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SIDRA SOLUTIONS

# SIDRA INTERSECTION FEATURES

## Technical Note

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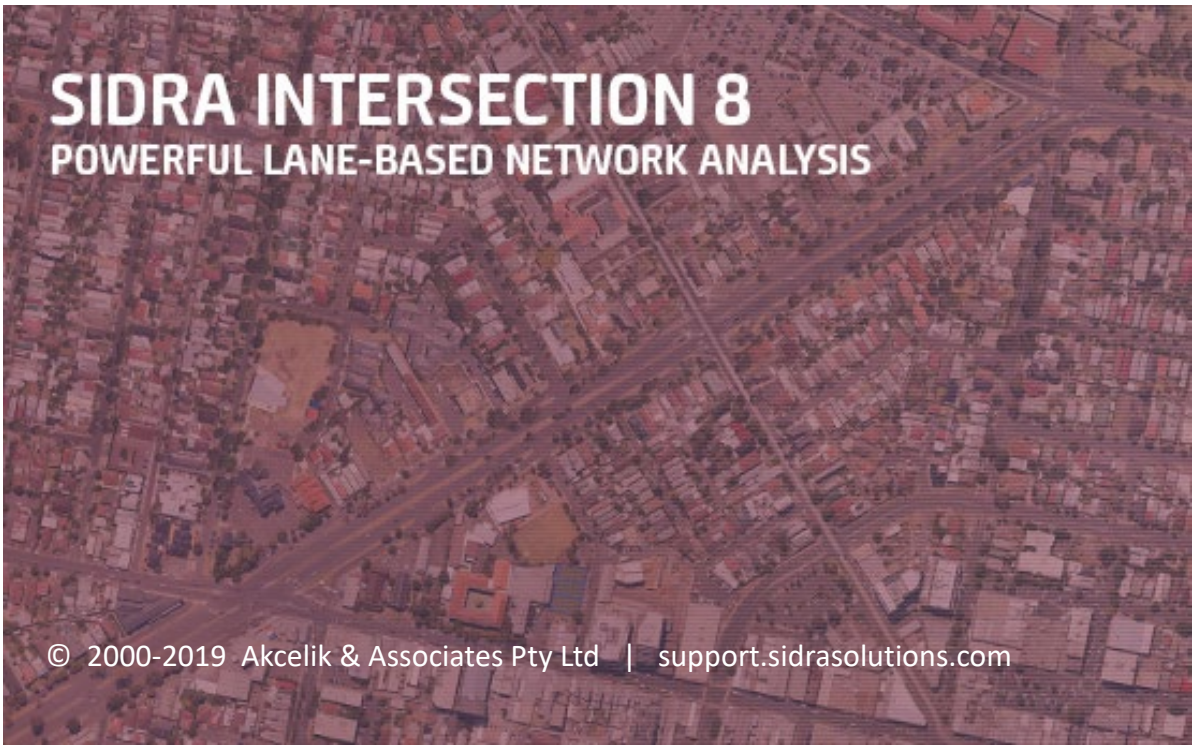
SIDRA INTERSECTION 8
POWERFUL LANE-BASED NETWORK ANALYSIS
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## ACKNOWLEDGEMENTS

**Akcelik & Associates Pty Ltd acknowledges the contributions by numerous users from many countries around the world through their valuable comments towards the development of SIDRA SOLUTIONS software products.**

**Quality Management System Certificate # QEC27492**

# SIDRA INTERSECTION Features

## CONTENTS

# 1 INTRODUCTION

SIDRA INTERSECTION is a software package for the analysis of both single intersections and networks of intersections. Thus, it can be used for analysing closely-spaced (paired / compound) intersections, pedestrian crossings near intersections, interchanges, and for general network applications (currently up to 20 Sites are allowed).

The important aspects of modelling closely-spaced intersections are blockage of upstream entry lanes due to queues in limited storage space of downstream intersection lanes, capacity reduction due to lane blockage, capacity constraint that applies to oversaturated lanes, and platooned arrivals from upstream signalised intersections. These are discussed below in a little more detail.

In SIDRA INTERSECTION, the Sites and their connections define the Network. This allows the user to model many different network configurations, including some very complex arrangements, with ease.

The modelling applies to both undersaturated and oversaturated cases, i.e. covers the full range of degrees of saturation (v/c ratios).

### *Unique Lane-Based Network Model*

SIDRA INTERSECTION employs a unique **lane-based micro-analytical** network model allowing **all intersection types** – signals, roundabouts, sign control in one network.

**Backward Spread of Congestion** (queue spillback) resulting in capacity reduction at upstream lanes, and **Capacity Constraint** reducing the demand volumes of downstream lanes as a result of oversaturated upstream lanes (thus limiting the flows entering downstream lanes) are powerful features of this model.

Queue blockage and capacity constraint are two elements that are highly interactive with opposing effects. SIDRA INTERSECTION uses a network-wide **iterative approximation** method to find a solution that balances these opposing effects.

**Capacity reduction** for upstream intersection lanes is modelled based on the probability of blockage due to limited queue storage estimated for downstream intersection lanes.

Unlike the SIDRA INTERSECTION **lane-based** micro-analytical network model, the traditional **link-based** network models use links representing **lane groups** in which traffic conditions of individual lanes are aggregated and therefore lost in more aggregated traffic units. An **approach-based** method is a more extreme case of this where differing conditions of traffic in all approach lanes are aggregated to some assumed average (balanced) condition.

Such link-based (lane-group based) and approach-based network models cannot identify **backward spread of congestion**, **midblock lane changes** and **unequal lane use** at closely-spaced intersections adequately.

### *Diverse Movement Classes*

**Movement Classes** (light vehicles, heavy vehicles, buses, bicycles, large trucks, light rail / trams as well as six user-configured classes) can be allocated to different lanes, lane segments and signal phases. This provides a unique method for modelling of Bus Priority Lanes, Bicycle Lanes, and so on.

### *Lane Movements*

**Lane Movements** are used to model the blockage of upstream lanes depending on **lane choices** of movements from approach lanes to exit lanes. These will affect **second-by-second platoon patterns** for coordination modelling for signals and **mid-block lane changes** generally.

### *Signal Platoon Movements*

SIDRA INTERSECTION uses **lane-based second-by-second arrival and departure flow patterns** as a function of **Signal Offsets** to model signal platoons for internal approaches of Sites in **coordinated signal systems** and **Common Control Groups**. The model includes a unique *platoon dispersion* model.

Unlike traditional network models that use aggregate models of *links* or *lane groups*, the *lane-based* model for platoon movements between upstream and downstream Sites (on internal approaches) takes into account **midblock lane changes** that apply to second-by second platoon patterns. This is particularly important in evaluating closely-spaced (paired) intersections with high demand flows where vehicles have limited opportunities for lane changes between intersections. These requirements are important in modelling the forward movements of platoons for estimating performance measures (delay, back of queue, stop rate) as a function of signal offsets, geometric design and flow conditions.

SIDRA INTERSECTION network model also includes the use of **extra bunching** for signal platoons arriving at roundabouts and sign controlled intersections for estimating the effect of upstream signals. Extra Bunching values are determined by the program automatically by default.

### *Network Signal Timings*

Network timing for signal coordination involves Network Cycle Time and Site Phase Time calculations as well as Signal Offsets calculated for Routes defined by users. Network Cycle Time, Site Phase Times and Signal Offsets can be specified by the user. Signal timings for Common Control Groups (CCGs), i.e. several signalised intersections operating under one signal controller, are calculated using a unique method that treats each CCG as a single entity.

## 2 WHAT KIND OF ROAD TRAFFIC FACILITIES CAN SIDRA INTERSECTION MODEL?

1. ***Any Network*** with up to 20 "Sites" to model mixed types of intersections, crossings and interchanges listed below
2. ***Signalised intersections and networks***
   - signalised intersections (fixed-time / pretimed and actuated)
   - large signalised and unsignalised intersections with wide median storage areas
   - paired (compound) intersections and interchanges operating under a single controller (***Common Control Group***)
   - ***Network timing for signal coordination*** (Network Cycle Time, Green Splits, Offsets)
   - coordinated signalised intersections with sign-controlled intersections between them
3. ***Roundabouts***
   - unsignalised roundabouts
   - roundabouts with metering signals
   - paired (compound) roundabouts
   - roundabout corridors
   - fully-signalised roundabouts (including signalised circulating roads)

4. ***Sign control***
   - two-way stop sign control
   - two-way give-way / yield sign control
   - staged crossings at sign-controlled intersections (including "seagull" T intersections)
   - all-way stop sign control
   - merge analysis
5. ***Pedestrian crossings***
   - at intersections
   - midblock signalised
   - midblock unsignalised
6. ***Bus lanes, light-rail / tram lanes, bicycle lanes and bus, light-rail / tram and bicycle signals***
7. ***Staggered T intersections***
   - signalised
   - roundabout
   - sign control
8. ***Interchanges***
   - single point interchanges (signalised)
   - signalised diamond interchanges
   - roundabout interchanges
9. ***Alternative intersections and interchanges*** including
   - diverging diamond interchanges (signalised)
   - continuous flow intersections
   - restricted cross street U turns
   - numerous variations and other types

# 3 SIDRA INTERSECTION MODEL FEATURES SUMMARY

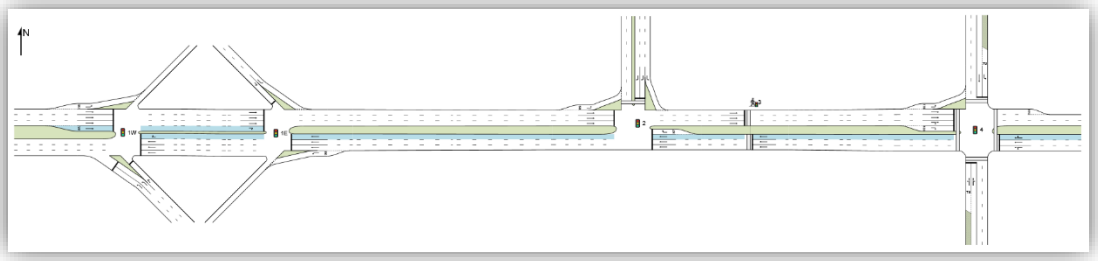
Also refer to "AKÇELIK, R. (2017) **Roundabout Model Comparison Table**. Akcelik and Associates Pty Ltd, Melbourne, Australia". (Available for download on www.sidrasolutions.com/Resources/Articles)

| Features | Comments |
|---|---|
| **MAIN FEATURES** | |
| **Research base** | The SIDRA INTERSECTION network model is a culmination of 40 years of research and development (20 years at the Australian Road Research Board and now 20 years at SIDRA SOLUTIONS)<br>Refer to over 100 research papers and reports on www.sidrasolutions.com/Resources/Articles<br>Our research papers and reports on Research Gate (www.researchgate.net) enjoyed about 37,000 reads and 1943 citations in five years. |
| **Lane-based model** | Fundamental differences from link (lane group) based and approach-based models |
| **Easy to configure** | Sites connected to form a Network; up to 20 Sites per Network; contra-flow lanes allowed; easy to clone and modify Networks to test alternative treatments |
| **Routes** | User-defined Routes for travel performance reports and displays, and Signal Offset calculations |
| **All Site types** | Signals, roundabouts, sign control, pedestrian crossings |
| **Movement Classes** | Light vehicles, heavy vehicles, buses, bicycles, large trucks, light rail/trams and six user-configured classes with different vehicle characteristics (including queue space, speed, acceleration, mass, etc) can be allocated to different lanes, lane segments and signal phases, and signal platoon patterns can be tracked separately |
| **Special Movement Classes** | Used for estimation of unequal lane use at closely-spaced intersections and interchanges; intersection turning volumes layered so as to identify external approach through movements that become turning movements at downstream internal approaches and the dogleg movements between side roads |
| **Fuel consumption and emission models ($CO_2$, CO, HC, $NO_x$)** | Environmental impacts of proposed traffic design, operations and planning schemes can be assessed<br>Models calibrated for modern vehicles<br>Four-mode elemental model (acceleration - cruise - deceleration - idle) applied to vehicle paths of queued and unqueued vehicles in individual lanes |
| **Demand and Sensitivity analysis** | Design Life, Flow Scale and Parameter Sensitivity analysis for Sites and Networks |
| **NETWORK MODEL** | |
| **Queue Spillback (backward spread of congestion)** | Analytical model based on the probability of blockage of upstream lanes by downstream queues at all types of facilities<br>Back of queue extending upstream at intermediate locations with continuous lanes including major roads at sign-controlled intersections modelled |
| **Saturation flow and capacity reduction** | Dynamic saturation flow estimation to allow for upstream lane capacity losses due to lane blockage with effect on signal timing calculations |

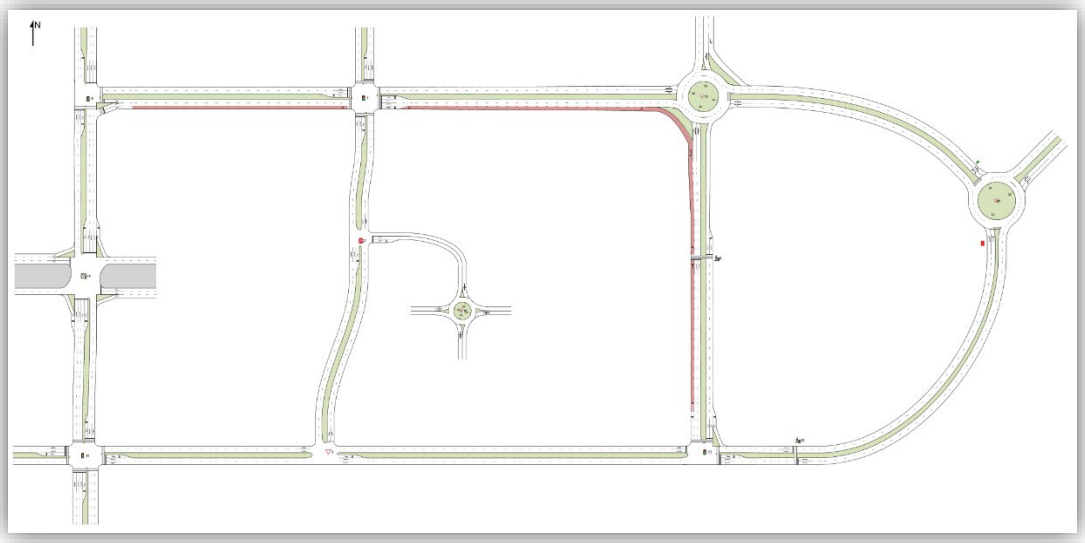
| Features | Comments |
|---|---|
| **NETWORK MODEL - *continued*** | |
| **Capacity constraint** | Exit flow rates from oversaturated upstream lanes entering downstream lanes are limited to capacity flow rates (arrival flow rates differ from demand flow rates) |
| **Iterative method** | Network-wide iterative process to find a capacity - performance solution that balances the opposing effects of queue spillback (lane blockage) and capacity constraint, with corresponding signal timing solution where applicable |
| **Lane movements** | Flow proportions for lane movements from each approach lane to each exit lane can be specified; relevant to modelling forward movement of platoon patterns and backward effect of lane blockages |
| **Traffic volumes** | Site turning volumes (origin-destination demand flow rates) used |
| **Midblock inflow and outflow rates** | Determined from Site origin-destination demand flow rates; significant effect on signal platoon modelling |
| **Midblock lane changes** | Determined from upstream and downstream lane flow rates to allow the user to calibrate external approach lane use |
| **Unreleased Vehicles** | There are no Unreleased Vehicles in SIDRA network analysis. The issue of individual vehicles not being able to enter from the origin zones into the simulated network is specific to microsimulation modelling. In SIDRA INTERSECTION analytical modelling, the effect of congestion on delays, travel times, queues and so on are taken into account fully in accordance with the specified demand flow rates on "external approaches" of the network. |
| **BASIC MODEL ELEMENTS** | |
| **Back of queue model (average and percentile queues)** | Key parameter to estimate lane-based probabilities of blockage or overflow in queue spillback and short lane models with percentile queue modelling; used for signals as well as gap-acceptance processes (roundabouts and sign control) |
| **Short lane model** | Complex multiple short lane configurations modelled<br>Blockage of upstream intersection lanes by short lane queues that overflow into full-length lanes at a downstream intersection modelled |
| **Shared lane model** | Blockage of movements with different signal control characteristics blocking each other in shared lanes modelled using the *free queue* method |
| **Pedestrians** | Extensive treatment of pedestrian movements at intersections including effect on signal timings (including pedestrian actuation feature) and effect of pedestrians on vehicle movement capacities |
| **SIGNAL TIMINGS** | |
| **Network timing for signal coordination** | |
| **Cycle time and phase times** | Practical cycle time, optimum cycle time and user-given cycle time with program-determined and user-given phase times |
| **Offsets for signal coordination** | Calculated for Routes defined by users |
| **Common Control Groups (CCGs)** | Signal timing method for several signalised intersections operating under one signal controller as a single entity |

| Features | Comments |
|---|---|
| **SIGNAL TIMINGS - *continued*** | |
| **Signal timing (general)** | Fixed-time / pretimed (EQUISAT), actuated and semi-actuated signal analysis methods |
| | Simple and complex phasing arrangements; variable phasing analysis |
| | ARR 123 critical movement identification method |
| | Green split priority for coordinated movements |
| | Undetected movements and phase transition methods |
| | Pedestrian actuation (variable pedestrian minimum time effects) |
| | Phase actuation (phase skipping); phase frequency adjustments |
| | Late start and early cut-off |
| | Give-way / yield controlled and continuous slip / bypass lanes |
| | Turn On Red (gap acceptance method for capacity estimation) |
| | SCATS parameters output |
| **SIGNAL PLATOONS** | |
| **Signal platoons** | Lane-based method to determine second-by second arrival and departure flow patterns as a function of Signal Offsets including a unique *platoon dispersion* model |
| | Midblock lane changes and midblock inflows and outflows taken into account when moving signal platoon patterns between intersections |
| | Second-by-second signal platoons modelled and tracked for each Movement Class separately |
| **Extra bunching** | *Effect of upstream signals* on gap-acceptance capacity of roundabouts and two-way sign-controlled intersections modelled by increased bunching |
| **ROUTES** | |
| **Route as a series of movements in one direction of travel** | Routes can be defined in a very flexible way for travel performance results and signal offset calculations |
| **Route travel time** | Route travel times include geometric delays, acceleration and deceleration delays |
| | For oversaturated conditions, travel times include delays experienced until all vehicles arriving during the analysis period have departed |
| **NETWORK and ROUTE OUTPUT** | |
| **Network reports and displays (whole Network and by Routes)** | Network Summary, Network Displays, Lane Displays, Arrival Flows, Network Flows, Signal Offsets |
| **Route reports and displays** | Route Summary, Route Displays, Lane Displays, Time-Distance diagrams |
| **Signal Timing reports** | Phasing Summary, Timing Analysis, Movement Timing |
| **Roundabout and Sign Control reports** | Roundabout Analysis, Roundabout Metering, Sign Control Analysis |
| **Site reports and displays (individual Sites and Network Sites)** | Diagnostics and Detailed Output reports; Intersection, Movement and Lane Summary reports; Movement Displays and Lane Displays; LOS Summary display; Graphs; Lane Flows, Lane Blockages and Lane Changes reports |

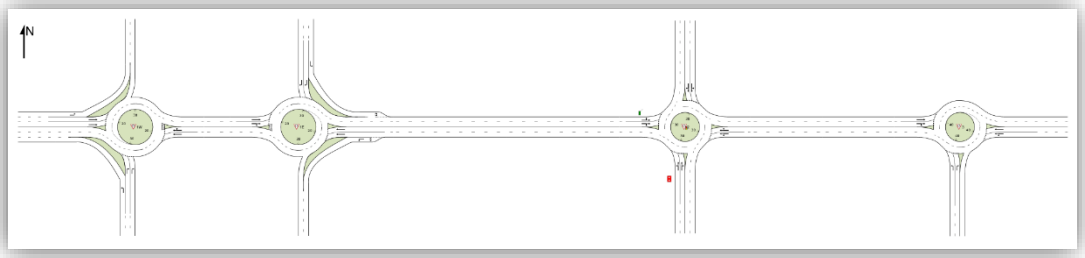
# 4 SIDRA INTERSECTION LAYOUT AND OUTPUT DISPLAY EXAMPLES



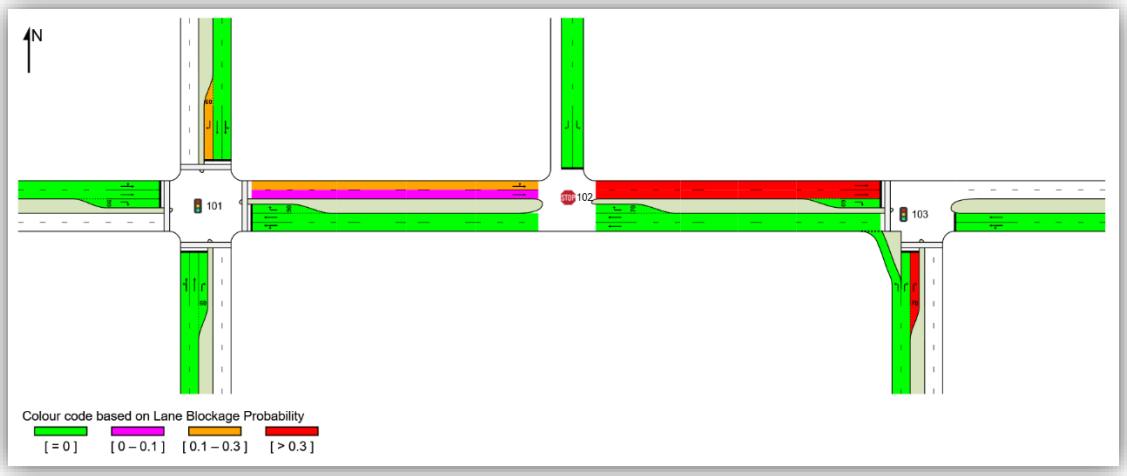
**Signalised arterial with diamond interchange**



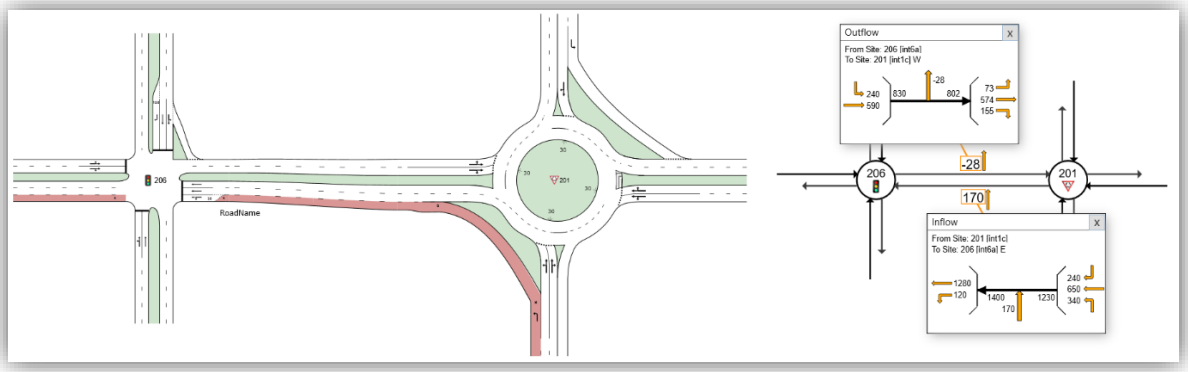
**Large network**



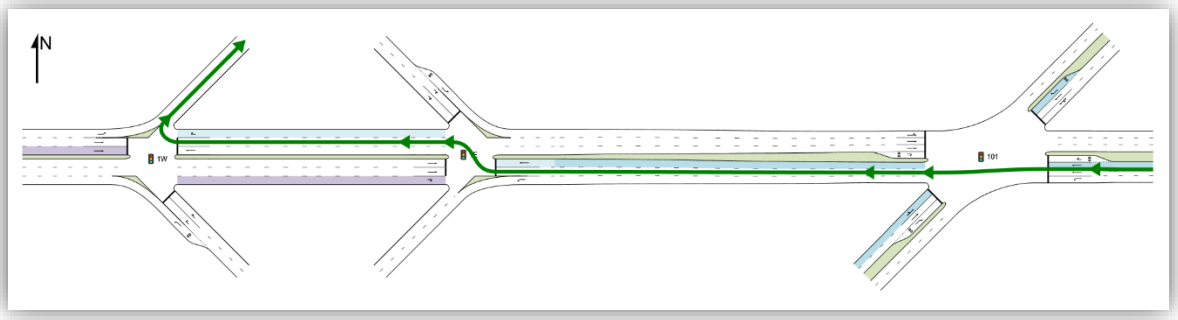
**Roundabout corridor with interchange**




**Coordinated signalised intersections with sign control between them**
(Lane Display showing probabilities of blockage)




**Closely-spaced signals and roundabout with bus lane**
(Network Flows display showing a midblock inflow and outflow)




**Diverging Diamond Interchange and a closely-spaced intersection**
(Route Layout display showing Westbound Route to freeway on ramp)

# 5 NEW FEATURES OF SIDRA INTERSECTION VERSION 8

**SIDRA INTERSECTION Version 8 offers much improved network model processing efficiency and much improved workflow efficiency** through substantial enhancements to the user interface including improved visualisation and new output reports and displays. It also incorporates various important model improvements. The following is a summary of the new features of SIDRA INTERSECTION Version 8.

- Substantial increases are achieved in **computing speeds** for the iterative network analysis method enabling introduction of facilities for optimum timings as well as demand and sensitivity analysis for networks. Average computing speeds about 5 to 10 times faster than previous versions can be expected in Network analysis.
- Significant **user interface improvements** introduced for ease of use of the software include:
    - graphical displays of Intersection Geometry, Volumes, Signal Phasing and Movement IDs within most Site input dialogs for assisting the input data entry process and allowing direct in-display data entry;
    - Project Summary report using the new Site Category and Network Category parameters;
    - User Report facility based on user-defined report templates;
    - enhanced Input Comparison and Output Comparison facilities using results from different Projects;
    - various commands that were hidden in right-click menus in previous versions made available in the Site / Network / Route ribbon or in Site Output sections;
    - right-clicking an output report or display opens the relevant Site / Network / Route input menu and some display commands;
    - double-clicking Site / Network / Route name opens the relevant layout picture;
    - where Network parameters override Site data, there is no need to process the Network again if any of the corresponding parameters are changed in Sites that constitute the Network.
- **Output reports and displays** have been enhanced significantly. New Site, Network and Route output reports and displays include:
    - Lane Changes, Lane Flows, Network Flows and Midblock Flows displays for the whole Network with pop-up boxes showing demand and arrival flows by movement class;
    - Approach Distances display for Networks;
    - Signal Coordination displays in the form of Lane Displays for Sites, Networks and Routes, and Movement Displays for Sites;
    - Route Travel Performance report;
    - Saturation Flows report for signalised Sites;
    - Critical Movements display for signalised Sites with a Phase - Movement Timings Display and an ARR 123 style Critical Movement Diagram;
    - Movement Timing display for Common Control Groups (CCGs) showing all movements of the CCG together.
- Various **model improvements** include:
    - Optimum Cycle Time for Networks;

- Optimum Cycle Time and Optimum Maximum Green Settings for Common Control Groups;
- new Phase Time calculation options;
- improved treatment of Uncoordinated and Unconnected Sites for signal timing calculations;
- Network Demand and Sensitivity analysis methods for Design Life, Flow Scale and Parameter Sensitivity;
- Queue at Start of Green for signalised Sites;
- enhanced methods used for stopping conditions in Network and Site model iterations with Network Model Variability Index and Site Model Variability Index parameters given in various output reports and displays;
- improvements to the iterative method used for Site capacity and timing analyses resulting in fewer cases of unsettled results.

SIDRA INTERSECTION Version 8 was released in April 2018. Work on SIDRA INTERSECTION Version 9 is in progress.

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