Some common and differing aspects of alternative models for roundabout capacity and performance estimation

TRB International Roundabout Conference
Carmel, Indiana, USA, 18-20 May 2011
Presenter: Rahmi Akçelik

SIDRA SOLUTIONS

Disclaimer

The author is the developer of the SIDRA INTERSECTION model used in the study presented in this paper.

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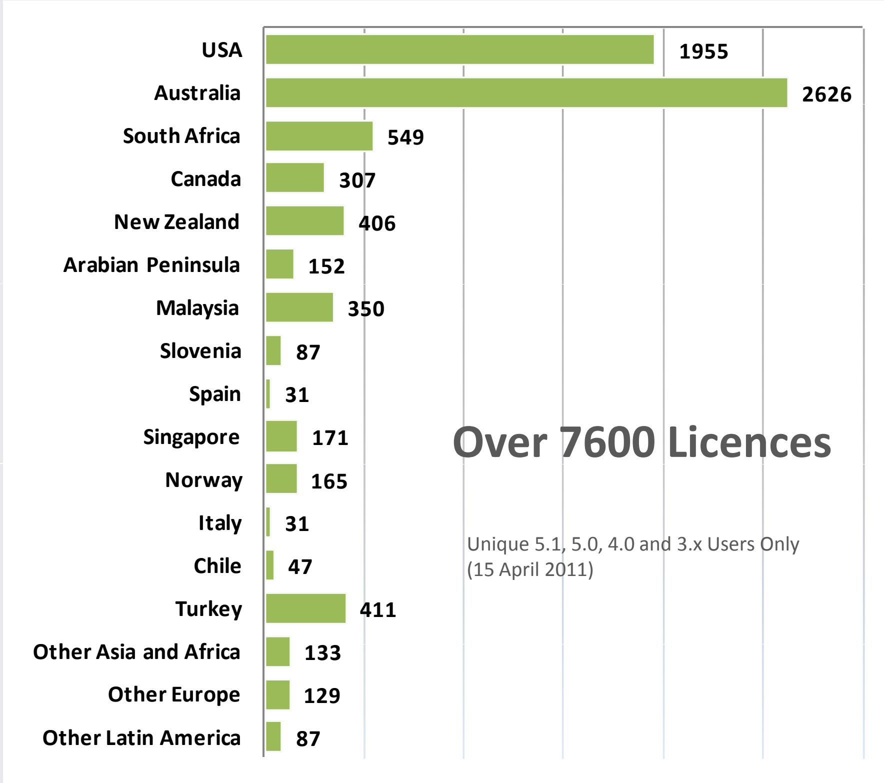
Disclaimer

First about SIDRA INTERSECTION ...

SIDRA INTERSECTION Software Status



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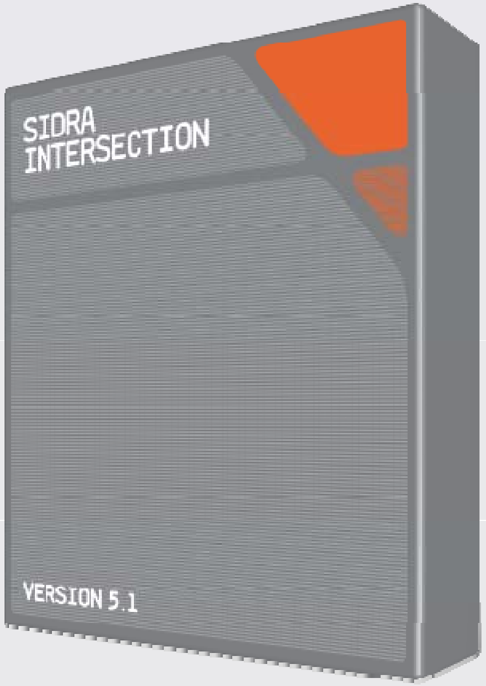
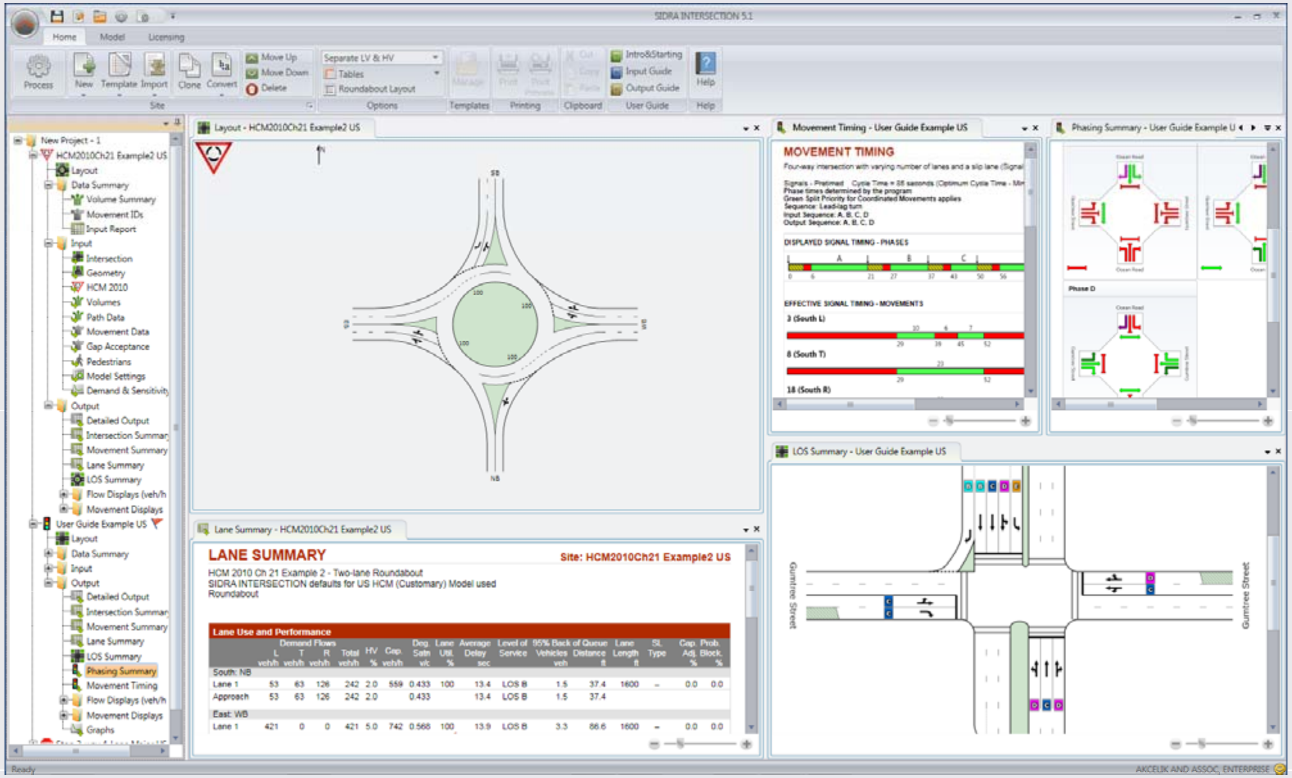
Recent developments



SIDRA INTERSECTION 5.1 released a month ago



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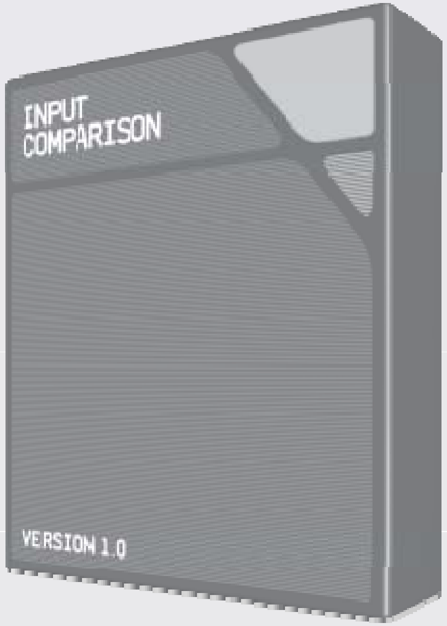
SIDRA UTILITIES & API



new ...

INPUT COMPARISON program for **data auditing**

SIDRA UTILITIES (programs and Excel applications):

- **VOLUMES** and **ANNUAL SUMS** Excel Applications
- **OUTPUT COMPARISON**
- **VARIABLE RUN**
- **INPUT COMPARISON**

Application Programming Interface (API)

- Enables interfacing other programs to SIDRA INTERSECTION

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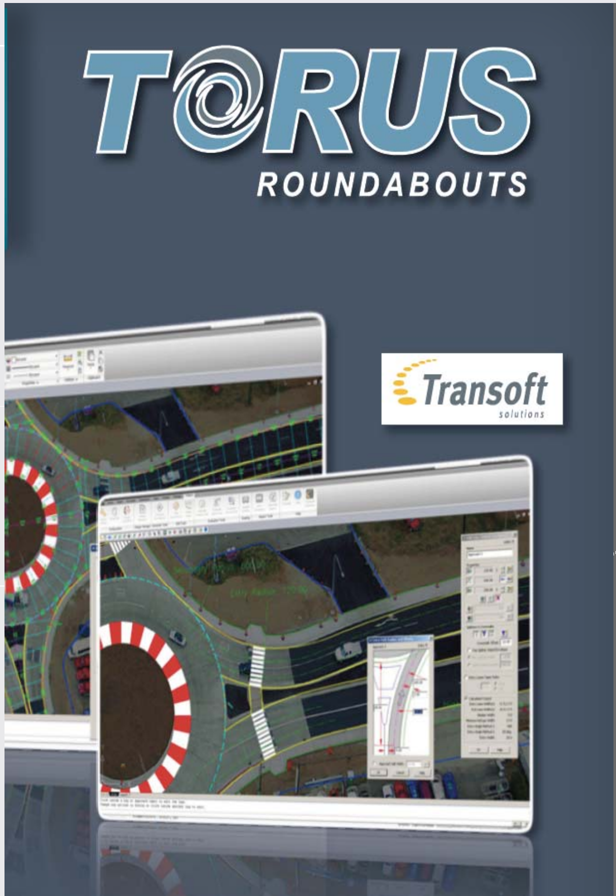
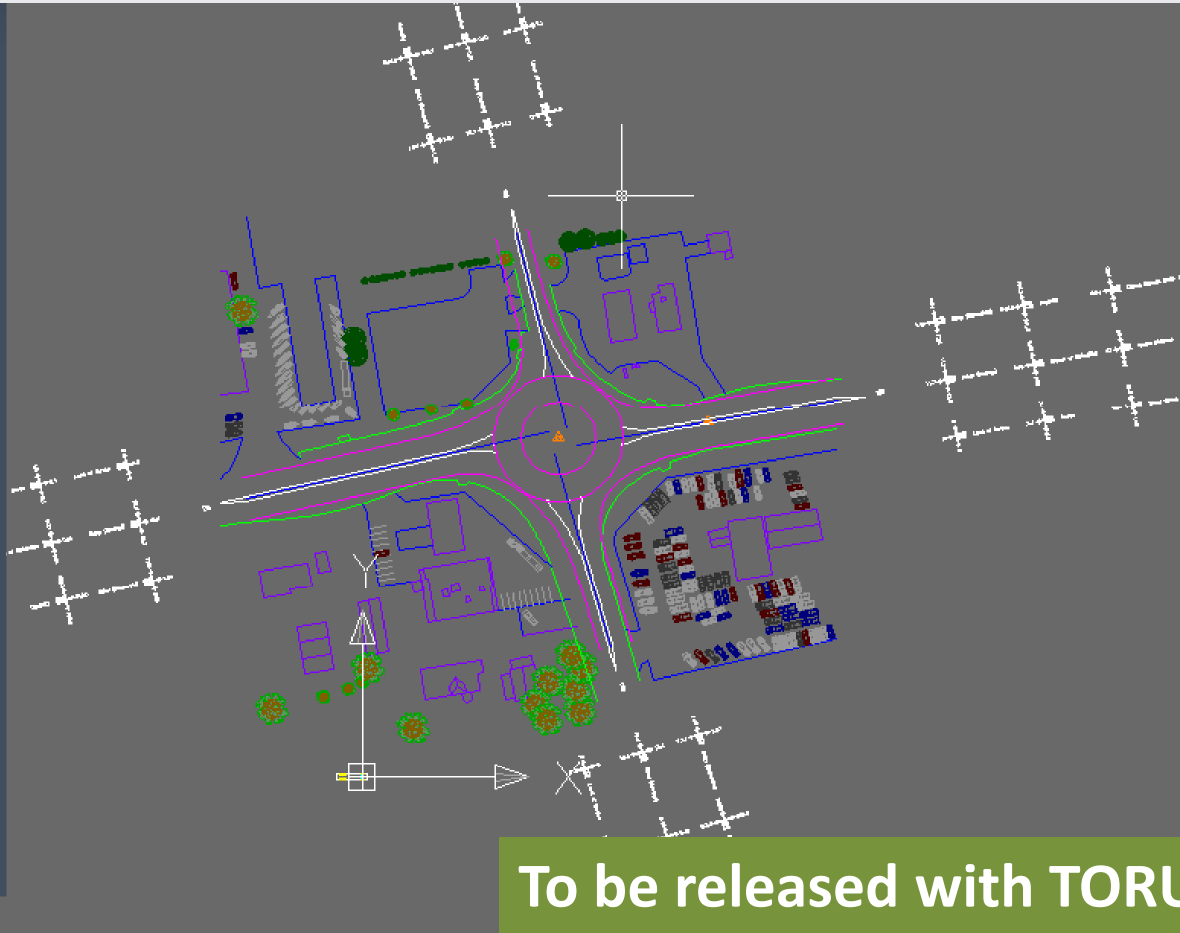
Interlinking with major software packages

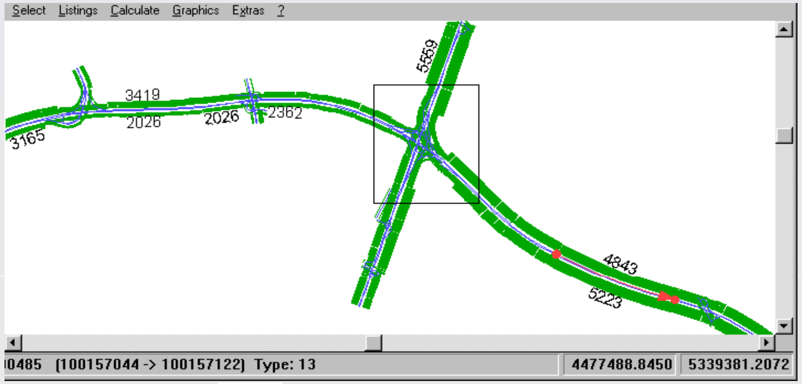




To be released with TORUS 3

Interlinking with major software packages

VISUM



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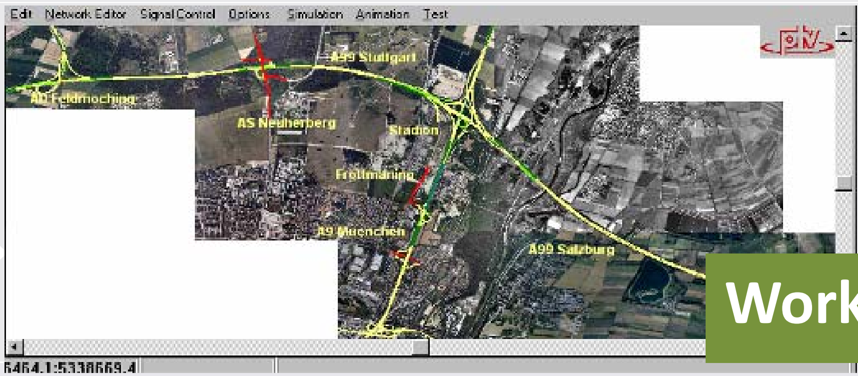
ptv vision

ptv traffic mobility logistics.

VISSIM

ANM



Work in progress

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MODELING: Roundabout Metering Signals

Red and yellow aspects

Unbalanced flow conditions

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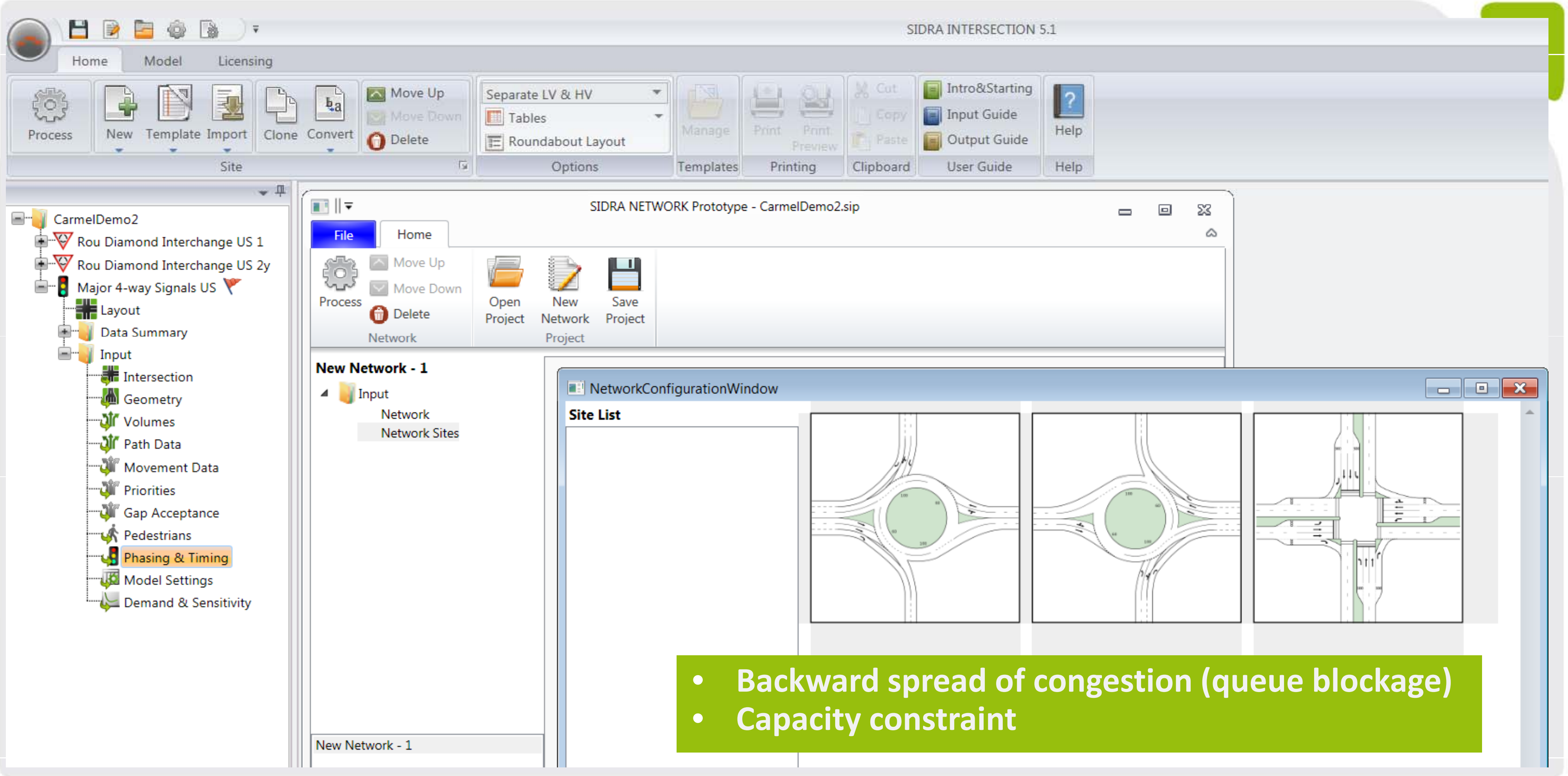
SIDRA NETWORK >> SIDRA INTERSECTION 6.0



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

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Roundabout capacity models

The aim of the paper is to enhance understanding of the fundamental aspects of different roundabout capacity models available around the world.

Three well-known analytical models of roundabout capacity are considered:

- 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.

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Roundabout capacity models

- A detailed table comparing the features of the three capacity models presented.
- The UK TRL and SIDRA Standard models compared in relation to several geometric parameters (entry radius, entry angle, inscribed diameter and flaring).
- A multi-lane roundabout example used for detailed comparison of estimates of capacity and degree of saturation (v/c ratio) produced by these.

Also refer to: AKÇELIK, R. (2010). An Assessment of the Highway Capacity Manual 2010 Roundabout Capacity Model. Paper presented at the TRB International Roundabout Conference, Carmel, Indiana, USA, 2011.

No model is perfect ...

There is no more common error than to assume that, because prolonged and accurate mathematical calculations have been made, the application of the result to some fact of nature is absolutely certain.

Alfred N. Whitehead (1861-1947), English mathematician and philosopher
(In: M.J. Moroney, Facts from Statistics, Penguin Books, 1951, p. 271)

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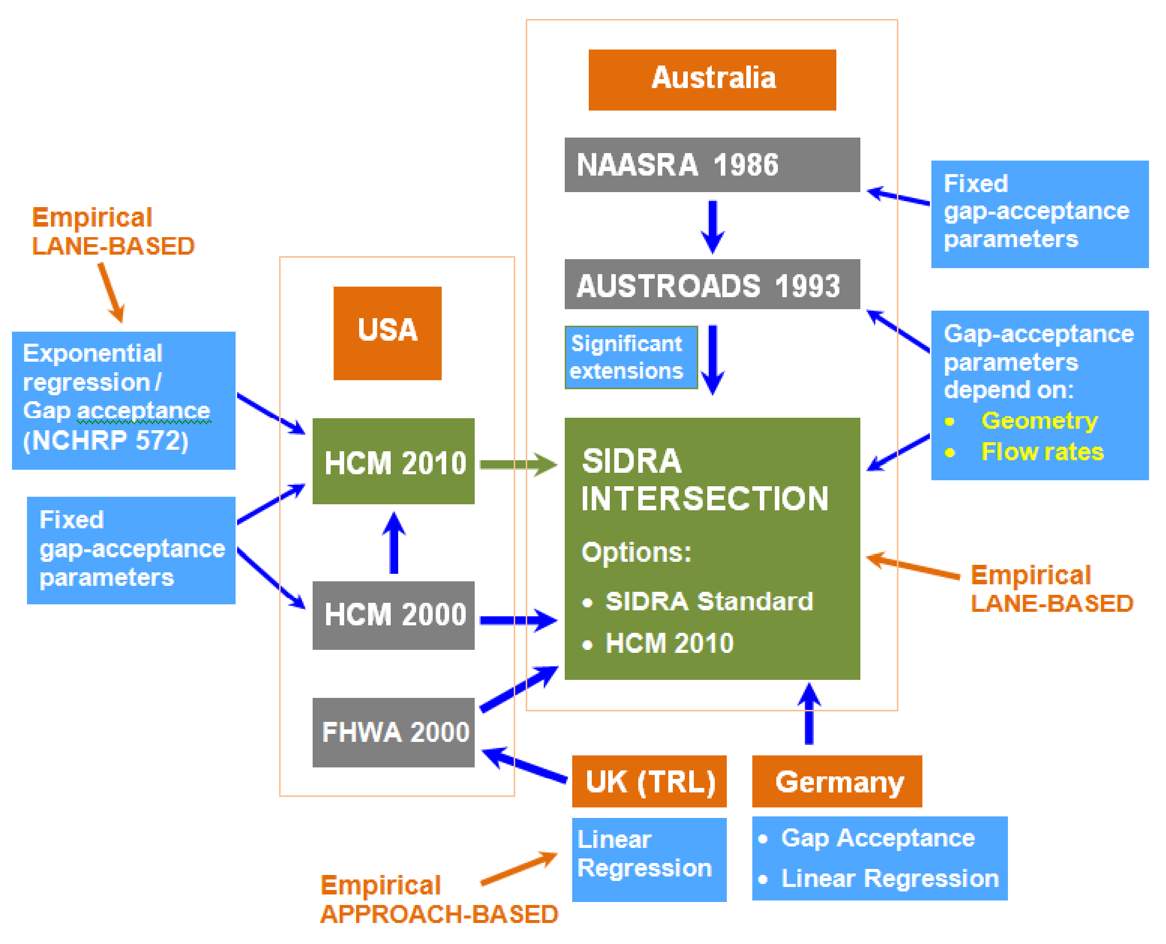
Roundabout capacity models in SIDRA INTERSECTION



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Capacity of roundabouts: SIMPLE !

- Roundabout is an intersection
- Intersection is an interrupted facility
- Interruption means time loss due some form of control: YIELD at roundabout
- Thus, capacity, Q (veh/h):

$$Q = s\ u$$

s = saturation (queue discharge) flow rate (veh/h)
u = proportion of time when the vehicles can depart from the queue (signals are green or gaps are available in the opposing stream).

Capacity of roundabouts

Saturation flow rate (s) is the maximum flow rate that can be sustained when there is a queue and the vehicles can depart from the queue, i.e. signals are not red or the gaps in the opposing stream are not too short.

In gap-acceptance methodology, the **follow-up headway, t_f** corresponds to a saturation flow rate which is the maximum gap-acceptance capacity that can be achieved when the opposing flow is close to zero (**y intercept**):

$$s = 3600 / t_f$$

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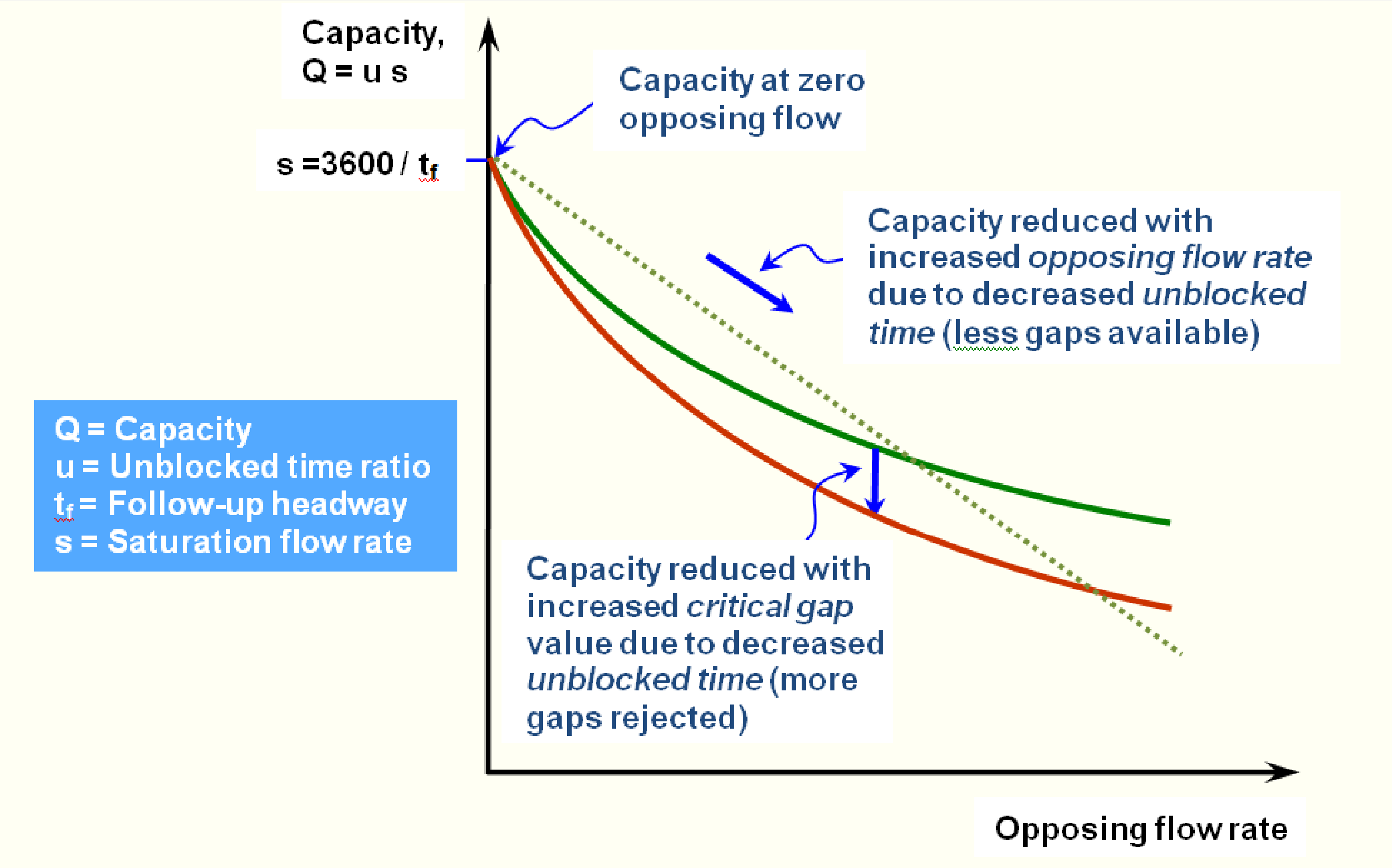
Roundabout capacity



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Comparison of main model features

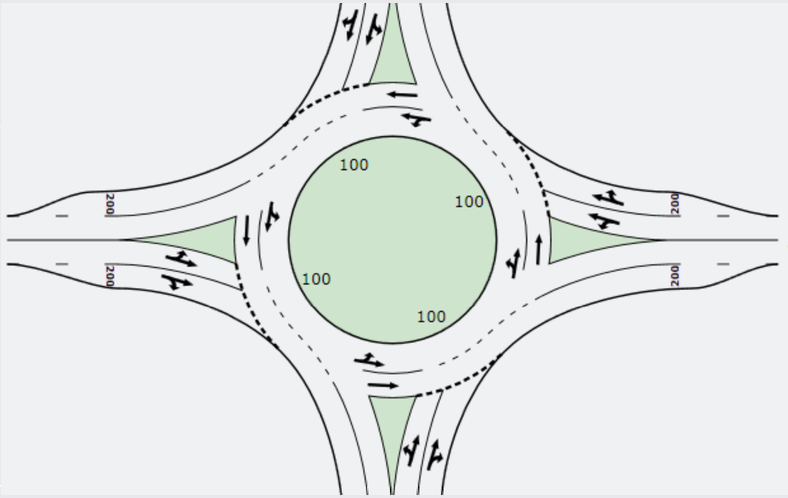
Categories of features compared

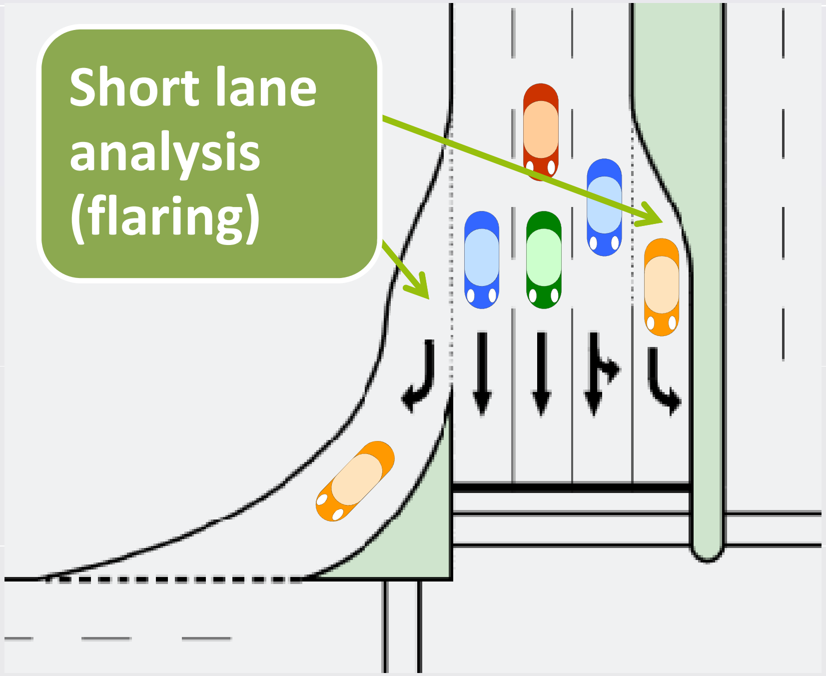
(refer to the detailed table given in the paper)

- Methodology (lane-based / approach-based)
- Individual Entry and Circulating Lanes
- Lane Utilization for Multilane Approaches
- Volume / Capacity Ratio (critical lane or approach)
- Unbalanced Flows (Origin-Destination flow patterns)
- Driver Behavior Parameters
- Roundabout Geometry Parameters
- Heavy Vehicles
- Model Calibration

These cannot be modeled using an approach-based method

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





Effectiveness of flaring (short lanes) depends on flow conditions

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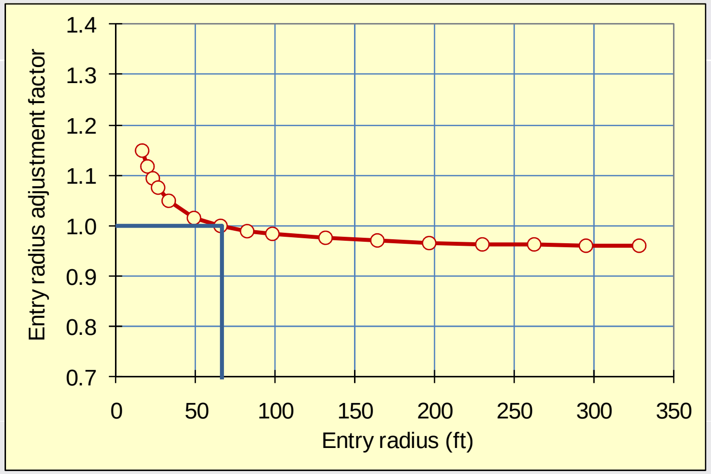
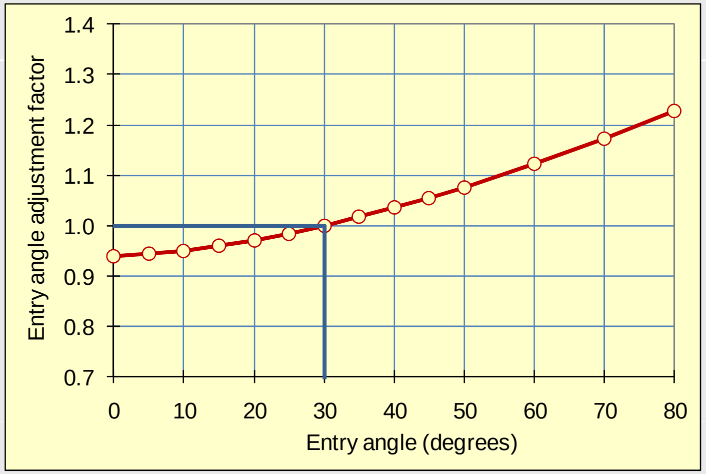
Entry Radius and Entry Angle in *SIDRA Standard* model





$f_r = 0.95 + 1 / r_e$

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

r_e is the entry radius (m)

ϕ_e is the entry angle (degrees)

Customary units:

$f_r = 0.95 + 3.28 / r_e$

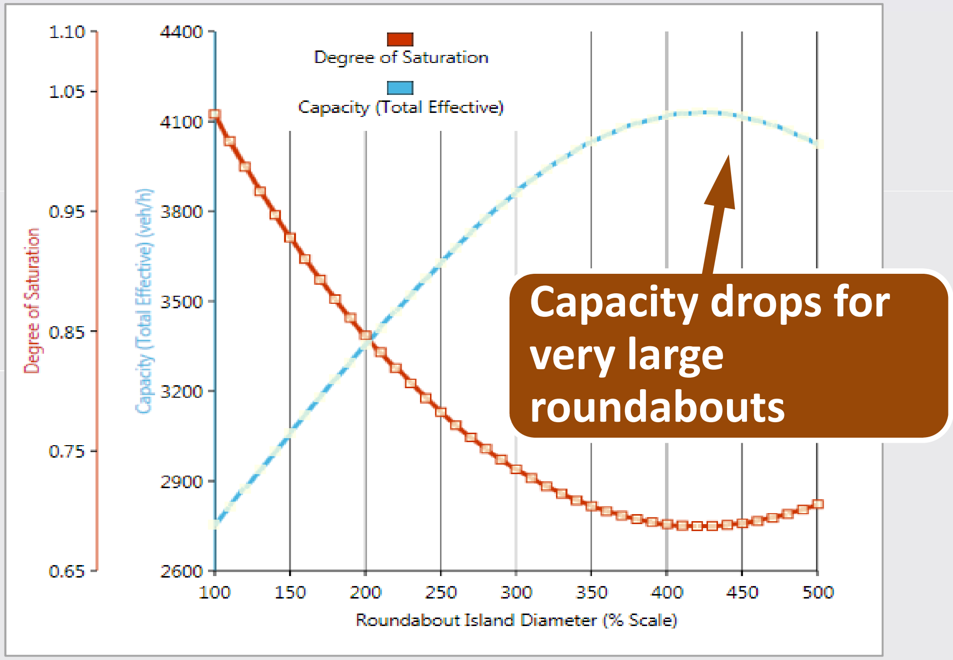
r_e is the entry radius (ft)

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

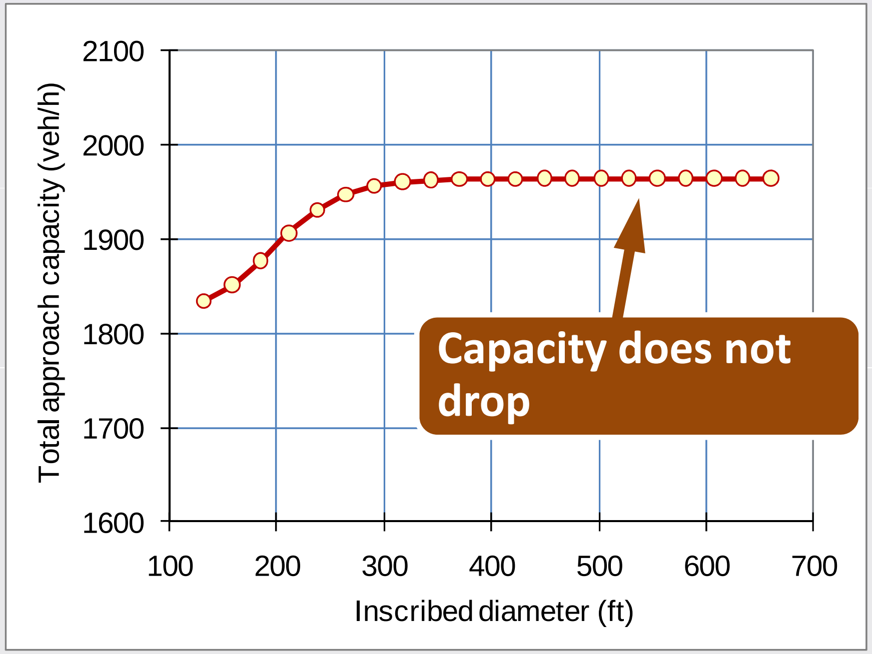
r_e (m)	r_e (ft)	ϕ_e (degrees)	*UK TRL*	*SIDRA Standard*
5	16	70	1.40	1.35
10	33	60	1.18	1.18
20	66	45	1.05	1.05
30	98	35	1.00	1.00
40	131	**30**	0.98	0.98
60	197	15	0.92	0.93
80	262	5	0.89	0.91
100	328	0	0.87	0.90

Roundabout Size: Inscribed Diameter

SIDRA Standard model



UK TRL model (RODEL, ARCADY)



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Model calibration issue with the TRL model

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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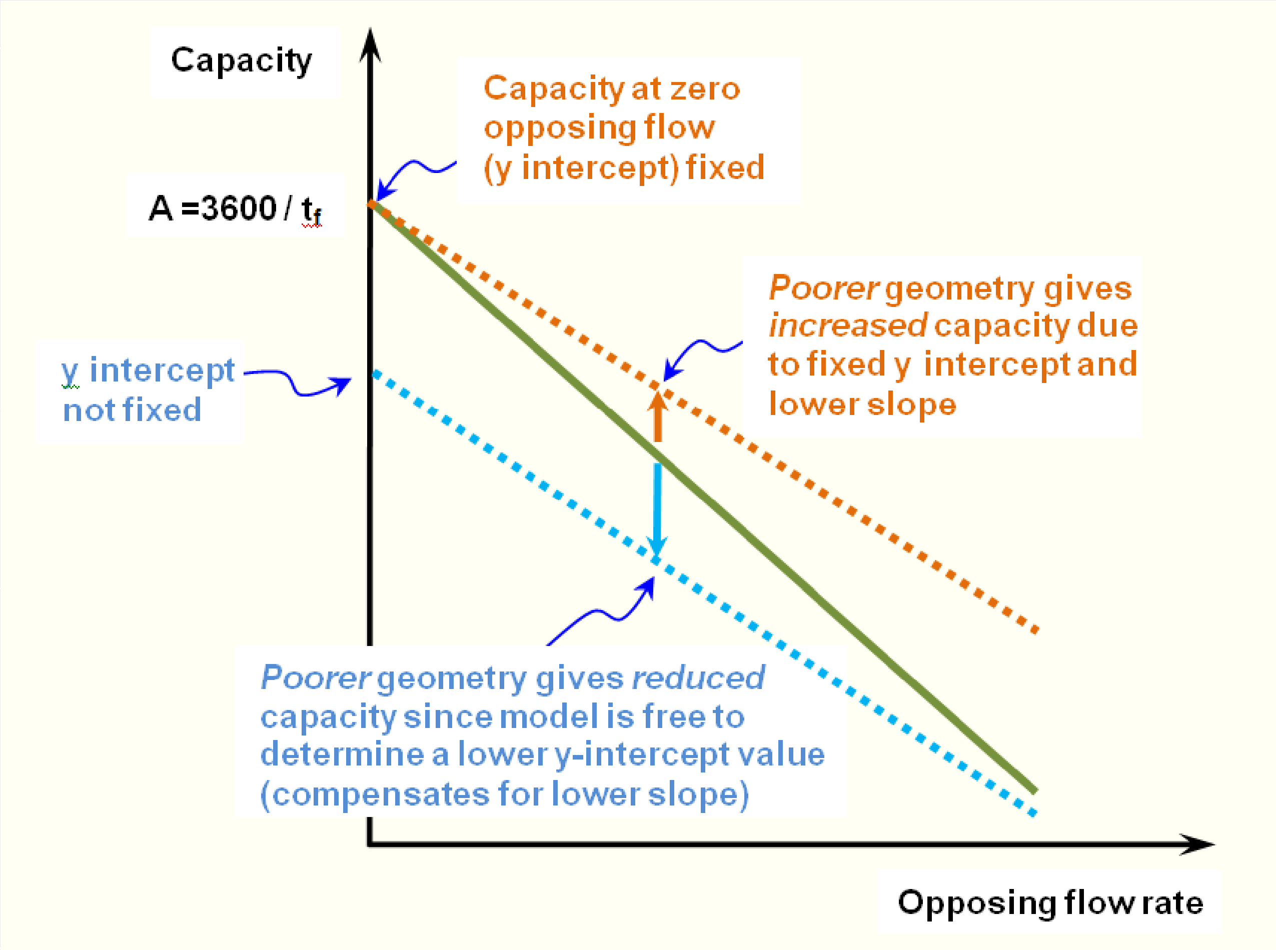
Problematic nature of the UK TRL model when the y intercept is fixed for calibration purposes



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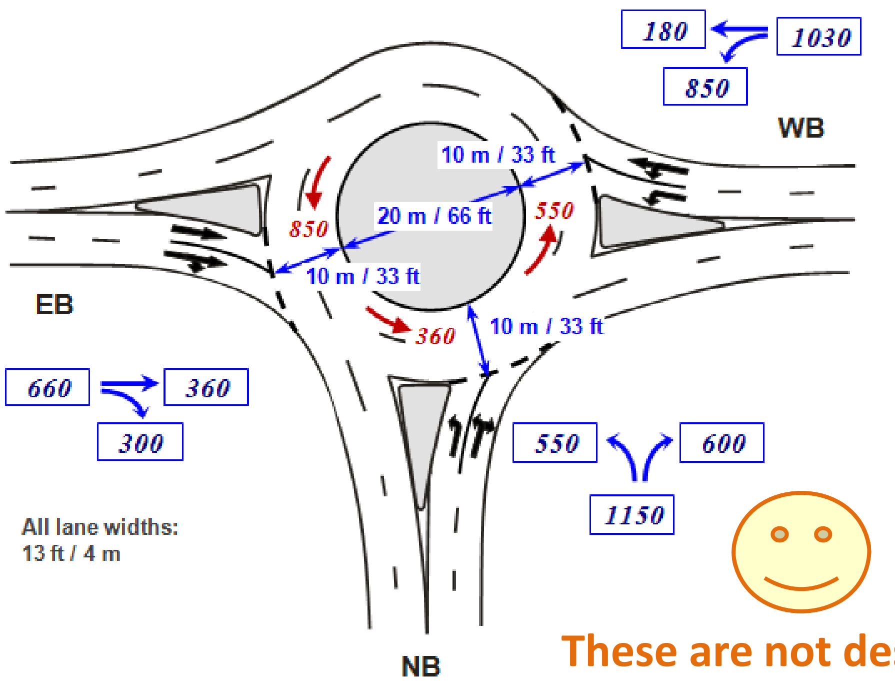
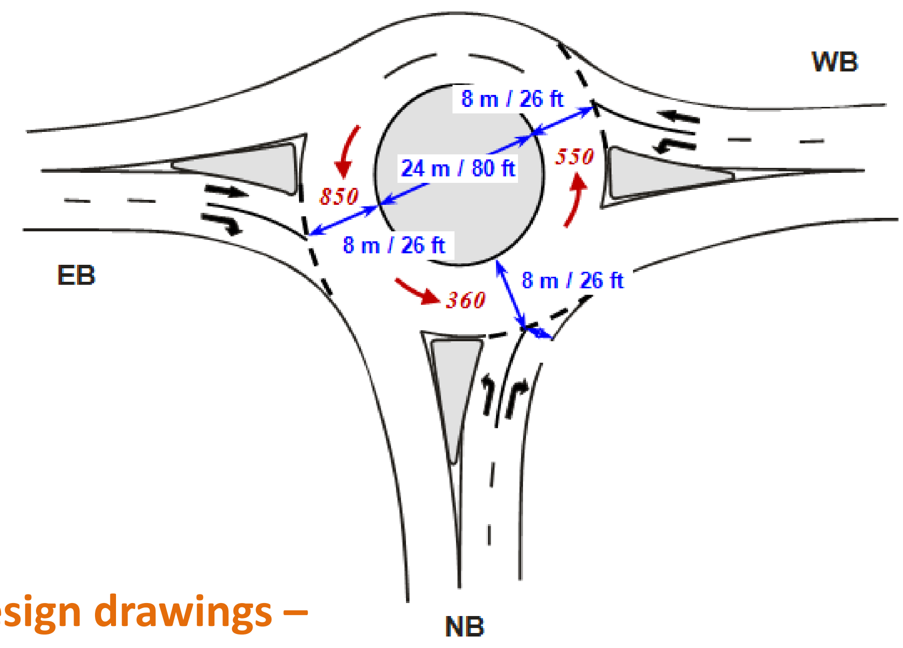
Example to test different lane configurations

Two-lane circulating road and shared approach lanes

Single-lane circulating road and exclusive approach lanes





These are not design drawings –
no path overlap analysis, etc please !

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Capacity models used

- HCM 2010 >> SIDRA INTERSECTION 5.1
- SIDRA Standard for US* >> SIDRA INTERSECTION 5.1
- TRL (linear regression) ** >> Excel application.

* Environment Factor = 1.2

** Capacity at zero circulating flow (y intercept) = 0

Example to test different lane configurations

Approach	Total Approach Flow (veh/h)	Circulating Flow (pcu/h)	Critical Lane	Critical Lane Flow (veh/h)	Critical Lane Capacity (veh/h)	Degree of saturation (v/c ratio)
Case (i): Two-lane circulating road and shared approach lanes						
HCM 2010 Capacity Model						
NB (South)	1150	360	2 (R) *[1]*	600 *[1]*	878	0.68
WB (East)	1030	550	2 (LT)	522	769	0.68
EB (West)	660	**850**	2 (TR)	337	623	0.54
SIDRA Standard Capacity Model (Environment Factor = 1.2)						
NB (South)	1150	360	2 (R) *[1]*	600 *[1]*	887	0.68
WB (East)	1030	550	2 (LT)	515	719	0.72
EB (West)	660	**850**	2 (TR)	330	604	0.55
UK TRL Model (Capacity at Zero Circulating Flow = 1130)						
NB (South)	1150	360	Average	575	991	0.58
WB (East)	1030	550	Average	515	917	0.56
EB (West)	660	**850**	Average	330	801	0.41

Example to test different lane configurations

Approach	Total Approach Flow (veh/h)	Circulating Flow (pcu/h)	Critical Lane	Critical Lane Flow (veh/h)	Critical Lane Capacity (veh/h)	Degree of saturation (v/c ratio)
Case (ii): Single-lane circulating road and exclusive approach lanes						
HCM 2010 Capacity Model						
NB (South)	1150	360	2 (R)	600	788	0.76
WB (East)	1030	550	1 (L)	**850**	**652**	**1.30**
EB (West)	660	**652** *[2]*	1 (T)	360	589	0.61
SIDRA Standard Capacity Model (Environment Factor = 1.2)						
NB (South)	1150	360	2 (R)	600	987	0.61
WB (East)	1030	550	1 (L)	**850**	**824**	**1.03**
EB (West)	660	**824** *[2]*	1 (T)	360	539	0.67
UK TRL Model (Capacity at Zero Circulating Flow = 1130)						
NB (South)	1150	360	Average	575	991	0.58
WB (East)	1030	550	Average	**515**	**917**	**0.56**
EB (West)	660	**850**	Average	330	801	0.41

No change !

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Importance of LANE-BY-LANE model

Problem originally identified by Barbara Chard (UK)

Refer to:

CHARD, B. (1997). **ARCADY Health Warning: Account for unequal lane usage or risk damaging the Public Purse!** Traffic Eng. and Control, 38 (3), pp 122-132.

Also:

AKÇELIK, R. (1997). **Lane-by-lane modelling of unequal lane use and flares at roundabouts and signalised intersections: the SIDRA solution.** Traffic Engineering and Control, 38 (7/8), pp 388-399.

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Recommended investigation: microsimulation model challenge

Analyse this example using microsimulation:

- **Identify the difference between cases i and ii using microsimulation.**
- **Analyse this example further for varying geometry parameters:**

Entry lane width	Central island diameter	Circulating road width 1-lane	Inscribed diameter (1-lane circulating)	Circulating road width 2-lane	Inscribed diameter (2-lane circulating)	Entry radius	Entry angle
Default values							
13 ft (4.0 m)	100 ft (30 m)	25 ft (7.5 m)	150 ft (45 m)	30 ft (9 m)	160 ft (48 m)	65 ft (20 m)	30^o
Less favorable values							
12.5 ft (3.8 m)	80 ft (25 m)	21 ft (6.5 m)	122 ft (38 m)	26 ft (8 m)	132 ft (41 m)	50 ft (15 m)	40^o
More favorable values							
14 ft (4.3 m)	120 ft (36 m)	28 ft (8.5 m)	176 ft (53 m)	33 ft (10 m)	186 ft (56 m)	100 ft (30 m)	20^o

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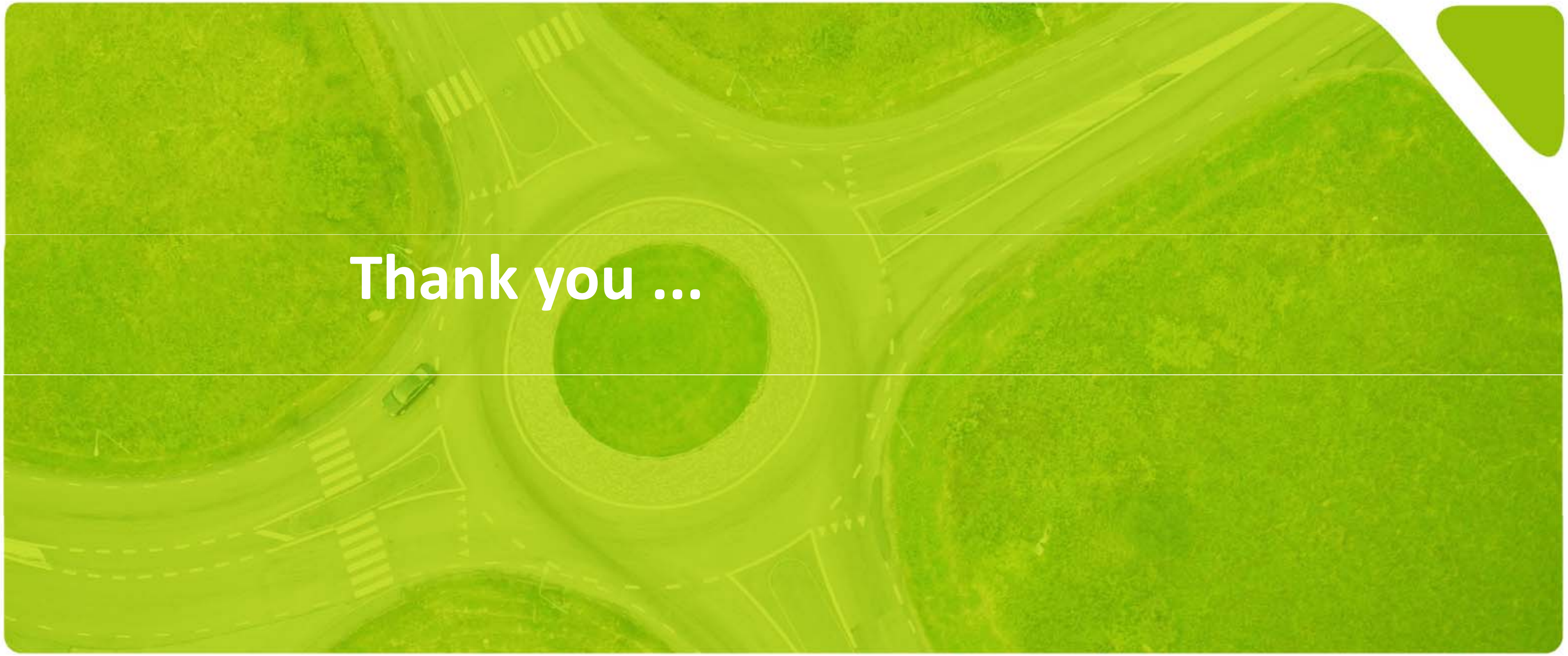
END OF PRESENTATION



Thank you ...

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