

TORONTO'S SIGNAL OPTIMISATION PROGRAM

by

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ABSTRACT

Toronto's revived Signal Optimization Program (SOP) is designed to make its traffic signals more efficient by improving signal communications, repairing defective equipment, upgrading controllers and cabinets, installing warranted left turn phases, gathering up-to-date traffic data, making timing adjustments and creating auxiliary timing plans. In December 2013 the City's SOP was approved by Toronto City Council as a fundamental part of Toronto's Congestion Management Plan (CMP). The CMP mandates that the City's signal timing plans must be kept current and its traffic management strategies up-to-date. This includes maintaining signal timing plans to ensure they are up-to-date and responsive to the needs of all road users - pedestrians, cyclists, transit and mixed traffic.

Toronto operates 2,288 signals on four traffic control systems - TransSuite TCS, SCOOT, Aries and the City's in-house MTSS. The 329 signals on SCOOT are not part of the SOP. After several years of being "reactive" rather than "proactive", Toronto initiated the SOP in 2011 with a study of 15 signals on University Ave in downtown Toronto. The Program expanded to 112 signals in 2012, 245 signals in 2013 and 224 signals in 2014. In 2015, Toronto will be retiming 343 signals on 11 routes. The City anticipates that it will re-time all its non-SCOOT signals by 2019. Since well-timed traffic signals are a foundation of good system management and operations, Toronto will start a new retiming effort to complete all signals in a new cycle starting in 2020.

Initiatives undertaken since the inception of the SOP are:

- development of night plans for all intersections
- development of weekend/shopping plans for selected intersections
- updating Gardiner closure plan for Bloor St
- updating Don Valley Parkway closure plan for Victoria Park Ave
- use of Bluetooth devices to supplement GPS-based travel time studies

Toronto has found that traffic signal retiming is very cost effective and can produce benefit-cost ratios as high as 91 to 1. To date, all completed studies have shown substantial reductions in travel time, stops, emissions, and fuel consumption. The 2013 studies showed the following - reduction in delays of 11% or over 520,000 hours each year; reduction of vehicle stops by 11% or over 44 million each year, and reduction of fuel consumption of 8% or 2.8 million litres of fuel each year. This last benefit reduced annual greenhouse gas emissions by 8% or by 73 tonnes of carbon dioxide.

Since there is concern about the impact that retiming can have on side street traffic and pedestrians in the morning and afternoon peak periods, the City is currently in the process of developing a *Signal Timing Policies and Strategies* document that deals with all aspects of signal timing including signal coordination within the context of the City's Official Plan.

1. INTRODUCTION

Toronto's revived Signal Optimization Program (SOP) is designed to make its traffic signals more efficient by improving signal communications, gathering up-to-date traffic data, repairing defective equipment, upgrading controllers and cabinets, installing warranted left turn phases, making timing adjustments and creating auxiliary timing plans. Even though the SOP began in late 2012, it was approved by Toronto City Council in December 2013 as a fundamental part of Toronto's City's Congestion Management Plan¹ (CMP). The CMP mandates that the City's signal timing plans must be kept current and its traffic management strategies up-to-date. This includes maintaining signal timing plans to ensure they are up-to-date and responsive to the needs of all road users - pedestrians, cyclists, transit and mixed traffic.

A coordinated signal system will assist in achieving the following benefits:

- increases traffic handling capacity of a road
- reduces likelihood of rear-end collisions and red-light running
- encourages travel within the posted speed limit
- reduces unnecessary stopping and starting which in turn reduces vehicle emission, noise and fuel consumption
- improves travel times
- reduces driver frustration.

In 2004, the City started a project to convert the legacy Main Traffic Signal System (MTSS) to TransSuite TCS. This project will be completed in December 2015. The conversion required the replacement of the MTSS communication circuits with DCS circuits. The telecom provider was not efficient in meeting the City needs resulting in over 500 intersection being without communication in 2012 which generated numerous complaints about poor signal coordination. Recognising this situation was not tenable, the City decided to move to cellular wireless using an existing City IT contract. Therefore, from 2012 onwards the City was in a position to restart its signal coordination efforts.

The 2015 SOP is a continuation of the initiative that started in 2012. 112 signalised intersections on four corridors were reviewed in 2012. 245 signalised intersections on eight corridors were reviewed in 2013. 224 signalised intersections on seven corridors were reviewed in 2014. The 2015 and 2016 goals are to re-time 343 and 351 signals respectively.

2. TRAFFIC CONTROL SYSTEMS

There are 2288 traffic signals in the City of Toronto of which eight are on "local" control. As explained in Appendix A, the remaining 2280 are controlled by four traffic signal control systems which are located at the City's Traffic Management Centre:

- TransSuite Traffic Control System (TCS), supplied by TransCore ITS Inc., controls 1714 signals.

¹City of Toronto, *Toronto's Congestion Management Plan 2014 - 2018*, October 2013
<http://www1.toronto.ca/City%20Of%20Toronto/Transportation%20Services/TMC/Files/PDF/Congestion%20Management/Congestion%20Management.pdf>, accessed February 1, 2015.

- Main Traffic Signal System (MTSS), an interval-based system developed in-house, currently controls 97 signals but will be decommissioned by December 2015 with the conversion of all MTSS signals to the TransSuite TCS.
- Aries, supplied by Econolite Canada Ltd, controls eight signals on Queens Quay.
- SCOOT (Split Cycle Offset Optimization Technique), supplied by Siemens Mobility Traffic Controls, controls 329 signals.

All four systems are capable of providing signal coordination. However, signal coordination is not provided on Aries since all signals on Queens Quay operate "free" to provide priority to the Harbourfront LRT streetcars. Cross-system coordination can be achieved between TransSuite TCS, MTSS and Aries. SCOOT cannot provide cross-system coordination with the other three systems as it is a traffic adaptive system that changes cycle length, split and offset frequently.

3. OBJECTIVES

The objective of the program is to reduce stops, travel time, delay and fuel consumption by optimizing traffic signal operations using Synchro v7 and SimTraffic v7 software applications while complying with the City's Signal Timing policies. Synchro is a macroscopic analysis and optimization application that can model signalized intersections based on the Highway Capacity Manual methodology. SimTraffic is a traffic simulation application that can perform micro-simulation and animation of vehicle and pedestrian related traffic. Both software applications are widely used in North America for signal optimization projects.

4. CHALLENGES & SOLUTIONS

In Toronto, there are many challenges in maintaining a coordinated traffic signal system, some of which are listed below:

1. Reliable communication between central computers and field computers to ensure that the field equipment clocks are synchronized with the central system clock and to download signal timing changes from the central system to the field.
2. Not enough staff resources to conducting traffic coordination studies on a regular basis.
3. Damage to inductive loop detection which results in phase recall and signal cycling issues. Pedestrian button failure, especially in winter months, causes signal cycling.
4. Curb-lane parking by time of day e.g. parking on one side of road during the peak periods.
5. Aging traffic hardware and software that is susceptible to malfunctions which results in non-optimal system performance.
6. Accommodating the needs of pedestrians, especially in the downtown core where limited pedestrian storage on sidewalks is an issue.
7. The loss of traffic lanes due to road construction, development, filming, festivals, and special events requires signal timings to be adjusted since road capacity and travel time between intersections are affected by lane reductions.
8. Unconditional transit signal priority (TSP) on streetcar and several bus routes, which can result in green time extension of up to 30 seconds for transit. Since TSP is provided through pre-emption, frequent TSP activations impacts the City's attempts to coordinate

traffic signals. As a result, signal coordination is adversely affected in the peak periods on routes on which TSP is enabled.

9. Pedestrian Priority Phase (PPP) signals at Yonge St/Dundas St and Yonge St/Bloor St operate at higher cycle lengths and are not coordinated with adjacent signalized intersections.
10. Most of Toronto's roadways are "two-way" and have balanced traffic flows. This situation makes signal coordination more challenging when attempting to provide coordination for both directions.

The above challenges are being mitigated by the following:

1. Replacement of the existing Digital Channel Services (DCS) lines on TransSuite TCS by cellular wireless.
2. Hiring consultants to undertake most of the studies with City staff providing project management and technical oversight.
3. The City is moving away from its dependency on intrusive detection, such as inductive loop detectors, to "non-intrusive" detection such as radar, video, acoustic and LED. Contracts for new traffic control signals specify non-intrusive vehicle detection and all road construction projects specify non-intrusive detection as a replacement when in-pavement loop detectors are damaged. With more reliable communication in place, the City is running daily reports to determine faulty pushbutton locations and then take steps to fix the problems.
4. Curb-lane parking in peak periods has been reduced in the downtown core and is being reviewed in other parts of the City.
5. All interval-based controllers and cast aluminum cabinets will be replaced by phase-based controllers and NEMA TS2 Type 1 cabinets by December 31, 2015.
6. Accommodating the needs of pedestrians in the downtown core takes precedence over traffic issues – this approach is in accordance with the City's draft *Traffic Signal Operations Policies and Strategies*².
7. The City is looking into lane rental charges that reflect the actual costs of occupying the roadway including the cost of additional delay to traffic waiting in queue or being diverted to alternative routes – this approach would reduce the roadway occupation duration for development related construction.
8. Later this year, the City will be conduct a review of TSP best practices - the intent is to determine if there should be changes to the way that TSP is currently implemented in Toronto.
9. The PPP signals are not coordinated with adjacent signals.
10. If a good two-way greenband is not achievable, then the decision is taken to provide a better one-way green band.

5. POLICY COMPLIANCE

Competing demands for road space has an impact on the provision of coordination – minimizing wait time for pedestrians, providing transit pre-emption for transit vehicles, parking on main corridors, and minimizing delay to side street vehicles. The following conditions were stipulated:

² City of Toronto Transportation Services, Draft document *Traffic Signal Operations Policies and Strategies*, February 9, 2015.

For coordination between major and minor signalised intersections during peak periods, the following guidelines were followed:

- Maintain consistent cycle lengths between major and minor signals.
- Operate larger control areas to maintain traffic flow through many intersections.
- Operate minor intersections at longer cycle lengths facilitate coordination.
- Feasibility of gating (i.e. green time upstream close to downstream bottleneck) where queue routinely build up.

For coordination between major and minor signalised intersections during off-peak periods, the following guidelines were followed:

- Operate major (fixed) signals with different cycle lengths from minor (semi-actuated) signals (i.e. recognize that pedestrians are not willing to wait long periods in the off-peak before deciding to jaywalk).
- Maintain coordination between fixed and semi-actuated signals only if spacing is less than 150 metres or a queue is likely to form between the fixed time and semi-actuated signals.
- Double cycle length between major and minor signals on major arterials if conditions permit.
- Aim to equitably serve land uses such that queues and cycle failures are minimized.

These principles are now contained in the City's *Traffic Signal Operations Policies and Strategies* that was recently completed

6. REQUEST FOR PROPOSALS

One of the keys to providing coordination is for staff to conduct traffic studies to determine the appropriate signal timing plans for a particular route. It was recognised that existing staff resources are not adequate to undertake comprehensive signal coordination studies in addition to the daily operational duties. Consultants are required to develop and implement a minimum of four plans (morning peak, off-peak, afternoon peak, night) for all intersections. Some intersections also require weekend plans (Saturday and Sunday) and shopping plans.

Consultants are hired through the following process:

- City staff determine the routes to be completed considering the following:
 - last time the route was coordinated
 - planned construction (road reconstruction, major utility work, water main installation/upgrade, sewer main installation/upgrade etc)
 - status of MTSS to TransSuite conversion
 - complaints from the public
 - ensuring that yearly projects are spread out across the City.
- City staff develop a Request for Proposal (RFP) for consultants to undertake a comprehensive signal coordination review by conducting traffic signal analyses, speed and delay studies and providing recommendations to optimize traffic signal coordination and operations. The RFP includes the proposal evaluation table, the mandatory requirements that

must be complied with, the evaluation criteria and the available points that could be awarded for each of the areas within the proposal.

- In a two stage evaluation process, consultants are first evaluated based on the technical component. Consultants that pass the technical evaluation are then evaluated on the combined technical/cost evaluation. Two consultants are generally hired each year through the process.

As part of the RFP process, the City provided the following technical documentation to proponents:

- List of traffic signals
- Toronto's Synchro 7 and SimTraffic Guidelines
- Saturation Flow Rates report
- Pedestrian Timing at Signalised Intersections
- Summary of Offset Reference Phasing for City Controllers
- Methodology for Bluetooth Analysis
- Assumptions and References for Calculating Benefits
- Samples of Expected Outputs for Reporting
- Typical timing cards
- Signal Operations Policies and Strategies report.

7. STUDY TASKS

The process of a typical signal coordination study is as follows:

Data Collection and Review

- Obtain traffic count data from Traffic Safety Unit (TSU) for each intersection including turning movements and peak hour factor for each traffic approach. Arrange for new counts if current count is more than two years old.
- Collect intersection geometric configurations via drawings, Google Streetview and field visit - lane configuration, pedestrian crossing distances, lane widths, intersection grade, storage lane lengths, curb radius, inventory of detectors and types and length of detector loops, etc.
- Review past/current signal related concerns, requests and recommendations to ensure they are considered during the study.
- Undertake a mode of control (MOC) assessment at each intersection to determine if the current MOC is valid.
- Update the control area spreadsheet to reflect existing control area strategy.
- Review of existing hardware for potential upgrade to improve the functionalities.

Coordination

- Coordinate with various divisions to confirm if there are no planned work/events that may impact normal traffic conditions within the project limit during the study.
- Coordinate with District offices to obtain information on parking regulations, ongoing investigations and development applications.

Base Traffic Model Development

- Conduct travel time studies during the busiest three hours within each study period. The travel time studies were supplemented by Bluetooth devices that record travel times over a full week.
- Conduct site observations for all study periods, including nights, weekends and during planned expressway closures.
- Data entry into the Synchro model to reflect existing conditions.
- Calibrate model using Simtraffic simulation and field visit data.

Alternatives Analysis using Traffic Model

- Develop alternatives taking into account the City's signal timing policies relating to cycle length, MOC, walk speed, pedestrian wait time, closely spaced signals etc.
- Report on MOEs for the various alternatives and review alternatives with City staff.
- Choose preferred option for each period and identify any controller changes (e.g. cycle length, split, offset, new plans, plan start/end times, enabling features in other periods) and equipment changes to accommodate identified signal modifications (e.g. left turn green arrows, new detection, relocated detection, cabinet/controller change).

Implementation

- Resolve any communication issues from the Central System to the intersections.
- Prepare and issue timing cards to City's signals maintenance contractor for field implementation.
- Implement timings in the Central System and verify changes in the field.
- Calibrate model using Simtraffic simulation and field visit data. Validate green band via TSD functionality on Central System and by field visits.
- Conduct travel time studies during the busiest three hours within each study period. The travel time studies were supplemented by Bluetooth devices that record travel times over a full week.

Reporting

- Hold bi-weekly meetings with City staff to provide project updates.
- Submit monthly status reports.
- Submit two interim reports and a final report. The final report contains an executive summary for distribution to senior management.

8. STUDIES

Given the ongoing issues with communication, it was a challenge to undertake any large scale signal coordination project in the years prior to 2012. In 2012 the City started its rollout of wireless communication to the signals that are on the TransSuite TCS and routes became available for which coordination studies could be done. The intent was that two-thirds of the signals would be handled by consultants with the other one-third being done by City staff. Delivery of the City portion has been problematic because of ongoing staff retention issues.

As shown in Appendix B, 112 intersections were completed on three routes in 2012, 245 on six routes in 2013 and 224 on seven routes in 2014. 343 signals are planned for 2015. The 2014 target was 350 intersections but this target was not achieved since none of routes assigned to City staff

was done. The Bloor St study, conducted in 2012, included the updating of the Gardiner Closure Plan which accommodates diversion of traffic when there are planned or unplanned closures of the Gardiner Expressway. The Victoria Park Ave study, conducted in 2013, included the updating of the Don Valley Parkway (DVP) Closure Plan which accommodates diversion of traffic when there are planned or unplanned closures of the DVP. The 2015 SOP includes the use of Aimsun microsimulation software to model traffic signal priority on a bus route (Bathurst St) and a streetcar route (Dundas St).

9. BENEFITS

The 2012 - 2014 studies have resulted in reductions in overall vehicle delay, travel time, vehicle emissions, stops and fuel consumption on the corridors that were optimised; also, there was a slight increase in vehicle speed on these corridors.

MOE	Comparison			
	Before	After	Difference	% Difference
Total Delay (hr)	9,935,000	8,740,000	-1,195,000	12.0%
Stops (#)	1,300,289,000	1,163,751,500	-136,537,500	-10.5%
Average Speed (km/h)	28.95	30.39	1.44	5.0%
Total Travel Time (hr)	42,148,500	40,333,000	-1,815,500	-4.3%
Fuel Consumed (l)	155,960,500	148,035,500	-7,925,000	-5.1%
Emissions (kg)	3,658,170	3,467,895	-190,275	-5.2%

Table 1 – Summary MOEs (2012-2014)

As shown in Table 1, based on a comparison of the "before" and "after" Synchro models, the following improvements can be reported for the three year period 2012 - 2014:

- reduction in delays of 12% or 1.2 million hours
- reduction in vehicle stops by 10.5% or 136.5 million
- reduction in travel time by 4.3% or 1.8 million hours
- reduction in fuel consumption by 5.1% or 7.9 million litres
- reduction in emissions by 5.3% or 46,875 kg
- increase in average vehicle speed by 1.44 km/h or 5.0%

The MOEs for the individual years 2012, 2013 and 2014 are shown in Appendix C.

The reduction of fuel consumption is estimated to be 7,925,000 l over the three year period. Based on the United States Environmental Protection Agency's Greenhouse Gas Equivalencies Calculator³, the reduction of fuel consumption is equivalent to the reduction of carbon dioxide emissions from 1,678 homes' electricity use for one year or carbon sequestered by 15,069 acres of forest in one year.

³ United States Environmental Protection Agency, Greenhouse Gas Equivalencies Calculator, <http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results>, accessed February 19, 2015.

Year	2012	2013	2014	2012-2014
Signalised intersections	112	245	224	581
Annual benefit	\$11,952,943	\$21,044,820	\$16,823,880	\$49,821,643
3-year Life Cycle Benefit	\$35,858,829	\$63,134,460	\$50,471,640	\$149,464,929
Cost	\$392,000	\$811,800	\$803,729	\$2,007,529
Cost per intersection	\$3500	\$3,500	\$3,688	\$3,455.30
Benefit/cost ratio	91:1	71:1	63:1	74:1

Table 2 – Benefit/Cost Ratio for 2012-2014

As shown in Table 2, the benefit/cost ratios in 2012, 2013 and 2014 were 91:1, 71:1 and 63:1 respectively. The cumulative saving over the three year period is conservatively estimated at \$149.5 million. The total life cycle benefit/cost ratio is estimated at 74:1. This means that for every dollar invested by the City, there was a potential saving of \$74.00 to the public.

The benefit/cost ratios were calculated using the following conservative assumptions:

- Eight hours for 250 weekdays per year - two hours for the morning peak period, four hours during the off-peak period and two hours for the afternoon peak period.
- Travel time saving is based on \$15.86 per hour.
- Stops saving is based on \$0.014 per stop.
- Fuel consumption saving is based on \$1.18 per litre.
- New timings last only three years.

The cost per intersection included the following:

- Consultant services – project management, traffic studies, network model development, development of alternatives and analysis, meetings, presentations, reports.
- City staff time:
 - ITS Operations – RFP preparation, RFP evaluation, contract award, contract management, data preparation, meetings with consultant, review/check traffic models, review reports, timing card preparation, liaising with Traffic Safety Unit, District offices and other divisions, field validation
 - Traffic Safety Unit – extracting intersection counts and arterial counts from database, arranging for additional intersection counts and arterial counts.
 - District Traffic Operations – provision of bylaw information, review recommendations
- Signals Maintenance Contractor – program controllers, install cabinets/controllers (if required), signal modifications.

10. FUTURE WORK

If the 2015 and 2016 targets are met, the City would complete coordination studies on 1275 traffic control signals by December 2016. Based on the current funding and availability of City resources, we anticipate that all TransSuite signals will be coordinated by December 2019. In August 2014, Toronto City Council requested staff to report on the cost implications of

undertaking an additional 500 signals over the 2015 – 2017 period⁴. Even though no additional funding was provided for 2015, there is the likelihood that additional funding will be provided to undertake 150 more in each of 2016 and 2017. If the additional 300 signals are approved, we anticipate that all 1815 TransSuite signals will be coordinated by December 2017. The City will then be able to undertake further studies for major arterials on a five-year cycle and on a ten-year cycle for minor arterials and collectors. This requirement is now enshrined in the City's draft *Traffic Signal Operations Policies and Strategies* which bring the City in line with the frequencies practiced in other major municipalities⁵.

Even though the City owns Synchro Studio 8, the City did not specify in its RFPs that Synchro Studio 8 should be used since consultants had expressed concerns about the results produced by Synchro Studio 8. The consulting community has indicated that their concerns were addressed in the recently released Synchro Studio 9; the City will be specifying Synchro Studio 9 in future RFPs.

11. CONCLUSIONS

After several years of inactivity on coordination studies due to the MTSS to TransSuite project, the City embarked on an aggressive program to retime all its signals by December 2019. To date, coordination studies have been completed on about 25% of Toronto's signals and the results have been quite promising. The benefit/cost to date has been between 63:1 and 91:1. We expect these benefits to be maintained as we optimise the remaining 75% of signals.

⁴ City of Toronto, City Council Meeting of August 25 – 27, 2014, Congestion Management Plan, <http://app.toronto.ca/tmmis/viewAgendaItemHistory.do?item=2014.MM55.62>, accessed February 28, 2015.

⁵ Tarnoff, P.J., and J. Ordonez. *Signal Timing Practices: State of the Practice*. Institute of Transportation Engineers, Washington, D.C., March 2004.

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APPENDIX A – TRAFFIC CONTROL SYSTEMS

The City of Toronto utilizes four traffic signal systems to control 2280 traffic control signals. The four systems are:

Main Traffic Control System (MTSS)

MTSS was developed in-house in the 1960's and is the City's oldest system. It currently operates 97 traffic control signals using pre-determined traffic signal timing plans. There are a minimum of three signal timing plans at each signalised intersection - a morning peak plan, an off-peak plan and an afternoon peak plan. While it is capable of providing traffic signal coordination, the system has limitations due to its age and is subject to frequent maintenance which negatively affects the system's ability to ensure signal coordination. MTSS relies on second by second communications to maintain coordination i.e. a loss of communication results in a loss of signal coordination.

TransSuite Traffic Control System (TCS)

Recognizing that MTSS was coming to the end of its useful life, the City reviewed alternatives to MTSS in 2002 and decided on the TransSuite TCS. After the completion of exhaustive testing in 2004, the City embarked on a program to replace MTSS. The replacement program, costing \$32 million, is on schedule to be completed by December 31, 2015. The TransSuite TCS supports multiple brand controllers using National Transportation for ITS Communications Protocol (NTCIP). When completed, the TransSuite TCS will control 1,950 traffic control signals. The TransSuite TCS is more reliable in providing a coordinated signal system than MTSS. TransSuite relies on second by second communication to monitor signal operation but relies on the field equipment to maintain coordination i.e. the field equipment can maintain signal coordination for about 24 hours if there is a loss of communication.

The replacement program includes the following:

- Replacement of the MTSS computers and central software by TransSuite TCS servers and central software.
- Redesign of the communications interface between the central system and the field since the existing MTSS communications were no longer being supported by the telecom provider.
- Upgrading the field controllers from legacy interval-based to industry standard phase-based capable on communicating via the most up-to-date communications protocol. Upgrading the field cabinets to ensure compatibility with the TransSuite TCS. Newer cabinet assemblies use the NEMA TS2 Type 1 controllers. Older M cabinets, that are reused on the TransSuite TCS, use the NEMA TS2 Type 2 controllers.
- Upgrading signal timings for all existing plans to comply with an overall pedestrian walk speed of 1.0 m/s and a pedestrian clearance walk speed of 1.2 m/s.

Urban Traffic Control (UTC)/Split Cycle Offset Optimization Technique (SCOOT)

UTC/SCOOT consists of two components – UTC and SCOOT. UTC provides pre-determined traffic signal timing plans and is used as a stop-gap measure if SCOOT is not available. SCOOT is the adaptive traffic control component that determines its traffic timing plans based on real time traffic information received from vehicle detectors located on the approaches to signalised intersections. The system is capable of providing traffic signal coordination as a by-product of SCOOT optimisation, but like MTSS, it has come to the end of its useful life and needs upgrading or replacement. UTC/SCOOT was first installed in Toronto in 1992 at 75 traffic control signals. At its peak, SCOOT was expanded to 346 traffic control signals - 58 signals are in the Central Business District and the other 288 are on 16 major arterial roads spread across the City. SCOOT now controls 329 signals.

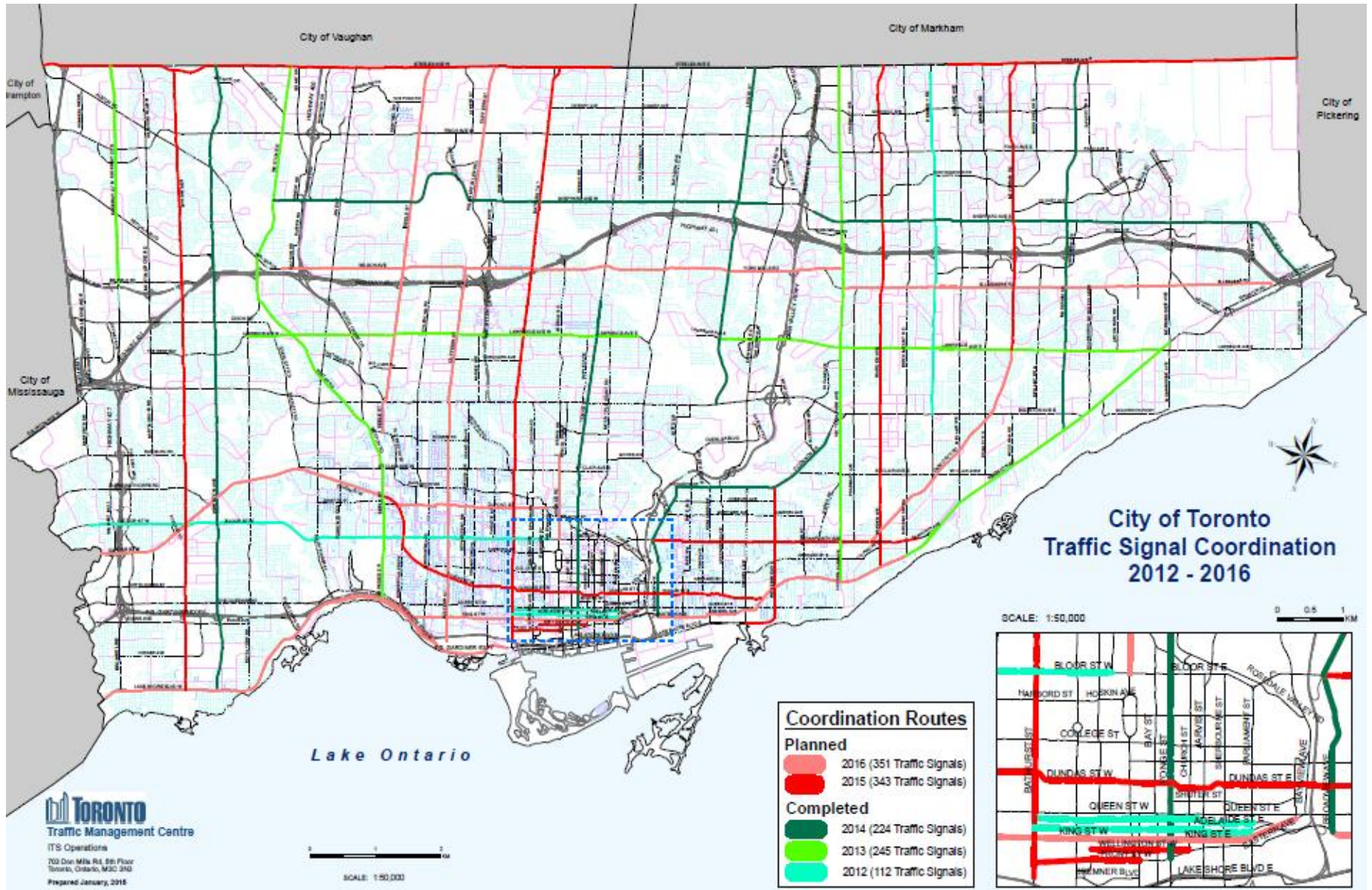
Aries

Aries is the system used to manage the eight traffic control signals along Queens Quay, specifically, to provide priority to streetcars that travel on the exclusive transit right-of-way on the Harbourfront LRT. Vehicle detectors located within the streetcar track allowance are used to provide priority for streetcars. While signal coordination can be provided on Aries for mixed traffic, this feature was never used since the focus on Queens Quay was to serve transit vehicles as quickly and as efficiently as possible. The Aries system will be replaced by TransSuite later this year as part of the Waterfront Revitalization Project.

APPENDIX B – SIGNAL COORDINATION ROUTES (2012 – 2014)

Route	From/To	No of Signals
2014		
Sheppard Ave W	Weston Rd to Shaughnessy Blvd	36
Sheppard Ave E	Hurons Hill Way to Kingston Rd/Port Union Rd	35
Yonge St	Yonge Blvd to Front St	39
Markham Rd	Steeles Ave E to Kingston Rd	28
Islington Ave	Steeles Ave to Lake Shore Blvd	37
O'Connor Dr/Broadview Ave	Sunrise Ave to Eastern Ave	26
Leslie St	Steeles Ave to Eglinton Ave	23
	Total	224
2013		
Lawrence Ave W	Scarlett Rd to Bayview Ave	43
Kingston Rd	Highway 401 to Birchmount Rd	39
Highway 27	Steeles Ave W to Belfield Rd	9
Weston Rd/Keele St/Parkside Dr	Steeles Avenue W to Spring Rd	60
Lawrence Ave E	Leslie Street to East Ave	53
Victoria Park Ave	Steeles Ave E to Kingston Rd	41
	Total	245
2012		
Adelaide St/Richmond St	Parliament St to Bathurst St	38
Kennedy Rd	Steeles Ave E to Danforth Rd	23
Bloor St	Bedford Rd to Mill Rd	51
	Total	112

APPENDIX B1 – MAP OF COMPLETED AND PLANNED ROUTES



APPENDIX C – YEARLY MEASURES OF EFFECTIVENESS

2012 Routes

MOE	Comparison			
	Before	After	Difference	% Difference
Total Delay (hr)	1,320,500	919,000	-401,500	30.4%
Stops (#)	137,115,500	109,706,000	-27,409,500	-20.0%
Average Speed (km/h)	26.4	29.0	2.6	10.0%
Total Travel Time (hr)	14,095,000	13,453,000	-642,000	-4.6%
Fuel Consumed (l)	14,323,000	12,554,000	-1,175,500	-12.4%
Emissions (kg)	379,250	332,465	-46,875	-12.3%

From an environmental perspective, the reduction of fuel consumption is estimated to be 1,175,500 l/year. The reduction of fuel consumption is equivalent to the reduction of carbon dioxide emissions from 249 homes' electricity use for one year or carbon sequestered by 2,236 acres of forest in one year.

2013 Routes

MOE	Comparison			
	Before	After	Difference	% Difference
Total Delay (hr)	2,100,500	1,939,500	-161,000	-7.7%
Stops (#)	576,462,500	526,312,500	-58,978,000	-8.7%
Average Speed (km/h)	28.8	30.0	1.2	4.3%
Total Travel Time (hr)	13,958,500	13,427,000	-531,500	-3.8%
Fuel Consumed (l)	69,424,500	66,542,000	-2,882,500	-4.2%
Emissions (kg)	1,540,535	1,476,545	-63,990	-4.2%

From an environmental perspective, the reduction of fuel consumption is estimated to be 2,882,500 l/year. The reduction of fuel consumption is equivalent to the reduction of carbon dioxide emissions from 610 homes' electricity use for one year or carbon sequestered by 5,480 acres of forest in one year.

2014 Routes

Measure of Effectiveness (MOE)	Comparison			
	Before	After	Difference	% Difference
Total Delay (hr)	6,514,000	5,881,500	-632,500	-9.7%
Stops (#)	586,711,000	527,733,000	-58,978,000	-10.1%
Average Speed (km/h)	30.4	31.5	1.1	3.5%
Total Travel Time (hr)	14,095,000	13,453,000	-642,000	-4.6%
Fuel Consumed (l)	72,213,000	68,939,500	-3,273,500	-4.5%
Emissions (kg)	1,738,385	1,658,885	-79,500	-4.6%

From an environmental perspective, the reduction of fuel consumption is estimated to be 3,273,500 l/year. The reduction of fuel consumption is equivalent to the reduction of carbon dioxide emissions from 693 homes' electricity use for one year or carbon sequestered by 6,227 acres of forest in one year.