

SIDRA for HCM

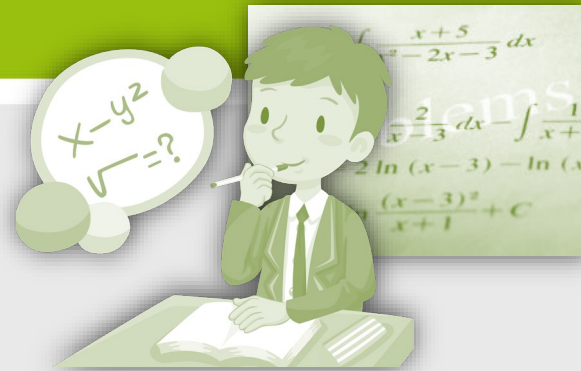
SIDRA Model Extensions for the Highway Capacity Manual - A short summary

TRB Highway Capacity & Quality of Service (ACP 40) Committee Meeting,
Transportation Research Board Annual Meeting, 6 January 2025

Author: Rahmi Akçelik

Presenter: Nagui Rouphail

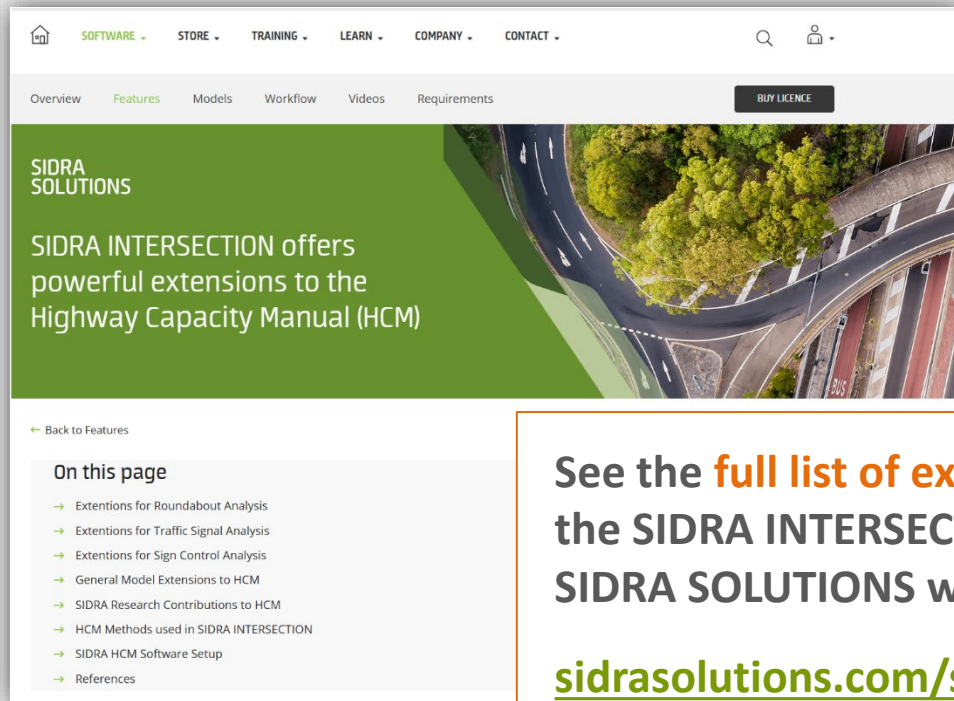
SIDRA for HCM



How do SIDRA and HCM relate?

- SIDRA and HCM are **analytical models** that use **common fundamental traffic modeling principles**.
- SIDRA INTERSECTION software **complements** the Highway Capacity Manual (HCM) as an **advanced intersection and network analysis tool**.
- The **SIDRA HCM Software Setup** is calibrated using the HCM model parameters.
- Unlike other software packages, SIDRA INTERSECTION **does not claim to be a simple replication of the HCM procedures**. Instead, it offers **significant extensions to the capabilities of HCM**.

For more detail



See the **full list of extensions to the HCM** offered by the SIDRA INTERSECTION software given on this SIDRA SOLUTIONS web page:

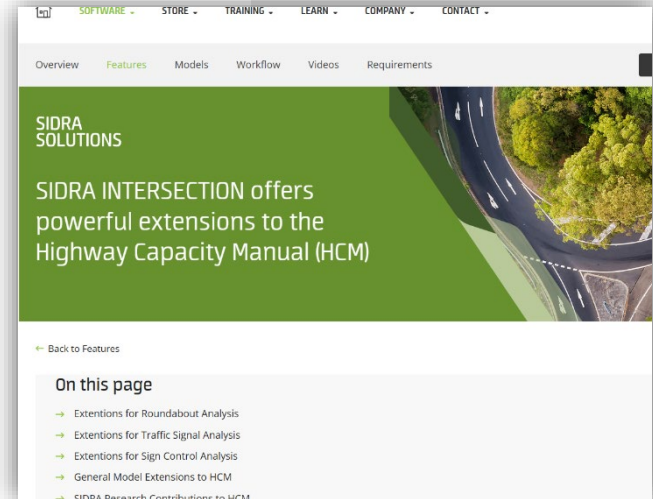
sidrasolutions.com/software/sidra-intersection/features/highway-capacity-manual-hcm-sidra-intersection

Detailed information on SIDRA SOLUTIONS website

The SIDRA SOLUTIONS website presents detailed information on:

- **Model extensions** to the HCM offered by SIDRA INTERSECTION
 - ❖ for **roundabout** analysis
 - ❖ for **traffic signal** analysis
 - ❖ **sign control** analysis
 - ❖ **general model extensions**
- **SIDRA research contributions to HCM**
- **HCM methods** used in SIDRA INTERSECTION
- **SIDRA HCM Software Setup**

The following slides present short discussions on a small amount of this information as listed in the following slide.



Presentation plan

- About SIDRA
- **A selected list of model extensions** to the HCM offered by SIDRA INTERSECTION
- SIDRA (Akçelik) **research contributions to HCM**
- References

Emphasis of this presentation is on **models**
(not on user interface features)



About SIDRA



About SIDRA



About SIDRA - Software versions

First released in 1984



Continuous development
in response to user feedback



SIDRA INTERSECTION 9.1

Micro-analytical software for
modeling Intersections and Networks

Current Version: **9.1**

New version in Beta testing:

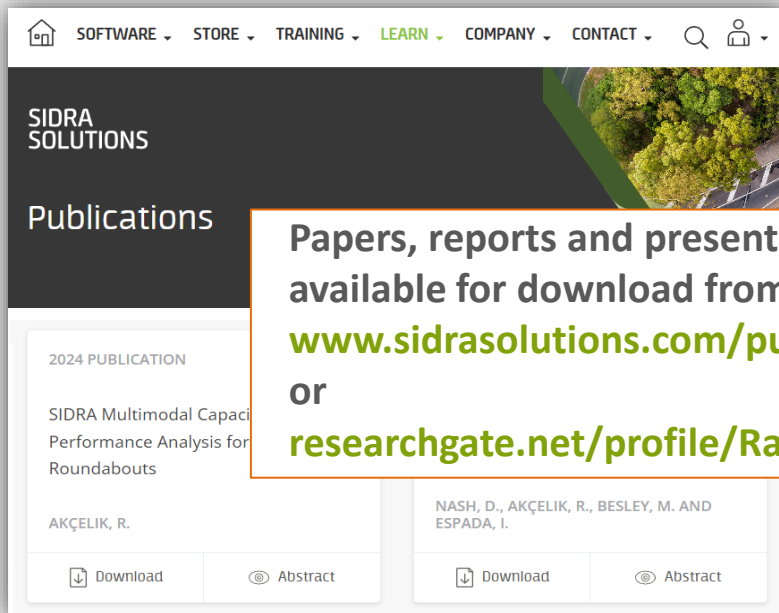
SIDRA INTERSECTION 10

(**25th** major SIDRA version
since its first release)

About SIDRA - Strong research base

Analytical traffic modeling:
Empirical and theoretical methods
combined

45 years at Australian Road Research Board
(1979-1999)
and Akcelik & Associates (since 1999)



Rahmi Akçelik

Research Gate

Reads	Citations	Reported
152,043	3,315	3 Jan 2025

Google Scholar: 6,379

SIDRA for Roundabout Analysis

See the following TRB presentation for **detailed information about SIDRA roundabout analysis**:

AKÇELİK, R. (2024). **SIDRA Multimodal Capacity and Performance Analysis for Roundabouts**. Presentation at TRB 103rd Annual Meeting, Session 3068: Multimodal Operations and Capacity of Roundabouts in the US and Beyond, Washington D.C., USA, January 2024.

Available for download from:

<https://www.sidrasolutions.com/learn/publications/sidra-multimodal-capacity-and-performance-analysis-roundabouts>



Source: ITE Journal

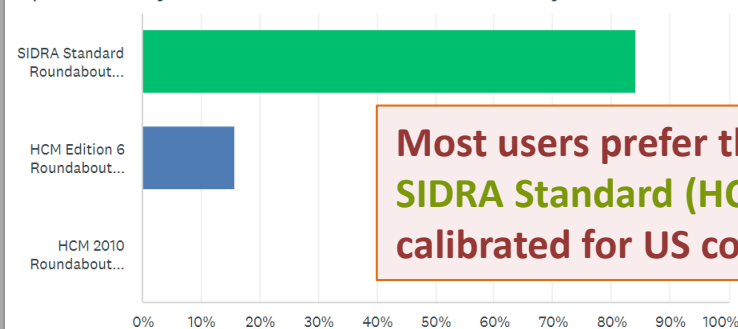
About SIDRA - The most popular roundabout analysis software in the USA

The most popular roundabout analysis software in the USA

According to the TRB document **Roundabout Practices, A Synthesis of Highway Practice (NCHRP SYNTHESIS 488)**, SIDRA INTERSECTION is the **most widely-used software tool in the USA** for roundabout analysis.

[Download from <https://www.nap.edu>]

If you are using a US HCM software setup of SIDRA INTERSECTION, which roundabout capacity model option do you use for roundabout analysis?



Most users prefer the SIDRA Standard (HCM) model calibrated for US conditions

ANSWER CHOICES	RESPONSES
SIDRA Standard Roundabout Capacity Model	84.21%
HCM Edition 6 Roundabout Capacity Model	15.79%

Refer to:

<https://www.sidrasolutions.com/software/sidra-intersection/features/roundabouts/most-widely-used-software-tool-usa>

A selected list of **model extensions** to the HCM offered by SIDRA INTERSECTION



- A selected list of model extensions to the HCM offered by SIDRA INTERSECTION



A selected list of **model extensions** to the HCM offered by SIDRA INTERSECTION

1. Multi-modal and lane-based modeling (general feature)

Combined with the **lane-based** method, multi-modal approach allows:

- modeling of **Bus priority** and **Bicycle lanes and special Bus and Bicycle signals**, and similar capabilities,
- more detailed analysis including **gap acceptance model by Movement Class**, and
- **separate performance output by**
 - Movement Class,
 - Pedestrians, and
 - Persons.

Vehicle movements by Movement Class
as a basis of all data and modeling for vehicle movements:

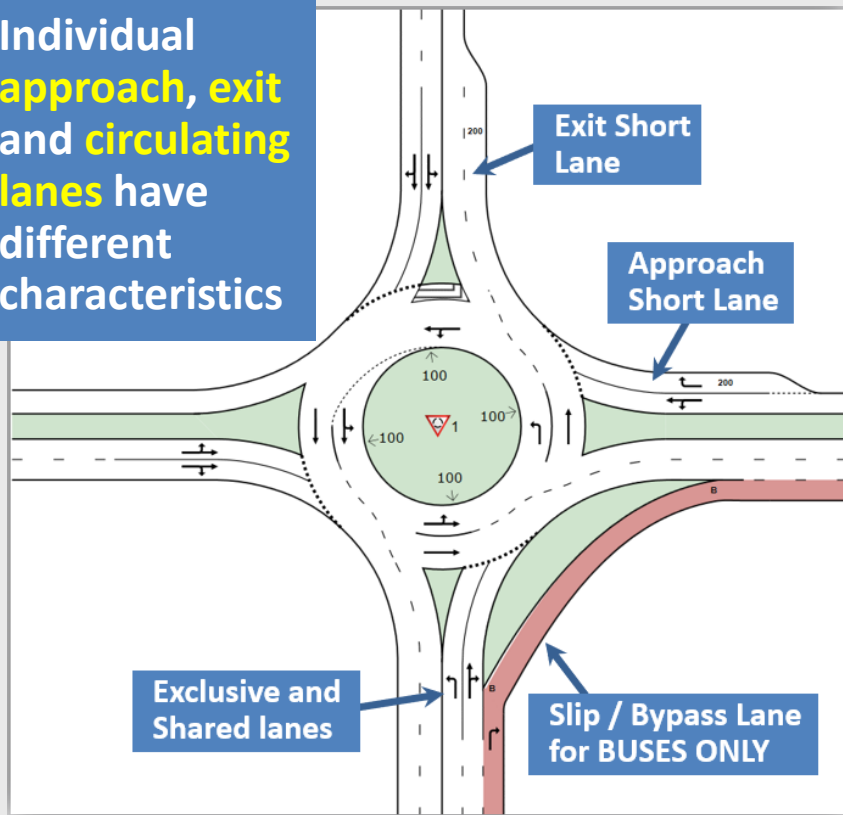
Light Vehicles
Heavy Vehicles
Buses
Bicycles
Large Trucks
Light Rail / Trams
Six **User-Defined Movement Classes**



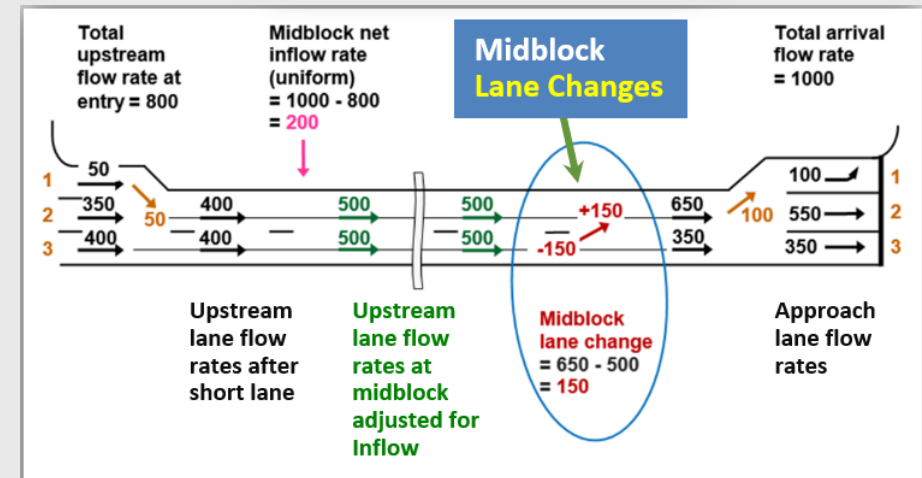
A selected list of **model extensions** to the HCM offered by SIDRA INTERSECTION

Importance of lane-based model (not by lane groups or movement groups)

Individual **approach, exit and circulating lanes** have different characteristics



Lane underutilisation



For **signalised intersections**, Lane-based **second-by-second platoon movements** are subject to **midblock lane change** adjustments

A selected list of **model extensions** to the HCM offered by SIDRA INTERSECTION

2. Signal timing analysis

The **basic elements of SIDRA** signal timing analysis:

- Unique **Critical Movement Identification** method (example in next slide)
- Use of **Target Degrees of Saturation (v/c Ratios)** for **Required Green Times** in **EQUISAT** and **ACTUATED** signal timings
- **Green Split Priority** method for **coordinated** and **user-specified priority** movements, and
- **Multiple Green Periods** for phasing requirements related to **complex intersection geometry**, **signal control** and **multimodal traffic analysis** (new in SIDRA INTERSECTION 10: **more than 2 green periods**)



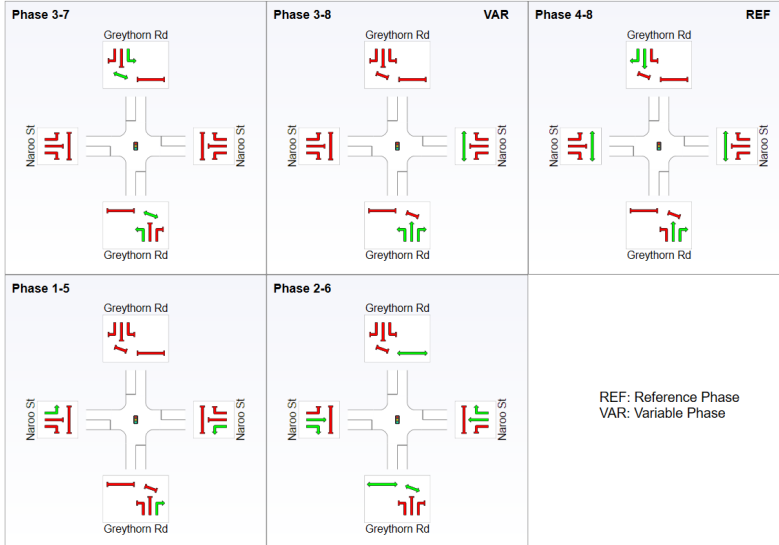
A selected list of **model extensions** to the HCM offered by SIDRA INTERSECTION

Critical Movement Identification (using critical path method)

INPUT PHASE SEQUENCE

Site: 102 [beg2a US]

Phase Sequence: Leading Left Turns with Variable Phase
Reference Phase: Phase 4-8
Input Phase Sequence: 3-7, 3-8*, 4-8, 1-5, 2-6



CRITICAL MOVEMENTS FOR SIGNAL TIMING

Phase Sequence: Leading Left Turns with Variable Phase

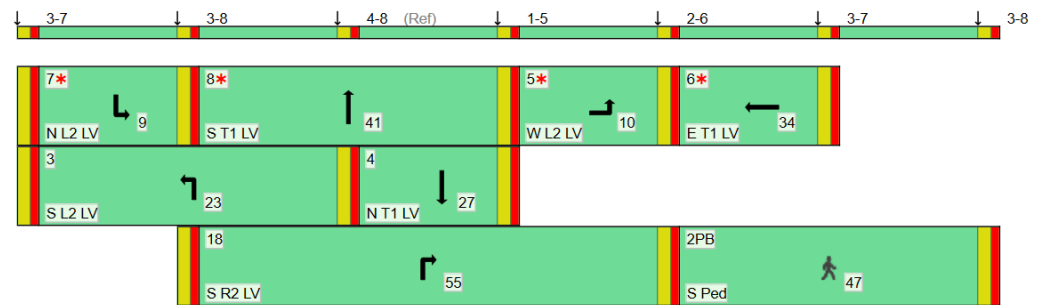
Input Phase Sequence: 3-7, 3-8*, 4-8, 1-5, 2-6

Output Phase Sequence: 3-7, 3-8*, 4-8, 1-5, 2-6

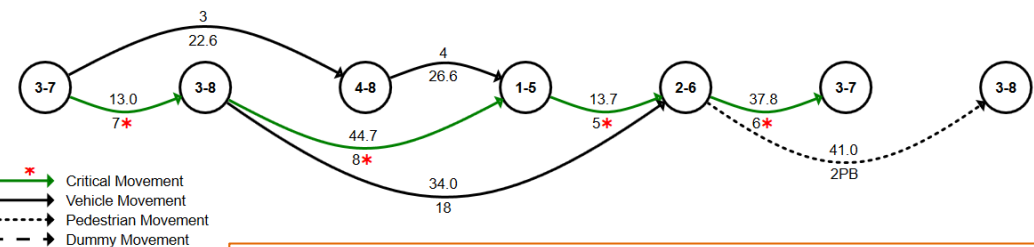
Reference Phase: Phase 4-8

(* Variable Phase)

Phase - Movement Timings Display



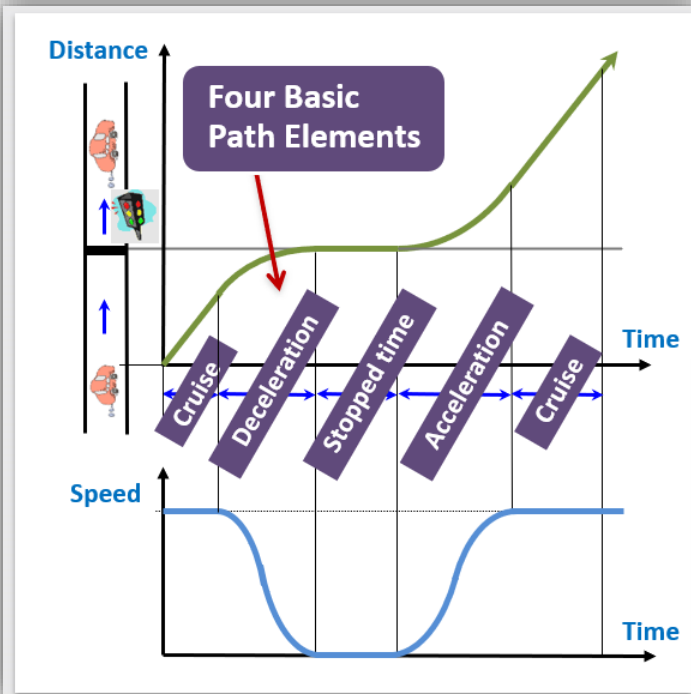
Critical Movement Diagram



Total Required Time for the critical (longest) path :
Movements 7, 8, 5, 6: $13.0 + 44.7 + 13.7 + 37.8 = 109.2$

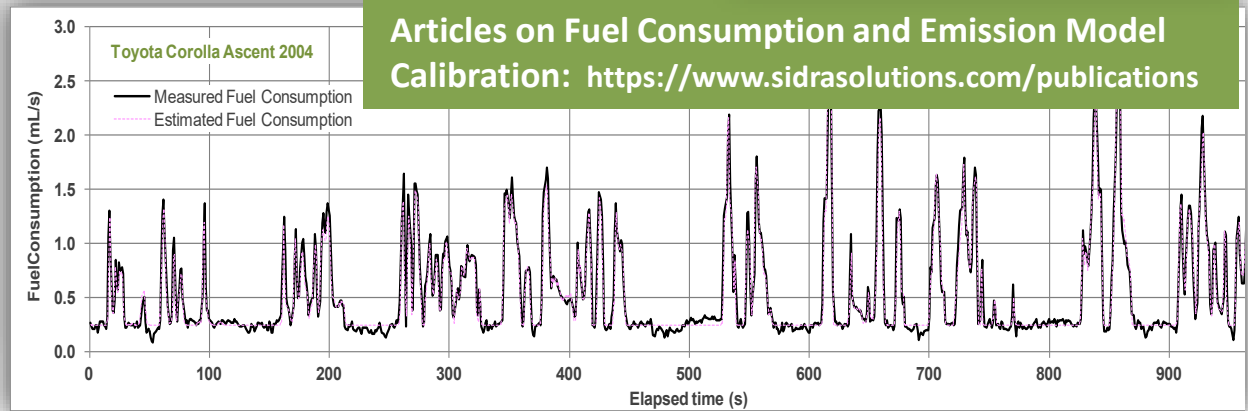
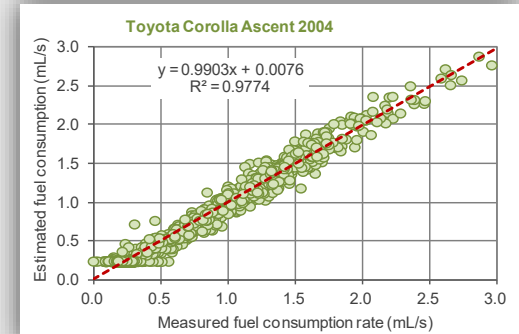
A selected list of **model extensions** to the HCM offered by SIDRA INTERSECTION

3. **Drive Cycle method** (cruise, acceleration, deceleration and idling) for modeling delay, travel time, operating cost, fuel consumption and emissions



Used for estimating

- Emissions - CO₂, CO, HC, NO_x
- Fuel Consumption
- Operating COST
- Geometric Delay



Articles on Fuel Consumption and Emission Model Calibration: <https://www.sidrasolutions.com/publications>

A selected list of **model extensions** to the HCM offered by SIDRA INTERSECTION

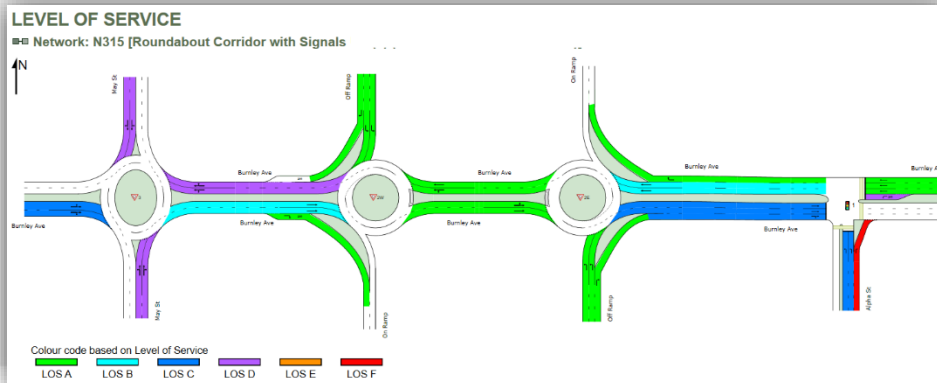
4. Roundabout Corridors and Networks with all types of intersections, interchanges and pedestrian crossings

Lane-based Network model

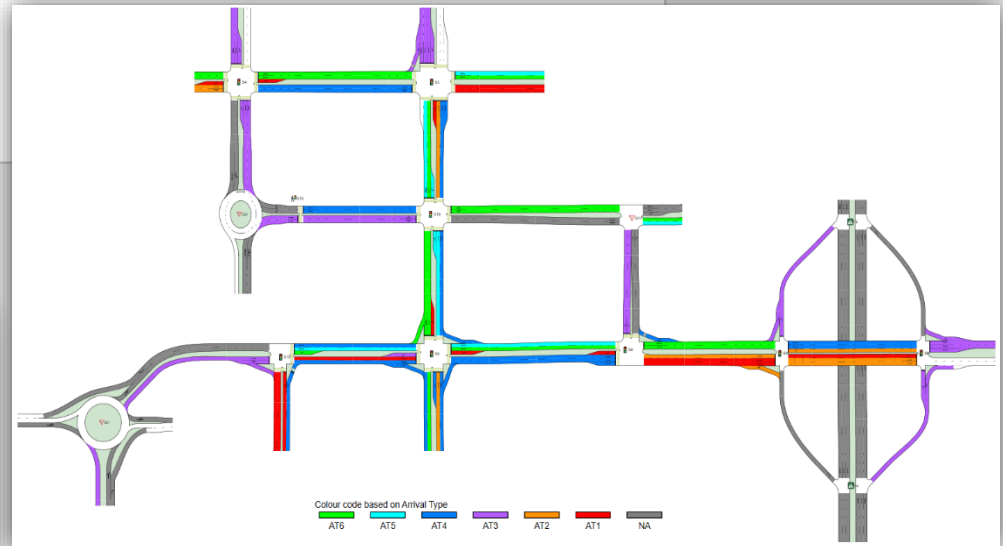
Up to 50 Sites

- Lane Blockage
- Capacity Constraint
- Midblock Lane Changes

Example: Roundabout interchange with signalized intersection



Example: Lane-based signal coordination display



SIDRA Network Templates

Alternative Intersections

Continuous Flow Intersection (CFI)
P-Turn
Restricted Crossing U-Turn (RCUT)

Roundabouts

Double Teardrop Roundabout.
Roundabout with Signalised Pedestrian Crossings
Roundabout with Zebra Pedestrian Crossings

Interchanges

Divergabout
Diverging Diamond Interchange (DDI)
Double Roundabout Interchange (DRI)
Signalised Diamond Interchange (SDI)
Unsignalised Diamond Interchange (UDI)

Staged Crossings

Staged Crossing at Four-Way Intersection
Staged Crossing at T-Intersection (3 Types)

Paired Intersections

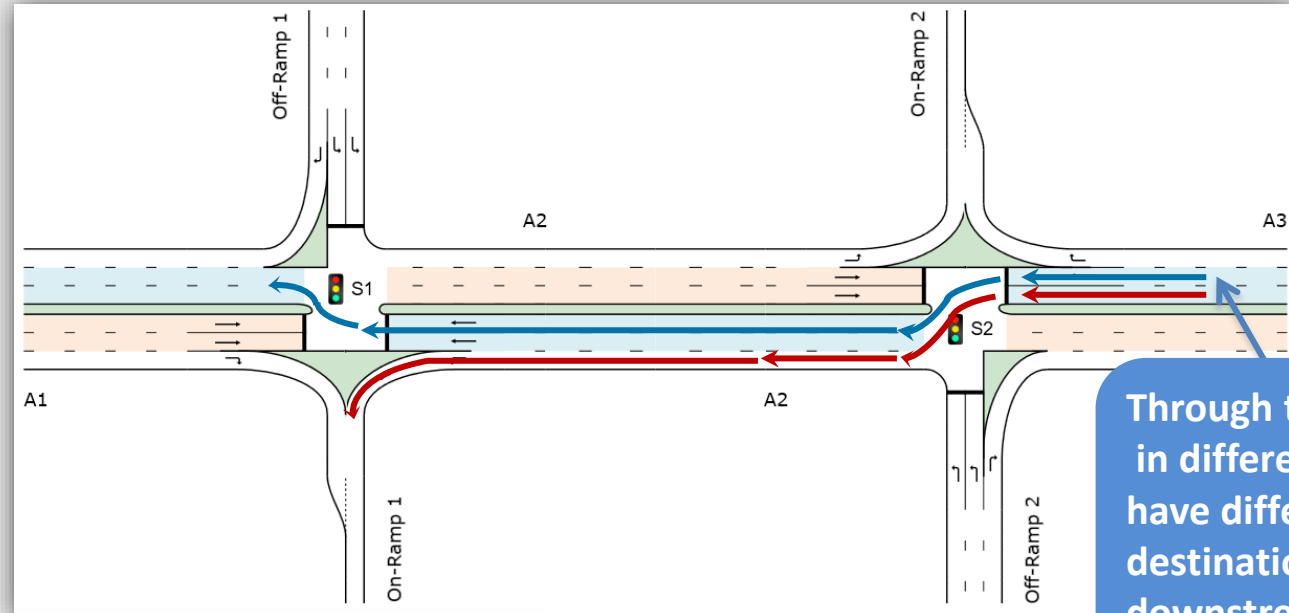
Wide-Median Intersection	Staggered T - Signals
Signalised Roundabouts	Staggered T - Unsignalised

Diverging Diamond Interchange (DDI)

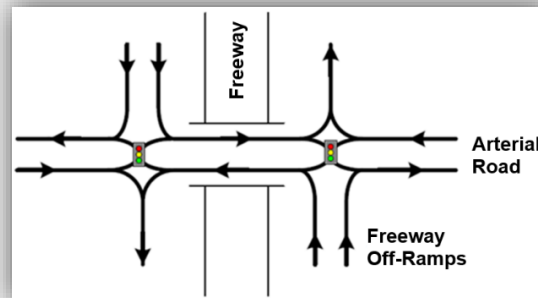
Lane allocation by
**SPECIAL MOVEMENT
CLASSES** for turning
movements

Common
Control
Group

Network Templates
are available



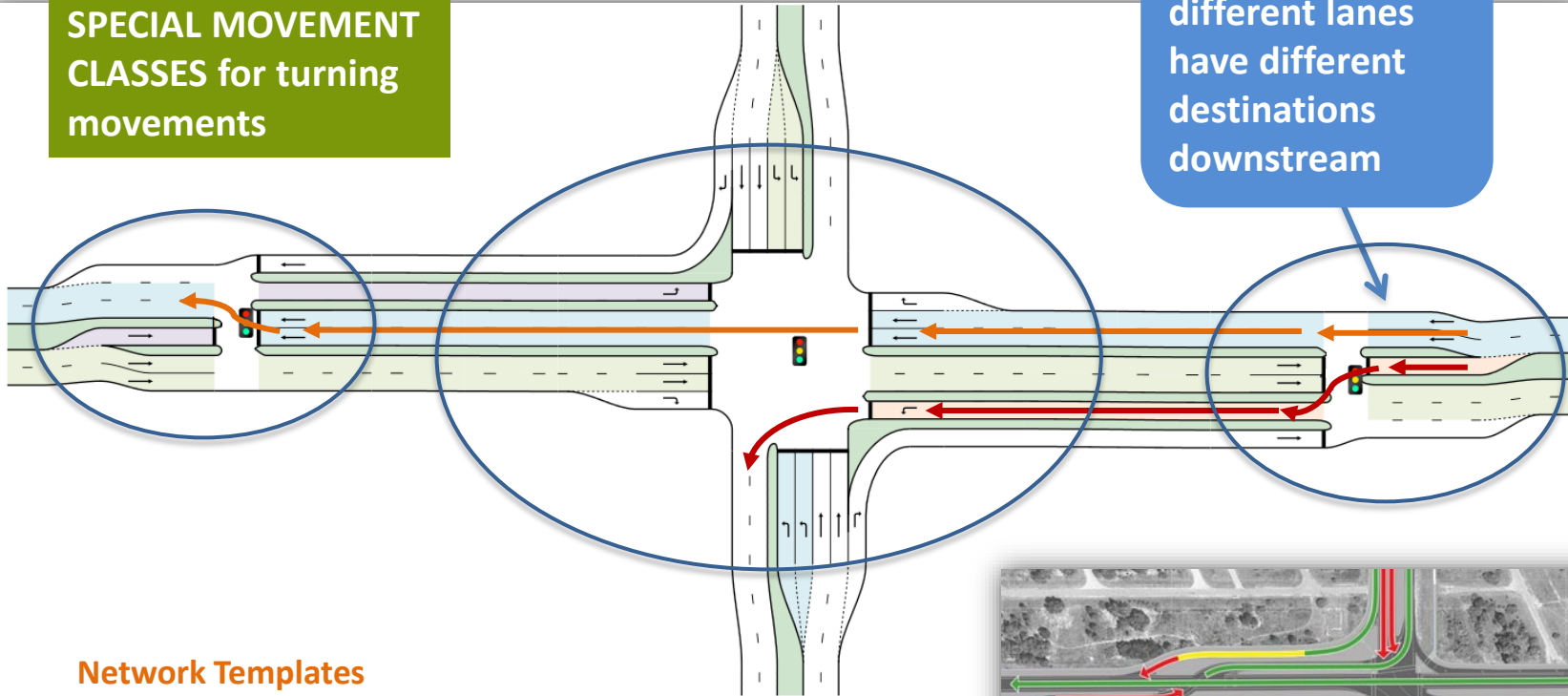
Through traffic
in different lanes
have different
destinations
downstream



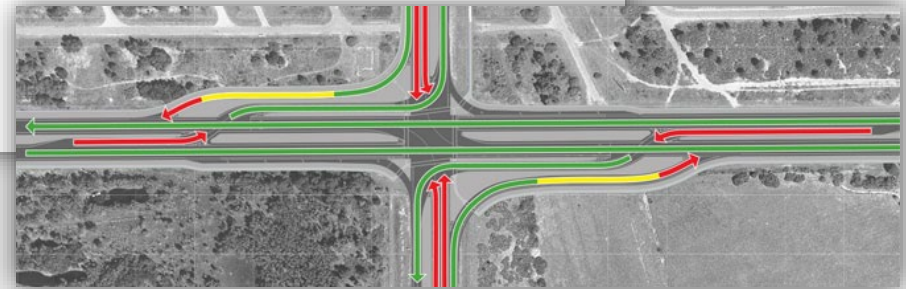
Continuous Flow Intersection (CFI)

Lane allocation by
**SPECIAL MOVEMENT
CLASSES** for turning
movements

Through traffic in
different lanes
have different
destinations
downstream



Network Templates
are available



A selected list of **model extensions** to the HCM offered by SIDRA INTERSECTION

5. Roundabout Metering Signals

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

Congestion caused by **UNBALANCED flow patterns** at roundabouts can be alleviated using metering signals

AKÇELIK, R., SMIT, R. and BESLEY, M. (2014). **Recalibration of a vehicle power model for fuel and emission estimation and its effect on assessment of alternative intersection treatments**. Paper presented at the TRB 4th International Roundabout Conference, Seattle, WA, USA.

www.sidrasolutions.com/publications



SIDRA research contributions to HCM

- **SIDRA (Akçelik) research contributions to HCM**



SIDRA research contributions to HCM

This is a summary of Dr Akçelik's contributions to the Highway Capacity Manual.
See **REFERENCES - SIDRA Research Contributions to HCM** at the end of this presentation.

1. The **second term of the HCM delay equation** is based on the model developed by Akçelik. See **Roess (1983), Roess, Prassas and McShane (2019); Akçelik (1980, 1981, 1988, 1990).**
HCM Edition 7: Chapters 19, 20, 21, 22.

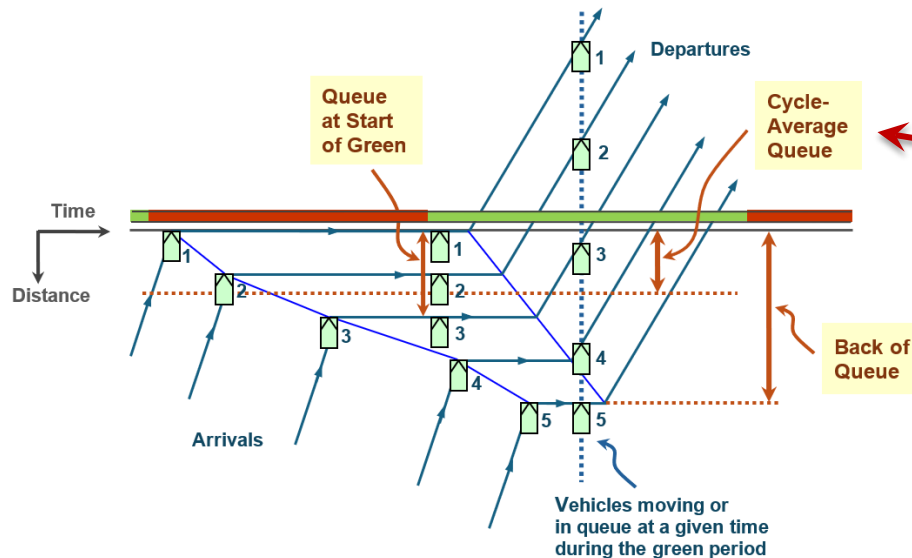
$$d_2 = 900 T \left[(X_A - 1) + \sqrt{(X_A - 1)^2 + \frac{8 k I X_A}{c_A T}} \right] \quad \text{Equation 19-26}$$

Notes:

- The **second term of the queue length equation** is similar to the delay equation.
- An anomaly in the **earlier HCM delay equation** was corrected in HCM 2000 edition.

SIDRA research contributions to HCM

2. A back of queue model developed for signalized intersections was used in HCM 2000 edition. Refer to Chapter 16, Appendix G in HCM 2000. See Akçelik (1998, 2001). HCM Edition 7: Chapter 31 (Sections 3 and 4).



Notes:

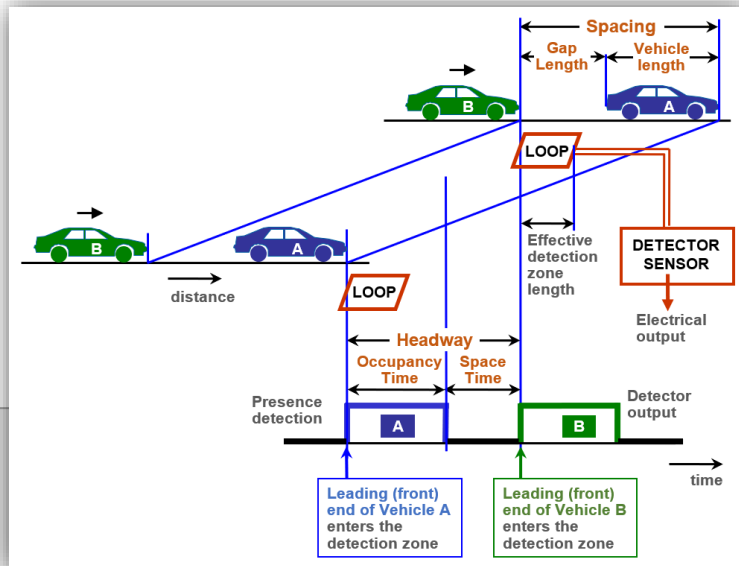
- For roundabouts and sign control, HCM calculates the **cycle-average queue** as the product of the delay and arrival flow rate.
- **Cycle-average queue** is also applicable to **signalized intersections**.

SIDRA research contributions to HCM

3. **Actuated signal analysis method** developed jointly by Prof. Courage and Dr Akçelik was used in HCM 2000. Refer to Chapter 16, Appendix B in HCM 2000.

See Akçelik (1994, 1995); Courage and Akçelik (1994); Courage, et al (1996).

HCM Edition 7: Chapters 19 (Section 2), 31 (Section 2).



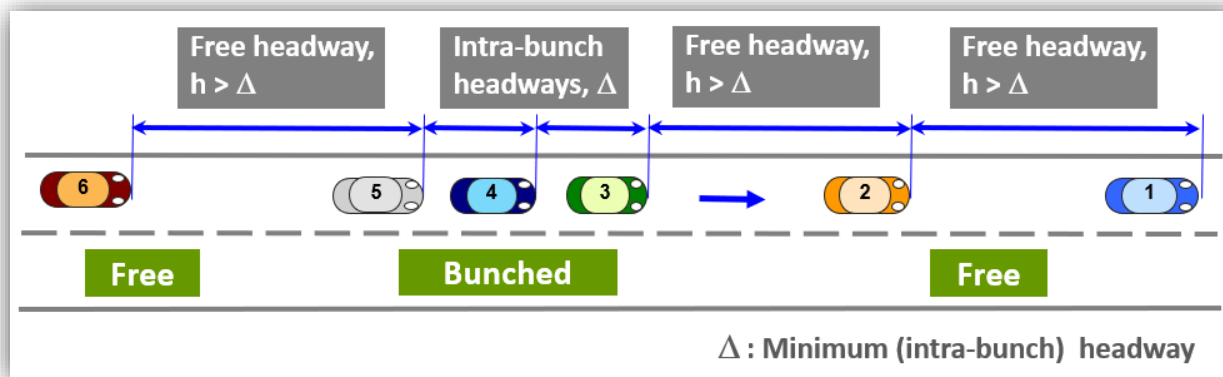
Note:

- Dr Akçelik's early work and the SIDRA software affected the signal timing methods in HCM generally. See Roess (1983); Roess, et al (2019); Akçelik (1980, 1981, 1988, 1990).

SIDRA research contributions to HCM

4. **Bunched exponential model of arrival headway distribution** is used in the actuated signal model. See Akçelik and Chung (1994); Akçelik (2007).

HCM Edition 7: 31 (Section 2).



Note:

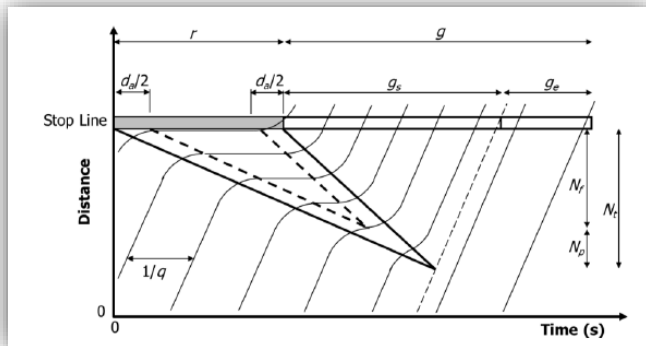
The **HCM roundabout and TWSC capacity equations** are based on simple negative exponential model of arrival headway distributions.

SIDRA research contributions to HCM

5. **Progression Factor (PF_2) for Queue Length** and related performance statistics for signalized intersections was used in HCM 2000. Refer to Chapter 16, Appendix G in HCM 2000. See Akçelik (1995, 1996, 2001).

HCM Edition 7: Chapter 19 (Section 3), Chapter 31 (Section 5)

Exhibit 31-20 (HCM Edition 7, Chapter 31, Section 4))



Note:

Is this "**Progression Adjustment Factor, PF_2** " used in the **HCM back of queue model** for signalized intersections? Author could not find it in Chapters 19 and 31 (there is only **PF** for delay; **PF_2** was used in HCM 2000).

If it is true, this means that progression effects on back of queue length are not taken into account in the HCM.

SIDRA for HCM

Conclusion

Considering that SIDRA and HCM use common fundamental traffic modeling principles, it is recommended that various SIDRA model extensions described here and fully listed on the SIDRA solutions website are considered for future improvements to the Highway Capacity Manual.

sidrasolutions.com/software/sidra-intersection/features/highway-capacity-manual-hcm-sidra-intersection

Document Reference

AKÇELİK, R. (2025). **SIDRA Model Extensions for the Highway Capacity Manual - A short summary**. Presentation at TRB Highway Capacity & Quality of Service (ACP 40) Committee Meeting, Transportation Research Board Annual Meeting, Washington D.C., USA, January 2025.



About SIDRA



References



Most of these references are available for download from
<https://www.sidrasolutions.com/publications>

REFERENCES - SIDRA Model Extensions to the HCM (1)

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END OF PRESENTATION

Thank you!

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