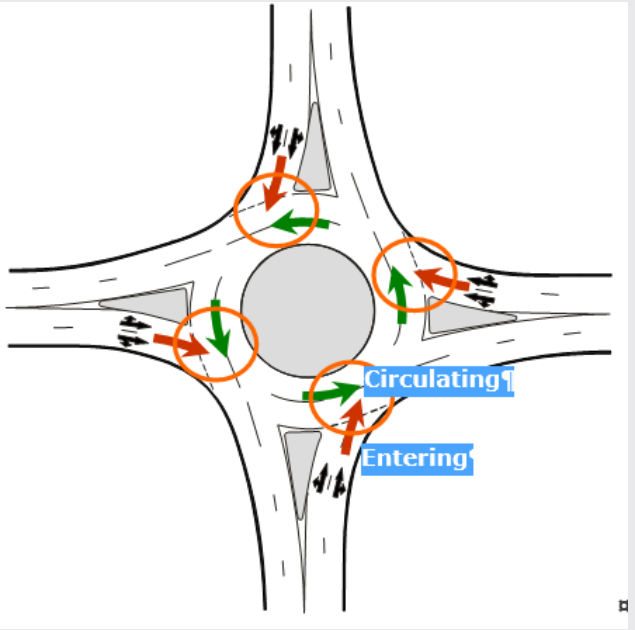
Capacity model with roundabout approach interactions

Roundabout is analysed as a closed system with interactions among roundabout entries

- **Capacity constraint**
- **Bunched headway distribution** model for the circulating flow
- **Lane balance** of circulating flow rates
- **Unbalanced flow conditions**

None available in the US Highway Capacity Manual, and none except capacity constraint available in the UK TRL roundabout capacity models …

NOT as series of T intersections …



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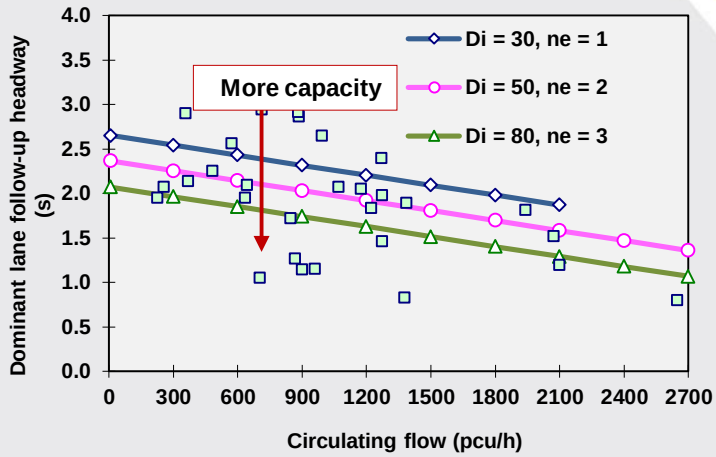
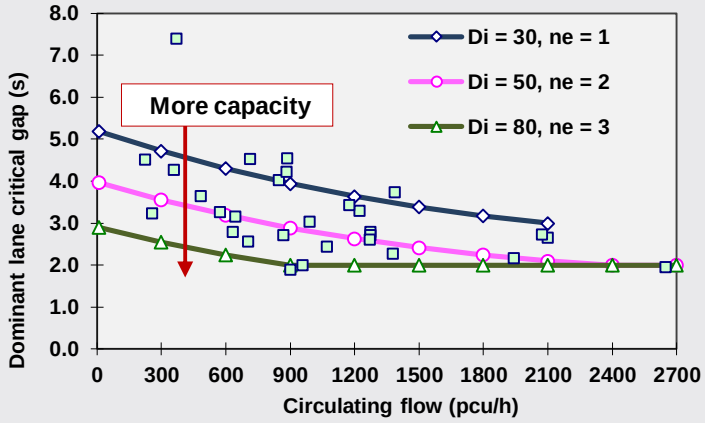
Other Advantages of SIDRA INTERSECTION Roundabout Capacity Model

- Follow-up headway and critical gap values:
  - sensitive to roundabout geometry
  - decrease with increased circulating flows
- Slip / Bypass lanes (give way and continuous)
- Upstream signal effects (extra bunching)
- Metering signals
- Network model





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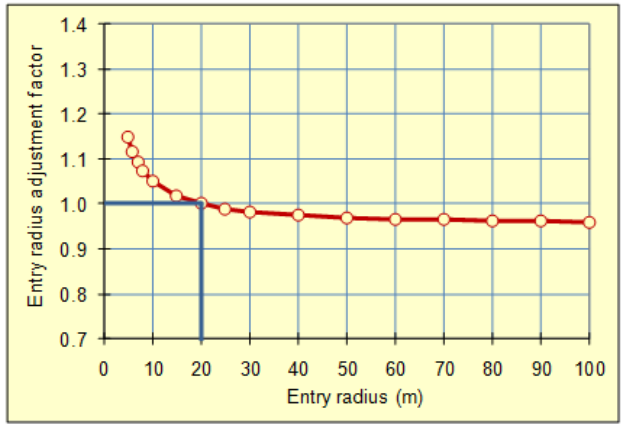
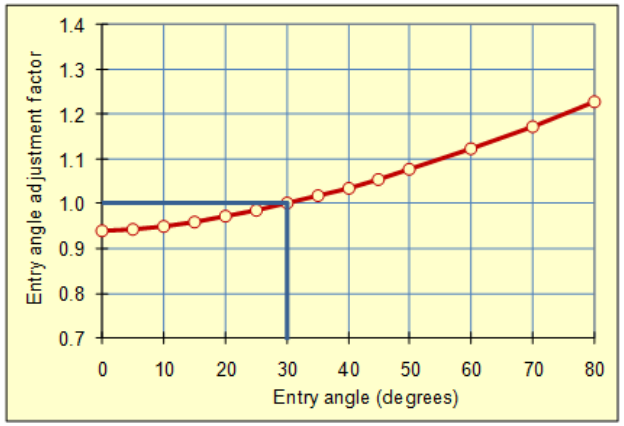
Entry Radius and Entry Angle in *SIDRA Standard* model





$f_r = 0.95 + 1 / r_e$

$f_a = 0.94 + 0.00026 / f_e^{1.6}$

r_e is the entry radius (m)

f_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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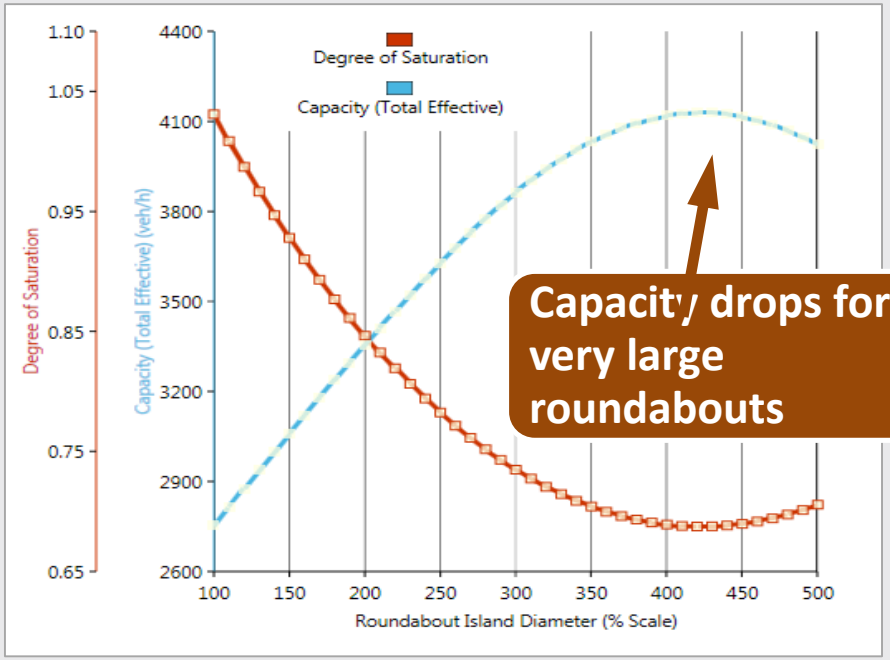
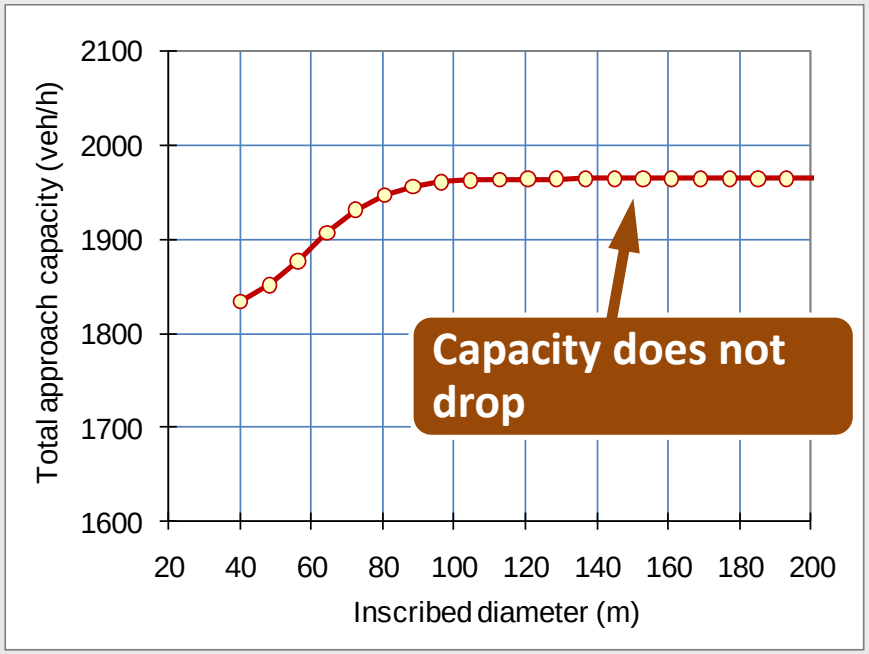
Roundabout Size: Inscribed Diameter

SIDRA Standard model



UK TRL model (RODEL, ARCADY)



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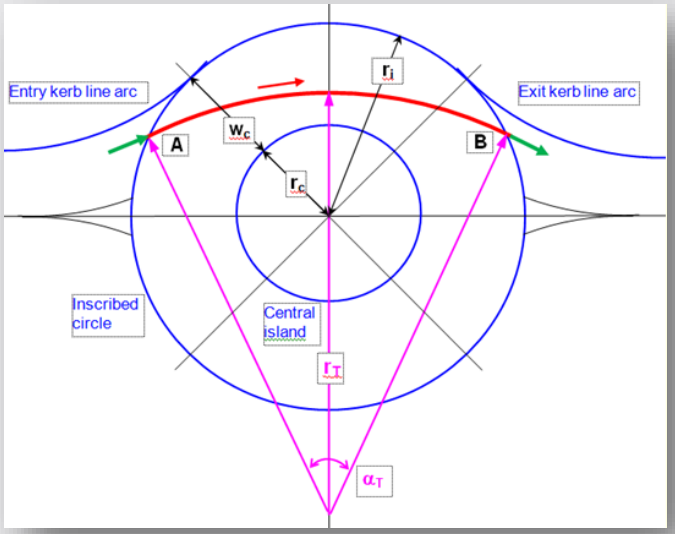
Roundabout model – LOW DEMAND

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



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Roundabout model – HIGH DEMAND

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

Roundabout Metering Signals

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

Metered Approach: McDonald St

Controlling Approach: Nepean Hwy SE

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.

www.sidrasolutions.com/Resources/Articles

Driving on the left-hand side of the road

Metering Signals research: 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

Automatic traffic counter for circulating traffic

Video

Video trailer

Manual turning volume counts

+ Floating car with GPS unit
+ Signal timings

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Metering Signals Research

The roundabouts covered by the VIC ROADS project are shown in following slides. For further information:

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.

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.

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

Controlling Approach:
Mickleham Rd North

Metered Approach:
Mickleham Rd South

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Boundary Road / Governor Road, PM Peak

Controlling approach: Boundary Rd South

Metered approach: Governor Rd

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Greensborough Bypass / Diamond Creek Rd, AM Peak

Controlling approach:
Diamond Creek Rd

Metered approach:
Civic Dve

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South Gippsland Hwy / Pound Rd, PM Peak

Controlling approach:
South Gippsland Hwy North

Metered approach:
South Gippsland Hwy South

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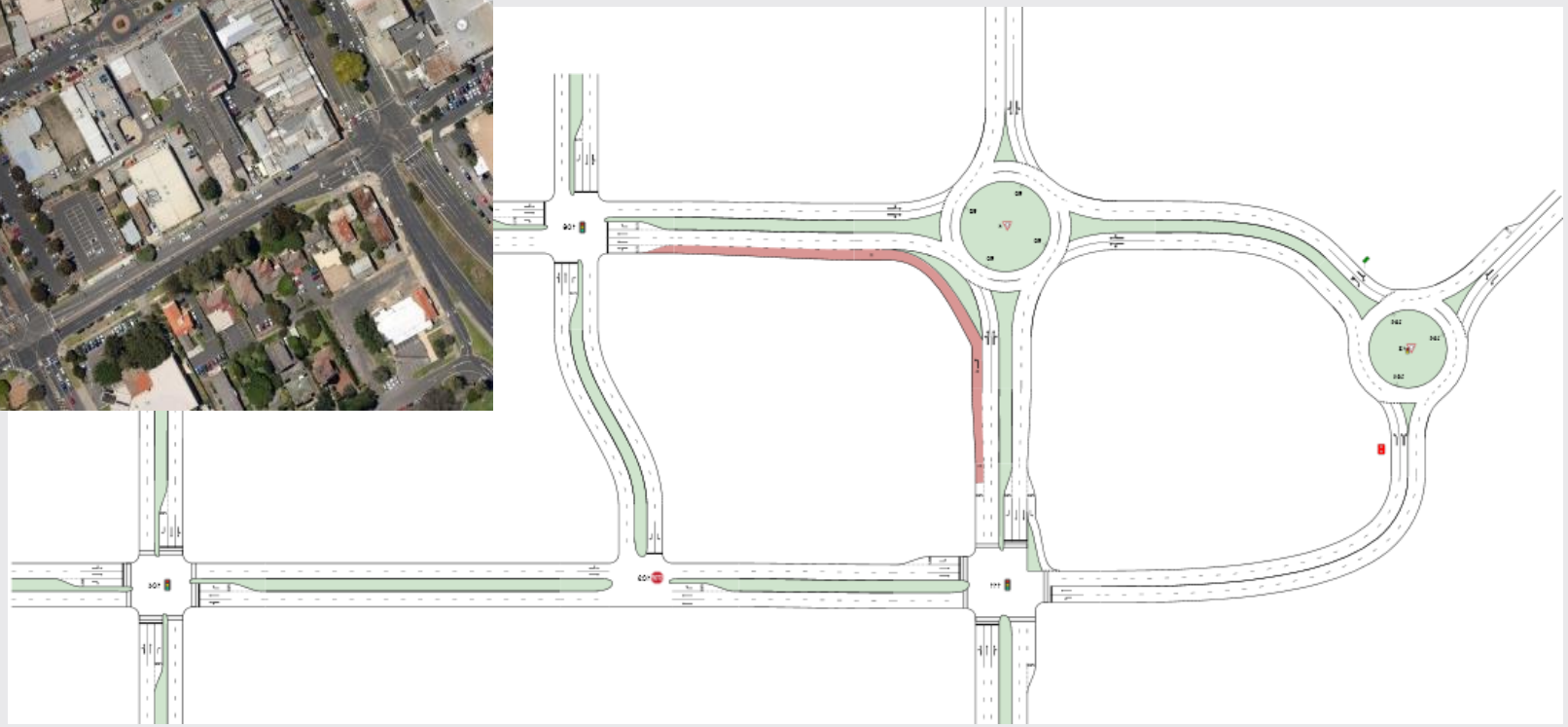
South Gippsland Hwy / Pound Rd

Conversion to signalised intersection

http://vicroads.vic.gov.au

SIDRA NETWORK Model includes roundabouts



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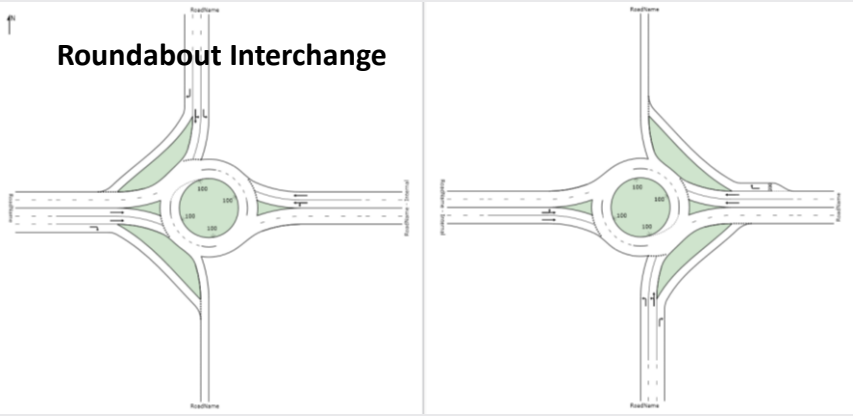
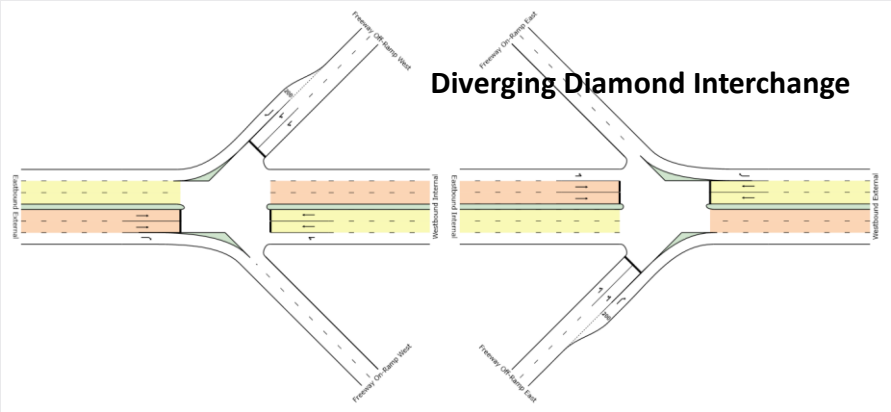
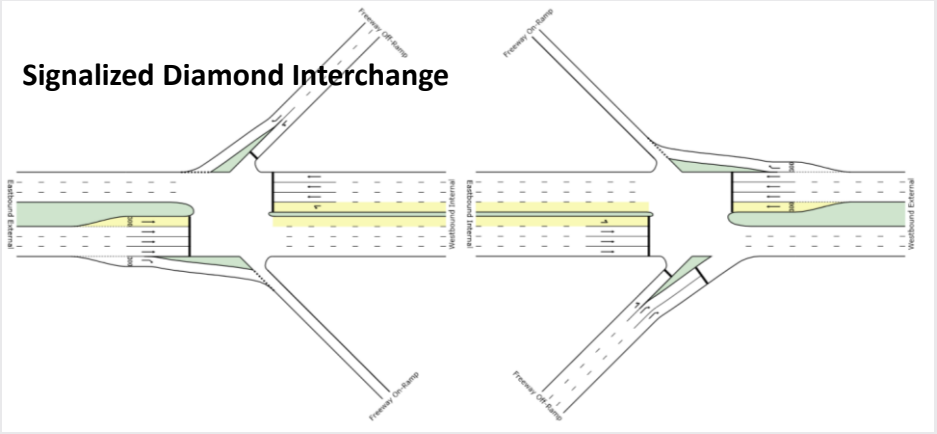
Network Example: Freeway Interchange Comparison







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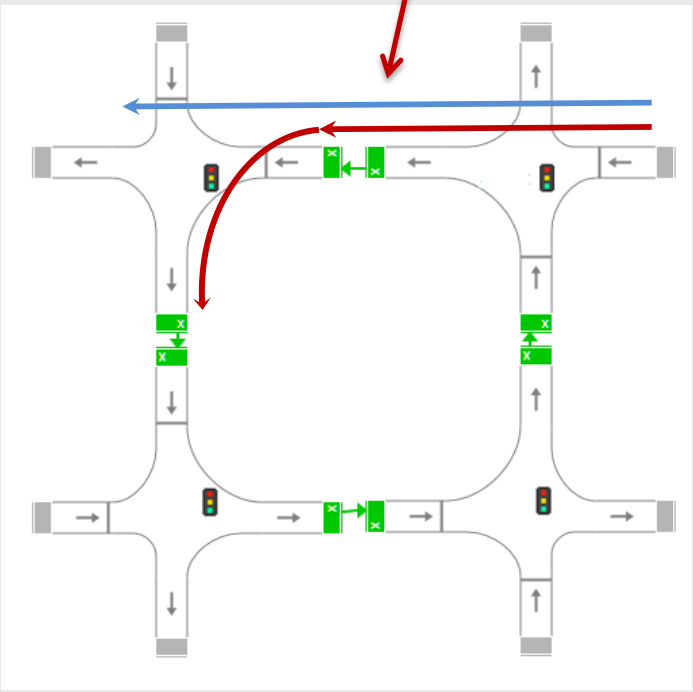
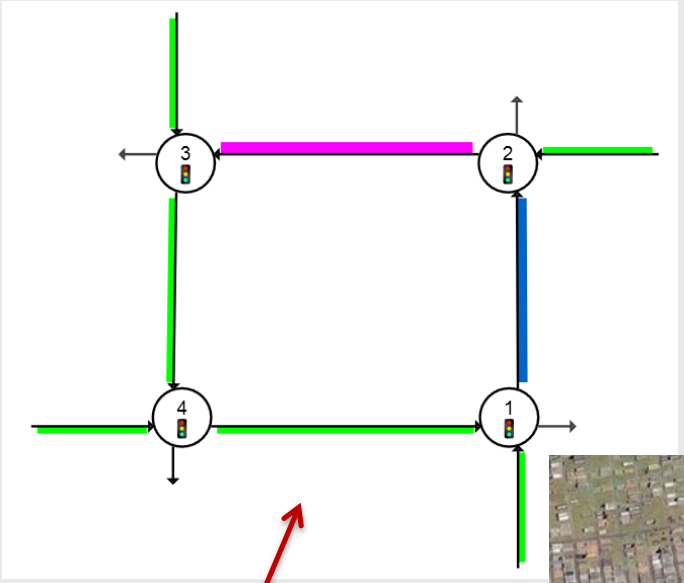
Network Example: Fully Signalised Roundabout

Lane allocation by SPECIAL MOVEMENT CLASSES for turning movements





Network Displays

Templates will be available

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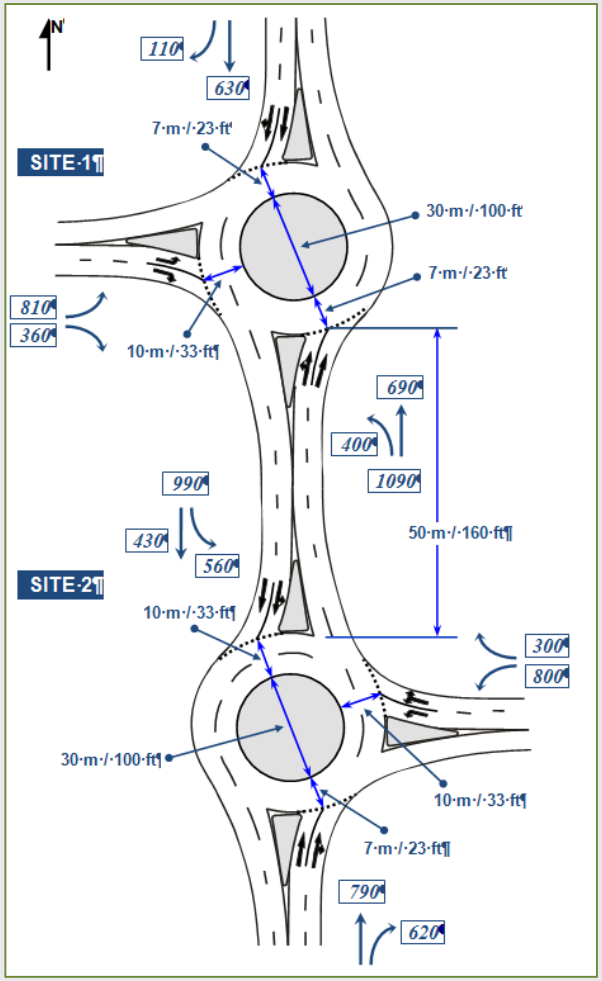
Network Example for Midblock Lane Changes: Staggered T Roundabouts

Paper presented at the Canadian ITE 2013 Annual Meeting: available on www.sidrasolutions.com/Resources/Articles



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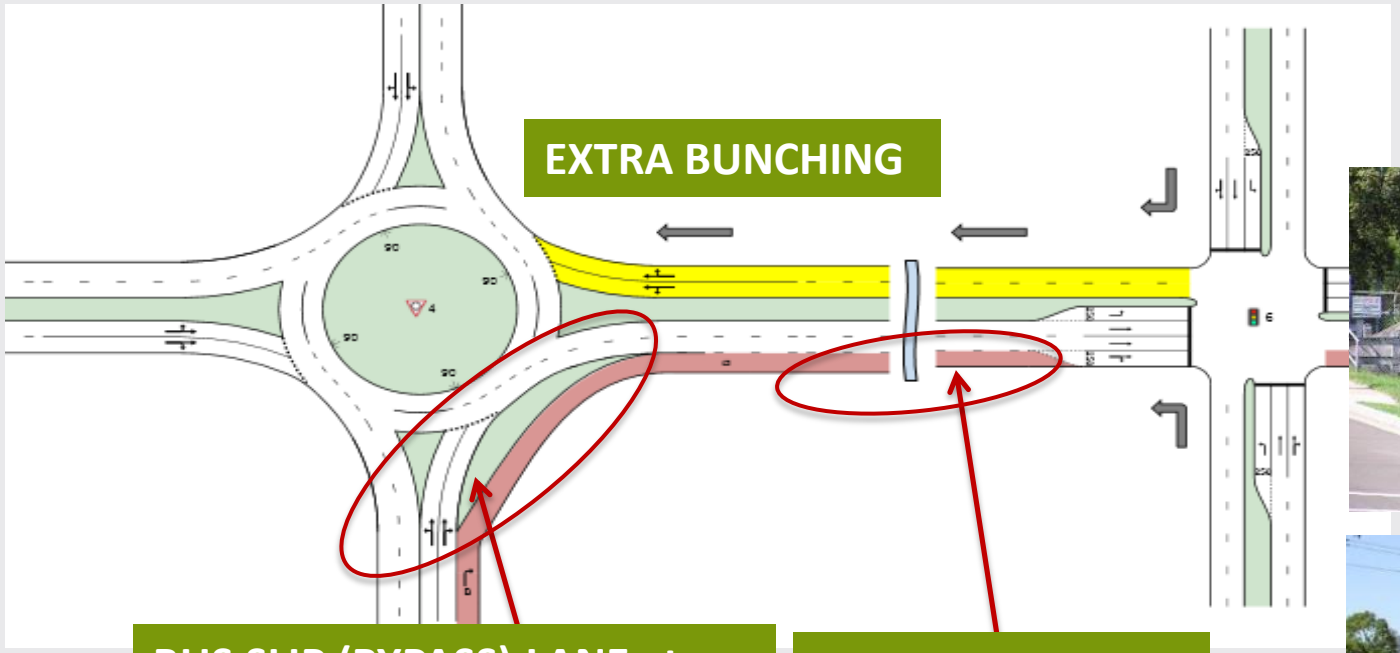
Network Example for EXTRA BUNCHING: Signals and Roundabout with Bus lane



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Extra Bunching model for roundabouts and sign controlled intersections

Extra Bunching can be specified as **INPUT** according to the distance to upstream signals and the amount of platooning.

In **Network analysis**, use the **PROGRAM** option for the program to determine the Extra Bunching value.

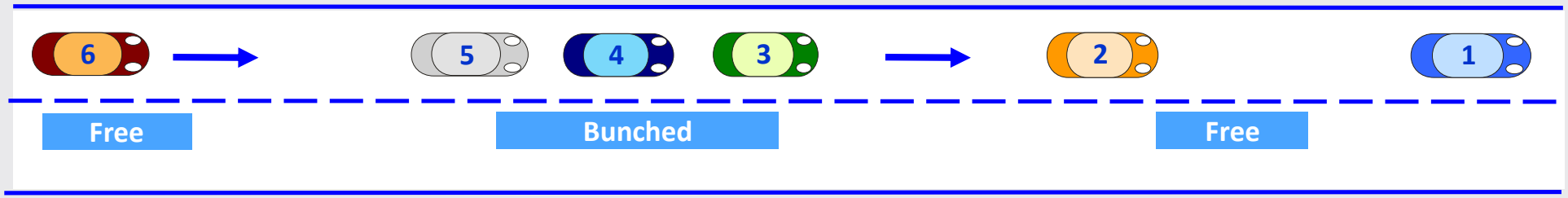
Individual vehicles

↓

Traffic flow

Bunched exponential distribution of headways (delay parameter)

Not in US Highway Capacity Manual or other analytical models …



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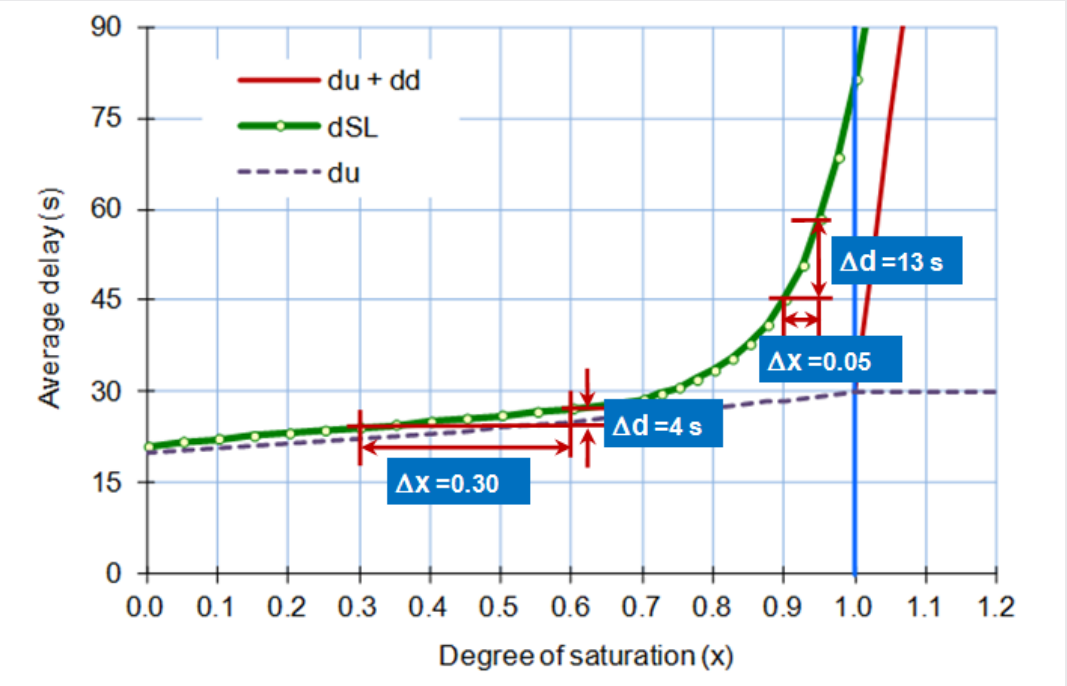
Fundamental Diagram of Intersection Performance

Two main components of delay / queue / stops:

- **Red / Blocked Time effects**
- **Congestion / Overflow effects**

Nonlinearity due to Congestion component



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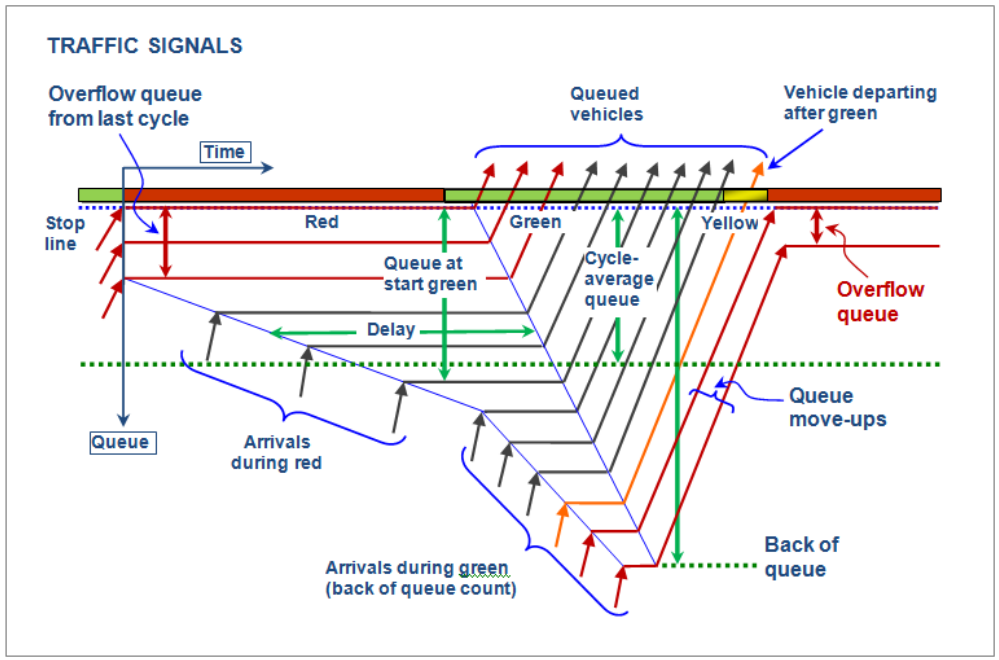
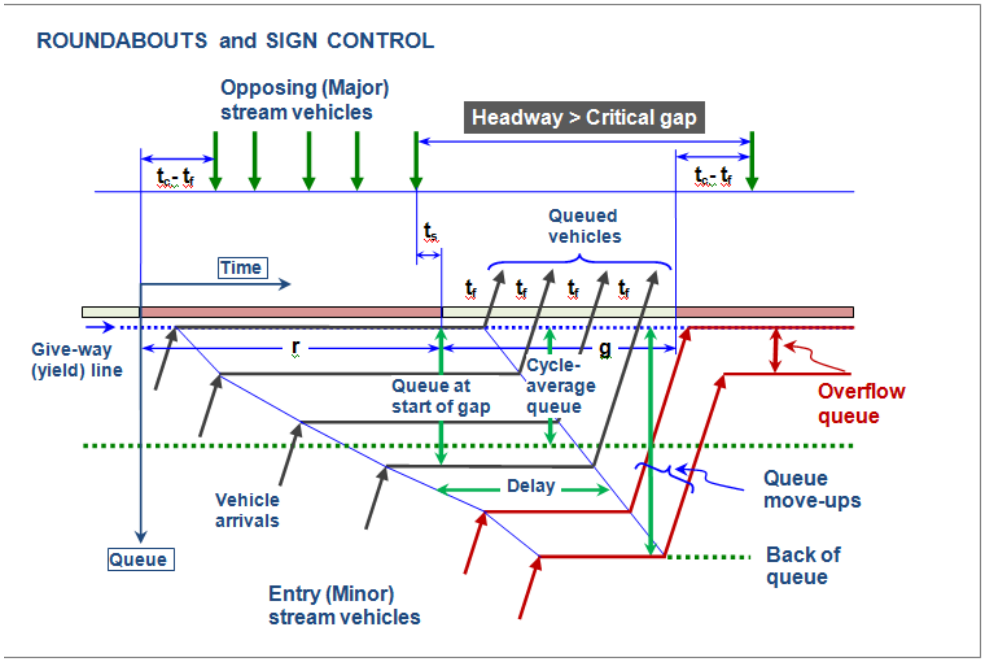
Overflow Queues in SIDRA INTERSECTION

Bulletin 4 ➡ ARR 123 ➡ SIDRA





Not in US Highway Capacity Manual or the UK TRL methodologies …

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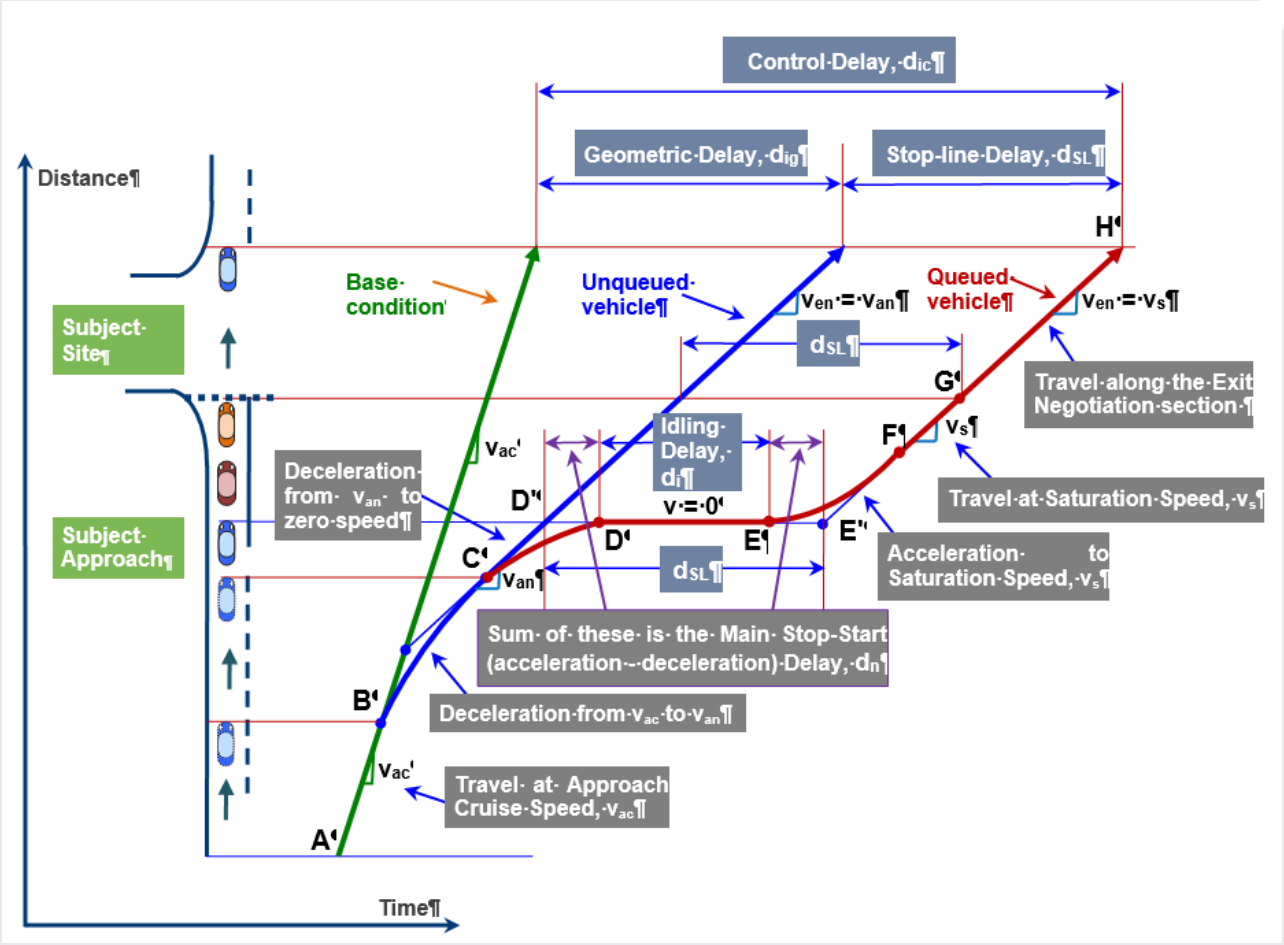
Consistency in Definitions of Performance Measures

Control Delay and Geometric Delay

All vehicles slow down to a safe negotiation speed at roundabouts. Geometric delay depends on approach and exit cruise speeds as well as the roundabout negotiation speeds, which depend on the geometric characteristics of the roundabout.

Not in US Highway Capacity Manual or the UK TRL methodologies …



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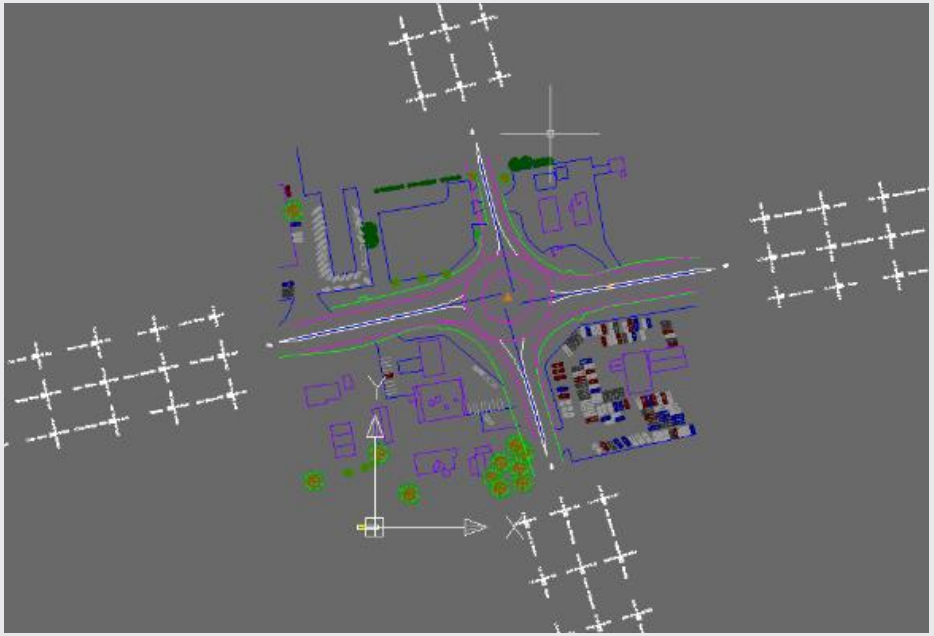
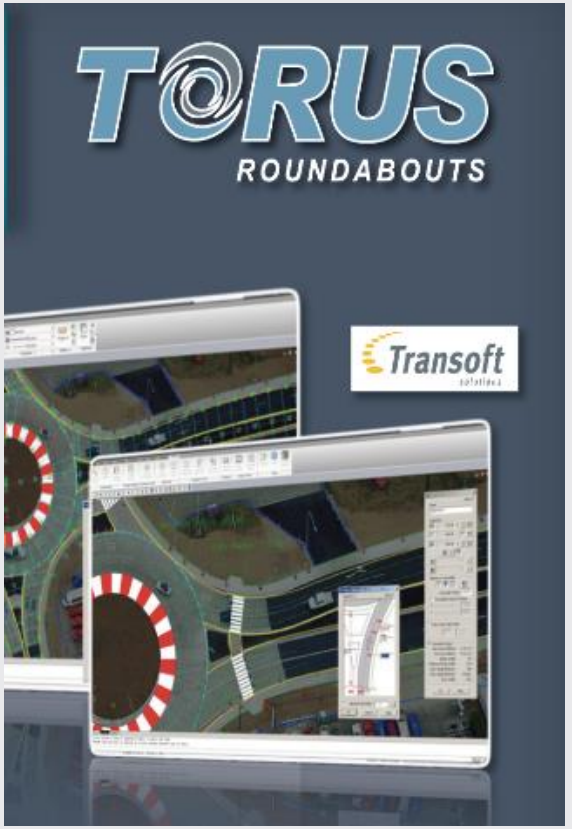
SIDRA INTERSECTION API

API link to the roundabout design software packages

TORUS





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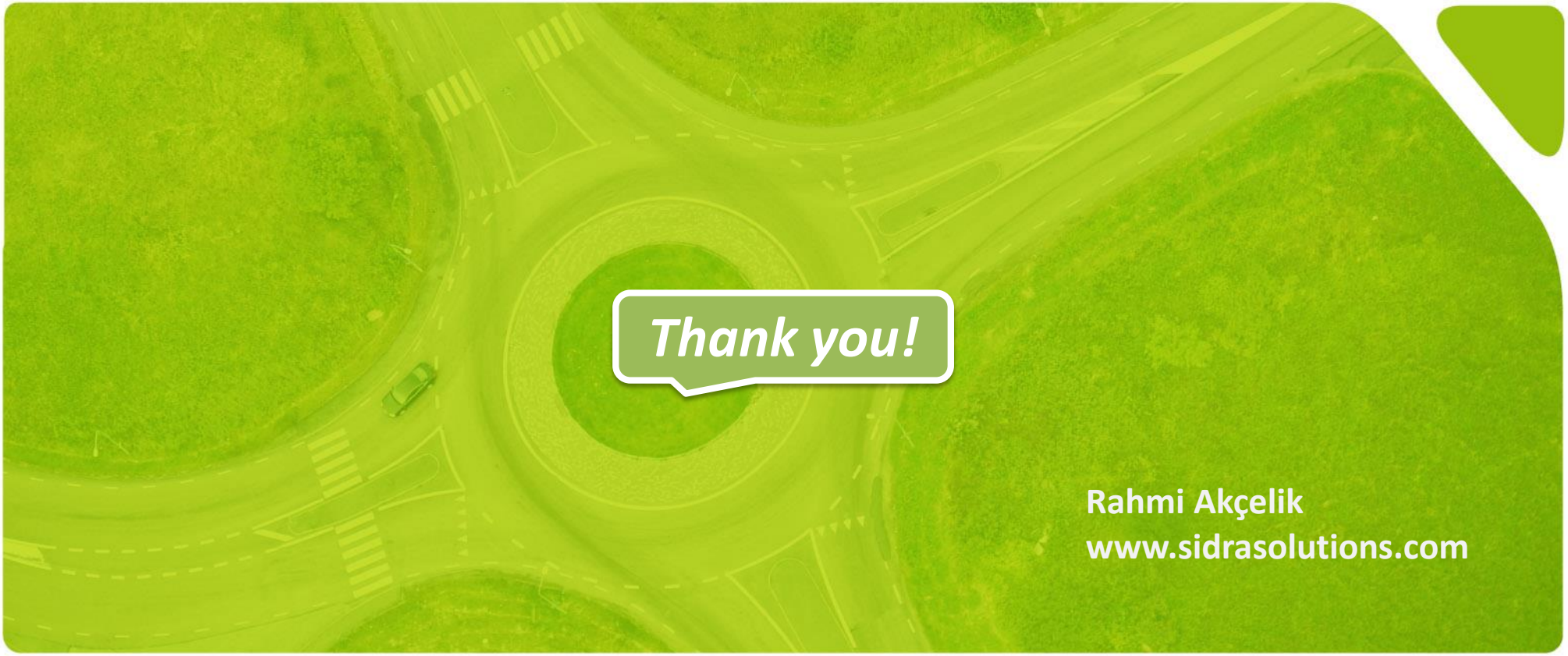
END OF PRESENTATION



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