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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.

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.

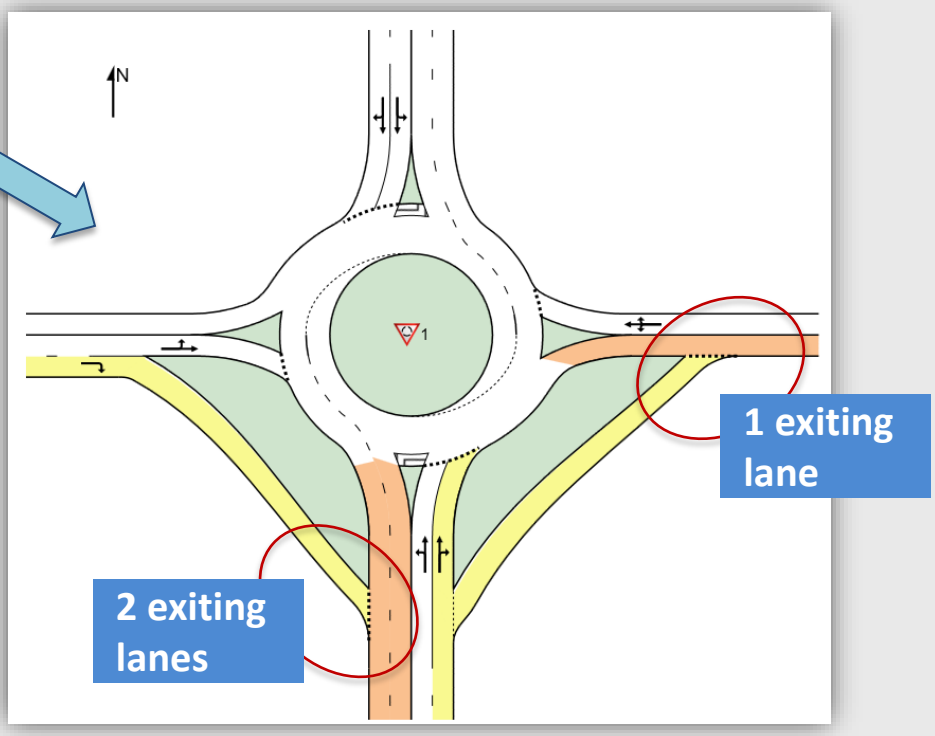
Presentation Content

- 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:

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

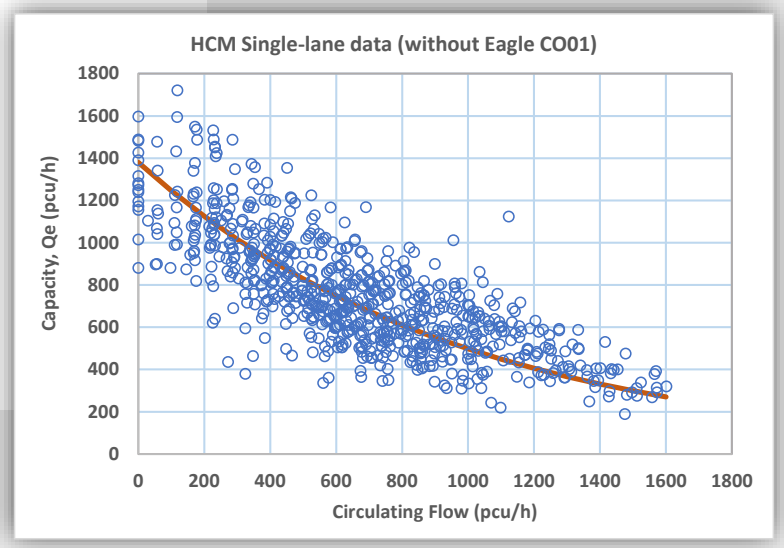
$$A = 3600 / t_f$$

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

Same capacity equation for HCM 6 and HCM 6x models

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.



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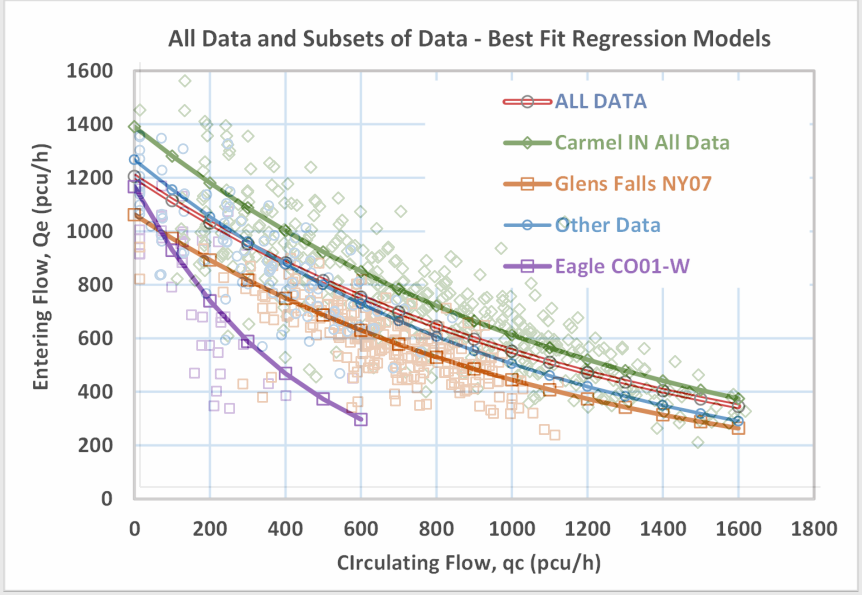
HCM Edition 6 roundabout capacity model

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

AKÇELIK, 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.

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



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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

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HCM 6x capacity model Default parameters

HCM Edition 6 Extended ("HCM 6x") model Default parameter values

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

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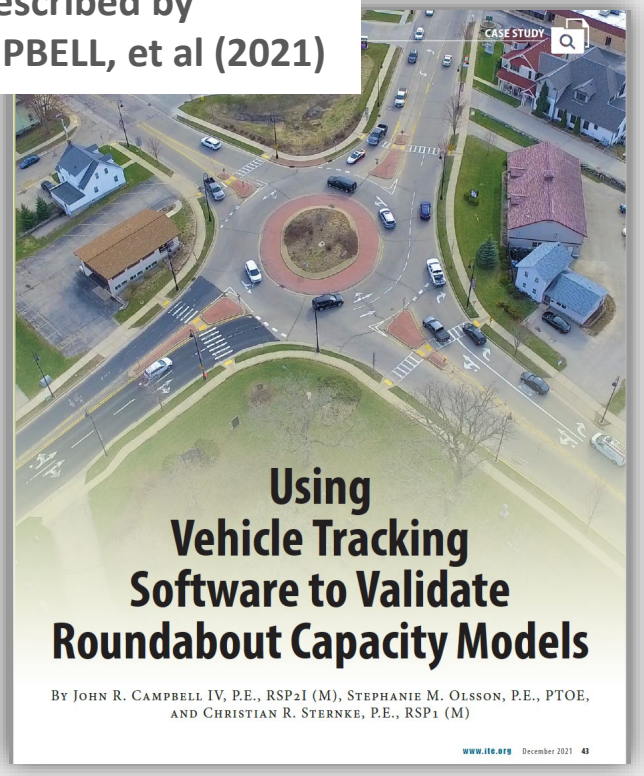
HCM 6x capacity model Wisconsin parameters

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

	A	B	t_f	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)



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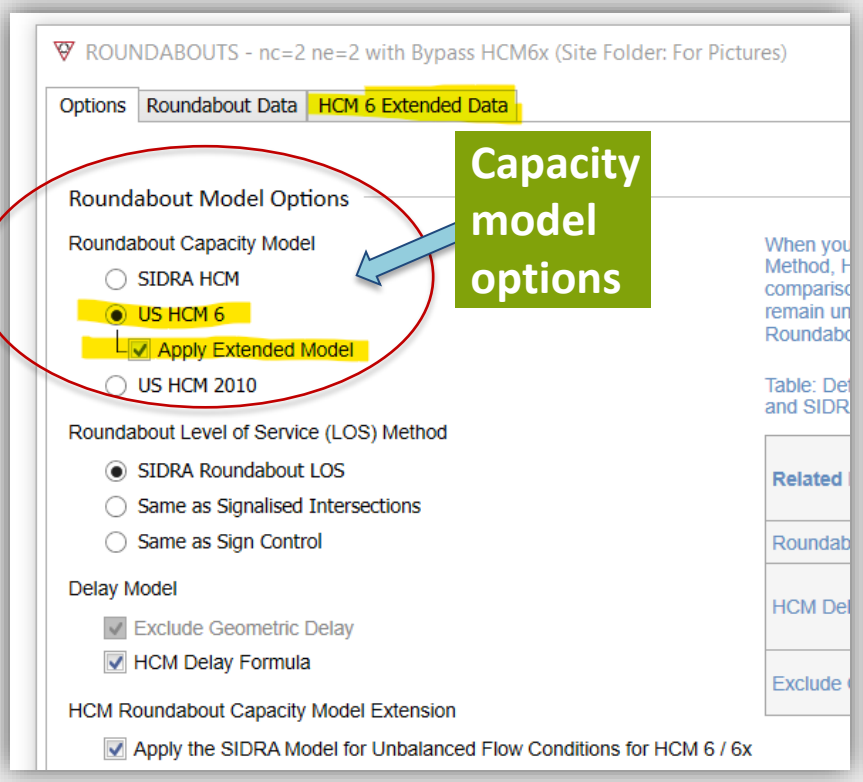
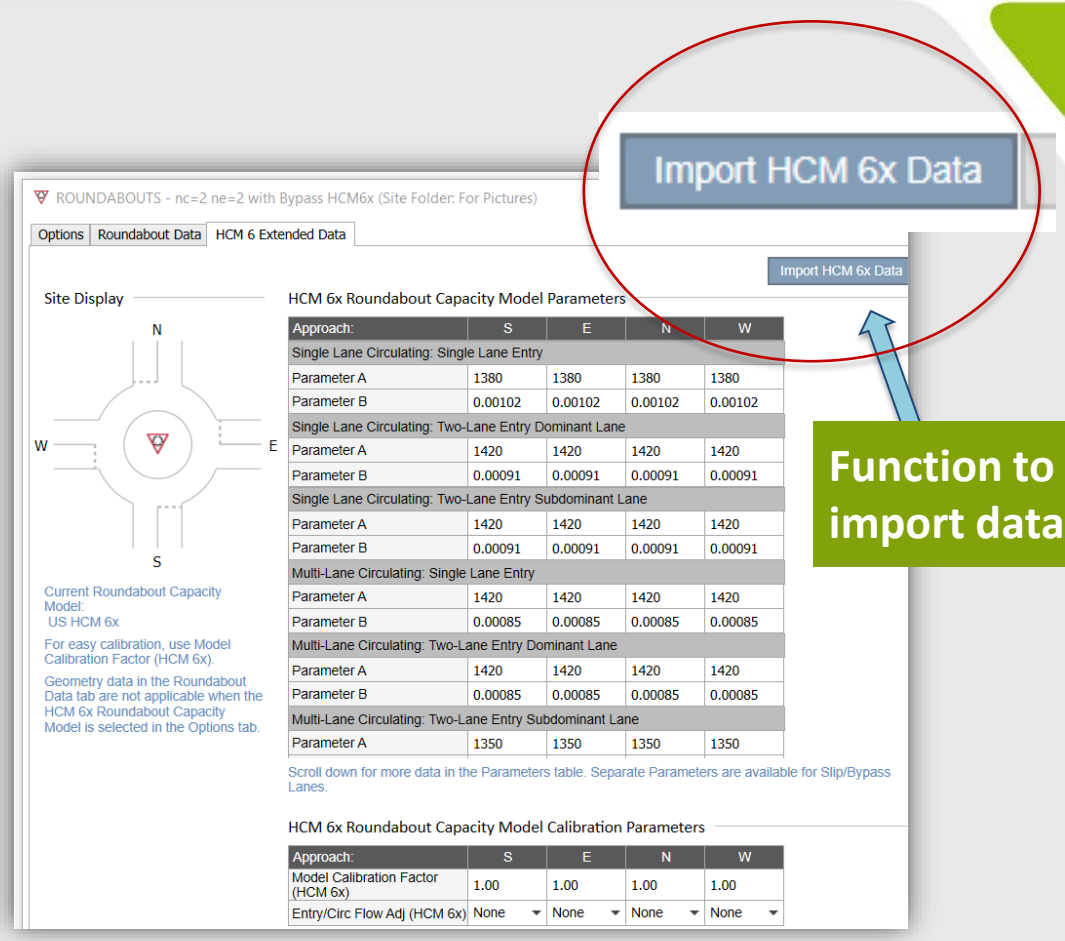
HCM Edition 6 Extended
Roundabout Capacity Model option

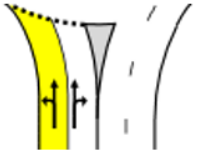
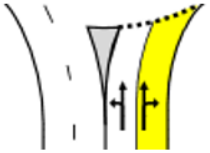
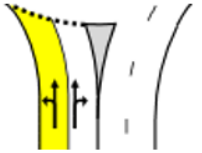
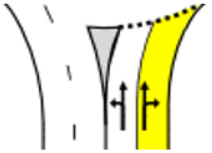
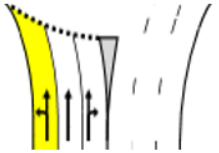
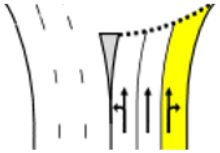
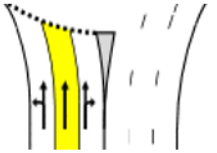
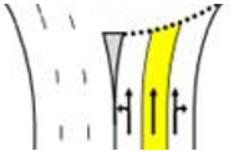




Dominant lanes

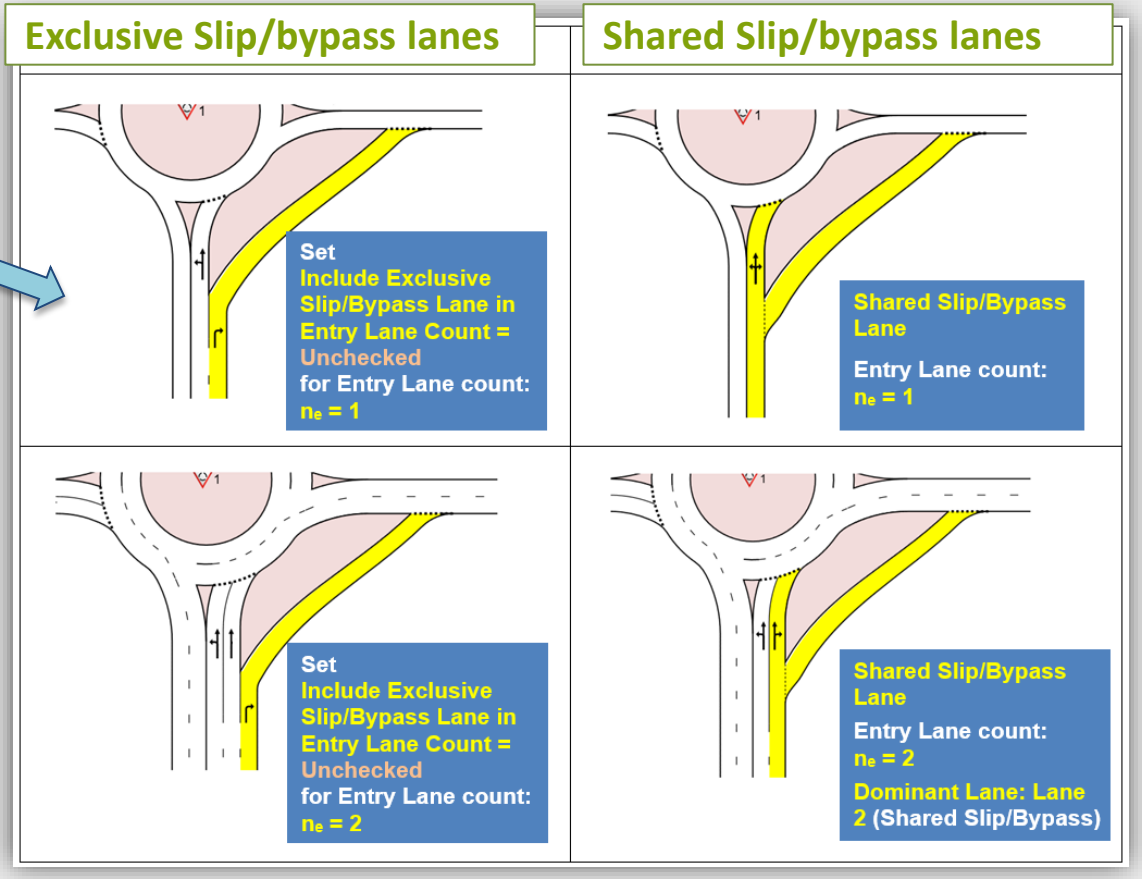
The dominant lanes of an approach are those with higher capacity (as opposed to **sub-dominant** lanes).

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)

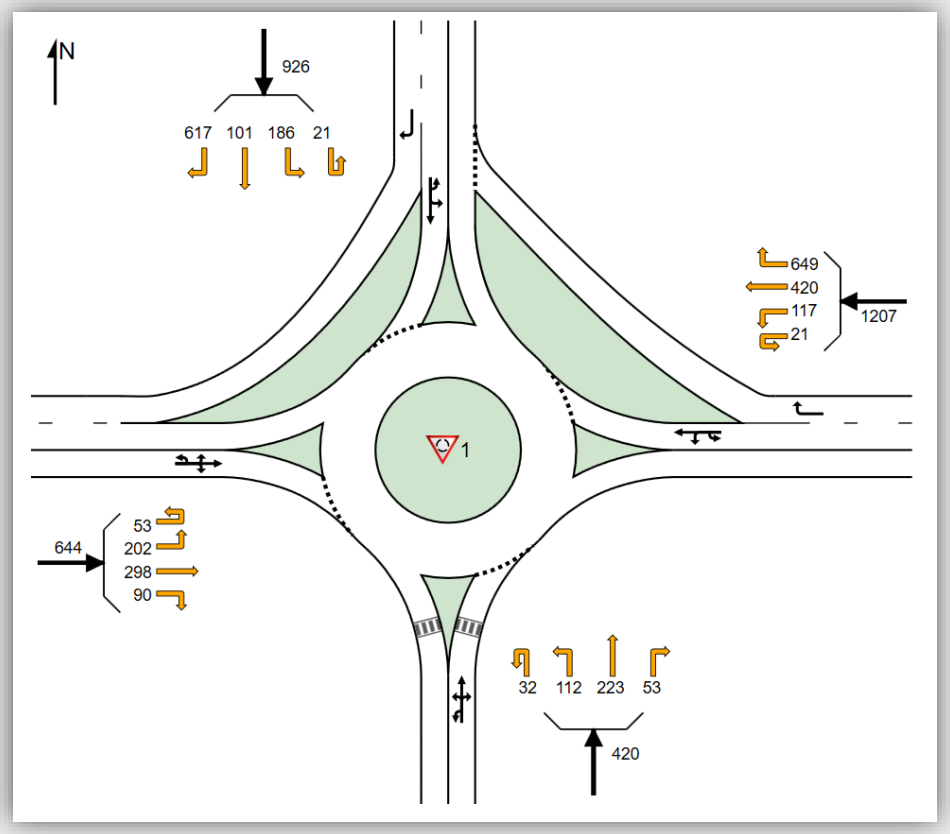
Treatment of Slip/Bypass Lanes in HCM 6 Extended Roundabout Capacity model

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

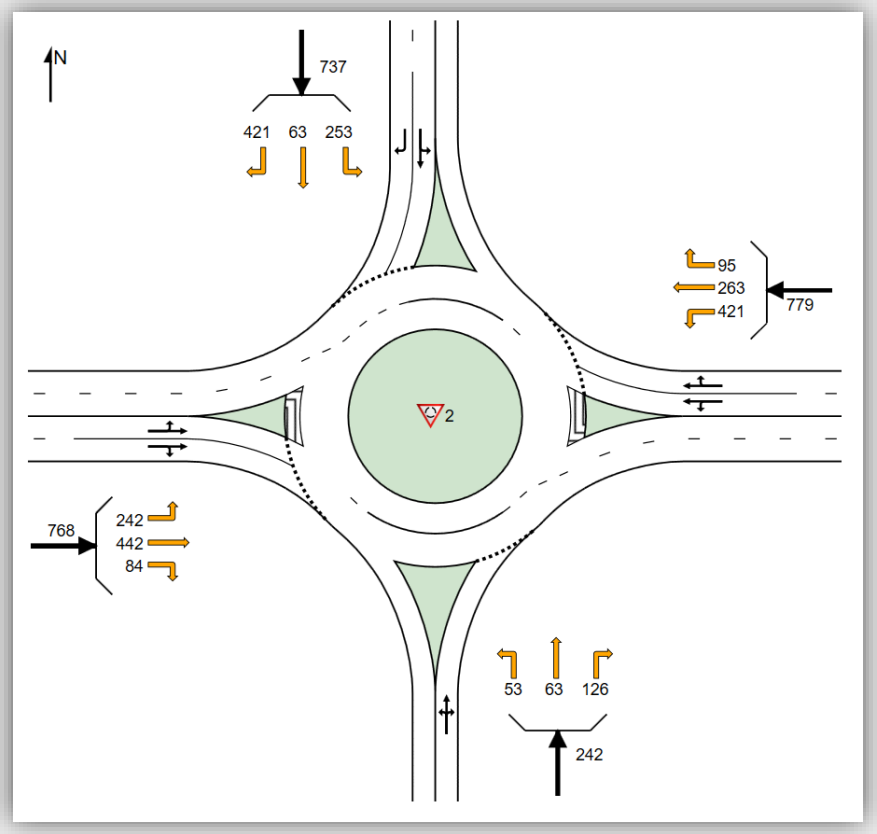


HCM Roundabout Examples: Geometry and Demand Flows

HCM Roundabout Example 1

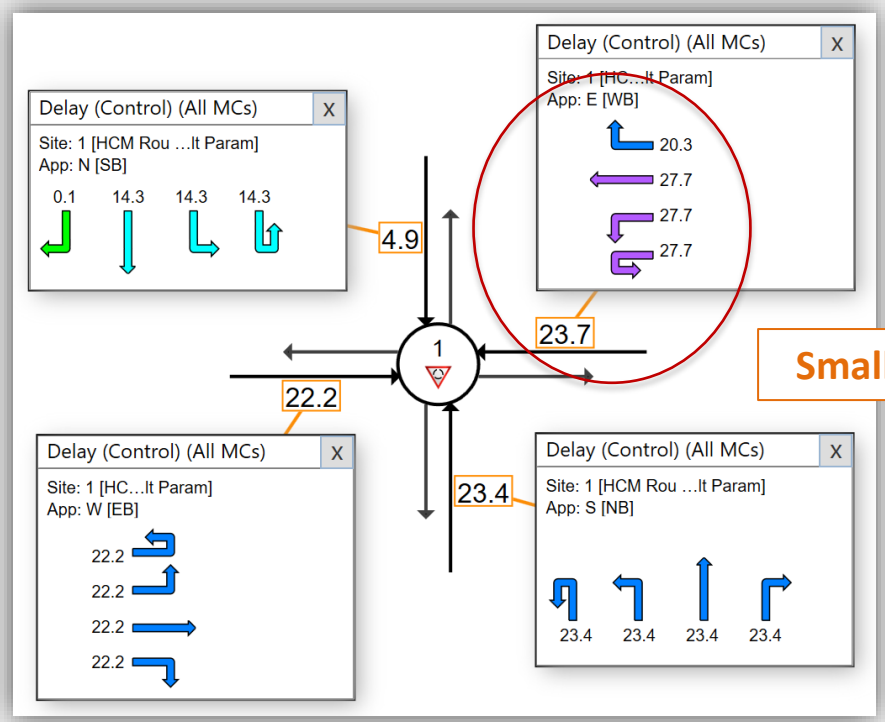


HCM Roundabout Example 2

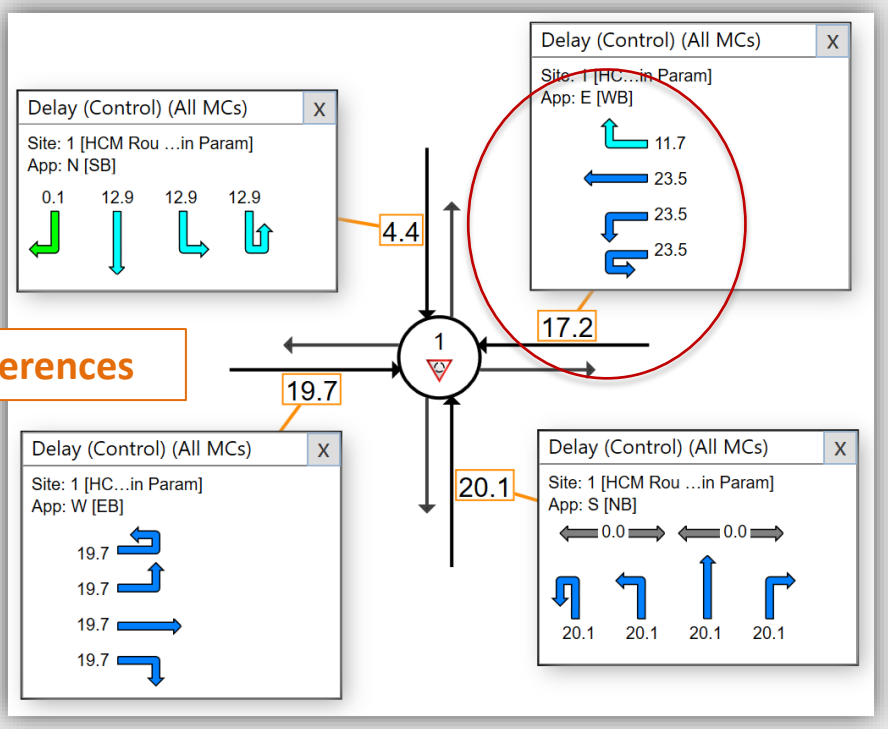


Delay & LOS estimates using the default HCM model parameters and the Wisconsin survey parameters

Example 1 - Default HCM parameters



Example 1 – Wisconsin survey parameters



Small differences

Colour code based on Level of Service

LOS A | LOS B | LOS C | LOS D | LOS E | LOS F

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.**

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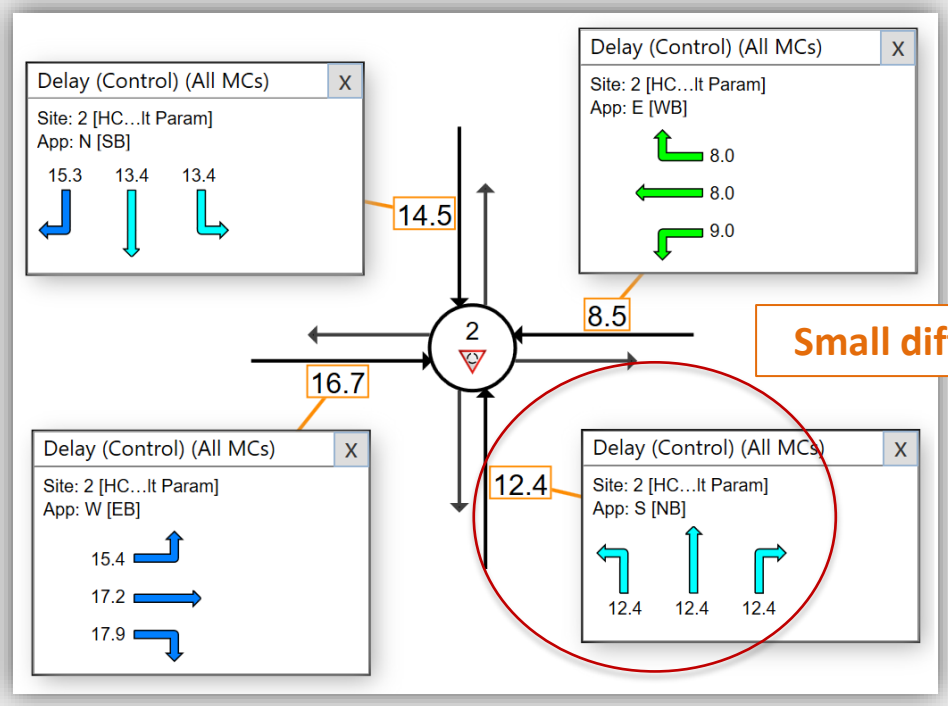
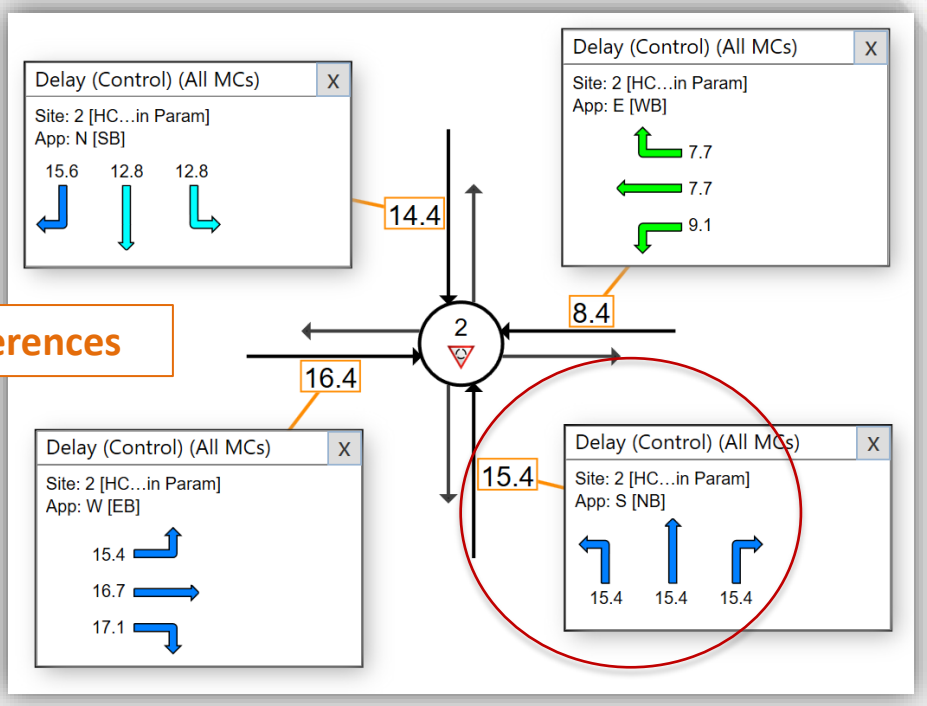
Delay & LOS estimates using the default HCM model parameters and the Wisconsin survey parameters

Example 2 - Default HCM parameters



Example 2 – Wisconsin survey parameters



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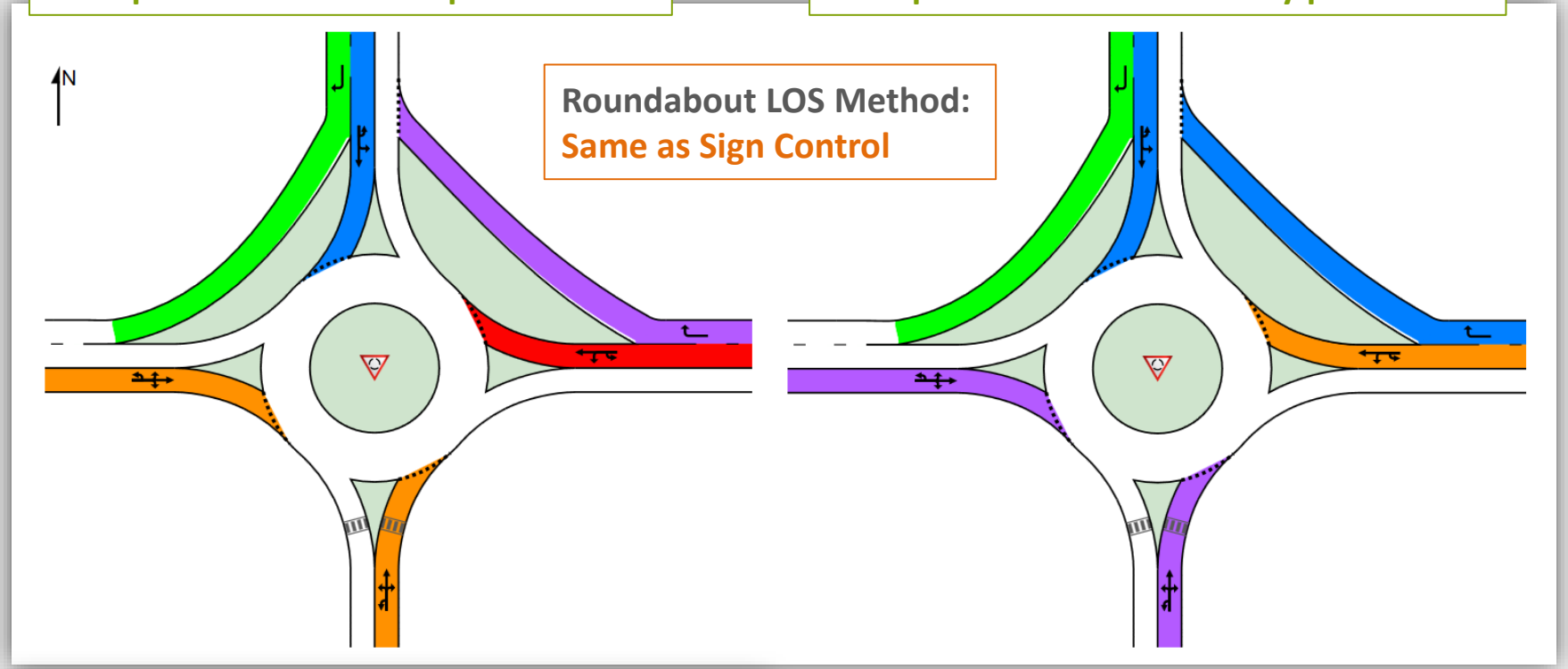
Level of Service for Example 1
Design Life: After 5 years with 2% compound growth

Example 1 - Default HCM parameters

Example 1 – Wisconsin survey parameters



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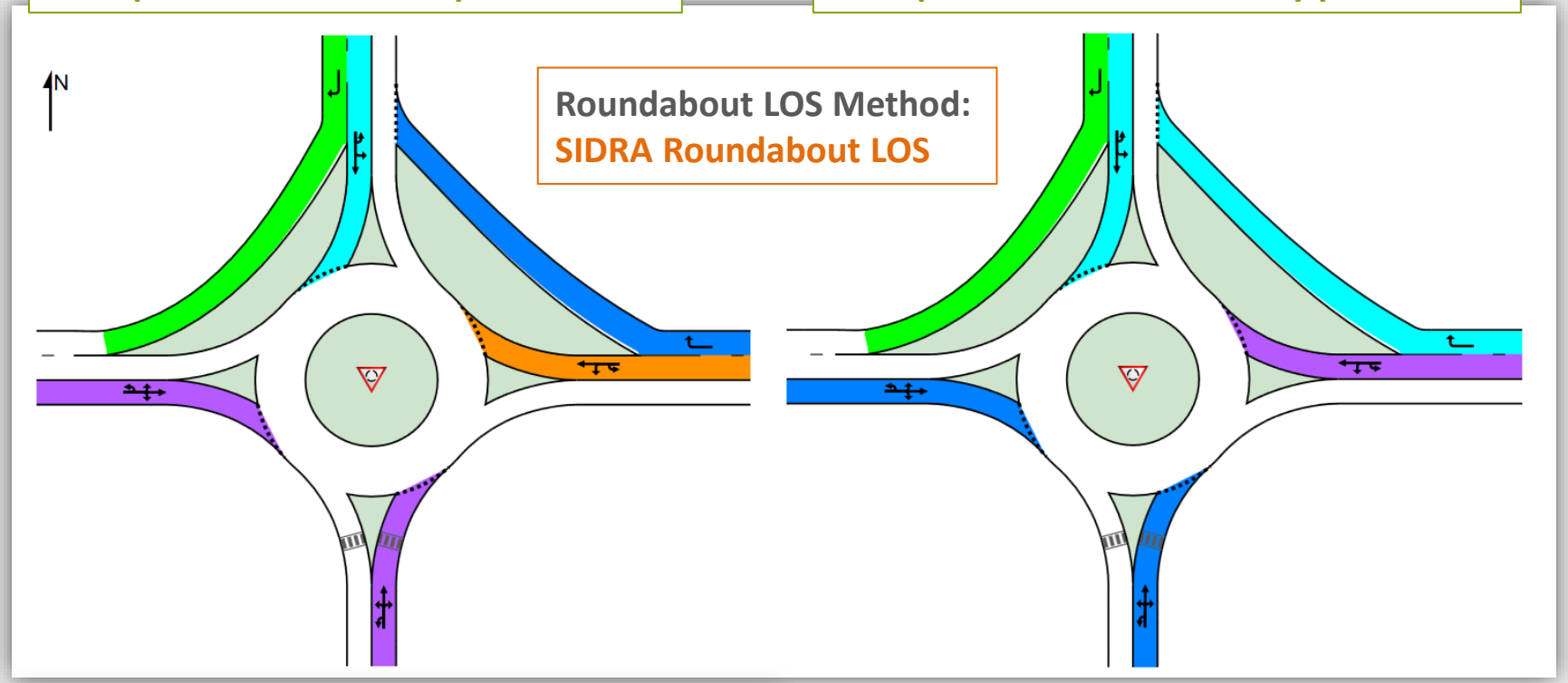
Level of Service for Example 1
Design Life: After 5 years with 2% compound growth

Example 1 - Default HCM parameters

Example 1 – Wisconsin survey parameters



Colour code based on Level of Service

LOS A	LOS B	LOS C	LOS D	LOS E	LOS F

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

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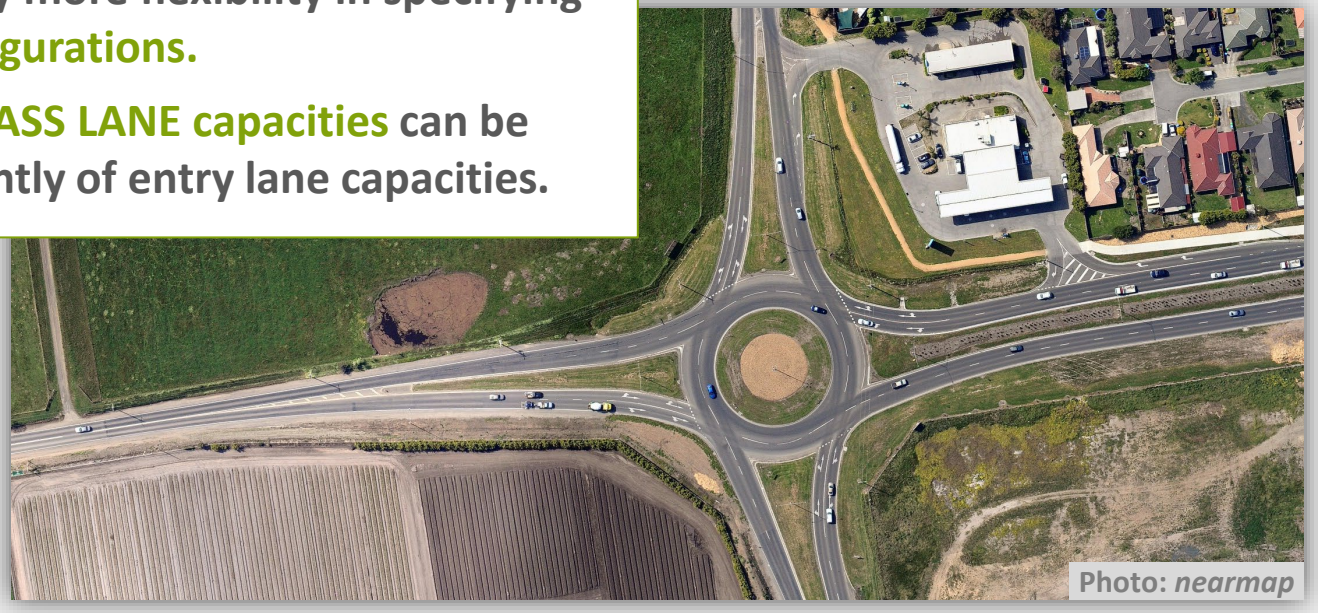
Conclusion

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.



END OF PRESENTATION

Thank you!

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