

YONGE STREET – HIGHWAY 401 INTERCHANGE SOLUTION

Proposal To Eliminate Gridlock in South North York Centre Area With A High Performance
Free-Flowing Non-Weaving User-Friendly Multimodal Interchange Solution

Toronto, Ontario

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Version 1 Check www.yonge-401.com for latest version

Raymond Jean Consulting - a problem is just an opportunity for a better solution

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Executive Summary

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Introduction

The North York Centre area has been designated as an urban growth centre and mobility hub and continues to see rapid development. With high density rapid developments, the south North York Centre area is now plagued with some of the worst gridlock traffic in the Greater Toronto Area. The source of major gridlock problems in the south North York Centre area are two left turns at the Yonge Street - Highway 401 interchange. Since both of these two left turns cross oncoming traffic, they require a signalized (traffic light) intersection and a long left turn “waiting” lane to hold their extremely long queue. The two problematic left turns are:

- Southbound Yonge Street to eastbound Highway 401 (via Lord Seaton) (N-E 401 on-ramp) left turn with signalized intersection causes an extremely long queue during AM rush which causes gridlock traffic throughout the south North York Centre area (Yonge Street Area Traffic Management Study - City of Toronto / iTRANS Project # 4656 (YSTMS #4656)).
- Westbound Highway 401 to southbound Yonge Street (E-S 401 off-ramp) left turn with signalized intersection and westbound Highway 401 to northbound Yonge Street (E-N 401 off-ramp) channelized right forced merge (without dedicated lane on Yonge Street) also causes long queue along Highway 401 westbound at Yonge resulting in traffic congesting on the Highway 401 westbound collector lanes (Yonge-401 interchange - MTO / iTRANS Project # 2671).

Purpose

The purpose of this document is to introduce an alternative solution to the proposed southbound Yonge Street to eastbound Highway 401 (N-E 401 on-ramp) left turn flyover ramp which would only address one of the two problematic left turns at this interchange. The lower cost high performance multimodal Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving interchange configuration will address both problematic left turns, give comparable interchange performance as a much more costly interchange with 4 left turn flyover ramps and would provide a user friendly interchange for drivers, pedestrians and cyclists.

Double Crossover Diamond With Signalized Intersection Crossovers

Since we drive on the right-hand side of the road, on the arterial road all right turns onto the highway on-ramp and from off-ramp are free-flowing (no signalized intersection required). Left turns at interchange usually require signalized intersection on the arterial road to cross in front of oncoming traffic. These left turns also require left turn “waiting” lanes to hold extremely long queues during peak time.



Photo 1: N-E 401 Left Turn “Waiting” Lane - Southbound Yonge Street to Eastbound Highway 401 on-ramp (N-E 401 on-ramp) left turn “waiting” queue in mid-morning. Notice, higher service volume right turn is clear without any queue.

At most interchange configurations, all right turns are usually at the outer four ramps, while the left turns are usually at the inner four ramps. If we drive on the left-hand side of the road to service these left turns then the left turn would also be free-flowing and would not form any long queues thus there’s no need for left turn “waiting” lanes which could be returned to “active duty”.

The challenge then becomes how both direction of traffic would crossover each other as they transverse between the outer part of the interchange where driving on the right hand side of the road is normal and the inner part where driving on the left hand side of the road is optimal. Crossovers with at-grade signalized intersection or grade-separated overpass - underpass system. Does the performance cost of navigating through the crossovers outweigh the performance improvements of driving on the left-hand side of the road to service its free-flowing left turns.

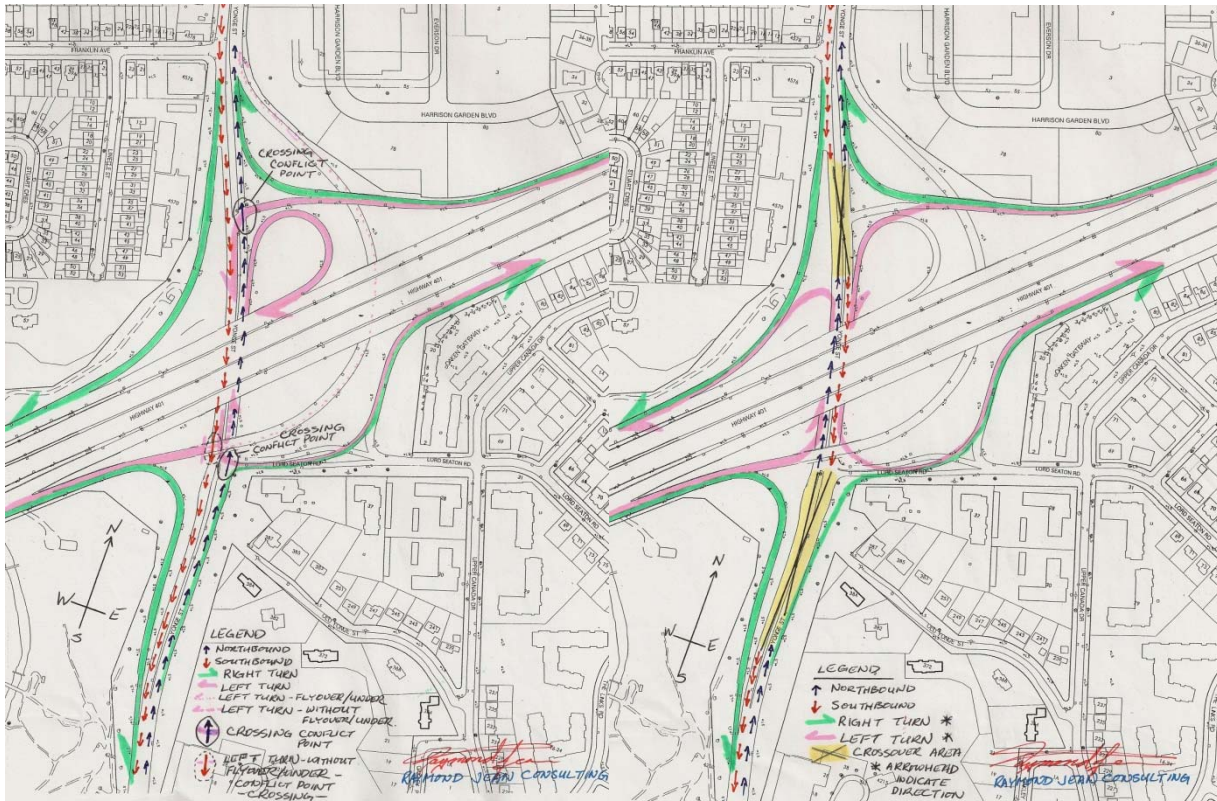


Illustration 1: Current Right & Left Turns

Illustration 2: Proposed Right & Left Turns & Crossovers

Notice: all right turns (green) are in outer part of interchange while left turns (pink) are in inner part. Map on left shows current interchange with right hand side of the road driving throughout along with two (+1 possible) left turn conflict points. Map on right shows left hand side of road driving only in inner part of interchange without any left turn conflict points. Crossover areas are in yellow highlights.

In the last few years, the U.S. Department of Transportation Federal Highway Administration (FHWA) has been actively promoting a new interchange design called the Double Crossover Diamond (DCD) Interchange system (also known as Diverging Diamond Interchange - DDI) as a relatively cost effective method to increase traffic capacity, decrease traffic congestion, improve traffic flow and safety at diamond based interchanges that experiences serious traffic congestion caused by left turns at signalized intersections. This award winning interchange design takes less construction time to build, typically cost less than half as much to build compared to more traditional interchange structures that may not give the same increase in capacity.

A Double Crossover Diamond allows each direction of traffic on the arterial road to service its own free-flowing right turn on-ramp in the outer right turning ramp area as it enters the interchange. The crossover then set traffic to drive on the left-hand side of the road to service all its left turns in the inner ramp area as free-flowing left turns. A second crossover is needed to place traffic back onto the usual right-hand side of the road to service a right turn off-ramp in the outer right turning ramp area as it leaves the interchange.

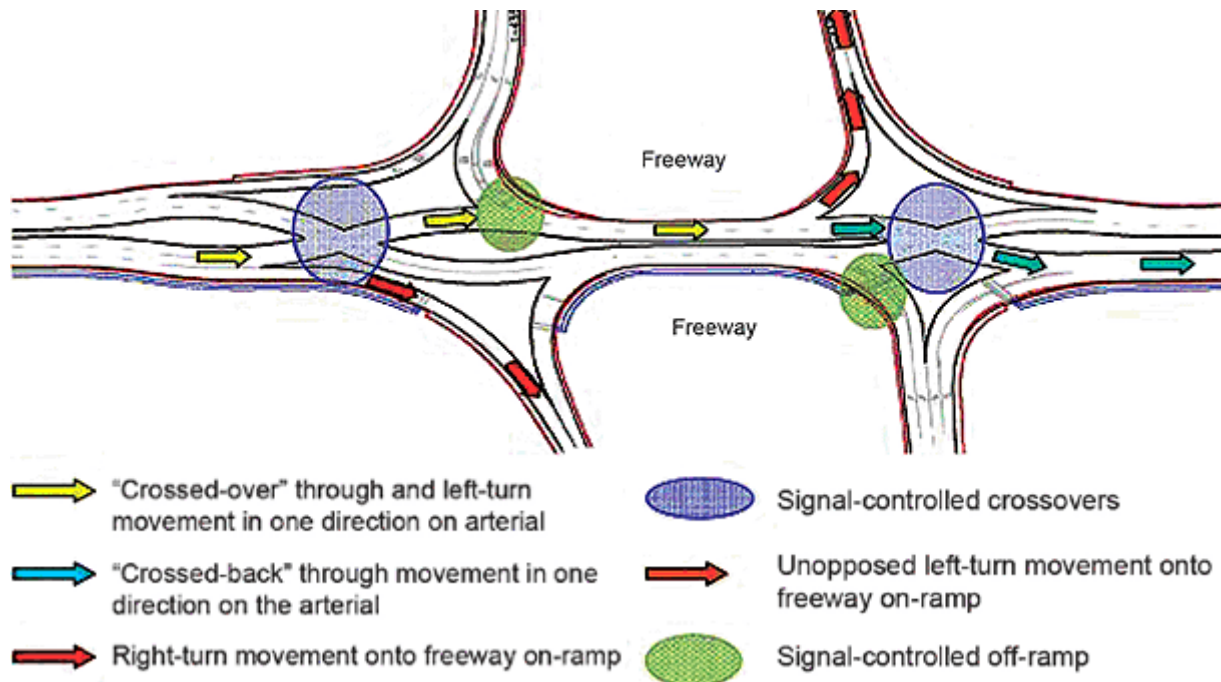


Illustration 3: Double Crossover Diamond Traffic Movement

<http://www.fhwa.dot.gov/publications/research/safety/09054/index.cfm>

The U.S. Department of Transportation Federal Highway Administration (FHWA) Turner-Fairbank Highway Research Center (TFHRC) have shown that a Double Crossover Diamond With Signalized Intersection Crossovers will reduce delays by 15 to 60%, increase total capacity by 10 to 30% and double the rate of left turns compared to a more conventional diamond interchange. A Double Crossover Diamond With Signalized Intersection Crossovers will take significantly less time to design and construct. Construction cost is also typically 50 to 80 percent lower than more traditional interchange structures that may not even provide a similar level of performance improvement.

“The main reasons to choose a DCD interchange design instead of a conventional interchange design include traffic operational benefits, potential safety benefits, right-of-way benefits, and reduced construction costs. DCD interchanges are especially suitable in suburban/urban settings where limited and costly right-of-way and reduced duration of construction are critical issues. Environmental benefits have not yet been estimated, but it is clear that the reduced congestion and possible safety benefits will result in reduced fuel consumption and pollution. Some situations where DCD interchanges are most applicable are as follows:

- Heavy volumes of left turns onto freeway ramps.
- Moderate and unbalanced through volumes on bridge approaches on the arterial road.
- Moderate to very heavy off-ramp left-turn volumes.
- Limited bridge deck width availability.”

U.S. Department of Transportation - Federal Highway Administration “Double Crossover Diamond Interchange” October 2009

<http://www.fhwa.dot.gov/publications/research/safety/09054/index.cfm>

List of existing Double Crossover Diamond With Signalized Intersection Crossovers in the U.S.A.:

- First: Springfield, Missouri at I-44 and Hwy 13 - opened June 21, 2009. First Double Crossover Diamond Interchange conversion in USA (cost \$3.2 million & 6 month construction VS \$10 million & 2 years construction for alternative standard rebuild with Single Point Urban Interchange system).
- Second: Springfield, Missouri at US-60 and National Avenue - opened July 12, 2010
- Third: American Fork (Salt Lake City), Utah at I-15 and Main Street - opened August 23, 2010. First Double Crossover Diamond Interchange built from the ground up in USA
- Fourth: St. Louis, Missouri at I-270 and Dorsett Road - opened on October 17, 2010
- Fifth: Alcoa, Tennessee at US-129 and Bessemer Street
- Sixth: Lexington, Kentucky at Harrodsburg Road (US-68) & New Circle Road (Route-4)
- Seventh: Lehi, Utah at Timpagonos Highway (Utah-92) & Interstate 15

There are numerous Double Crossover Diamond With Signalized Intersection Crossovers currently in the construction, design and study stages throughout the United States. In addition to the three Double Crossover Diamonds Missouri already have, they currently have plans for 4 more:

- I-435 & East Front Street, Kansas City
- I-70 & Stadium Blvd., Columbia
- US-65 & Chestnut Expressway, Springfield
- US-65 & Battlefield Road, Springfield

Table 1: Double Crossover Diamond Cost Savings VS Alternatives

Chart showing 70-75% cost saving using Double Crossover Diamond versus alternative design for both completed and planned projects.

Interchange	Location	DDI Cost (real or estimated)	Alternative Design Cost	Cost Savings
I-44 / Route 13	Springfield, MO	\$3.2 Million	Over \$10 Million	about 70%
I-435 / Front Street	Kansas City, MO	\$6.7 Million	Diamond \$11.4 Million Single Point Urban Interchange (SPUI) \$25 Million	about 75%
SR-265 / SR-62	Utica, IN	\$52 Million	\$118 Million	\$66 Million
I-590 / Winton Road	Brighton, NY	\$3-\$4 Million	SPUI \$10 Million Triple Left Diamond \$13.6 Million	about 75%

<http://www.divergingdiamond.com/benefits.html>

Don Saiko, P.E., Transportation Project Manager (Missouri) MoDOT: “There has been widespread interest in the diverging diamond interchange, especially when many state DOTs across the country are facing tough economic times and are seeing a dramatic decrease in funding. These agencies are looking for ways to improve traffic flow with decreased funding. The DDI is one way this can be done if it's the right solution. I have spoken to other state DOTs and private consultants in 35 states and many of them are pursuing the use of the DDI because of its low cost and improved traffic flow.”

More “Best of the States” in Transportation: New Traffic Interchanges - Missouri’s Diverging Diamond Interchange

<http://knowledgecenter.csg.org/drupal/content/more-%E2%80%9Cbest-states%E2%80%9D-transportation-new-traffic-interchanges-road-condition-monitoring-and-reg>

For more information on the Double Crossover Diamond With Signalized Intersection Crossovers interchange system, please see the following documentations and animations:

Diverging Diamond Interchange (DDI) (PowerPoint notes)

<http://www.acecmi.org/pdf/DDI.pdf>

U.S. Department of Transportation - Federal Highway Administration - Double Crossover Diamond

<http://www.fhwa.dot.gov/publications/research/safety/09054/index.cfm>

Animations:

TIME's video "Not Your Grandparents' Left-Hand Turn." - The Diverging Diamond Interchange: In Action

http://www.time.com/time/video/player/0,32068,739424268001_2044949,00.html

Features and Benefits of the Double Crossover Diamond (DCD) - Harrodsburg Road Double Crossover Diamond (DCD) Interchange (Good for history & usage in USA - gets too specific on location)

<http://www.youtube.com/watch?v=odoGAui6Qe8>

Diverging Diamond Interchange Visualization - Instructional video on how to drive in a diverging diamond interchange (Very good narration)

<http://www.youtube.com/watch?v=HD-0QnUILOQ&feature=related>

The Double Crossover Diamond interchange has won a number of engineering, productivity and environmental awards.

The diverging diamond interchange was listed by Popular Science magazine as one of the six best innovations in 2009 (engineering category) in "Best of What's New 2009"

<http://www.popsci.com/technology/gallery/2009-12/gallery-top-100-products-year?image=34>

The first Double Crossover Diamond interchange built in the United States at Springfield, Missouri at I-44 and Highway 13 also won an American Association of State Highway and Transportation Officials (AASHTO) award and a Governor's Award for Quality and Productivity.

<http://epg.modot.org/index.php?title=234.6> Diverging Diamond Interchanges

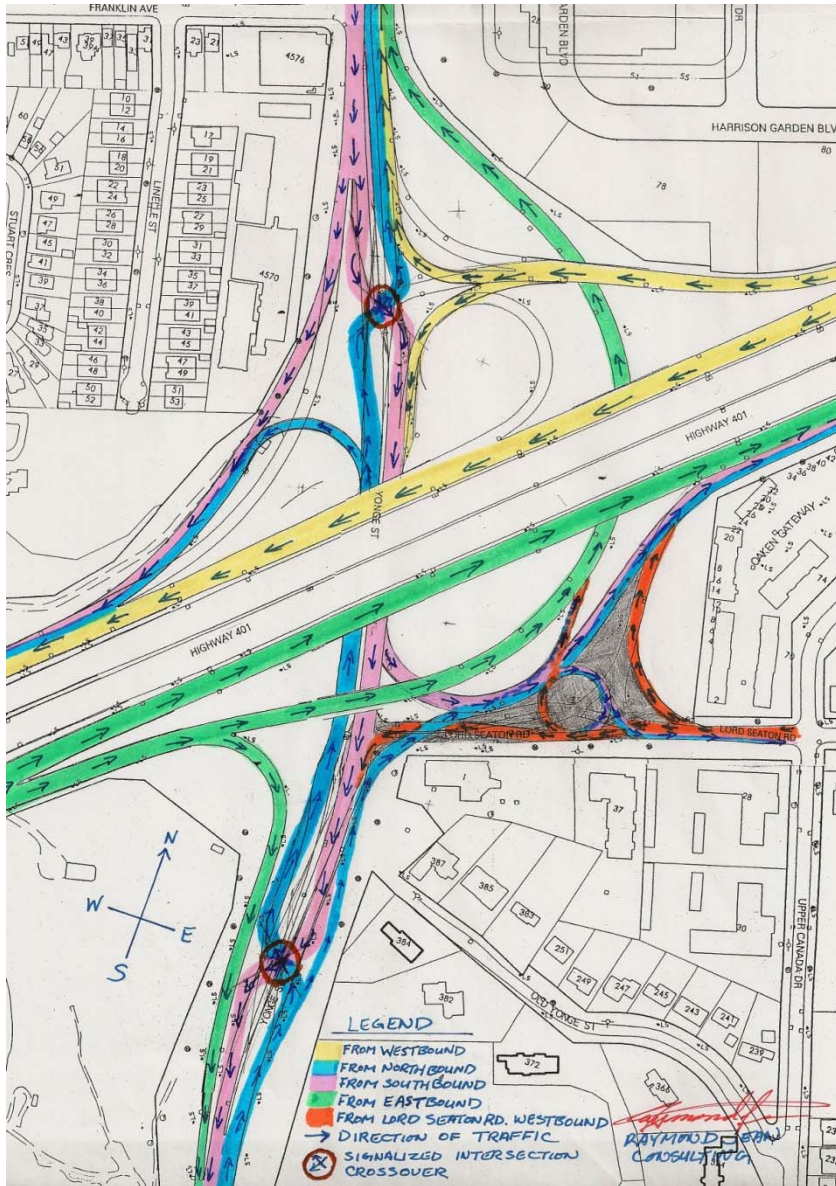


Illustration4: Yonge - 401 As DCD With Signalized Intersection Crossovers NOTE: New (S-W 401 on-ramp) ramp structures with 40m radius (standard on 270 degree “reverse jug-handles” of Parclov A4 throughout GTA) fit within MTO & City of Toronto property.

Double Crossover Diamond With Overpass – Underpass Crossovers

While there are numerous benefits of the Double Crossover Diamond With Signalized Intersection Crossovers solution, almost all of the negatives aspects relates to the at-grade signalized intersection itself, which can be eliminated by using a grade-separated overpass – underpass crossover. Furthermore, a safe perpendicular signalized intersection which must flex outward may not be possible in the South Crossover area due to topography and the narrow Yonge Street corridor.

By pure dumb luck, the Yonge Street - Highway 401 interchange is long enough along the arterial road that both North and South Crossover areas can fit a pair of overpass – underpass system creating the higher performance Double Crossover Diamond With Overpass – Underpass Crossovers solution; a completely free-flowing interchange without any signalized intersection, eliminate all the left turn problems (including the long left turn queues that gridlocks south North York Centre and causes traffic congestion along Highway 401 westbound collector lanes), reduce delays by significantly more than 15-60% (25-45% est.), increase total capacity by significantly more than 10-30% (15 -90% est.), improve traffic flow, increase left turn service volume by 3-4 folds, improve safety and transform this interchange into a efficient user-friendly interchange for drivers, cyclists and pedestrians.

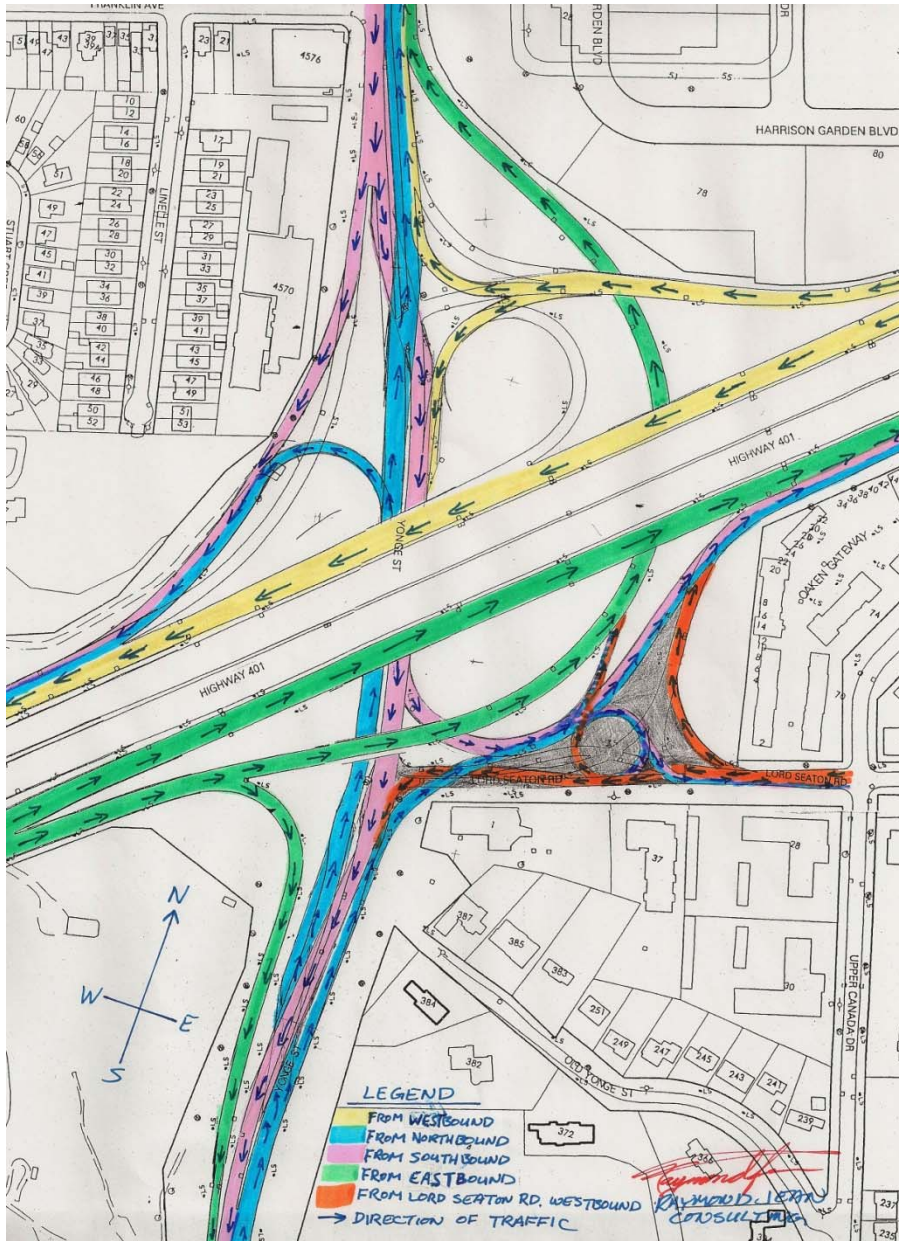


Illustration 5: Yonge - 401 As DCD With Overpass - Underpass Crossovers NOTE: Northbound Yonge Street should be on the overpass in the North Crossover and southbound Yonge Street should be on the overpass in the South Crossover.

Since Yonge Street already slopes at both the north and south crossover, manipulating the slopes to form a below grade underpass will help minimize the height, length and slopes of the ramps for the overpass above. There should already be enough room for the overpass at both the north and south crossover. Implementing a below grade underpass, will ensure a gentler ride for those travelling on the overpass and minimize overall cost.

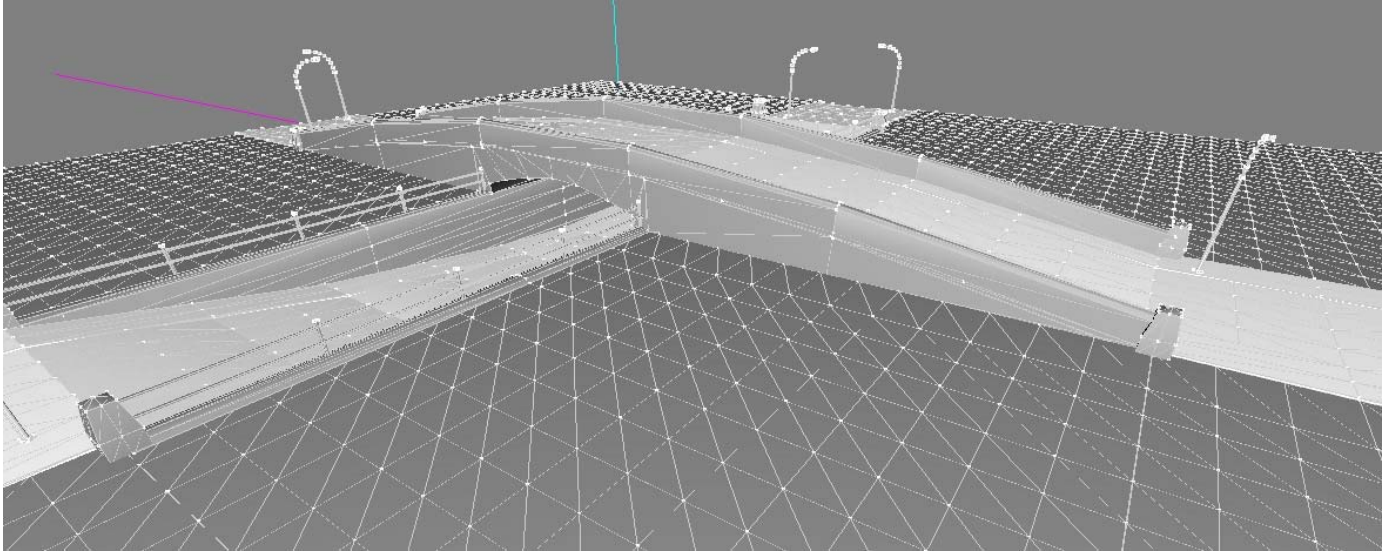


Illustration 6: Use Of Below Grade Underpass Helps Ensures Shorter Overpass With Gentler Ascending And Descending Ramps. NOTE: Our overpass – underpass will not be perpendicular as illustrated here.

<http://www.gamedev.net/blog/289/entry-1709696-bridgeunderpass-artwork/>

Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving

With the Double Crossover Diamond With Overpass – Underpass Crossovers solution, in heavy traffic a weaving problem may occur between the left turn off-ramp and the downstream left turn on-ramp downstream as both ramps utilize the same left lane along the arterial road. By having the left turn off-ramp (westbound Highway 401 to southbound Yonge Street off-ramp (E-S 401 off-ramp)) become the dedicated right lane of the arterial road by utilizing a short one lane overpass, left turn on-ramp (southbound Yonge Street to eastbound Highway 401 on-ramp (N-E 401 on-ramp)) traffic can freely use the left lane without any conflict; this is called the Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving solution.

Since the westbound Highway 401 to southbound Yonge Street off-ramp (E-S 401 off-ramp) become the dedicated right lane on southbound Yonge Street just before the Highway 401 overpass, the 3 current southbound Yonge Street lanes must be reduced to 2 lanes. This should be bearable since the current left turn “waiting” lane will be converted for “active duty”. As North York Centre continues to grow this bottleneck may eventually force the southbound Yonge Street to eastbound Highway 401 (N-E 401 on-ramp) left turn to be rerouted through a new tunnel under just east of the current Yonge Street underpass structures.

The Double Crossover Diamond With Overpass - Underpass Crossovers Without Weaving solution will in addition to all the benefits of the Double Crossover Diamond With Overpass – Underpass Crossovers solution will not suffer from a weaving problem in high volume traffic.

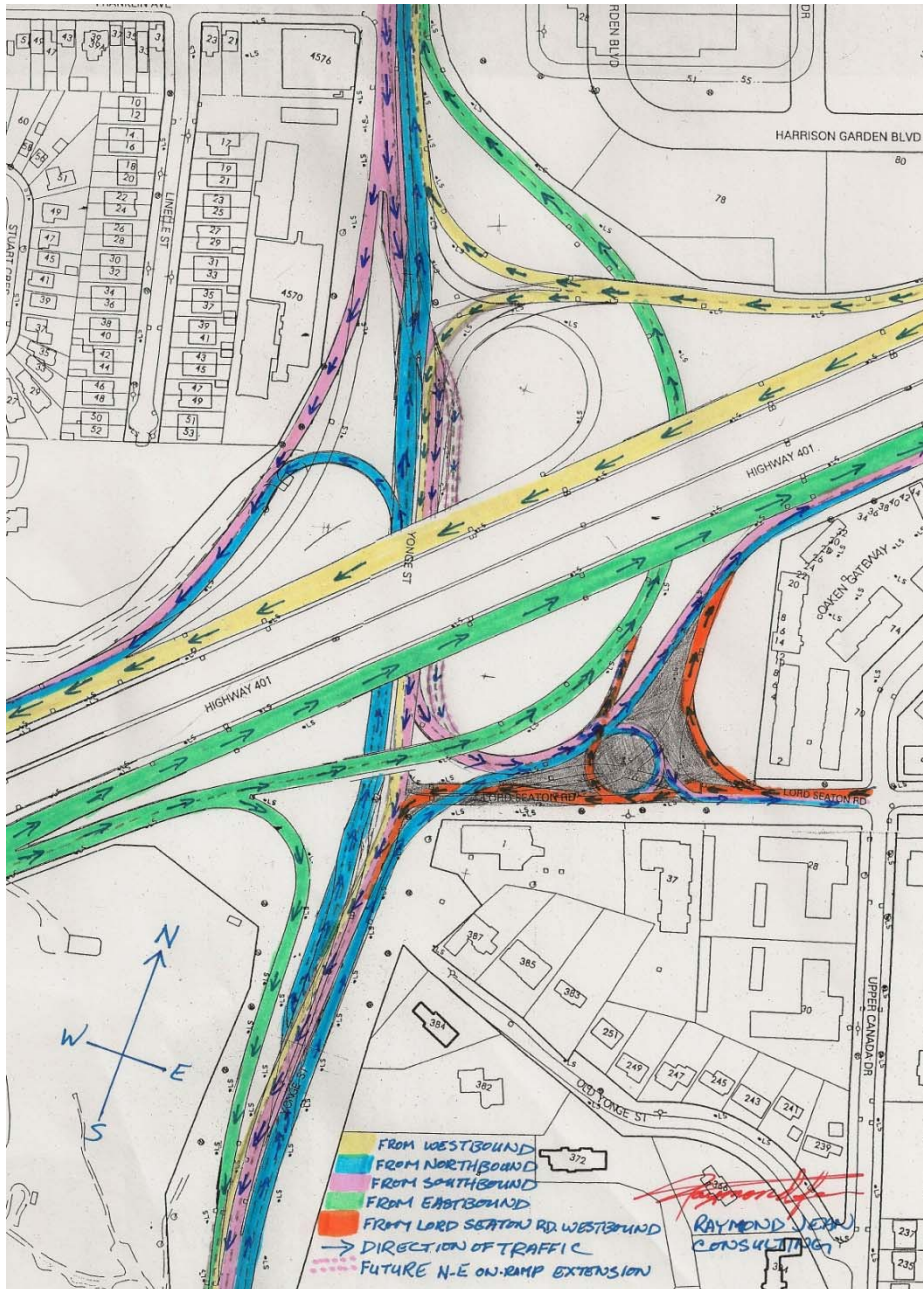


Illustration 7: Yonge - 401 As DCD With Overpass – Underpass Crossovers Without Weaving

Notice: Left turn off-ramp (westbound Highway 401 to southbound Yonge Street off-ramp (E-S 401 off-ramp)) use overpass to become dedicated right lane on arterial road (southbound Yonge Street). The other left turn off-ramp (eastbound Highway 401 to northbound Yonge Street “fly-over-Yonge-then-under-401” off-ramp (W-N 401 off-ramp)) does not contribute to weaving problem in inner part of interchange.

Multimodal: Integrated Pedestrian Sidewalk And Bike Lane Network

Crossover roads with bike lane and sidewalks to the right (relative to traffic direction) results in an integrated pedestrian sidewalk system bringing pedestrian traffic from both the east and west side of Yonge Street to a shared centre sidewalk under the Highway 401 overpass. This integrated pedestrian

sidewalk system will not only facilitate north-south pedestrian travel but also east-west pedestrian crossing of Yonge Street without the use of any signalized intersection.

The bike lane system will mirror the integrated pedestrian sidewalk network, and have a shared centre bike lane under the Yonge Street underpass. To enable both bike lanes and pedestrian sidewalk in the Yonge Street underpass without sacrificing any vehicular traffic lanes, the shared centre sidewalk will be elevated along the east side of the western underpass and the shared centre bike lane will be directly underneath in a trench system to give it adequate height clearance.

An additional, more scenic bike path can be built just west of Yonge Street and cross Highway 401 at the upper part of the Don Valley just under the Hogg's Hollow Bridge where an existing path already exist.

A pedestrian ramp structure could link the southern shared centre sidewalk to the current pedestrian overpass spanning Yonge Street at Lord Seaton Road to serve the St. Andrews community. The bike lane system could link to the proposed bike lane on Becroft Road via new bike lanes through deprecated city laneways and the wide pedestrian boulevard sidewalks along the west side of Yonge Street.

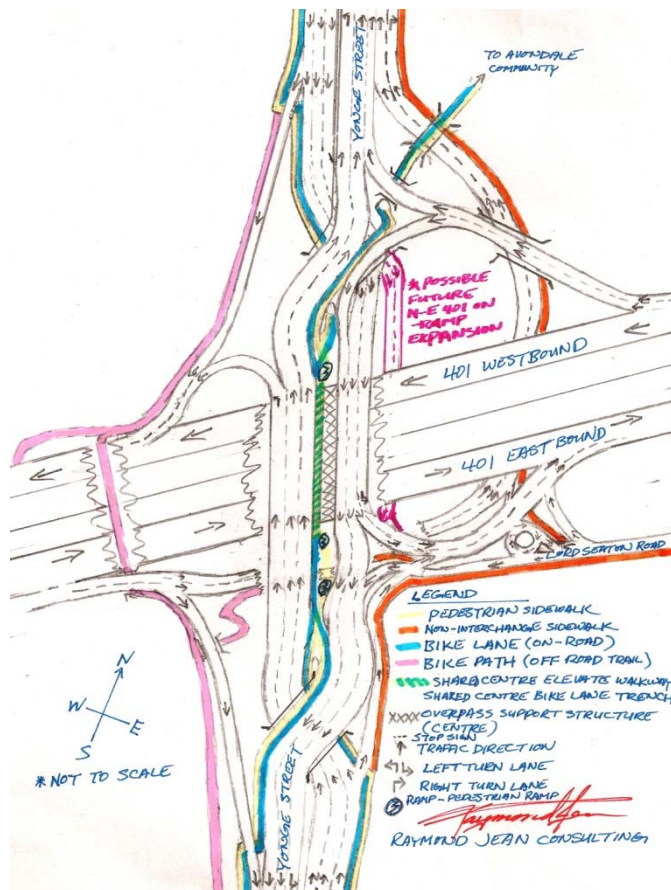


Illustration 8: Integrated Pedestrian Sidewalk & Bike Lane Network

Comparison To Proposed Flyover Ramp

Some problems with the proposed southbound Yonge Street to eastbound Highway 401 (N-E 401 on-ramp) flyover ramp:

- 0 Entrance for flyover too close to entrance for southbound Yonge Street to westbound Highway 401 off-ramp, causing confusion and last second lane changes
- 0 Cost of flyover ramp is expensive (currently budgeting for \$35 million)
- 0 Construction of flyover ramp will require various lane closure on Highway 401
- 0 Only address problem with southbound Yonge Street left turn to eastbound Highway 401 via Lord Seaton - does not address long queue problem with westbound Highway 401 to southbound Yonge Street which would require another flyover!

The basic requirements of a free-flowing southbound Yonge Street to eastbound Highway 401 (N-E 401 on-ramp) left-turn flyover ramp are:

- 0 Allow traffic from southbound Yonge Street to cross (flyover) northbound Yonge Street traffic at separate grade
- 0 Proceed with a left turn manoeuvre

Using conventional highway interchange design, the proposed southbound Yonge Street to eastbound Highway 401 (N-E 401 on-ramp) left-turn flyover ramp is 3 level high, about 700 metres long and must flyover all lanes of Highway 401 and the eastbound Highway 401 to northbound Yonge Street “fly-over-Yonge-then-under-401” off-ramp (W-N 401 off-ramp). But nowhere in the original criteria does it state the flyover needs to flyover Highway 401! So why does the flyover fly over the entire Highway 401?

With the Double Crossover Diamond With Overpass - Underpass Crossover Without Weaving solution; the southbound Yonge Street traffic fly-under (not over but with the same free-flowing results) northbound Yonge Street traffic at the grade-separated overpass - underpass system at the North Crossovers and then proceed to perform a free-flowing left turn just south of the Highway 401 overpass.

In the non-conventional Double Crossover Diamond With Overpass - Underpass Crossover Without Weaving solution, all 4 left turns fly-over or fly-under oncoming traffic in the North or South Crossover and proceed with a separate left turn; thus giving this interchange the performance comparable to having 4 left turn flyover ramps.

Table 2: Comparison Of Various Interchange Solutions

	Current (base)	Double Crossover Diamond With Signalized Intersection Crossovers	Double Crossover Diamond With Overpass – Underpass Crossovers	Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving	Current plus Southbound Yonge to Eastbound 401 flyover ramp	Current plus SB Yonge to EB 401 & WB 401 to SB Yonge flyover ramp	Current plus SB Yonge to EB 401 & WB 401 to SB Yonge & NB Yonge to WB 401 flyover ramp
Signalized Intersec- tions Required	2 – 2 phase signals	2 – 2 phase signals	None – Completely Free-Flowing Interchange	None – Completely Free-Flowing Interchange	1 – 2 phase signal (north)	None – Completely Free- Flowing Interchange	None – Completely Free- Flowing Interchange

Number of Free-Flowing Left Turns	2	4	4	4	3	4	4
SB-Yonge to WB-401 (N-W) - right	Free-flowing right turn	*	**	**	*	**	**
		On-ramp slightly shifted	On-ramp slightly shifted	On-ramp slightly shifted			
SB-Yonge to EB-401 (N-E) - left	(base) signalized intersection causes long queue resulting in North York Centre gridlock	2 times base left turn service volume (throughput)	3-4 times base left turn service volume (throughput)	3-4 times base left turn service volume (throughput)	3-4 times base left turn service volume (throughput)	3-4 times base left turn service volume	3-4 times base left turn service volume
		New highway specification on-ramp	New highway specification on-ramp	New highway specification on-ramp	New flyover ramp	New flyover ramp	New flyover ramp
			Possible Weaving Problem In Heavy Traffic				
NB-Yonge to EB-401 (S-E) - right	Signalized intersection right turn	*	**	**	*	**	**
		New highway specification on-ramp	New highway specification on-ramp	New highway specification on-ramp			
NB-Yonge to WB-401 (S-W) - left	Free-flowing 270 degree "reverse jug-handle" left turn	*	**	**	*	**	**
		New on-ramp on west side of Yonge Street	New on-ramp on west side of Yonge Street	New on-ramp on west side of Yonge Street			New flyover ramp
WB-401 to NB-Yonge (E-N) - right	Channelized forced merge onto NB-Yonge	Become dedicated lane on NB-Yonge	Become dedicated lane on NB-Yonge	Become dedicated lane on NB-Yonge	Channelized forced merge onto NB-Yonge	Channelized forced merge onto NB-Yonge	Channelized forced merge onto NB-Yonge
WB-401 to SB-Yonge	(base) signalized intersection	2 times base left turn service	3-4 times base left turn service	3-4 times base left turn service	Same as base	3-4 times base left turn service	3-4 times base left turn service

(E-S) - left	causes long queue resulting in WB-401 collector traffic congestion	volume (throughput)	volume (throughput)	volume (throughput)		volume	volume
		Become dedicated lane on SB-Yonge	Become dedicated left lane on SB-Yonge	Become dedicated right lane on SB-Yonge		New flyover ramp	New flyover ramp
			Possible Weaving Problem In Heavy Traffic				
EB-401 to SB-Yonge		*	**	**	*	**	**
(W-S) - right							
EB-401 to NB-Yonge	Free-flowing “fly-over-Yonge-then-under-401” ramp	*	**	**	*	**	**
(W-N) - left							
Delay	(base)	15-60% decrease	Much more than 15-60% decrease	Much more than 15-60% decrease	Should be similar to DCD with Signalized Intersection Crossovers	Similar to DCD with Overpass – Underpass Crossovers	Similar to DCD with Overpass – Underpass Crossovers
Total Capacity	(base)	10-30% increase	Much more than 10-30% increase	Much more than 10-30% increase	Should be similar to DCD with Signalized Intersection Crossovers	Similar to DCD with Overpass – Underpass Crossovers	Similar to DCD with Overpass – Underpass Crossovers
Cost (est.)		30-50% of base	30-50% of base plus cost of 2 overpass – underpass should still be less than cost of 1 flyover	30-50% of base plus cost of 2 overpass – underpass plus cost of 2 short overpasses should still be less than cost of 1 flyover	(base) 1 3-level flyover / currently budgeting \$35 million	2 times base (\$70 million)	3 times base (\$105 million)
Environmental	Gridlock traffic	Low pollution - Alleviate	2 nd Least pollution	Least pollution	Long ascending 2-	Two long ascending 2	Three long ascending 2

	spewing pollutants	gridlock pollutants but has stop & go traffic at signalized intersection	-Alleviate gridlock pollutants Ascending 1/2 level overpass - underpass at crossover	-Alleviate gridlock pollutants Ascending 1/2 level overpass - underpass at crossover	level flyover ramps causes more pollutants & distributes them higher up which will travel further downwind	& 3-level flyover ramps causes more pollutants & distributes them higher up which will travel further downwind	& 3-level flyover ramps causes more pollutants & distributes them higher up which will travel further downwind
Sidewalk	(base) Incomplete	Integrated but with signalized intersections	Integrated without signalized intersections	Integrated without signalized intersections	Incomplete	Incomplete	Incomplete
Bikes on road	Dangerous - No bike lanes Cyclist ride illegally on sidewalk	Safe - Integrated bike lanes but with signalized intersections	Very Safe - Integrated bike lanes without signalized intersection	Very Safe - Integrated bike lanes without signalized intersection	Dangerous - No bike lanes Cyclist ride illegally on sidewalk	Dangerous - No bike lanes Cyclist ride illegally on sidewalk	Dangerous - No bike lanes Cyclist ride illegally on sidewalk
Separate non-road bike path	None	Possible	Possible	Possible	Possible	Possible	Possible

* Slight increase in performance due to some decongestion of traffic in inner part of interchange.

** Much better increase in performance due to entire interchange becoming free-flowing (no signalized intersection).

Summary of Current Transportation Needs And Solution

High traffic volumes within the current Yonge Street – Highway 401 interchange has resulted in operational deficiencies including long delays and extensive left turn queues. The resulting traffic congestion and gridlock have contributed to collision trends and the redistribution of traffic to local residential streets, limiting access and circulation within the community.

The current Yonge Street – Highway 401 transportation system has incomplete pedestrian infrastructure and no existing designated cycling routes. These operational deficiencies will intensify with the traffic growth associated with approved, proposed and planned future development. Specific operational issues are noted below:

Delay and Queues: There are traffic capacity constraints resulting in long delays and extensive long for the following left turns:

- 0 southbound Yonge Street to eastbound Highway 401 (N-E 401 on-ramp) left turn results in gridlock throughout the south North York Centre area
- 0 westbound Highway 401 to southbound Yonge Street (E-S 401 off-ramp) left turn and westbound Highway 401 to northbound Yonge Street (E-N 401 off-ramp) channelized right forced merge (without dedicated lane on Yonge Street) resulting in traffic congesting on the Highway 401 westbound collector lanes

Any of the Double Crossover Diamonds solutions will eliminate the dangerous signalized intersection left turn and thus eliminate the extensive long left turn queue along with its left turn “waiting” lane. The Double Crossover Diamond With Overpass - Underpass Crossovers Without Weaving solution will also create a completely free-flowing high volume weave-free interchange where left turn service volume rate increase by about 3-4 folds, reduce delays by significantly more than 25-90%, total capacity increase by significantly more than 15-45%, improve traffic flow, improve safety and transform this interchange into an efficient user-friendly interchange.

Safety: Current left turns in front of oncoming traffic at signalized intersection can result in high impact head-on or T-bone crashes. With the free-flowing Double Crossover Diamond With Overpass – Underpass Crossovers and its derivative Without Weaving solution, the number of conflict points are reduced significantly and the severity of crashes are reduced to minor lane change type fender benders.

Pedestrian and Cycling Accommodation: The pedestrian sidewalk system at the current Yonge Street – Highway 401 interchange is incomplete, discourages pedestrian movement and contribute to pedestrian-vehicle conflicts. In addition there are no cycling connections within the current Yonge Street – Highway 401 interchange.

The main challenge is how to fit pedestrian sidewalks and bike lanes servicing both east and west side of Yonge Street all within the current Yonge Street underpass (at the Highway 401 overpass) that can only holds 3 northbound lanes, 3 southbound lanes and one narrow sidewalk without sacrificing any of the traffic lanes and without prohibitively expensive physical widening of the underpass. The Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving solution with pedestrian sidewalks place as usual directly right relative to the direction of traffic will create an integrated pedestrian sidewalk network bringing both east and west side pedestrian traffic to a shared centre elevated sidewalk along the east side of the western Yonge Street underpass. This will also allow pedestrians to safely cross Yonge Street legally without a signalized intersection. Likewise with bike lanes placed between the vehicular roadway and pedestrian sidewalk, the Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving solution will create an integrated bike lane network with a shared centre trench bike lane directly below the elevated shared centre sidewalk along the east side of the western Yonge Street underpass. (Alternatively, the city could adapt an amendment allowing cycling on the ground level shared centre sidewalk as was done at the Simcoe Street underpass south of Front Street.)

Improving Traffic Flow

By using a Double Crossover Diamond With Overpass – Underpass Crossovers, all signalized intersections have been eliminated and all off-ramps and on-ramps are free-flowing. Now design consideration for the Yonge Street – Highway 401 interchange will focus on improving traffic flow by:

- 0 Ensuring all on-ramps and off-ramps are highway specification
- 0 Eliminating any forced merge in favour of utilizing dedicated lanes
- 0 Eliminate or minimize any weaving.

Implementation

- 0 North Crossover with northbound Yonge Street on overpass
- 0 South Crossover with southbound Yonge Street on overpass
- 0 Southbound Yonge Street To Eastbound Highway 401 (N-E 401 on-ramp) Rebuild To Highway Specification
- 0 Northbound Yonge Street To Eastbound Highway 401 On-Ramp (S-E 401 on-ramp) Rebuild To Highway Specification
- 0 Eastbound Highway 401 Entrance Widen To Two Lanes
- 0 Westbound Highway 401 To Northbound Yonge Street Off-Ramp (E-N 401 off-ramp) Becomes Dedicated Right Lane On Northbound Yonge Street
- 0 Westbound Highway 401 Exit Widen To Two Lanes
- 0 Northbound Yonge Street To Westbound Highway 401 (S-W 401 on-ramp) On-Ramp Relocated To West Side Of Yonge Street
- 0 Southbound Yonge Street To Westbound Highway 401 On-Ramp (N-W 401 on-ramp) Adjustments
- 0 Westbound Highway 401 Entrance Widen To Two Lanes
- 0 Lord Seaton Road Roundabout
- 0 New Link Road
- 0 Lord Seaton Road Becomes One Way Westbound West Of Roundabout

Recommendations

The Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving interchange solution is highly recommended over the proposed southbound Yonge Street to Eastbound Highway 401 (N-E 401 on-ramp) flyover ramp for the Yonge Street – Highway 401 interchange.

The MTO (Ministry of Transportation of Ontario) and the City of Toronto’s Transportation department need to work together to implement the Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving interchange solution. Had the MTO and City of Toronto worked more closely together on the current restoration of the Highway 401 overpass, the old centre support structure supporting the overpass might have been removed from the Yonge Street underpass to make room for bike lanes or an east side pedestrian sidewalk or an additional traffic lane.

The Next Steps

Quantify change in traffic condition comparing current traffic with a simulation of this plan using a traffic simulation model. More specifically, the Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving solution VS Current interchange configuration with proposed southbound Yonge Street to eastbound Highway 401 (N-E 401 on-ramp) flyover on-ramp.

Since there are currently no Double Crossover Diamond With Overpass – Underpass Crossovers and its derivative Without Weaving interchanges in existence, it is especially important to model it on a computer traffic simulator to verify the expected performance data.

Establish a cost estimate for the Double Crossover Diamond With Overpass – Underpass Crossovers Without Weaving solution at the Yonge Street – Highway 401 interchange.

Some references for the next steps are as follow:

This article from the U.S. Department of Transportation Federal Highway Administration's (FHWA) Turner-Fairbank Highway Research Center (TFHRC), “Drivers Evaluation of the Diverging Diamond Interchange” discusses the computer model simulation of a Double Crossover Diamond With Signalized Intersection Crossovers

<http://www.fhwa.dot.gov/publications/research/safety/07048/index.cfm>

“FHWA's Turner-Fairbank Highway Research Center (TFHRC) and the Missouri Department of Transportation (MoDOT) demonstrated the human factors approach when they tested the design of a relatively new type of interchange, a double crossover diamond (DCD), in Kansas City, MO. TFHRC's Human Centered Systems Research team helped MoDOT build a simulation of the DCD, using three-dimensional (3-D) and four-dimensional (4-D) visualizations, in FHWA's Highway Driving Simulator.”

<http://www.fhwa.dot.gov/publications/publicroads/10septoct/05.cfm>

This is a very detailed How-To-Implement Double Crossover Diamond With Signalized Intersection Crossovers document, practically a blue print. “Missouri’s Experience with a Diverging Diamond Interchange - Lesson Learned”

<http://library.modot.mo.gov/RDT/reports/UnNumbrd/or10021.pdf>