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TRAFFIC CONTROL SIGNAL TIMING AND SYNCHRONIZATION

The Transportation Services Committee recommends:

1. **Receipt of the presentation by Steven Kemp, Director, Traffic Management & Intelligent Transportation Systems, and Paul Nause, Manager, Traffic Engineering & Integrated Intelligent Transportation Systems; and**

2. **Adoption of the recommendation contained in the following report dated September 21, 2011, from the Commissioner of Transportation Services.**

1. RECOMMENDATION

It is recommended that this report be received for information.

2. PURPOSE

This report provides information regarding traffic control signal timing and synchronization on the Regional road system and explains the challenges of optimizing the operation of signalized intersections to meet the conflicting needs of different road users.

3. BACKGROUND

The Region currently operates and maintains 776 traffic control signals

The Region currently operates and maintains 776 traffic control signals within the boundaries of York Region. Of that total, 659 are owned by the Region; 56 are maintained by the Region under an agreement with the Ontario Ministry of Transportation; 34 are maintained by the Region under an agreement for 407 ETR and 27 for the local municipalities of Aurora, Newmarket, Vaughan, Richmond Hill and Markham.

The Region installs approximately 30 new traffic control signals each year at an average installation cost of approximately $150,000 and ongoing annual operating and maintenance cost of approximately $6,000 per location.

In addition, the Region has a sophisticated communications infrastructure that connects each traffic control signal to a Centralized Traffic Control System (CTCS). This system allows staff to remotely monitor and make adjustments to the traffic control signal timings at each intersection.

Optimizing traffic control signal timing is one component of an overall strategy to manage traffic congestion in York Region. Other components include infrastructure improvements to relieve congestion i.e. new traffic signals, intersection improvements and road widening, infrastructure improvements to reduce car dependency e.g. bicycle lanes, transit and HOV lanes, event and incident management, intelligent transportation systems, travel demand management etc.

As part of a strategy to optimize traffic control signal timing, Regional staff proactively carry out corridor reviews to evaluate and improve traffic flow. Approximately 15 corridor reviews are completed each year for selected locations based on public feedback, development-related traffic growth and scheduled review cycles.

The corridor review process involves "before" travel time runs to collect data, then analyzing the data to fine tune the traffic control signal timing and synchronization in the field, and finally followed by "after" travel time runs to determine and verify corridor travel time results.

The results of a typical review is provided below. This example was completed on Yonge Street between Savage Road South to Davis Drive. Table 1 provides a summary of the travel runs for a weekday, and Table 2 provides a summary of the travel runs for a weekend. The results of the review are as follows:

Table 1
Traffic Signal Progression Analysis - Weekday
Yonge Street: Savage Road South to Davis Drive

Time Period and Direction	Before		After		Analysis	
	Travel Time (sec/veh)	No. of Stops	Travel Time (sec/veh)	No. of Stops	Travel Time Savings (sec/veh)	Percent Decrease in Travel Time
AM Peak (NB)	317	3	279	2	38	12
AM Peak (SB)	274	3	258	2	16	6
Off Peak (NB)	335	3	326	3	9	3
Off Peak (SB)	287	3	291	3	-4*	-1
PM Peak (NB)	462	6	333	3	129	28
PM Peak (SB)	324	3	303	3	21	6

- AM Peak northbound and southbound travel time decrease of 38 seconds/vehicle and 16 seconds/vehicle, respectively

- OFF Peak northbound travel time decrease of 9 seconds /vehicle and a slight travel time increase in the southbound direction of 4 seconds/vehicle*
- PM Peak northbound and southbound travel time decrease of 22 seconds/vehicle and 6 seconds/vehicle, respectively

Table 2
Traffic Signal Progression Analysis - Weekend
Yonge Street: Savage Road South to Davis Drive

Time Period and Direction	Before		After		Analysis	
	Travel Time (sec/veh)	No. of Stops	Travel Time (sec/veh)	No. of Stops	Travel Time Savings (sec/veh)	Percent Decrease in Travel Time
AM Peak (NB)	259	2	236	2	23	9
AM Peak (SB)	241	2	186	1	55	23
PM Peak (NB)	344	3	267	2	77	22
PM Peak (SB)	221	1	279	2	-58*	-26

- AM Peak northbound and southbound travel time decrease of 23 seconds/vehicle and 55 seconds/vehicle, respectively
- PM Peak northbound travel time decrease of 22 seconds/vehicle
- PM Peak southbound increase of 58 seconds/vehicle, however adjustments to the traffic signal synchronization result in balanced travel times between the northbound and southbound direction *

4. ANALYSIS AND OPTIONS

Traffic control signal timing and synchronization is a means to optimize the traffic signal system and to balance the competing needs of all road users

Different road users can have competing objectives and perspectives on what the optimal signal operation should be. At traffic control signals, pedestrians do not want to wait too long to cross and want enough time to cross the intersection safely; while local residents want to get in and out of their communities quickly. This means they may want new traffic control signals where none exists or they want longer red time for the Regional road users. Commuters, on the other hand, do not want to stop and want to get to their destinations as quickly as possible. The objective, as traffic engineers look at these competing demands, is to install new traffic control signals only where the benefits exceed the disbenefits as listed in Table 3.

Table 3
Installation of New Traffic Control Signals

Benefits	Disadvantages
• Provide more comfortable crossing opportunities for cyclists and pedestrians	• Increased delay and stops for major road traffic
• Reduced right angle collisions	• Increased frequency of rear-end collisions
• Decreased delay to minor road traffic during peak time periods	• Increased delay to minor road traffic during off-peak periods

Once installed, traffic control signals can seldom be considered in isolation; in addition to having signal timing that balances the competing needs at an intersection, a traffic control signal needs to be considered as part of a wider transportation network. Sometimes it is necessary to increase the wait time for side street traffic at a single intersection in order to achieve a more optimized transportation network. This is the case along an arterial corridor that has several traffic control signals, where signals are timed and coordinated so that motorists can travel along a route with minimal stops and delay.

In these cases, an increase in delay at any one intersection that forms part of an optimized arterial corridor, is offset by the improved traffic operations that result from achieving good synchronization along the length of the arterial roadway.

Approximately 18% of traffic signal requests that Regional staff receive are to improve the synchronization of traffic control signals along a specific corridor to reduce the incidence of "drivers hitting every red light"

The communication network to which all traffic control signals are connected, allows for the synchronization of green phases so that platoons of traffic can travel through a series of signals without stopping.

A well-synchronized corridor consists of coordination and progression. Coordination refers to the timing of the signals so that a succession of green lights can be provided in sequence through multiple signalized intersections. Progression is the uninterrupted flow of traffic through a series of coordinated intersections. It is only possible to retain progression throughout a network of coordinated signals if a number of factors are aligned:

- Spacing of Traffic Control Signals
- Vehicular Volumes
- Amount of side street vehicular traffic

- Amount of pedestrian traffic.
- Vehicle travel speeds

For good progression to be achieved, the green time at downstream traffic control signals need to be long enough to discharge the queue prior to the arrival of the platoon. There should be sufficient time to let the platoon progress through the intersection. At intersections of two high volume roads, it is not always possible to assign sufficient green time to discharge the queue and to accommodate the platoon. In addition, these types of intersections are constrained due to the traffic demand in all directions.

The legal posted speed is used as the basis for designing traffic progression through a series of traffic signals

Vehicles entering and exiting driveways, on-street parking, pedestrian activity, construction, etc. can cause travel speeds along a road to be highly variable and unpredictable. When the actual travel speeds, as a result of these factors, are lower than the design values, the platoon will reach the next intersection too late, and encounter a red indication. Conversely, when platoons drive faster than the speed limit, they could arrive too early at the next signal and encounter a red indication as well. Drivers who are consistently experiencing short duration stops at traffic control signals are often driving faster than the posted speed limit, which is our design speed for signal coordination.

During times of the day when there are strong directional flows, the priority is to achieve progression in the dominant flow direction

The direction of travel which has lower volumes will typically experience poor traffic progression due to the priority given to the dominant flow direction. When flows are more balanced, outside peak periods, two-directional coordination is required. It is extremely rare that intersection green times, spacing and travel times align to allow for ideal two-way coordination. In addition, intersections have a limited capacity depending on the number of lanes to deal with the traffic volumes. If the number of vehicles exceeds capacity, the time required for queues to clear will ‘consume’ most or all of the available green time, leaving inadequate green time to accommodate arriving platoons.

Servicing motorists entering from minor roads, left-turning motorists, pedestrians as well as having responsive signals for transit and emergency vehicles reduces the opportunity to synchronize traffic control signals

The majority of traffic control signals in York Region are traffic actuated which means the time allocated to the minor road, left-turns and pedestrian phases are only displayed when there is a demand. In cases when there is no demand, the unused green time is added to the major road green time; therefore, the start of a major road green phase is not fixed and is difficult to coordinate precisely with the start of a green phase at an adjacent traffic control signal. In these cases, providing the additional green time to the main street may appear to the driver that signals are not synchronized. This results in traffic leaving early and arriving at the next intersection too early.

The synchronization of traffic control signals is further complicated by traffic signal pre-emption. These traffic signal features intentionally disrupt signalization to provide traffic signal priority. At the majority of Regional traffic control signals, emergency vehicles and rapid transit (VIVA) buses are given priority. This enables emergency vehicles to travel quickly and safely and assists transit in adhering to time of day schedules. The result of a traffic signal pre-emption is a temporary loss of synchronization. Under these circumstances it can take several cycles to regain the synchronization along a corridor.

Intelligent Transportation Systems help improve progression by providing advanced technology to increase monitoring capabilities to evaluate traffic progression

In order to optimize travel for the VIVA buses and other road users on the future dedicated rapidways, a new centralized traffic control system will be acquired. The Region's existing system does not have the capability to manage the complex phasing, timing and responsive control required for traffic lanes and dedicated bus lanes.

The new centralized traffic control system will be able to respond to fluctuating traffic demands to adjust signal timing and optimize traffic flow. The system will also improve monitoring and data collection capabilities using strategically placed traffic sensors. Advancements in technology related to automatic vehicle location (AVL) systems, cellular phone tracking, Bluetooth sensors and smartphone GPS probing, provide opportunities to supply intelligent transportation systems with real time traffic data. The Transportation Services' Traffic Management and Intelligent Transportation Systems Branch are actively assessing the use of AVL data from the Region's Transit fleet, cellular phone data through an agreement with Intelligent Mechatronic Systems Inc. (formerly Intellione Inc.) as well as Bluetooth sensors deployed along the Highway 7 vivaNext construction. The data captured from these sources can help to assess the traffic conditions and progression on the Regional road network.

5. FINANCIAL IMPLICATIONS

There are three Technologists dedicated to all aspects of traffic signal operations, including signal timing and synchronization. The cost associated with traffic signal timing and synchronization improvements is included in the existing Transportation Services operating budget. The total annual operating cost for this activity is approximately $160,000 which represents less than 0.1% of the total Transportation Services operating budget.

The capital cost associated with centralized traffic signal control system replacement will be included in the overall project cost for vivaNext rapidway construction. The cost for the centralized traffic control system replacement will be determined after the detail design process is complete and the successful vendor has been selected.

6. LOCAL MUNICIPAL IMPACT

Optimizing traffic flows along an arterial corridor is achieved through good synchronization along the length of the arterial roadway. This helps the local municipalities avoid neighbourhood infiltration issues by keeping the traffic on the arterial roads.

7. CONCLUSION

Traffic patterns are ever changing due to growth and development, therefore, the need to continuously monitor and adjust traffic control signal timings is required to ensure progression along corridors. In addition, technology advancements in Intelligent Transportation Systems will assist in managing congestion and delays on the Regional road network.

For more information on this report, please contact Steven Kemp, Director, Traffic Management and Intelligent Transportation Systems at extension 5226.

The Senior Management Group has reviewed this report.

Traffic Control Signal Timing And Synchronization
"Why is the Light Always Red for Me?"

Presentation to
Transportation Services Committee
Please refer to Agenda Item D3

Steven Kemp and Paul Nause

October 5, 2011

Purpose of This Presentation

1. To provide information on the method used for traffic control signal timing and synchronization.
2. To explain the challenges of optimizing the operation of signalized intersections.

Outline

- ❑ Traffic Control Signal Infrastructure
- ❑ How Do Traffic Control Signals Work?
- ❑ Traffic Control Signal Timing
- ❑ Traffic Control Signal Synchronization
- ❑ Traffic Management Challenges
- ❑ Opportunities for Improvement

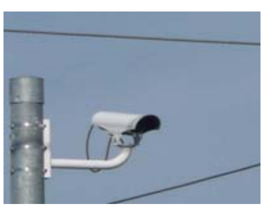
Traffic Control Signal Infrastructure and How Signals Work

Traffic Control Signal Infrastructure

❑ No. of Traffic Control Signals	776
❑ New Installations	30/yr
❑ Average Installation Cost	$150,000
❑ Annual Maintenance Costs	$6,000

- ❑ Other Components
  - ❑ Central Traffic Control System (CTCS)
  - ❑ Communications Infrastructure

Traffic Signals – How Do They Work?

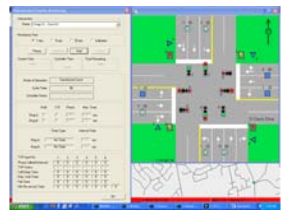




Traffic Signals – How Do They Work?





Traffic Signals – How Do They Work?

Traffic Control Signals will:

- ❑ increase delay to major road traffic (and sometimes for the cross street as well)
- ❑ increase the frequency of rear-end collisions

So why would you ever install one?

Traffic Signals – How Do They Work?

Traffic Control Signals will also:

- Reduce the number of right angle collisions (these are often the most serious)
- Provide more comfortable crossing opportunities for cyclists and pedestrians

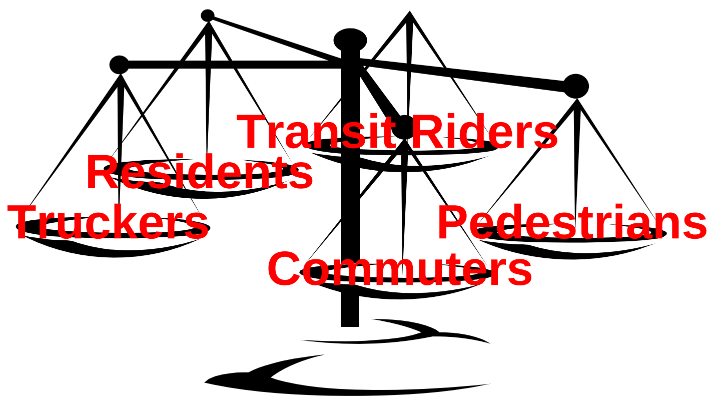
Efficiency/Safety Trade Off

Traffic Control Signal Timing

What Is "Optimized"?

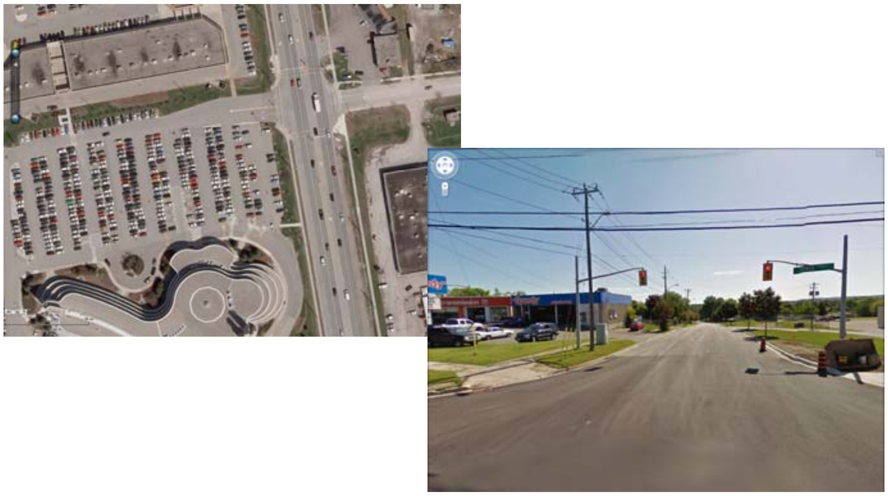
- Pedestrians
  - "Don't want to wait long"
  - "Want to have enough time to cross"
- Local Residents
  - "Want to get on and off major road quickly"
- Commuters
  - "Don't Want To Stop"
  - "Get from A to B as quickly as possible"

What Is Optimized?



How to balance these competing objectives?

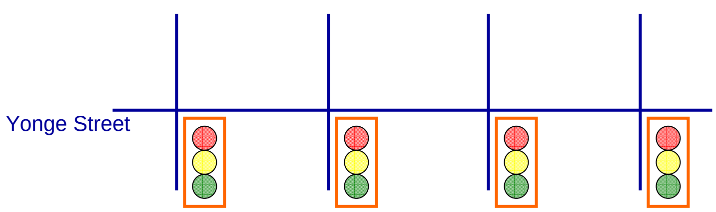
An Example – Yonge Street at Gladman



What is Optimized?

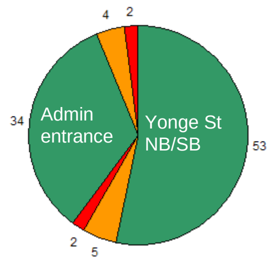
- Step 1 : Individual Traffic Control Signal Optimization

- Step 2 : Synchronized Traffic Control Signals in groups



What is “Optimized?”

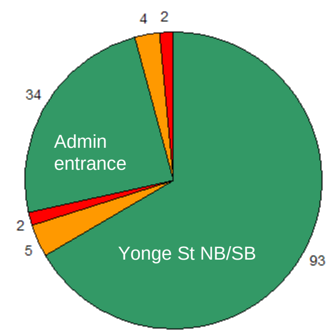
Stand Alone



Cycle length = 100 sec

No coordination with Yonge @ Eagle.

Coordinated



Cycle length = 140 sec

Same cycle time as Yonge @ Eagle.
Can coordinate signals.

Signal Timing Basics - Challenges

- Pedestrian crossing time requirements
- Need for left turn phases
- How much green time to allocate to each phase?
- Desire for coordinated signals in groups

Sometimes more green = less capacity

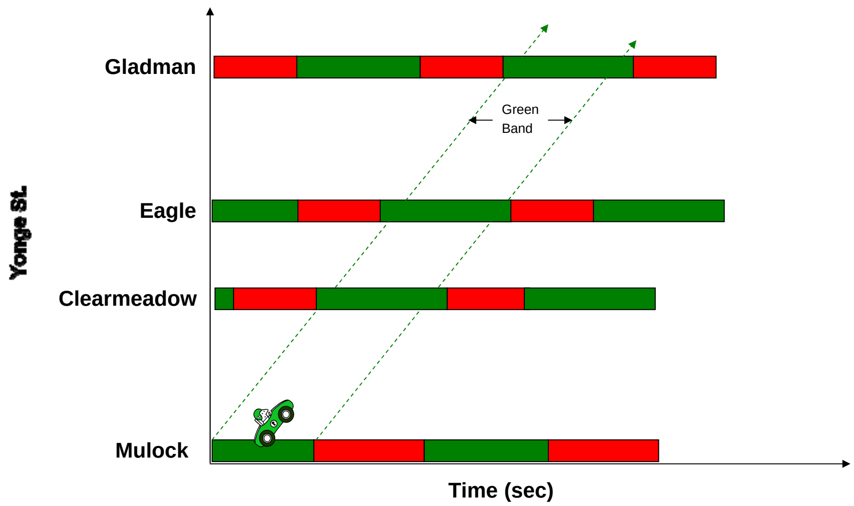
Sometimes more road = less capacity

Traffic Control Signal Synchronization

Traffic Control Signal Synchronization

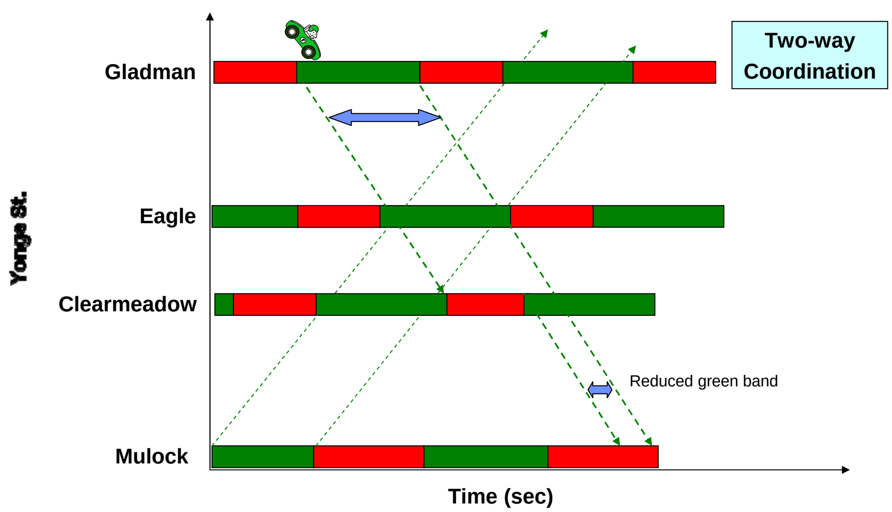
- Synchronize green phases so that <u>platoons</u> of traffic can travel through a series of signals to:
  - minimize stops; or
  - minimize travel time

Traffic Control Signal Synchronization



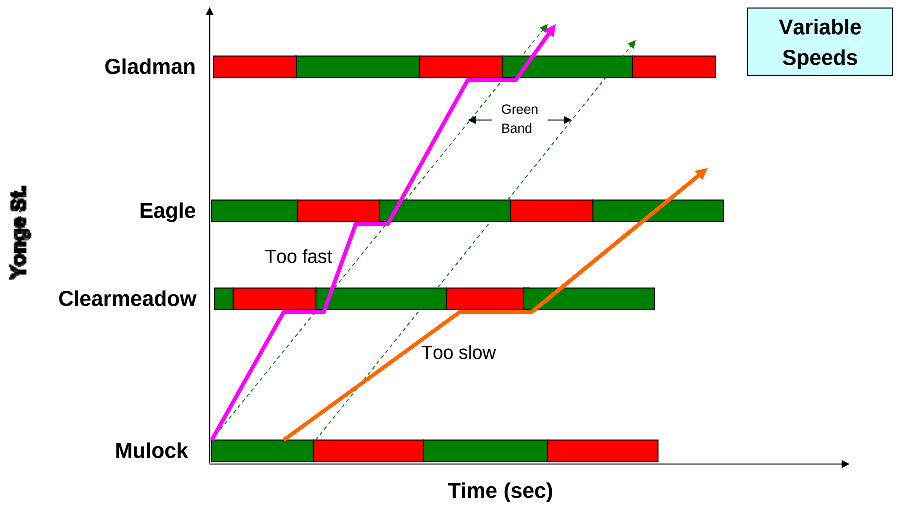
Why Do I Hit Every Red Light?

You Are Going the Opposite Direction



Why Do I Hit Every Red Light?

You Are Driving the Wrong Speed



Why Do I Hit Every Red Light?

- Congestion (standing queues)
- Left turns and Pedestrian phases
- Transit Priority
- Emergency Vehicle Pre-emption
- Out of date traffic signal timing

Traffic Management Challenges

- Balancing User Needs
- Responding to changing traffic patterns
- Capacity constraints and congestion

Opportunities for Improvement

- New Traffic Signal Control System
- Pro-active approach to signal timing updates
- Intelligent Transportation Systems

Discussion/Questions?