Recent Innovations and Applications in SIDRA INTERSECTION: Lane-Based Network Model

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AITPM 2016 National Conference
Transport Modelling Workshop
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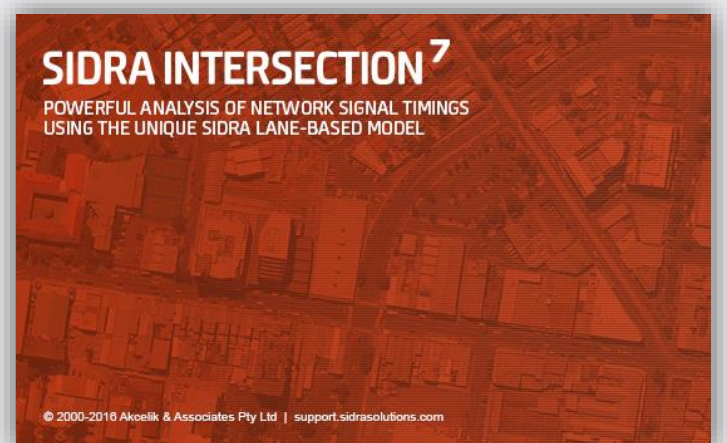
SIDRA INTERSECTION Network Model



The SIDRA INTERSECTION network model is largely built on the sound foundation of the lane-based methodology used in the single intersection model proven via research and used in practice during the last three decades.

The network model elements used beyond single intersection modelling are discussed in this presentation.

See the documentation listed at the end of this presentation. These are downloadable from: sidrasolutions.com/Resources/Articles

This is a modified version of the presentation given at the AITPM Transport Modelling Workshop held in Sydney on 29 July 2016.

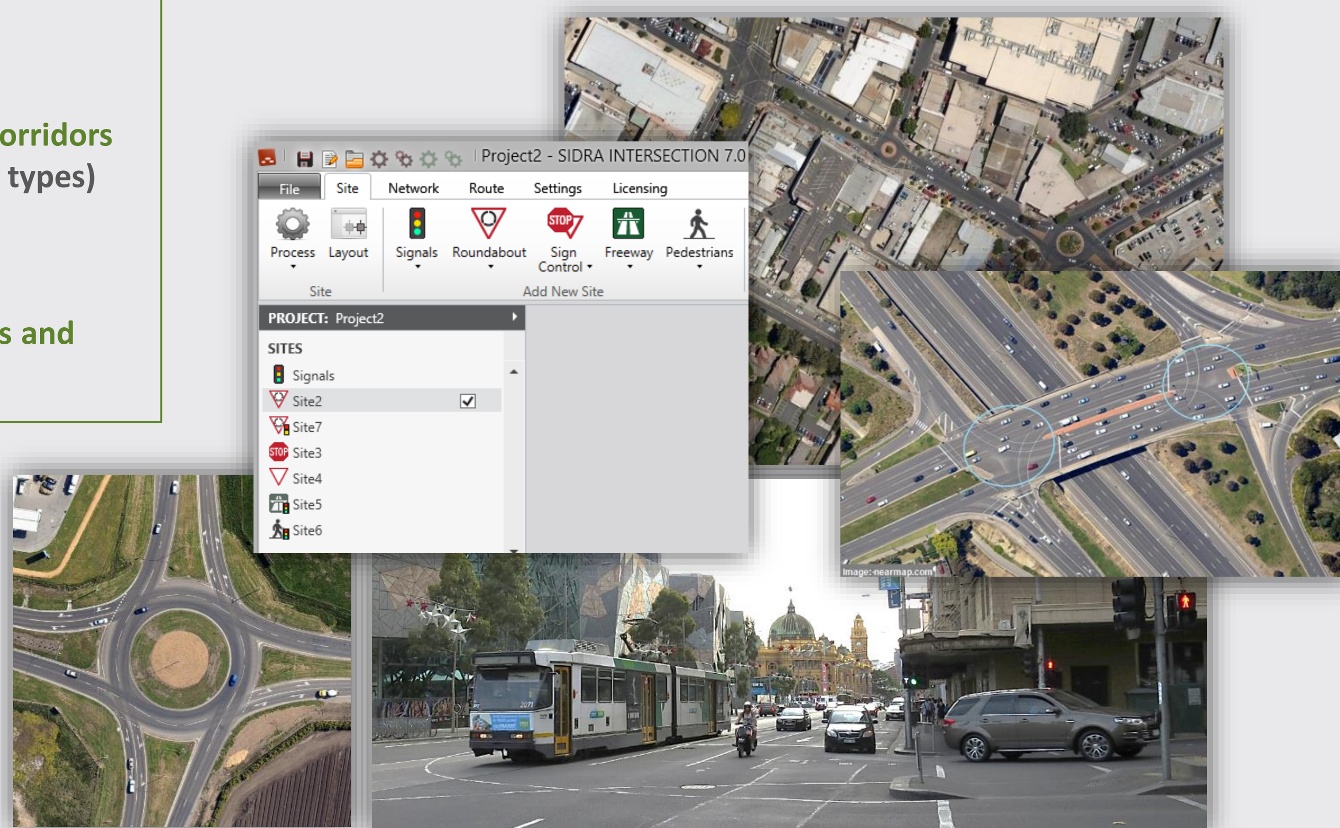
SIDRA SOLUTIONS

CONTENTS of this presentation

SIDRA SOLUTIONS

SIDRA INTERSECTION areas of application

- SINGLE INTERSECTIONS
- NETWORKS
  - General networks and corridors (any mix of intersection types)
  - Closely-spaced (paired) intersections
  - Alternative intersections and interchanges



SIDRA INTERSECTION areas of application

SINGLE INTERSECTIONS

- Signalised (Fixed-Time, Actuated)
- Roundabouts
  - Unsignalised
  - Roundabout Metering
- Sign Control
  - Two-Way Stop
  - Two-Way Give-Way
  - All-Way Stop
- Single-Point Interchange
- Pedestrian Crossings (Signalised and Unsignalised)
- Merging

NETWORKS

- General networks and corridors (any mix of intersection types)
- Closely-spaced (paired) intersections
  - Staggered T intersections
  - Freeway Diamond Interchange
  - Roundabout Interchange
  - Wide-Median Intersection (Signalised and Unsignalised)
  - Fully Signalised Roundabout
  - Staged Crossing (Unsignalised)
- Alternative intersections and interchanges
  - Diverging Diamond Interchange
  - Continuous Flow Intersection
  - Others

The relatively new network model is the subject of this presentation

NETWORK SIGNAL TIMING

- Common Control Group (single controller)
- Network timing for signal coordination.

SIDRA INTERSECTION network model background

- First released in 1984
- Continuous development in response to user feedback
- SIDRA INTERSECTION 6.0 | 6.1 | 7.0 (NETWORK Model)

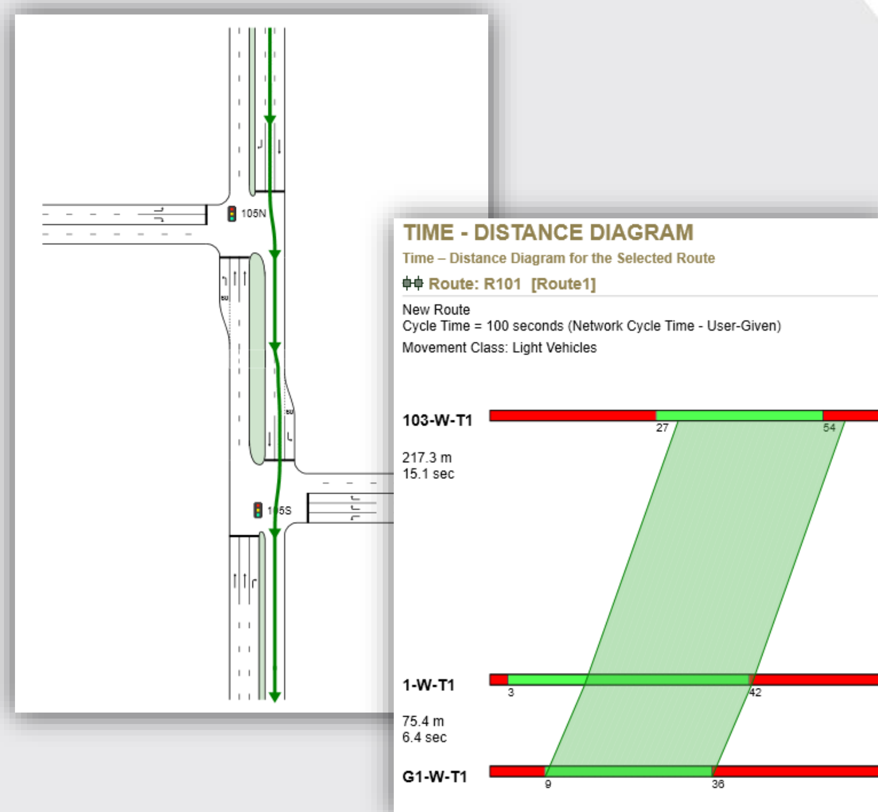
Versions 6.0 | 6.1 | 7.0 released during April 2013 – April 2016.

Biggest changes in the 30-year history of the software

- Network Model
- Network Timings for
  - Signal Coordination
  - Common Control Groups
- Routes
- Movement Classes

SIDRA INTERSECTION Version 7 new features

- **Network signal timings**
  (CYCLE TIME, PHASE TIMES and SIGNAL OFFSETS)
- **Common Control Groups**
  (**cycle time and green split** method for multiple Sites controlled by a single controller)
- **ROUTES** for performance reports and displays, and for signal **Offset** calculations
- **Network output by Routes**
  (Route Output Comparison and
  Network Output Comparison by Routes)
- Larger number of **User Movement Classes**
- New **roundabout capacity model** option for HCM Edition 6 (to be available soon)
- Many model and user interface improvements



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Detailed LANE-BASED Network Model

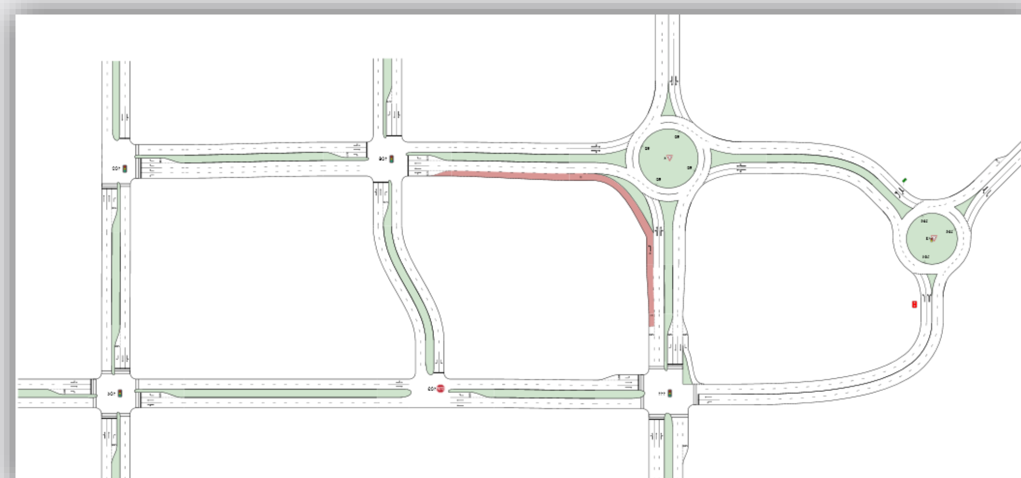
Unique lane-based NETWORK MODEL

All intersection types
(signals, roundabouts, sign control)

Paired Intersections and
larger networks

Easy to CONFIGURE using Sites:

In SIDRA INTERSECTION,
the Sites and their connections
define the Network.



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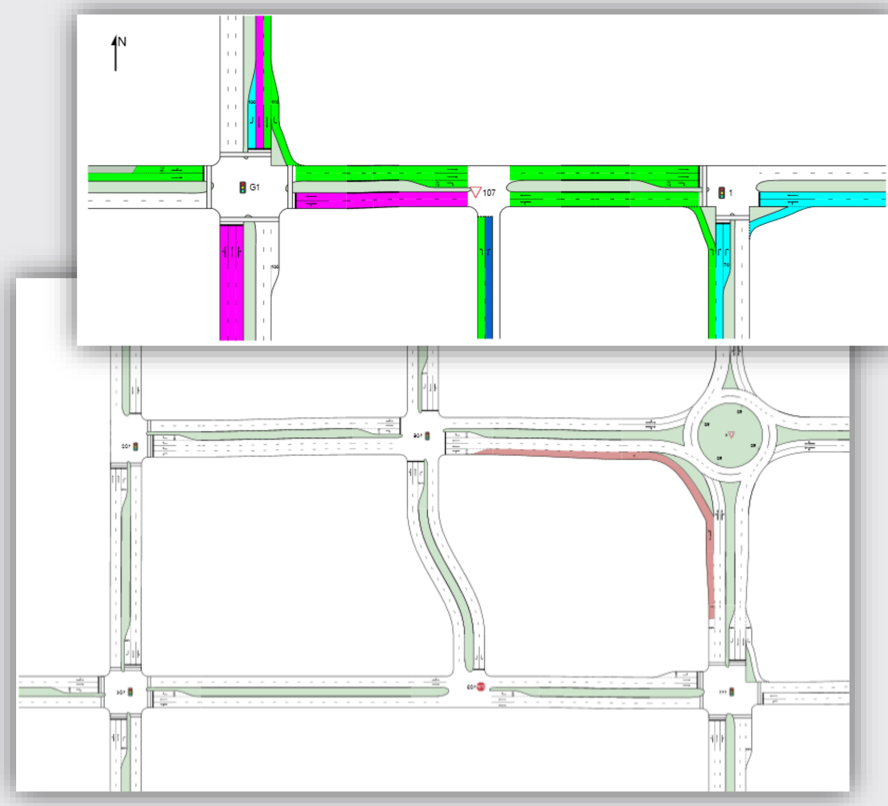
Basic Aspects of the Lane-Based Network Model

- Lane-based modelling **for intersections**
- Lane-based **network model with MIDBLOCK LANE CHANGES**
- **Lane blockage**, **capacity reduction** and **capacity constraint** using an iterative method
- Importance of the **back of queue** model and **lane-based probability of blockage**
- Use of **Special Movement Classes** for closely-spaced intersections
- **Signal platoon** model



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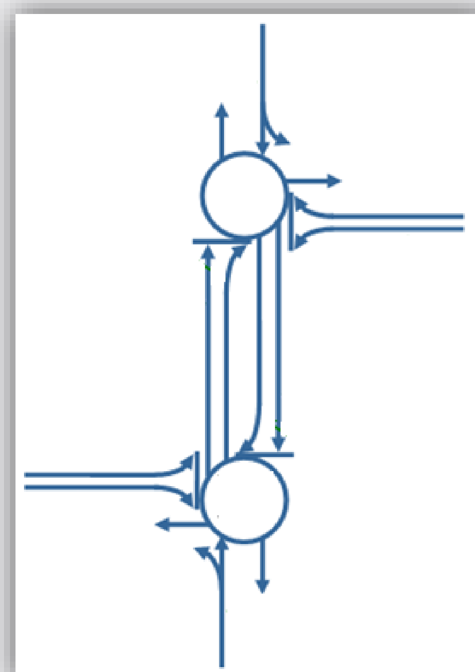
Lane-Group (Link) Based Modelling

In traditional lane-group (link) based network models:

- individual lane conditions are aggregated
- there is not sufficient information about queue lengths, lane blockage probabilities, backward spread of queues, and so on
- there are unnecessary approximations in the saturation flow estimation process and this affects:
  - capacity estimation therefore estimation of all performance parameters including queue length
  - signal timing (cycle time and green time) calculations.

Lane level of detail helps with capacity and performance estimation as well as signal timing analysis.



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Lane-Based Network Model

A lane-based model is particularly important in evaluating

- closely-spaced (paired) intersections
- high demand flows
- cases where vehicles have limited opportunities for lane changing between intersections.

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Importance of Lane-Based Model

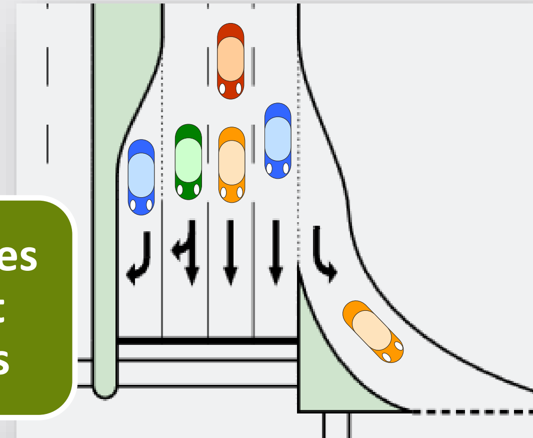
LANE-BASED (all model steps)

INPUT >> MODEL >> OUTPUT

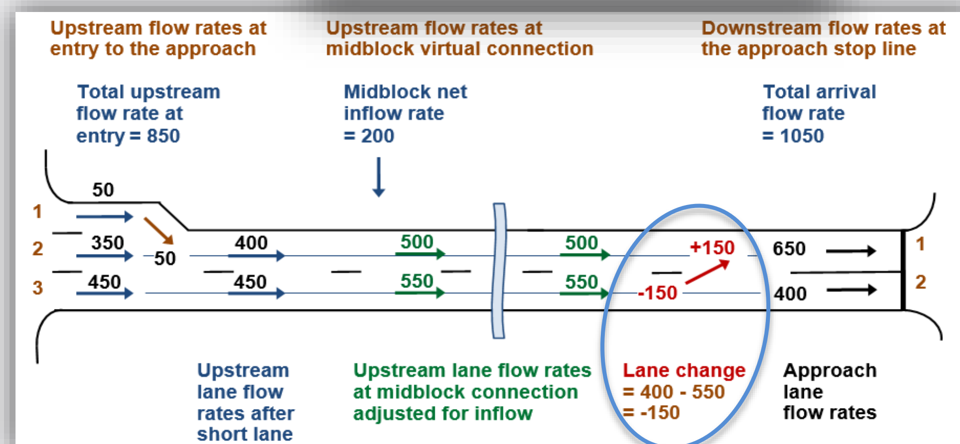
Important for

- **INTERSECTIONS**
- **NETWORKS**
  Lane queues, queue spillback, capacity constraint, signal platoon arrival and departure patterns, midblock lane changes.

Individual lanes have different characteristics



Midblock Lane Changes



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Movement Classes

Light Vehicles

Heavy Vehicles

Buses

Bicycles

Large Trucks

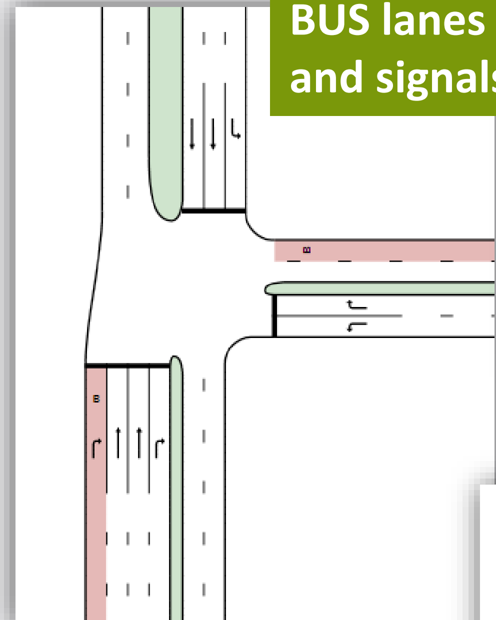
Light Rail / Trams

User Classes
(for special movement treatment)

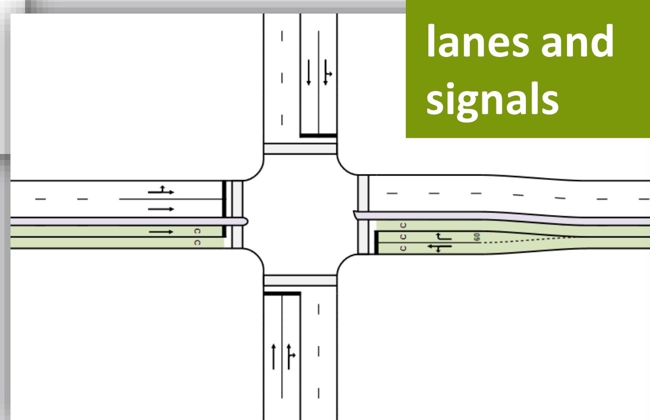
Combined with the lane-based method, Movement Classes allow modelling of **BUS PRIORITY, BICYCLE and LIGHT RAIL / TRAM lanes and signals**, and so on …

Examples: Bus Priority and Bicycle Lanes and Signals

BUS lanes and signals



BICYCLE lanes and signals



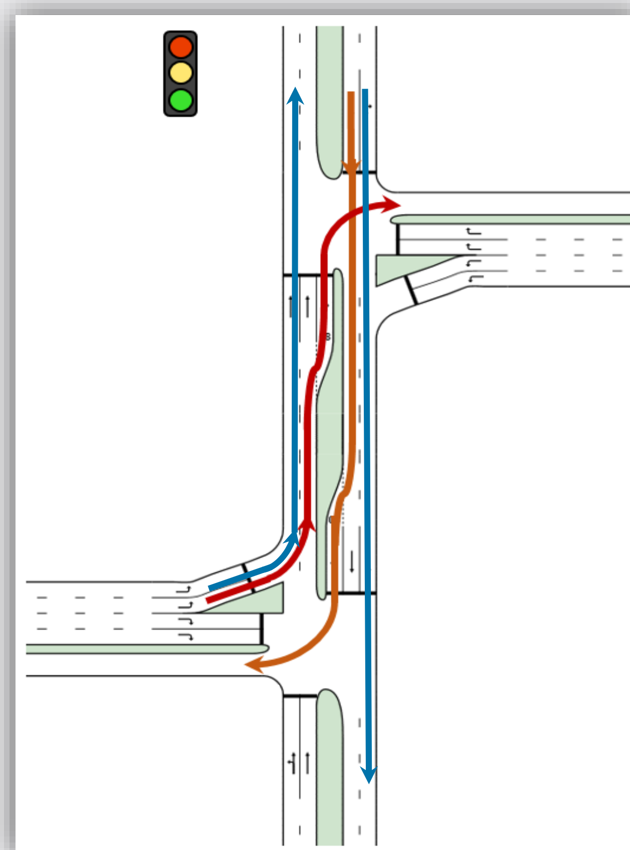
The use of Special Movement Classes

Examples of Special Movement Classes include:

- **dogleg movements** at staggered T intersections, and
- **through movements that become turning movements** at downstream internal approaches.

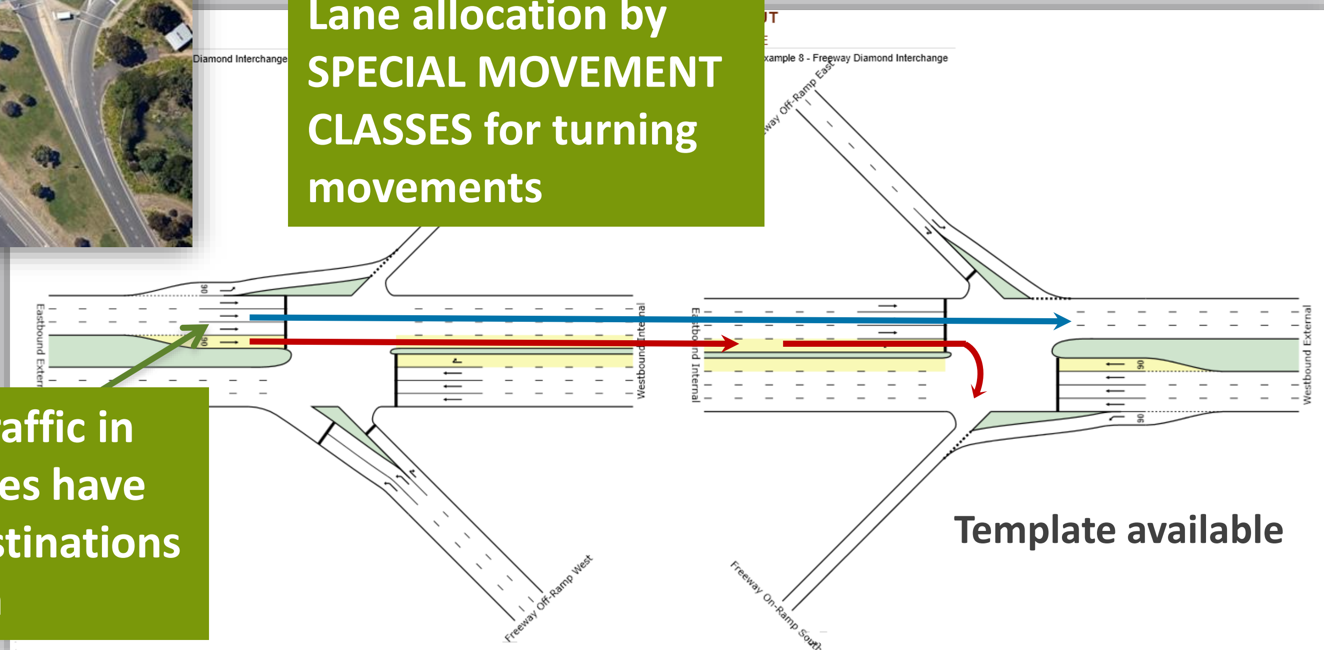
These movements can be assigned to separate lanes and separate signal phases, and their second-by-second platoon patterns can be tracked separately.

The use of Special Movement Classes allows better estimation of unequal lane use.



Network Examples:
Freeway Diamond Interchange

Doncaster Road - Eastern Freeway, Melbourne



Lane allocation by SPECIAL MOVEMENT CLASSES for turning movements

THROUGH traffic in different lanes have different destinations downstream

Template available

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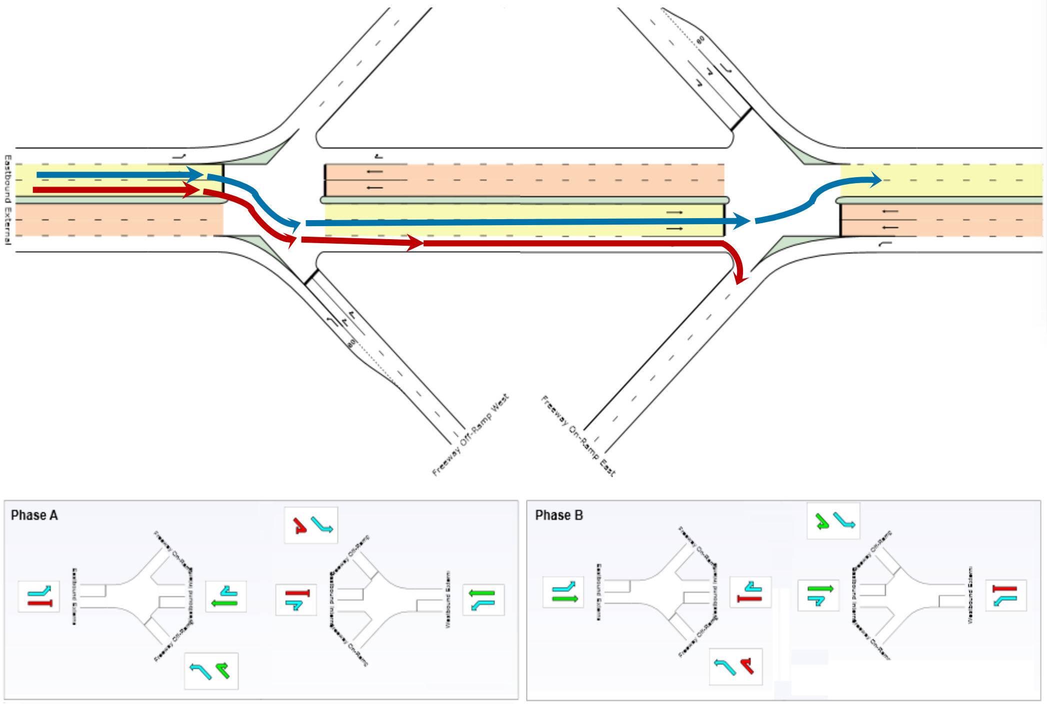
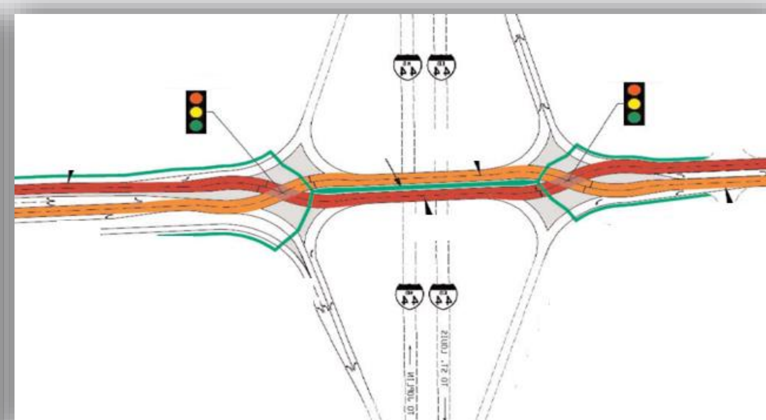
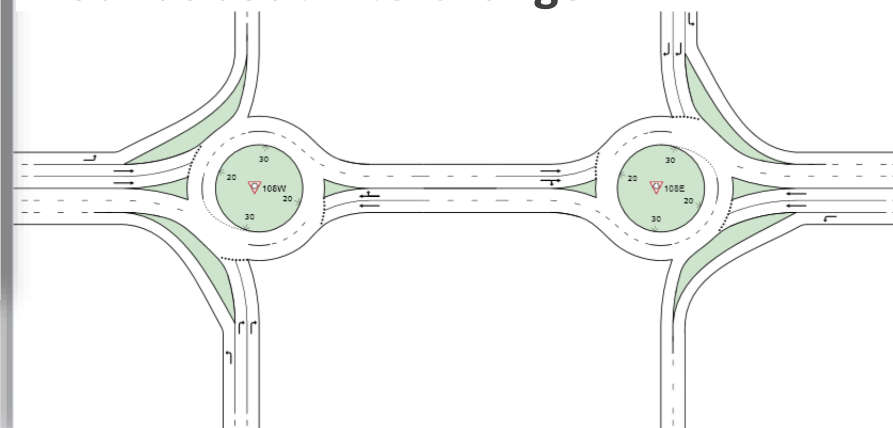
Network Examples:
Diverging Diamond Interchange, Roundabout Interchange

Diverging Diamond Interchange





Roundabout Interchange



Mike van Tonder (South Africa) - AITPM 2013 National Conference

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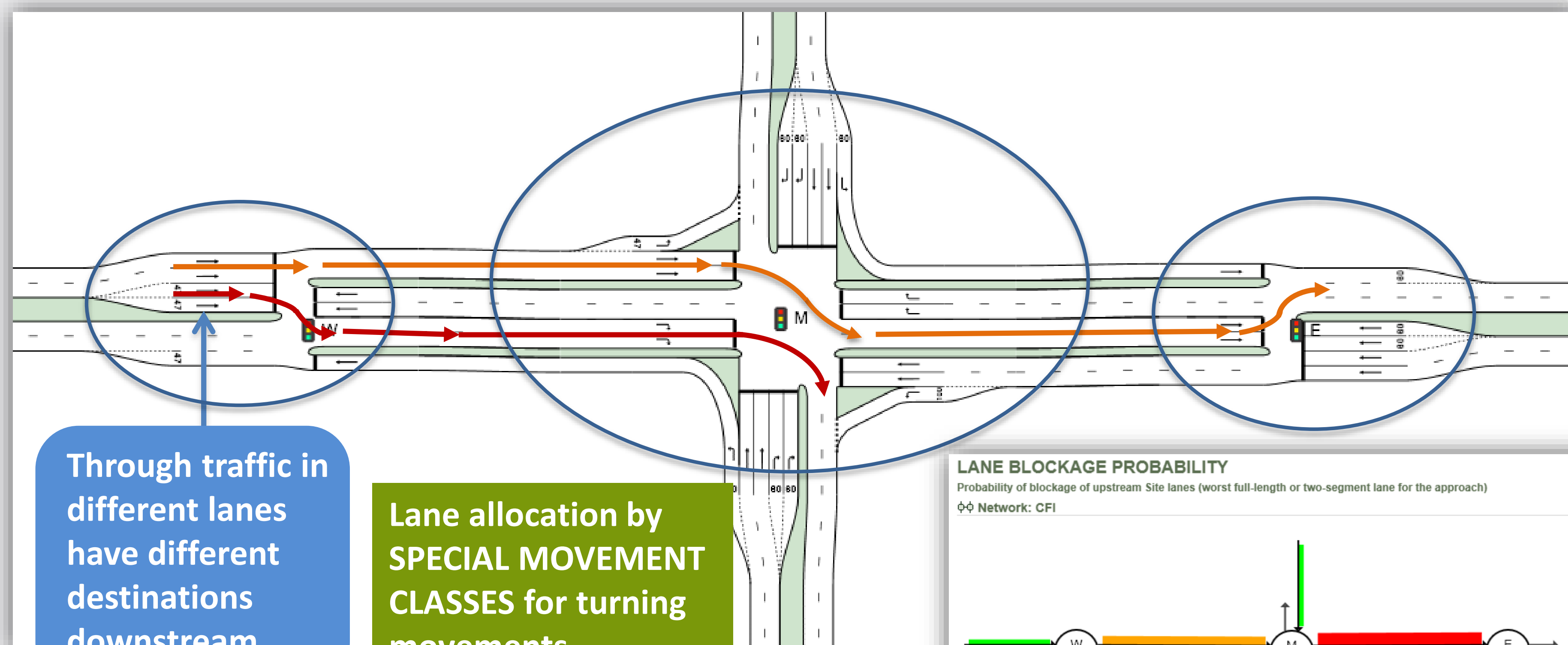
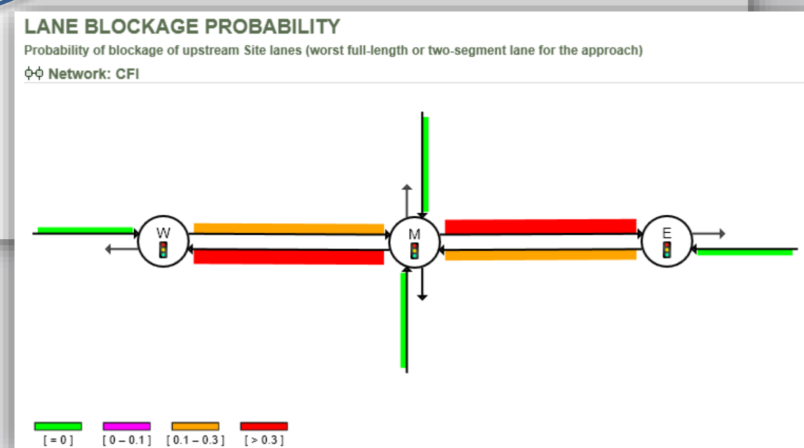
Network Examples:
Continuous Flow Intersection (CFI)



Through traffic in different lanes have different destinations downstream

Lane allocation by SPECIAL MOVEMENT CLASSES for turning movements



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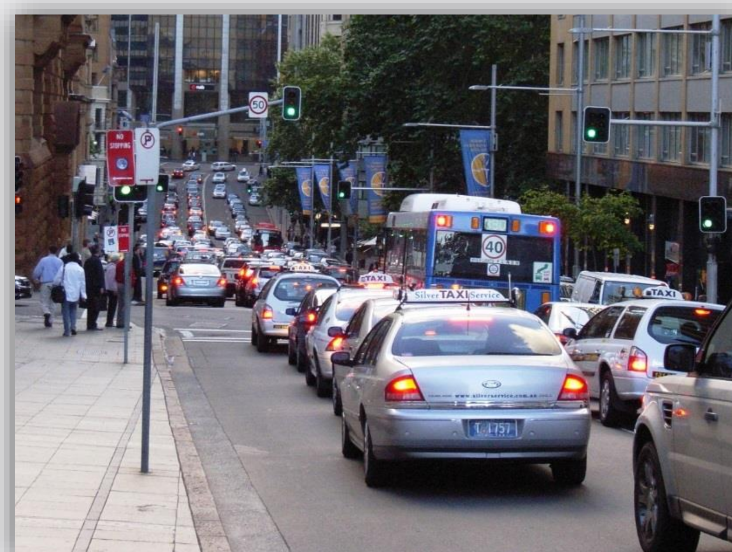
Iterative method for LANE BLOCKAGE and CAPACITY CONSTRAINT

Backward spread of congestion (reduced upstream capacity) → ← **Capacity constraint (reduced downstream arrival flows)**

- **Backward spread of congestion** and **capacity constraint** are highly interactive with opposing effects.
- SIDRA INTERSECTION uses a **network-wide iterative process** to find a solution that balances these opposing effects.
- Backward spread of congestion and capacity constraint are common to **all intersection types**.



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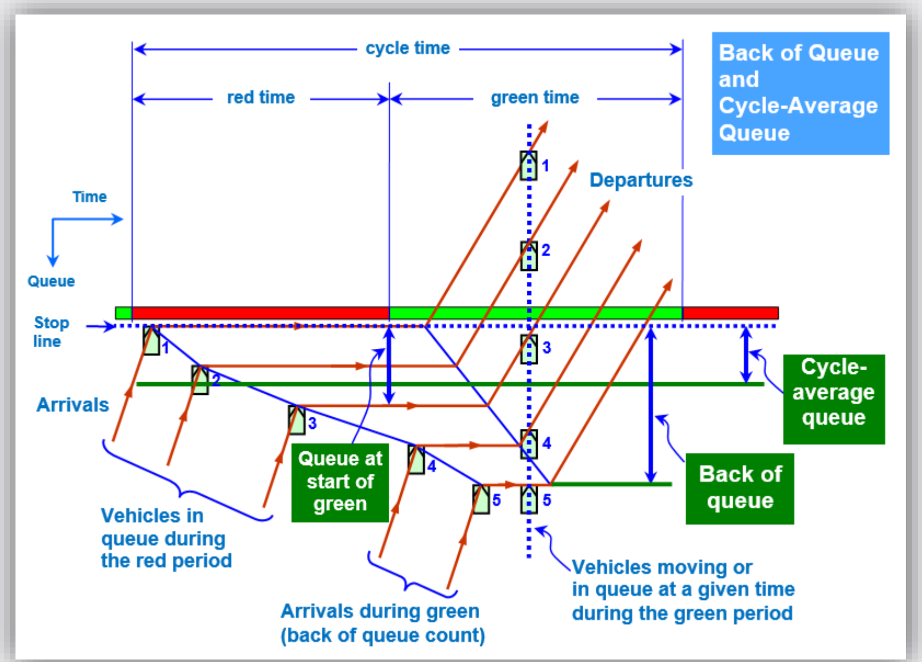
Importance of Back of Queue Model

Back of Queue Percentile and Probability of Blockage values are based on the variability of back of queue values in individual lanes

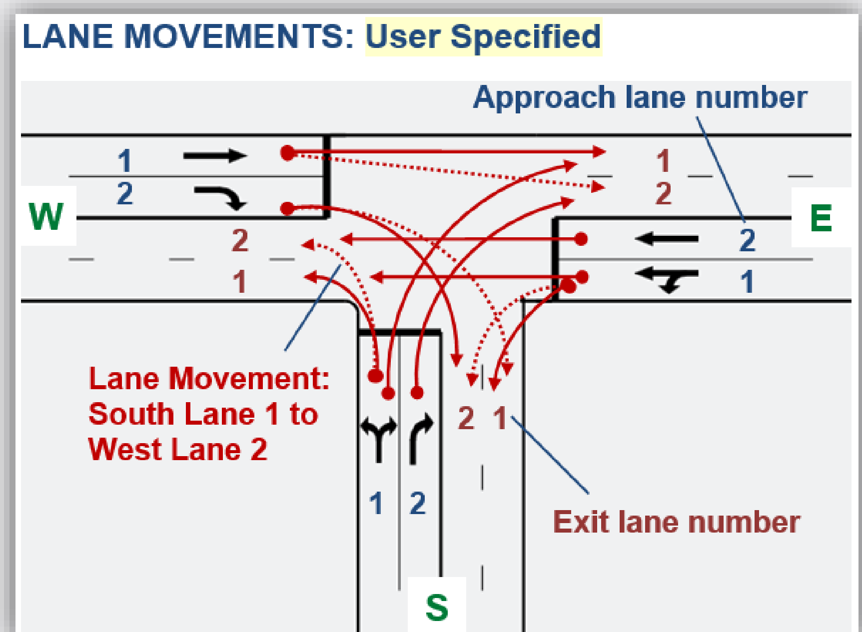


Back of Queue is important for modelling of short lane overflow and queue spillback in networks

Lane Movement Flow Proportions for signal platoons, lane blockage and midblock lane changes

Lane Movement Flow Proportions is an important parameter that determines:

- which **exit lanes** are chosen by departing approach vehicles (hence affect **midblock lane change rates** and **signal platoon patterns**)
- which upstream lanes are affected by **lane blockage** (hence **reduced capacity**).



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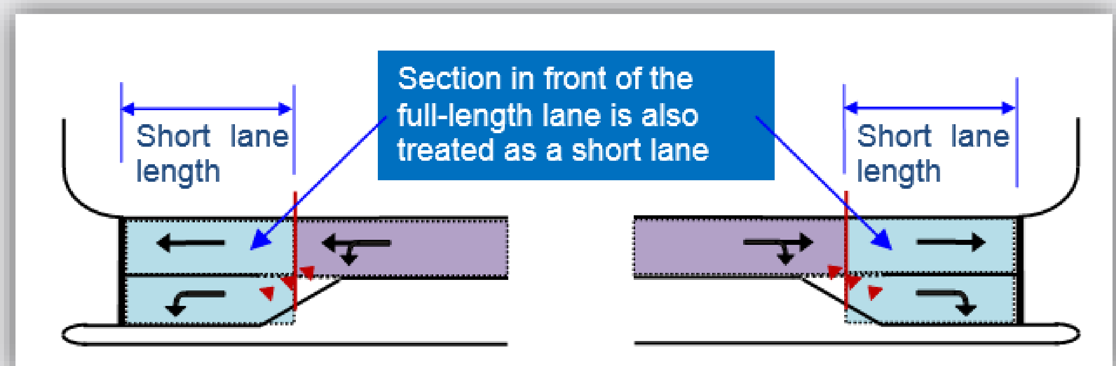
Short Lane Model for signal platoons and lane blockage

Changes introduced to the model used in old version of the software due to the **requirements of Network Model**:

- Stop-line saturation flow rates (headways) are needed for **second-by-second platoon departure patterns**.
- **Short lane overflow** into a full-length lane **blocking upstream intersection lanes**.



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Signal Timings for Common Control Groups

New cycle time and green split method for multiple Sites controlled by a single controller (Common Control Group)

TIMING ANALYSIS FOR COMMON CONTROL GROUP

Common Control Group: 209 [Fwy Int]
Network: 209 [Freeway Diamond Interchange]

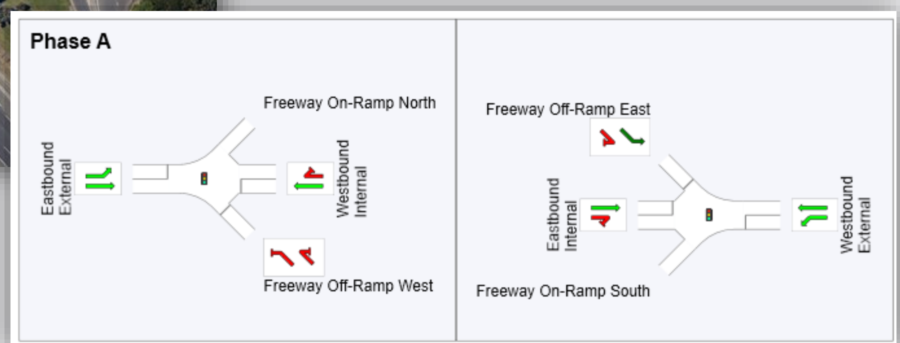
Fixed Time Isolated Cycle Time = 90 seconds (User-Given Cycle Time)

Phase times determined by the program
Sequence: CCG Phasing
Input Sequence: A, C, D
Output Sequence: A, C, D

Critical Movements and Cycle Time

Site ID	Critical Mov ID	Appr & Dest	Green Period	Phases [From	To]	Adjusted Lost Time sec	Adjusted Flow Ratio	Req Green Time Ratio	Required Mov Time sec
209W	6WLF	W_E	1	A	C	6	0.277	0.308	33.7
209E	4ELF	W_SW	1	C	D	6	0.196	0.218	25.6
209W	1WLV	SE_W	1	D	A	6	0.229	0.255	28.9
					Total	18	0.703	0.781	88.3

Cycle Time (sec):	Minimum	Maximum	Practical	Chosen
	36	150	82	90



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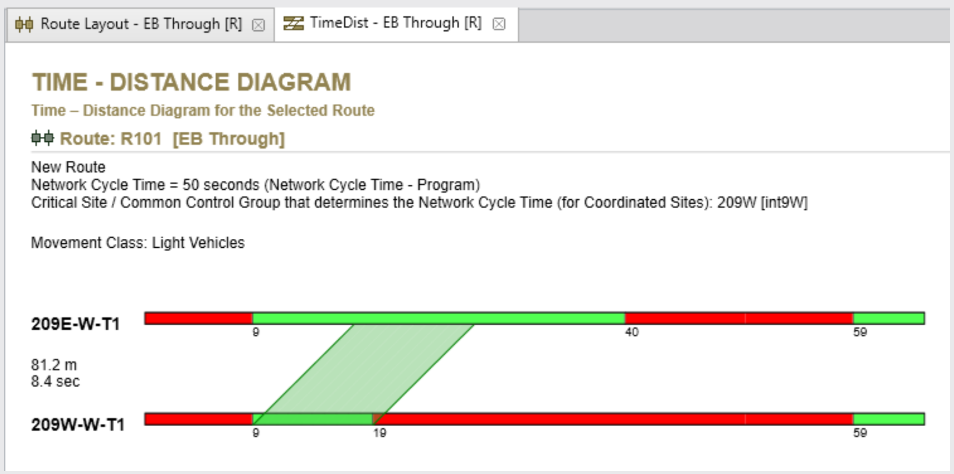
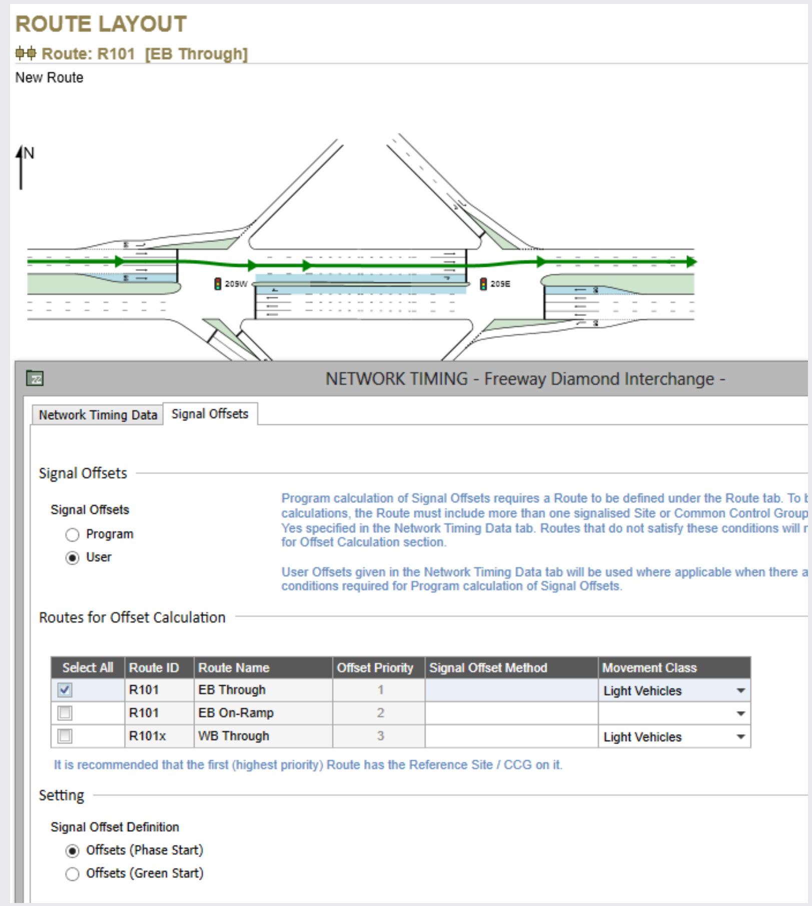
Network timing method for signal coordination

Network timing for signal coordination (different from Common Control Groups)

- Network Cycle Time and Green Splits
- Offsets for specified Routes





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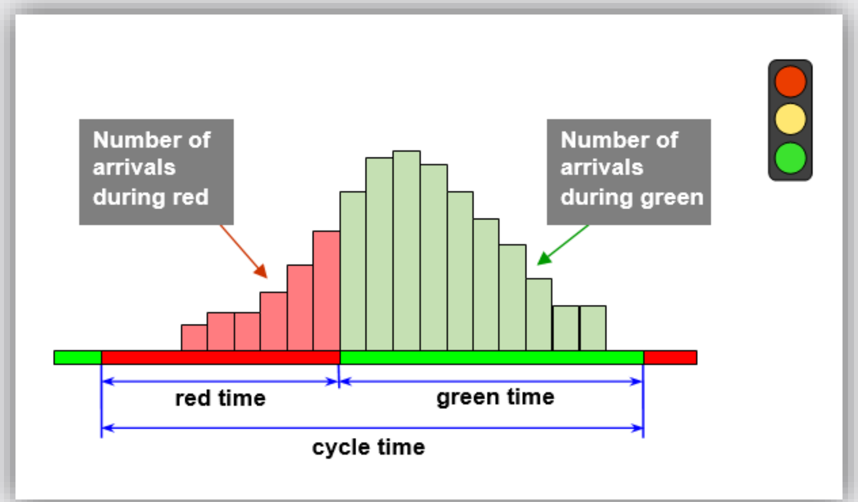
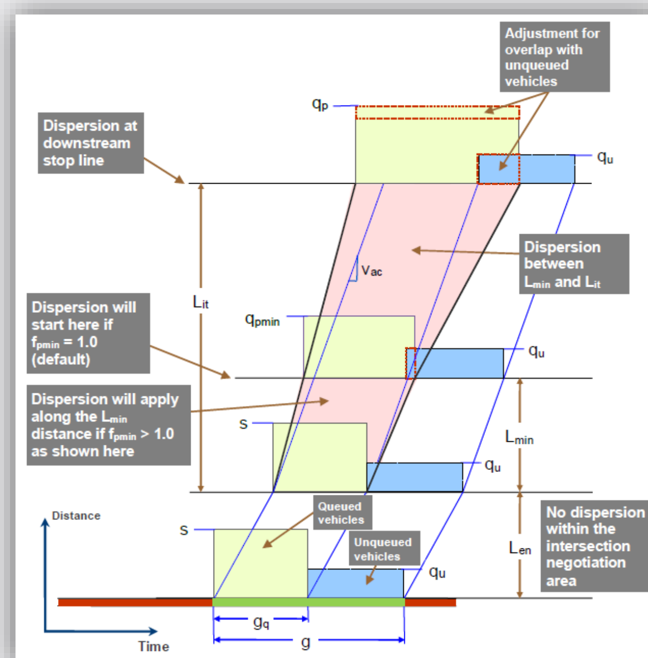
Signal Platoon Patterns

Using **signal offsets,** lane-based (not link-based) second-by-second platoon patterns are modelled to estimate:

- Percent Arriving During Green
- Platoon Ratio
- Arrival Types



Option for no PLATOON DISPERSION (for very short distances between intersections)



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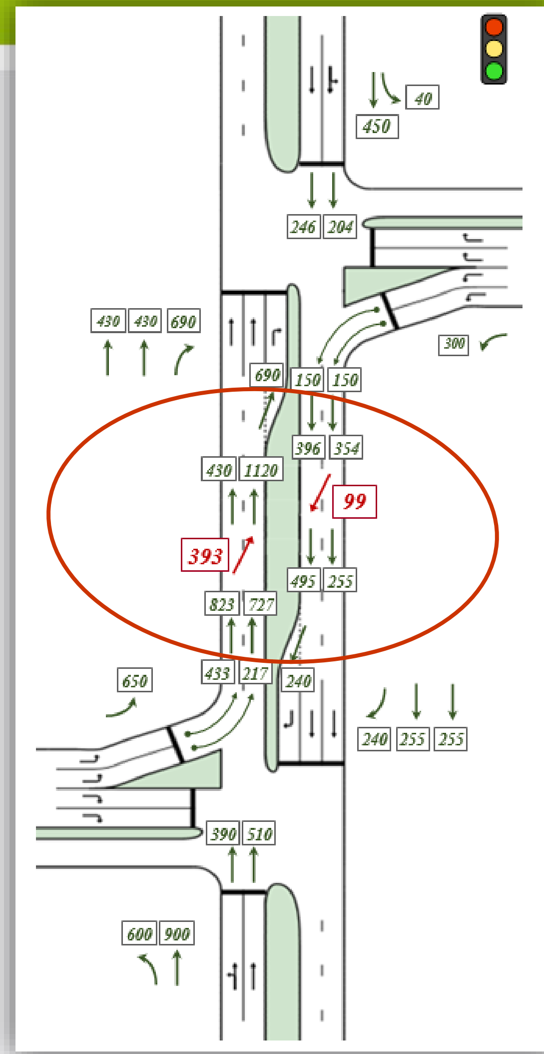
Lane-based Modelling of SIGNAL PLATOONS

The **lane-based** modelling of **platoon arrival patterns** at downstream approach lanes takes into account:

- **midblock lane changes** based on matching of upstream and downstream lane flow rates,
- **midblock inflow and outflow rates** implied by turning volumes, and
- **Movement Classes** (Light Vehicles, Heavy Vehicles, Buses, etc.) due to different lane use and approach cruise speeds.



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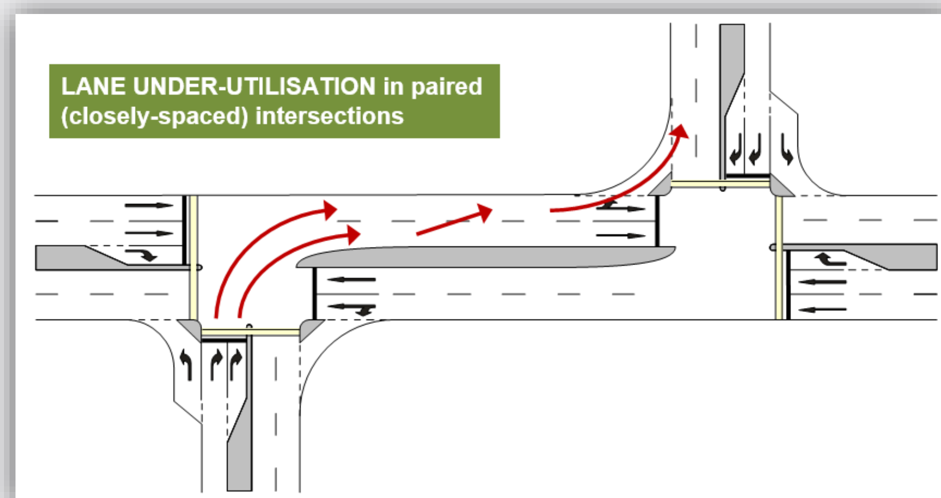
Unequal lane use at closely-spaced (paired intersections)

Modelling of unequal lane use at closely-spaced intersections is emphasised (significant effects on traffic performance and signal timing results).

This method coupled with a lane-based model allowing for:

- the backward spread of congestion,
- upstream capacity constraint,
- special movement classes,
- midblock lane changes,
- as well as features such as short lane overflow

produces improved results in assessing signal coordination quality and optimising signal offsets.



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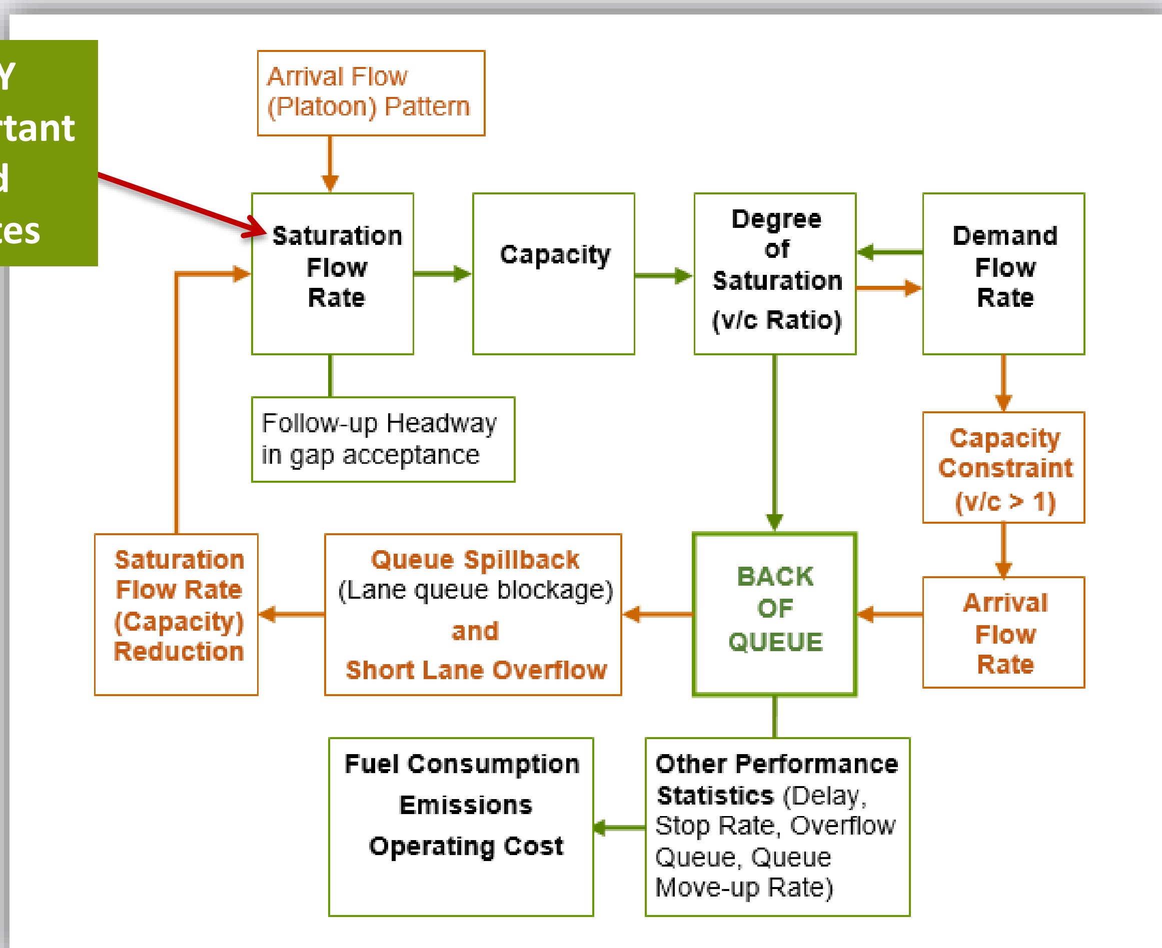
Summary:
Unique features of the lane-based network model

Estimation of this KEY PARAMETER is important for signal timings and performance estimates



The orange-coloured boxes and lines in this flow chart show the unique aspects of the SIDRA INTERSECTION network model.

The central role of Back of Queue (average and probabilities) in this process is emphasised.

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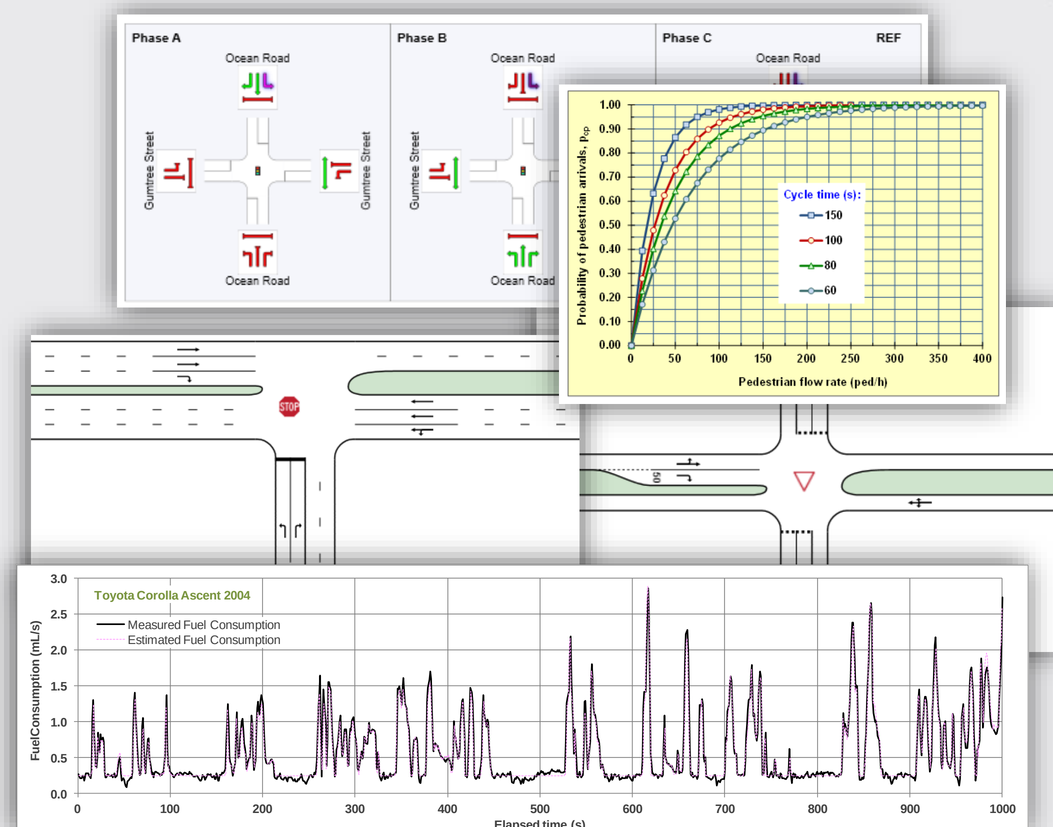
Other innovations …

- **Signal timings :**
  - Phase Frequency (e.g. SCATS)
  - Phase Actuation
  - Pedestrian Actuation
- **Two-way sign control model**: gap acceptance parameters are adjusted as a function of geometry and other conditions
- **Fuel consumption and emission models**: calibration for modern vehicles



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Case Study:
Road corridor in the historical city of Lucca (Tuscany, Italy)

University of Pisa researchers studied a 1.5 km road corridor with seven intersections including signals, roundabouts and two-way stop controlled intersections. The SIDRA NETWORK model used to analyze two scenarios showed that significant improvements could be made to traffic performance in the road corridor.

The researchers concluded:

> "This study has been possible thanks to SIDRA INTERSECTION (NETWORK version) that showed its capability of modelling both single intersections and the road corridor."

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Case Study: Beaconsfield Parade, Melbourne, Australia
VIC ROADS corridor project with bike lanes

"AM peak driving time between two points estimated by SIDRA INTERSECTION was much the same as the measured driving time between the same points."

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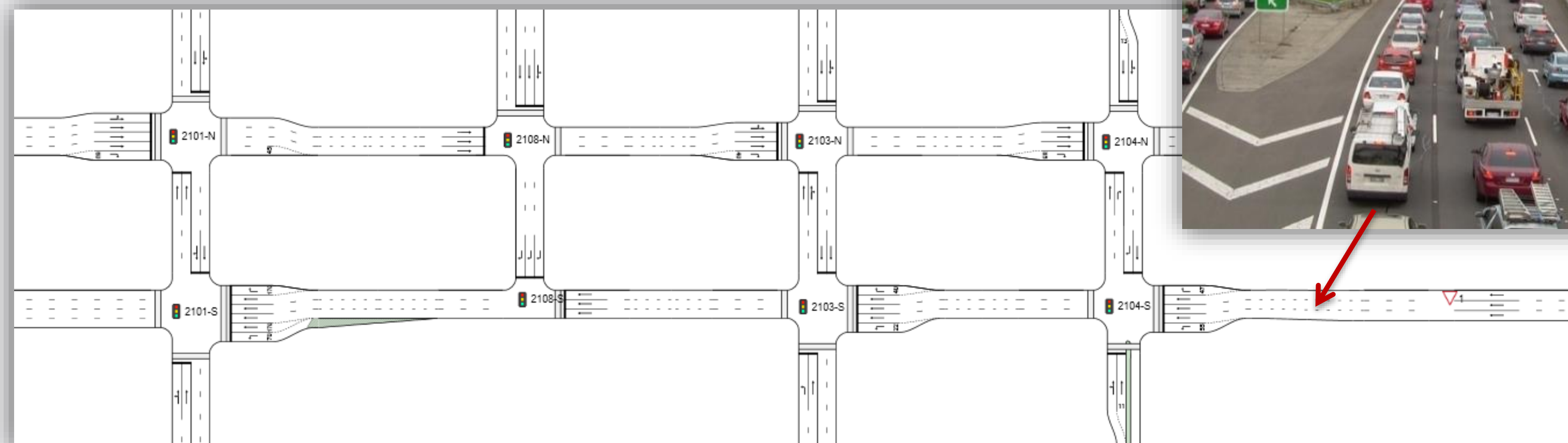
Case Study: Alexandra Parade, Melbourne, Australia Congested Corridor (Yumlu, et al 2014)

"The estimated 95th percentile back of queue values for westbound lanes for the 7.45 - 8.00 AM peak period were 2.9 to 3.3 km which is close to the observed value of 3.5 km."



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Documentation on SIDRA INTERSECTION Network Model - 1

Download from sidrasolutions.com/Resources/Articles

1. AKÇELIK, R. (2016). Comparing lane based and lane-group based models of signalised intersection networks. Paper presented at the TRB 7th International Symposium on Highway Capacity and Quality of Service (International Symposium on Enhancing Highway Performance (ISEHP)), Berlin, Germany, Jun 2016. Full paper published in Transportation Research Procedia, Vol 15, 2016, pp. 208-219
2. AKÇELIK, R. and BESLEY, M. (2015). Alternative Intersection Analysis Using SIDRA INTERSECTION. Presentation at the ITEANZ Innovative Intersections Seminar, Melbourne, November 2015.
3. AKÇELIK, R. (2015). Development of Network Signal Timing Methodology in SIDRA INTERSECTION. Presentation at the New Zealand Modelling Use Group Conference (NZMUGS 2015), Auckland, New Zealand, Sep 2015.
4. AKÇELIK, R. (2015). Modelling signal platoon patterns by approach lane use and movement class. Paper presented at the 21st International Conference on Urban Transport and the Environment (URBAN TRANSPORT 2015), Valencia, Spain, June 2015.

Continued >>

Documentation on SIDRA INTERSECTION Network Model - 2

Download from sidrasolutions.com/Resources/Articles

5. NICOLI, F., PRATELLI, A. and AKÇELIK, R. (2015). Improvement of the West road corridor for accessing to the New Hospital of Lucca (Italy). Paper presented at the *21st International Conference on Urban Transport and the Environment (URBAN TRANSPORT 2015)*, Valencia, Spain.
6. AKÇELIK, R. (2014). A New Lane-Based Model for Platoon Patterns at Closely-Spaced Signalised Intersections. Paper presented at the 26th ARRB Conference, Sydney.
7. YUMLU, C., MORIDPOUR, S. and AKÇELIK, R. (2014). Measuring and Assessing Traffic Congestion: a Case Study. Paper presented at the AITPM Annual Meeting, Adelaide, Australia.
8. AKÇELIK, R. (2014). Modeling Queue Spillback and Upstream Signal Effects in a Roundabout Corridor. TRB 4th International Roundabout Conference, Seattle, WA, USA.
9. AKÇELIK, R. (2013). Lane-based micro-analytical model of a roundabout corridor. CITE 2013 Annual Meeting, Calgary, Alberta, Canada.

End of Presentation

Thank you!

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