

**TRB 6th International Conference on Roundabouts
Monterey, California, USA, 15-18 May 22**

**HCM 6 Extended Roundabout Capacity Model
in SIDRA INTERSECTION**

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Acknowledgement

Akcelik & Associates would like to thank **Vicki S. Haskell, WisDOT Bureau of Traffic Operations** for raising the question regarding application of **HCM roundabout capacity model calibration** using the parameters from the **Wisconsin study** which led to the development described in this presentation.



Photo: *nearmap*

About this presentation

The **HCM Edition 6 Extended roundabout capacity model** application in SIDRA INTERSECTION 9.1 was developed using the results of roundabout surveys carried out for **Wisconsin DOT** in the USA (**Campbell, Olsson and Sternke, 2021**).

The following ITE Journal article provides information about the study relevant to this presentation:
<http://www.sidrasolutions.com/Resources/Articles>

CAMPBELL, J.R., OLSSON, S.M and STERNKE, C.R. (2021). Using Vehicle Tracking Software to Validate Roundabout Capacity Models. ITE Journal 91 (12), pp 43-49.

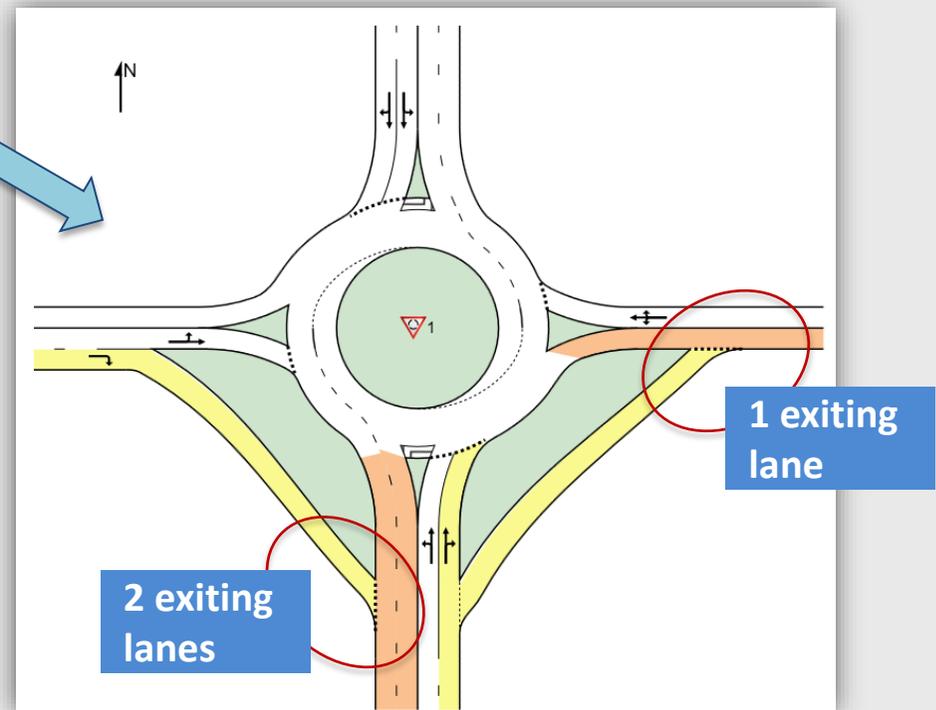
Presentation Content

- ❖ **HCM Edition 6 Extended (“HCM 6x”)** roundabout capacity model
- ❖ **HCM Edition 6 (“HCM 6”)** default capacity model parameters: also applicable to the **HCM6x** model
- ❖ Parameters from the **Wisconsin study**
- ❖ Some aspects of implementation in **SIDRA INTERSECTION 9.1**
- ❖ Results for **HCM Roundabout examples with default parameters and Wisconsin parameters**

HCM Edition 6 Extended roundabout capacity model

The HCM 6 Extended roundabout capacity model provides the ability to specify more detailed parameter values that **distinguish different lane configurations**.

In particular, this has an advantage over the HCM 6 model in providing the ability to calibrate **SLIP/BYPASS LANE capacities independently of entry lane capacities**.



HCM Edition 6 roundabout capacity model

The HCM Edition 6 roundabout capacity model is an **exponential model**.

The model is unchanged in HCM Edition 7:

$$Q_e = A \exp(-B q_c)$$

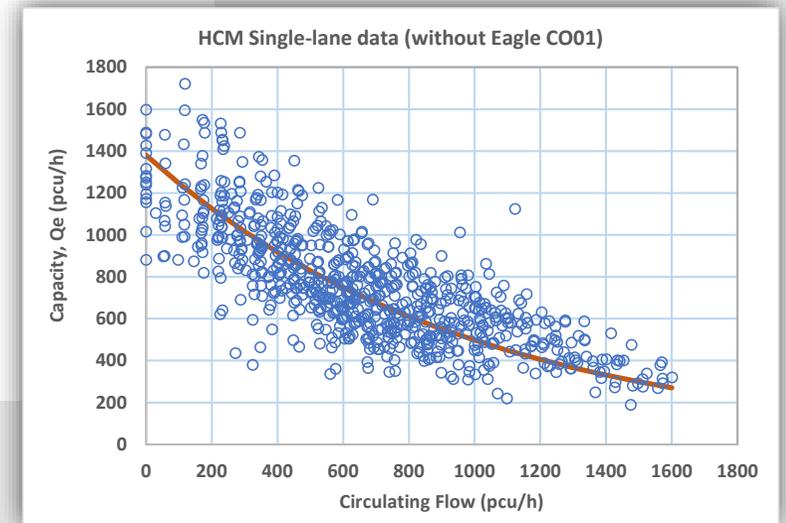
$$A = 3600 / t_f$$

$$B = t_o / 3600 = (t_c - 0.5 t_f) / 3600$$

Q_e : capacity (veh/h), q_c : Circulating flow (pcu/h),
 t_f : Follow-up headway (s), t_c : Critical gap (headway) (s),
 t_o : unused part of average accepted headway (s).

This is the basic capacity equation. **Pedestrian Factor**
and **Movement Class Factor** (for HVs, Buses, etc) are not
shown in the equation above.

Same capacity equation for
HCM 6 and HCM 6x models



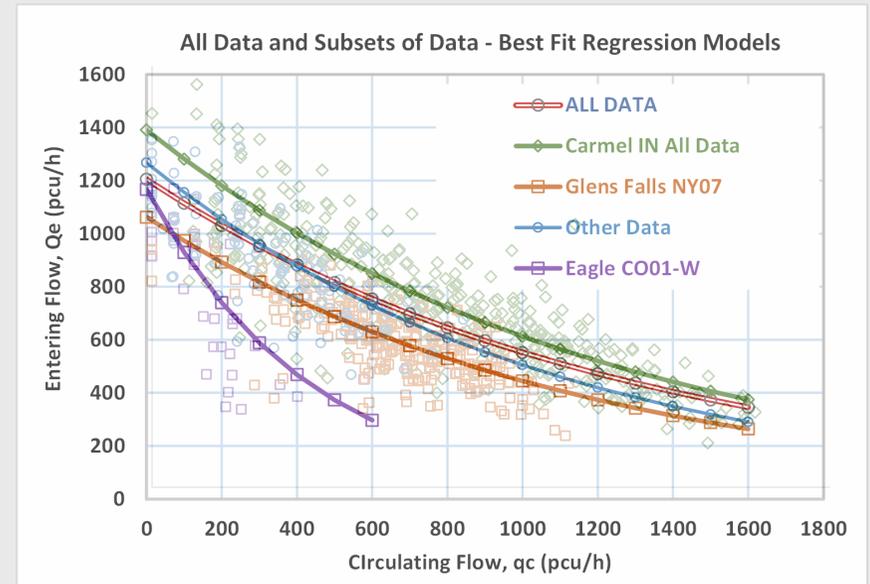
HCM Edition 6 roundabout capacity model

The HCM exponential (Siegloch M1) model is discussed in another presentation at this conference.

Two detailed reports are available for download from <http://www.sidrasolutions.com/Resources/Articles>

AKÇELİK, R., SHIRKE, C., BESLEY, M., ESPADA, I. and BILLINGHURST, D. (2022). **A Comparative Analysis of Exponential and Linear Roundabout Capacity Models Using HCM Research Data**. Technical Note. Akcelik & Associates Pty Ltd, Melbourne, Australia.

AKÇELİK, R. (2022). **Searching for a Gap Acceptance Theory Basis for Linear Capacity Models**. Technical Note. Akcelik & Associates Pty Ltd, Melbourne, Australia.



HCM 6 capacity model parameters

HCM Edition 6 ("HCM 6") model default parameters

	A	B	t_f	t_c	t_o
Single-Lane Circulating ($n_c = 1$)					
Single-Lane Entry ($n_e = 1$)	1380	0.00102	2.61	4.98	3.67
Multi-Lane Entry ($n_e > 1$) (All entry lanes for single-lane circulating $n_c = 1$)	1420	0.00091	2.54	4.54	3.28
Multi-Lane Circulating ($n_c > 1$)					
Single-Lane Entry ($n_e = 1$)	1420	0.00085	2.54	4.33	3.06
Multi-Lane Entry ($n_e > 1$)					
Dominant Lane (Right lane for US driving)	1420	0.00085	2.54	4.33	3.06
Subdominant Lane (Left lane for US driving)	1350	0.00092	2.67	4.65	3.31
Slip/Bypass Lanes					
One Exiting Lane ($n_{ex} = 1$) (All entry lane cases)	1380	0.00102	2.61	4.98	3.67
Two or More Exiting Lanes ($n_{ex} > 1$) (All entry lane cases)	1420	0.00085	2.54	4.33	3.06

t_f = Follow-up headway (s), t_c = Critical gap (s)

One-lane circulating,
one-lane entry model
parameters used

Two-lane circulating,
one-lane entry model
parameters used

HCM 6x capacity model Default parameters

HCM Edition 6 Extended (“HCM 6x”) model Default parameter values

	A	B	t_r	t_c	t_o
Single-Lane Circulating ($n_c = 1$)					
Single-Lane Entry ($n_e = 1$)	1380	0.00102	2.61	4.98	3.67
Two-Lane Entry ($n_e = 2$)					
Dominant Lane (Right lane for US driving)	1420	0.00091	2.54	4.54	3.28
Subdominant Lane (Left lane for US driving)	1420	0.00091	2.54	4.54	3.28
Multi-Lane Circulating ($n_c > 1$)					
Single-Lane Entry ($n_e = 1$)	1420	0.00085	2.54	4.33	3.06
Two-Lane Entry ($n_e = 2$)					
Dominant Lane (Right lane for US driving)	1420	0.00085	2.54	4.33	3.06
Subdominant Lane (Left lane for US driving)	1350	0.00092	2.67	4.65	3.31
Three-Lane Entry ($n_e = 3$)					
Dominant Lane (Middle lane)	1420	0.00085	2.54	4.33	3.06
Subdominant Lane (Left & Right lanes for US driving)	1350	0.00092	2.67	4.65	3.31
Slip/Bypass Lanes					
One Exiting Lane ($n_{ex} = 1$) (All entry lane cases)	1380	0.00102	2.61	4.98	3.67
Two or More Exiting Lanes ($n_{ex} > 1$) (All entry lane cases)	1420	0.00085	2.54	4.33	3.06

Default parameter values are selected to give the same capacity estimates as the original HCM 6 model.

Separate parameters for slip/bypass lanes

t_r = Follow-up headway (s), t_c = Critical gap (s)

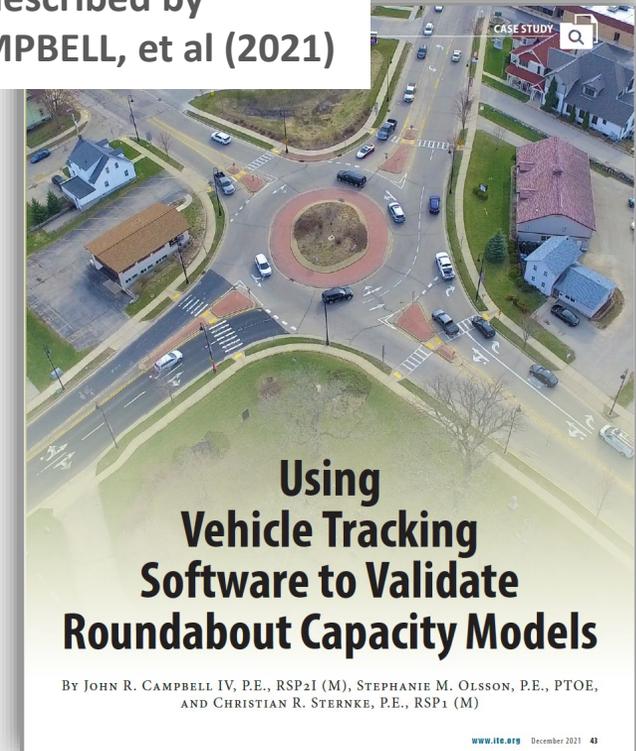
HCM 6x capacity model Wisconsin parameters

HCM Edition 6 Extended ("HCM 6x") model with Wisconsin parameter values

	A	B	t_r	t_c	t_o
Single-Lane Circulating ($n_c = 1$)					
Single-Lane Entry ($n_e = 1$)	1385	0.000944	2.60	4.70	3.40
Two-Lane Entry ($n_e = 2$)					
Dominant Lane (Right lane for US driving)	1440	0.000875	2.50	4.40	3.15
Subdominant Lane (Left lane for US driving)	1440	0.000958	2.50	4.70	3.45
Multi-Lane Circulating ($n_c > 1$)					
Single-Lane Entry ($n_e = 1$)	1385	0.000972	2.60	4.80	3.50
Two-Lane Entry ($n_e = 2$)					
Dominant Lane (Right lane for US driving)	1385	0.000833	2.60	4.30	3.00
Subdominant Lane (Left lane for US driving)	1385	0.000917	2.60	4.60	3.30
Three-Lane Entry ($n_e = 3$)					
Dominant Lane (Middle lane)	1500	0.000889	2.40	4.40	3.20
Subdominant Lane (Left & Right lanes for US driving)	1440	0.000931	2.50	4.60	3.35
Slip/Bypass Lanes					
One Exiting Lane ($n_{ex} = 1$) (All entry lane cases)	1565	0.000792	2.30	4.00	2.85
Two or More Exiting Lanes ($n_{ex} > 1$) (All entry lane cases)	1286	0.000944	2.80	4.80	3.40

t_f = Follow-up headway (s), t_c = Critical gap (s)

As described by
CAMPBELL, et al (2021)



SIDRA INTERSECTION 9.1

HCM Edition 6 Extended Roundabout Capacity Model option

ROUNDABOUTS - nc=2 ne=2 with Bypass HCM6x (Site Folder: For Pictures)

Options Roundabout Data **HCM 6 Extended Data**

Capacity model options

Roundabout Model Options

Roundabout Capacity Model

- SIDRA HCM
- US HCM 6**
- Apply Extended Model
- US HCM 2010

Roundabout Level of Service (LOS) Method

- SIDRA Roundabout LOS
- Same as Signalised Intersections
- Same as Sign Control

Delay Model

- Exclude Geometric Delay
- HCM Delay Formula

HCM Roundabout Capacity Model Extension

- Apply the SIDRA Model for Unbalanced Flow Conditions for HCM 6 / 6x

When you Method, H comparison remain un Roundab

Table: De and SIDR

Related

Roundab

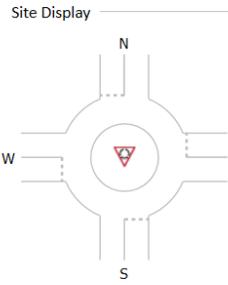
HCM De

Exclude

ROUNDABOUTS - nc=2 ne=2 with Bypass HCM6x (Site Folder: For Pictures)

Options Roundabout Data **HCM 6 Extended Data**

Site Display



Current Roundabout Capacity Model: US HCM 6x

For easy calibration, use Model Calibration Factor (HCM 6x).

Geometry data in the Roundabout Data tab are not applicable when the HCM 6x Roundabout Capacity Model is selected in the Options tab.

Import HCM 6x Data

Import HCM 6x Data

Function to import data

HCM 6x Roundabout Capacity Model Parameters

Approach:	S	E	N	W
Single Lane Circulating: Single Lane Entry				
Parameter A	1380	1380	1380	1380
Parameter B	0.00102	0.00102	0.00102	0.00102
Single Lane Circulating: Two-Lane Entry Dominant Lane				
Parameter A	1420	1420	1420	1420
Parameter B	0.00091	0.00091	0.00091	0.00091
Single Lane Circulating: Two-Lane Entry Subdominant Lane				
Parameter A	1420	1420	1420	1420
Parameter B	0.00091	0.00091	0.00091	0.00091
Multi-Lane Circulating: Single Lane Entry				
Parameter A	1420	1420	1420	1420
Parameter B	0.00085	0.00085	0.00085	0.00085
Multi-Lane Circulating: Two-Lane Entry Dominant Lane				
Parameter A	1420	1420	1420	1420
Parameter B	0.00085	0.00085	0.00085	0.00085
Multi-Lane Circulating: Two-Lane Entry Subdominant Lane				
Parameter A	1350	1350	1350	1350

Scroll down for more data in the Parameters table. Separate Parameters are available for Slip/Bypass Lanes.

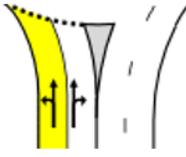
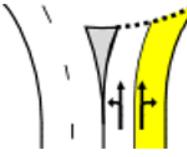
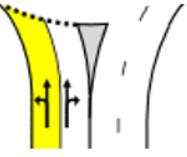
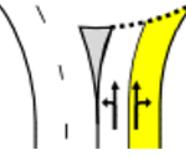
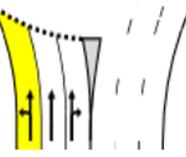
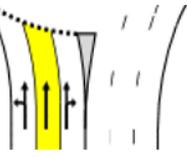
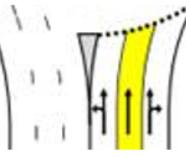
HCM 6x Roundabout Capacity Model Calibration Parameters

Approach:	S	E	N	W
Model Calibration Factor (HCM 6x)	1.00	1.00	1.00	1.00
Entry/Circ Flow Adj (HCM 6x)	None	None	None	None

Dominant lanes

The dominant lanes of an approach are those with higher capacity (as opposed to sub-dominant lanes).

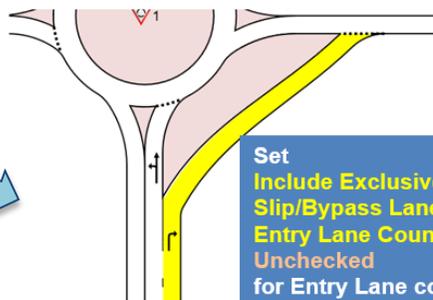
Dominant lane differs between HCM 6 and HCM 6x models for 3-lane entries.

Capacity Model >>	SIDRA Standard, HCM 6		HCM 6x	
Drive Rule >>	Drive rule = Left	Drive rule = Right	Drive rule = Left	Drive rule = Right
Software Setup >>	LH, NZ, NSW	RH, US, UM	LH, NZ, NSW	RH, US, UM
2-lane Entry ($n_e = 2$)	 Lane #1 (Left lane)	 Lane #2 (Right lane)	 Lane #1 (Left lane)	 Lane #2 (Right lane)
3-lane Entry ($n_e = 3$)	 Lane #1 (Left lane)	 Lane #3 (Right lane)	 Lane #2 (Middle lane)	 Lane #2 (Middle lane)

Treatment of Slip/Bypass Lanes in HCM 6 Extended Roundabout Capacity model

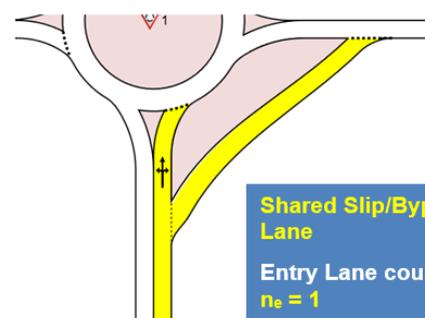
Counting the number of entry lanes with Exclusive and Shared slip/bypass lanes

Exclusive Slip/bypass lanes

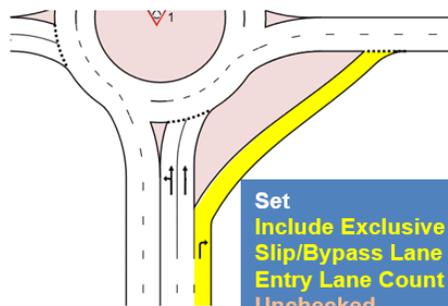


Set
Include Exclusive Slip/Bypass Lane in Entry Lane Count = Unchecked
for Entry Lane count:
 $n_e = 1$

Shared Slip/bypass lanes



Shared Slip/Bypass Lane
Entry Lane count:
 $n_e = 1$



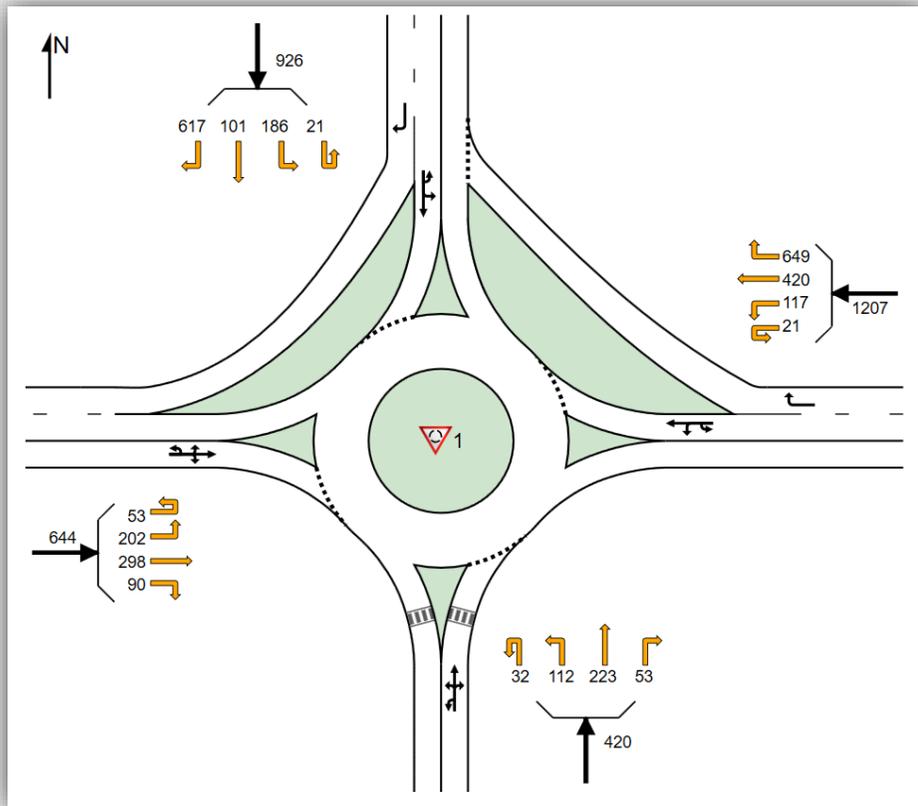
Set
Include Exclusive Slip/Bypass Lane in Entry Lane Count = Unchecked
for Entry Lane count:
 $n_e = 2$



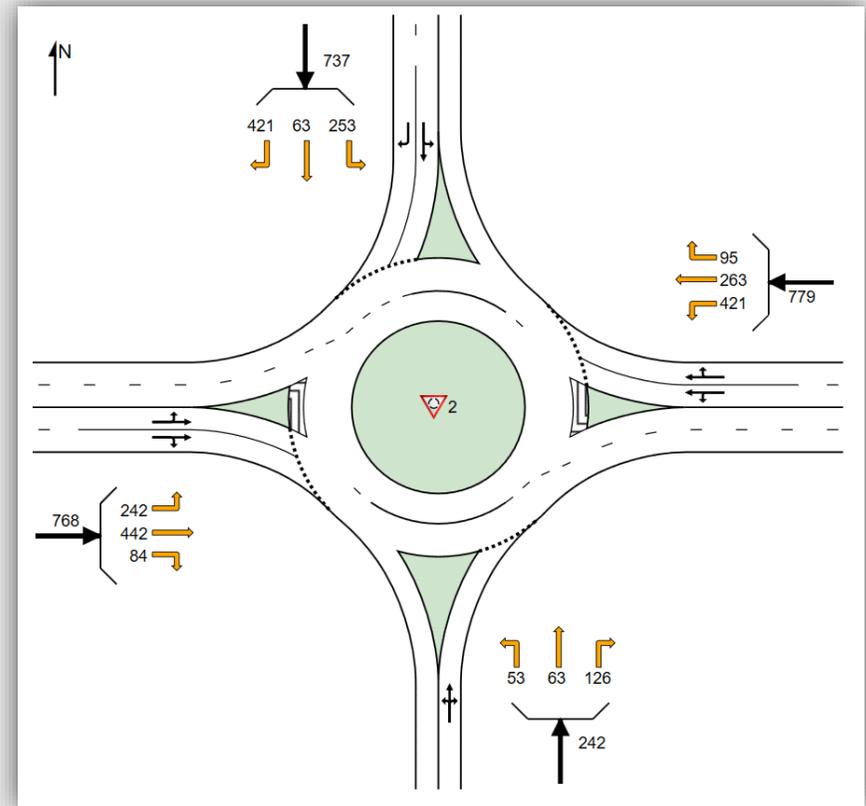
Shared Slip/Bypass Lane
Entry Lane count:
 $n_e = 2$
Dominant Lane: Lane 2 (Shared Slip/Bypass)

HCM Roundabout Examples: Geometry and Demand Flows

HCM Roundabout Example 1

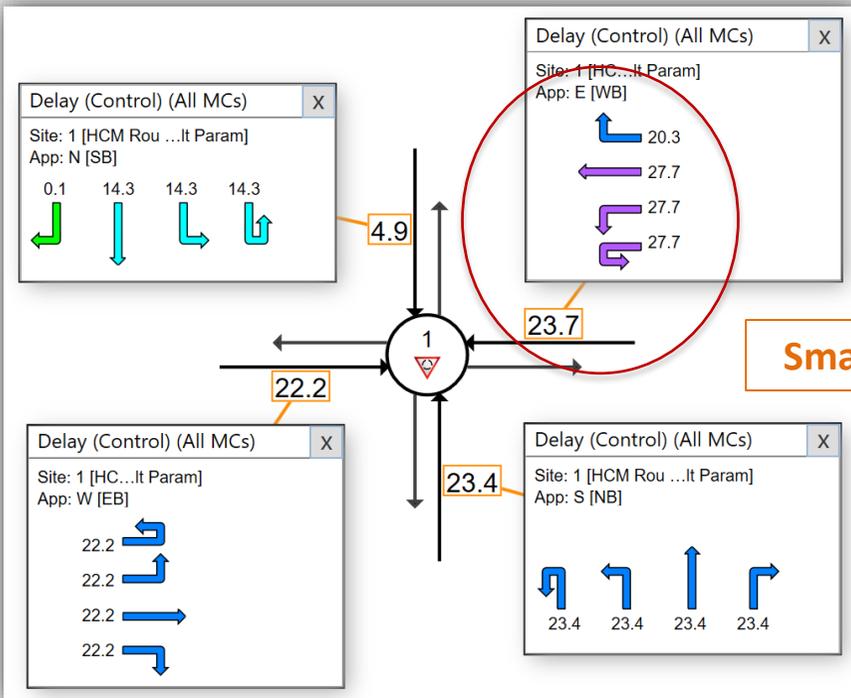


HCM Roundabout Example 2

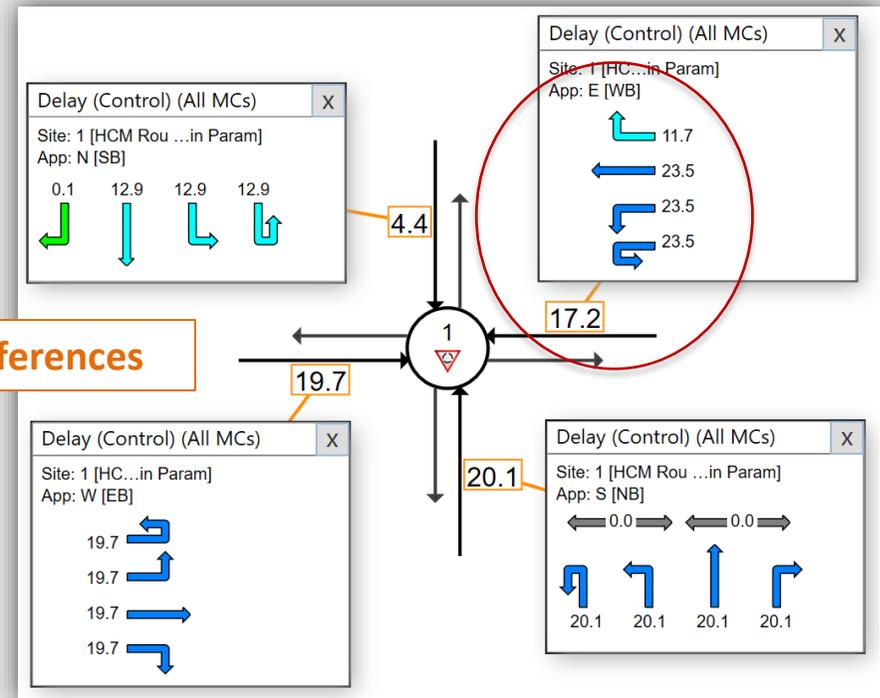


Delay & LOS estimates using the default HCM model parameters and the Wisconsin survey parameters

Example 1 - Default HCM parameters



Example 1 - Wisconsin survey parameters



Small differences

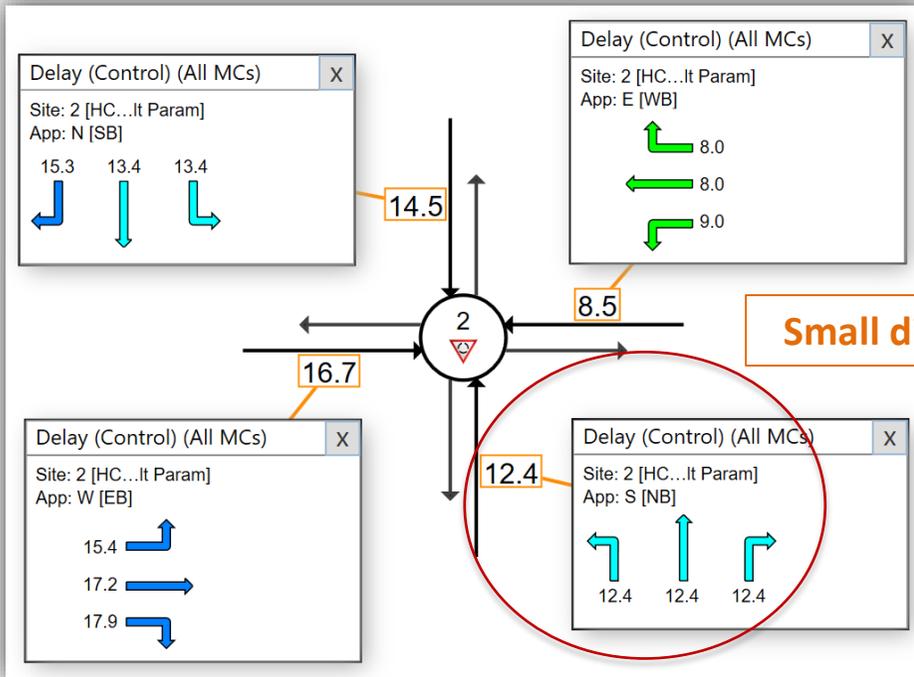
Colour code based on Level of Service



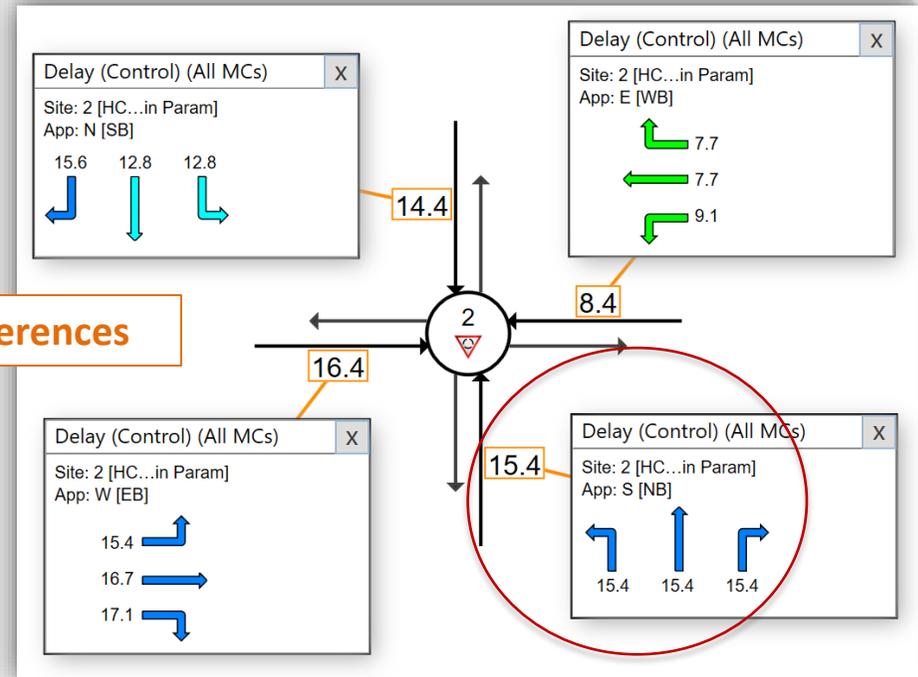
HCM Delay Formula (Stoplevel Delay): Geometric Delay is not included.
 Site Level of Service (LOS) Method: Delay & v/c (HCM 6).
 Roundabout Level of Service Method: **Same as Sign Control.**

Delay & LOS estimates using the default HCM model parameters and the Wisconsin survey parameters

Example 2 - Default HCM parameters



Example 2 - Wisconsin survey parameters



Small differences

Colour code based on Level of Service



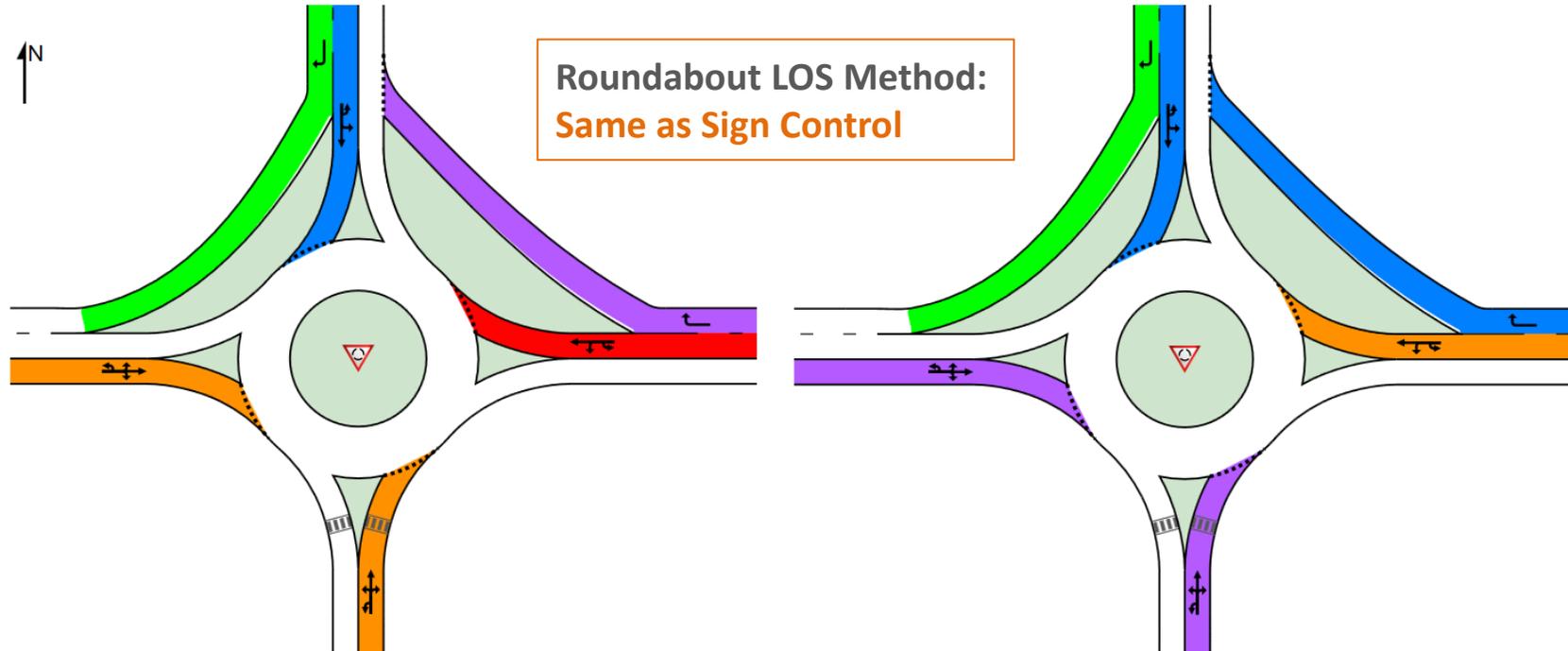
HCM Delay Formula (Stopline Delay): Geometric Delay is not included.
 Site Level of Service (LOS) Method: Delay & v/c (HCM 6).
 Roundabout Level of Service Method: **Same as Sign Control.**

Level of Service for Example 1

Design Life: After 5 years with 2% compound growth

Example 1 - Default HCM parameters

Example 1 – Wisconsin survey parameters



Colour code based on Level of Service



HCM Delay Formula (Stoptline Delay): Geometric Delay is not included.
Site Level of Service (LOS) Method: Delay & v/c (HCM 6).

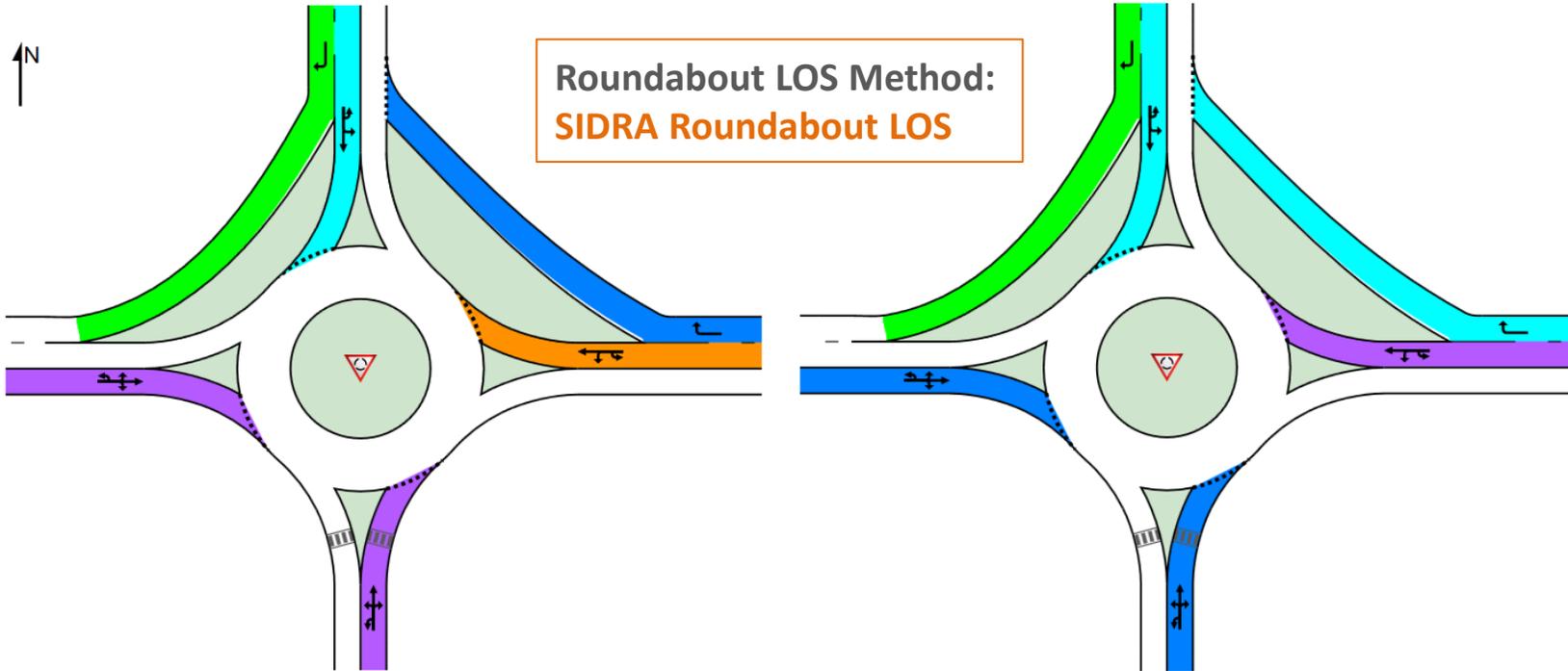
Level of Service for Example 1

Design Life: After 5 years with 2% compound growth

Example 1 - Default HCM parameters

Example 1 – Wisconsin survey parameters

Roundabout LOS Method:
SIDRA Roundabout LOS



Colour code based on Level of Service

Green	Cyan	Blue	Purple	Orange	Red
LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

HCM Delay Formula (Stopleveline Delay): Geometric Delay is not included.
Site Level of Service (LOS) Method: Delay & v/c (HCM 6).

Conclusion

The **HCM 6 Extended** roundabout capacity model in **SIDRA INTERSECTION 9.1** provides a useful functionality to specify more flexibility in specifying roundabout **lane configurations**.

In particular, **SLIP/BYPASS LANE capacities** can be calibrated independently of entry lane capacities.

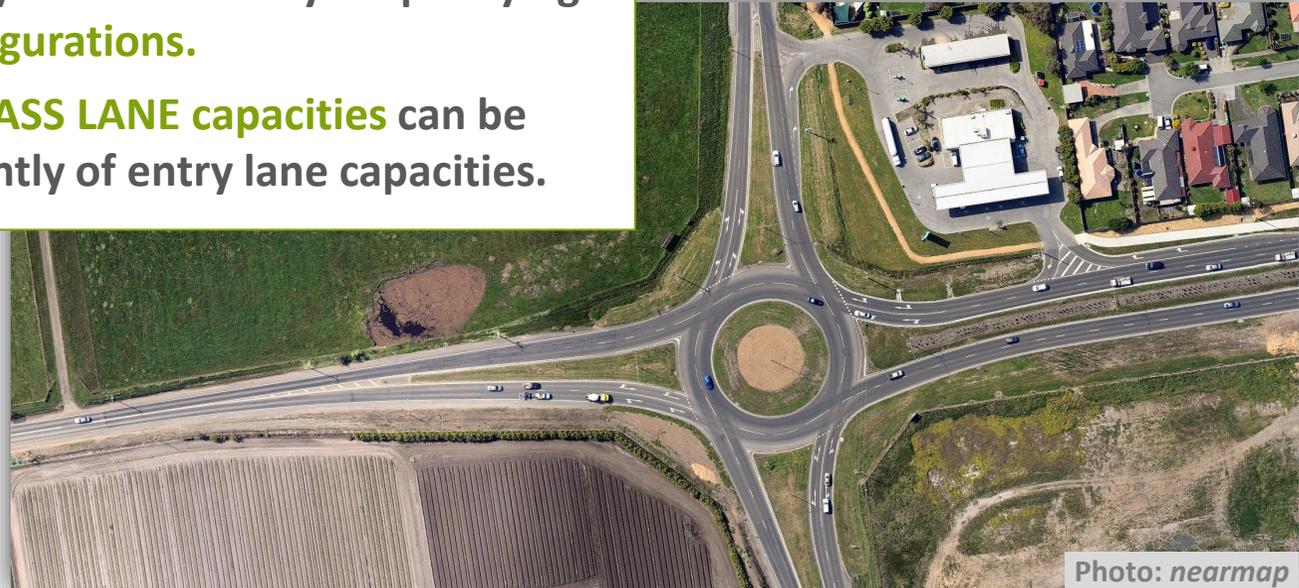


Photo: *nearmap*

END OF PRESENTATION

Thank you!