Pan Am Games, Traffic Network Monitoring and Post-Processing

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Abstract

The 2015 Pan Am and ParaPan Am Games were held in July and August, respectively, in the Greater Toronto Area (GTA). The games involved 7,700 athletes from 41 countries. The venues were distributed across a geographic area of 1,810 km^2 while the athletes' village was located in the Toronto waterfront area. One of the requirements associated with hosting the Games was to ensure that reliable travel times were provided for athletes and Games officials between the Village and the various Games venues. The Ministry of Transportation Ontario (MTO) proposed that a network of Temporary HOV Lanes (THOVL) be implemented during the Games to facilitate travel by athletes and officials.

Ensuring efficient and reliable travel times for Games athletes and officials was a considerable challenge in the context of widespread recurring traffic congestion across the highway system serving the GTA. At the same time, adverse impacts on commuting and other personal travel and on transit and commercial transportation needed to be managed to avoid significant delays. Two regional-level traffic management strategies were considered that affect the expressway system under the jurisdiction of MTO. The first of these involved the implementation of a THOVL network which included existing HOVLs and temporary conversions of general-purpose lanes (GPLs). The second strategy involved the development of traffic management plans to mitigate the impact of major incidents affecting the THOVL network. The planning and evaluation process supporting the implementation of the THOVL network involved the development and application of an extensive multi-level/hybrid traffic simulation using the AIMSUN traffic simulation package and was presented in a separate paper (Pringle and Nikolic, 2015). This paper focuses on the monitoring and post-evaluation process. The objective of the project was to answer the following questions:

1) How successful the implemented traffic management strategies were in (a) meeting the transportation objectives/targets for travel by athletes/officials/media; and (b) minimizing the impacts on GTA travel?

2) How did the actual outcomes compare with the planning (simulation) estimates?

Following the Games, the outputs generated from traffic simulation under different scenarios were compared with the observations generated from various sources during the Games. The main focus of this evaluation process was on the operation of the highway corridors accommodating the THOVL network. Traffic data from different sources within the THOVL network (i.e. loop detectors, Bluetooth sensors, video cameras, on-board GPS units and screen line counts) were collected and used for this post-evaluation. These comparisons confirmed a generally successful implementation of the traffic management strategies, in terms of expected (simulated) conditions vs. observed conditions. In terms of legacy value, the traffic simulation platform developed for this assignment, once expanded, will serve as basis for future traffic simulation work across the GTA by and for MTO; ensuring consistency and avoiding duplication.

1 Introduction

The 2015 Pan Am/ParaPan Am Games were held in the Greater Toronto Area, the Pan Am Games occurring July 10-26 and the ParaPan Am Games August 7-15. Given that the venues for the various events were distributed across the Greater Toronto Area (GTA) and beyond, while the Athletes' Village was located on the Toronto Waterfront, the transportation of the athletes, officials, and media represented a logistical challenge. A commitment was made to achieve specific travel time targets for trips between the Athletes' Village and key venue clusters. To achieve the targeted travel times in the context of the recurring congestion prevalent on the GTA highway system, a network of temporary HOV lanes (THOVL) was proposed with the intent of accommodating accredited Games vehicles as well as HOVs and transit vehicles. The THOVL Network, as implemented, is shown on Figure 1. It incorporates the existing HOV lanes on the Queen Elizabeth Way (QEW), Highway 403, and Highway 404. Additional temporary HOV lanes were implemented to create a cohesive network.
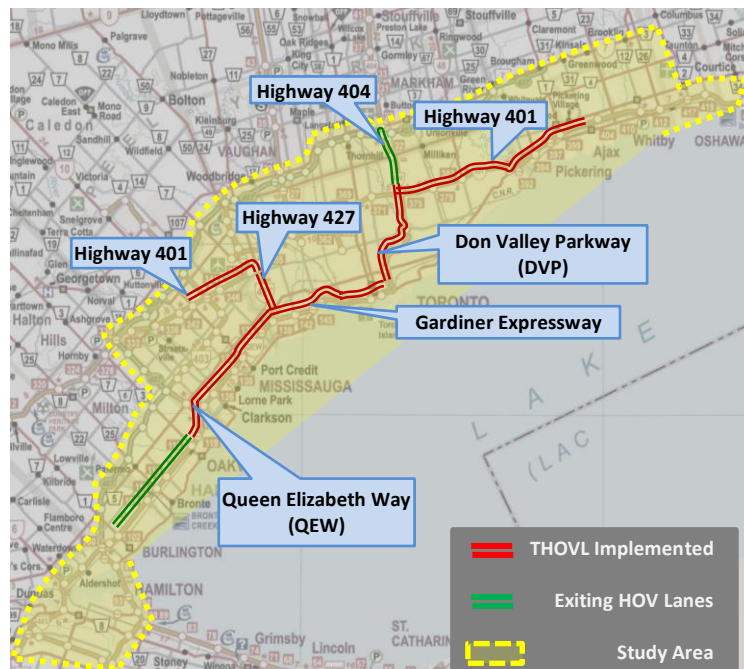
Figure 1: Temporary HOV Lane (THOVL) network

To evaluate improvements of the proposed THOV network on travel times and travel time reliability for "village-to-venue" trips, it was necessary to first develop and calibrate an extensive multi-level/hybrid traffic simulation using the Aimsun (TSS 2016) traffic simulation package. The study area covered by this model extends from Hamilton to Whitby and north to include Highway 407, as shown in Figure 1. As noted earlier, the model development, planning and evaluation process related to the implementation of the THOVL network was discussed in a separate paper (Pringle and Nikolic, 2015). This paper presents the results of traffic monitoring data collected in relation to the Games and undertakes comparisons between observed conditions and conditions as projected/evaluated during the assignment.

2   Methodology

The main focus of this evaluation process is on the operations of the highway corridors accommodating the THOVL network and includes two comparison groups:

1. **Business as usual (before the games) vs. during the Games:** To evaluate the impact of implementing the THOVL network and games related activities on the performance of the highway network; and
2. **Observed vs. planned:** To assess the performance of the simulation model by comparing the simulated results with observed traffic data.

The outputs generated from traffic simulation modelling under different scenarios were compared with the observations generated from various sources before and during the Pan Am and ParaPan Am Games. The following sections provide details of these comparisons. First the different data sources used to collect traffic data are described. Then, the results of the performance evaluation for each of the above comparison groups are presented.

2.1   Traffic monitoring inputs and qualifications

During the Games, traffic data was collected from different sources within the THOVL network. The list of data sources, their locations, and an overview of the collected data and its resolution include:

1. Loop Detectors
   - Available at more than 380 locations along the QEW, Highway 401 and 404
   - Collected volume and speed data
   - Traffic data was available for each traffic lane in 1-hour periods
   - Data was collected for 24 hours daily
2. Bluetooth Sensors
   - Available at 130 segments on DVP, Gardiner Expressway, QEW, Highway 401, 403, 404 and 427
   - Collected average travel time per segment
   - Travel time data was aggregated into 2-5 minute periods
   - Data was collected for 24 hours daily
3. Video Cameras
   - Installed at 6 locations on QEW, Highway 401, 403 and 427
   - Image processing technique was used to analyze the video recording
   - Average speed and volume data were evaluated for each lane of traffic
   - Data was aggregated for 15-min and 1-hour periods
   - Data was collected for 24 hours daily
4. GPS Units
   - Onboard units were installed in 400+ vehicles of the Pan Am Games' fleet
   - Full vehicle trajectories were available for each day during the games
   - GIS processing was used to analyze vehicle trajectories
5. Screen line count stations
   - Hourly volumes for 13 arterial roadways within the THOVL network, both directions
   - Data was collected for 24 hours daily

All of the traffic simulation modelling in AIMSUN was conducted for Day 11 (July 21, 2015) of the Games. The output results were generated for the same day between 5 pm and 6 pm. Observed traffic data for select days in the months of June, July, and August were used for the evaluation process, i.e.:

- June 18 – 19 (before the Games);
- July 20 – 22 (during Pan Am Games: HOV3+ policy in effect);
- August 11 – 13 (during ParaPan Am Games, HOV2+ policy in effect); and
- Screen line counts were collected from August 05 – 25 at several locations.

In order to undertake the evaluation process, the following performance measures were used:

- Travel times and speeds on highway corridors;
- Traffic volumes and speeds on the GPLs and THOVLs; and
- Point-to-point travel times for Athletes and officials from village to venues (from where they enter the THOVL network to where they leave the network)

3 Highway system performance

To evaluate the performance of the THOVL highway network, average speed and travel time for highway corridors were considered. Three different data sources were used to conduct this analysis: Bluetooth sensors, loop detectors, and video cameras. Results of this evaluation for the two comparison groups are described here after.

3.1 Business as usual (before the games) vs. during the Games

To compare the operations of the THOVL highway network before and during the Games, observed speed and volume data were collected from loop detectors and traffic cameras for select days in the months of June and July. Data was collected for several locations along highway corridors. The results are presented in Figure 2 and Figure 3.
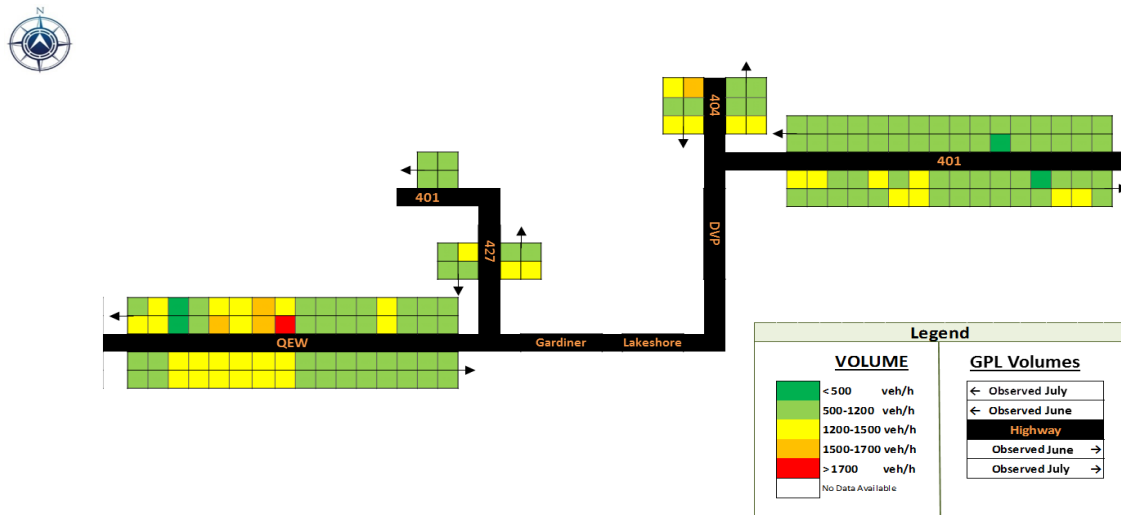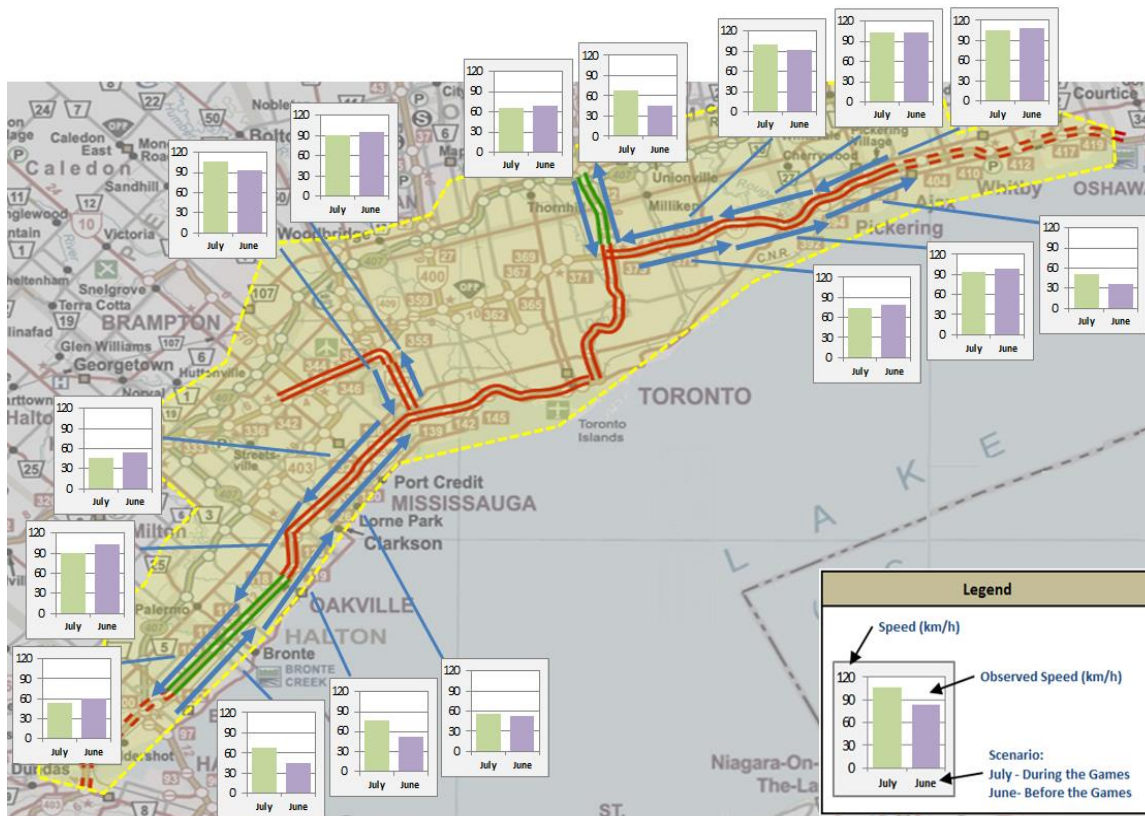

Figure 2: Observed <u>volume</u> comparison on GPL in the PM peak (5-6 pm): before (June) vs. during the games (July)

Figure 3: Observed <u>speed</u> comparison on GPL in the PM peak (5-6 pm): before (June) vs. during the games (July)

It can be seen that overall the operations of highway GPLs within the THOVL network during and before the Pan Am Games (month of July vs June) were similar. Observed data shows decrease in traffic volume and higher speeds at few locations (e.g. QEW EB, near Burlington and Oakville) which could be due to traffic diversion during the Games.

Observed travel times on both directions of the THOVL corridors were also collected via Bluetooth sensors and were compared for a typical weekday in June and July. The comparison between the observed corridor travel times before the games (June) and during the Games (July) showed that the average travel time along most of THOVL highway corridors increased during the Games. The highest increase rates were observed on the QEW WB and DVP NB corridors (156% and 113% respectively). The average travel times during the Games along some highways (e.g. HWY 401 EB) were less when compared to the period before the Games.

3.2 Observed vs. planned

To assess the performance of the simulation model, simulation results were compared with traffic data observed during the Games. Volume and speed data collected from MTO's loop detectors and video cameras during the month of July were used to assess the AIMSUN simulation results for the targeted 20% TDM. Figure 4 **to** Figure 7 present the results of this comparison separately for GPLs and THOVLs within the network.
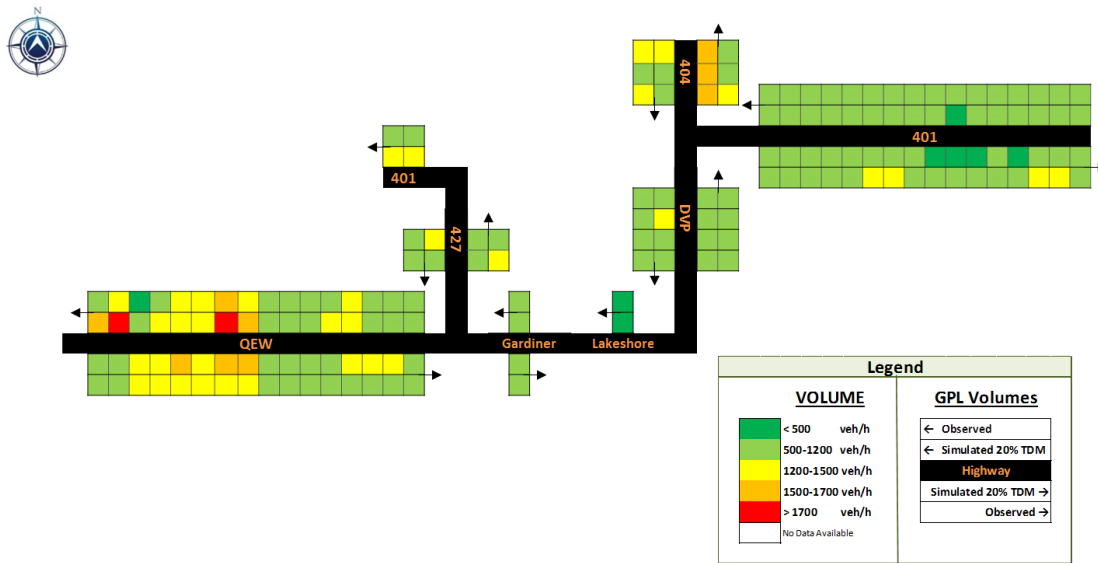
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Figure 4: <u>Volume</u> comparison on <u>GPLs</u> in the PM peak (5-6 pm), observed vs. planned (targeted 20% TDM)
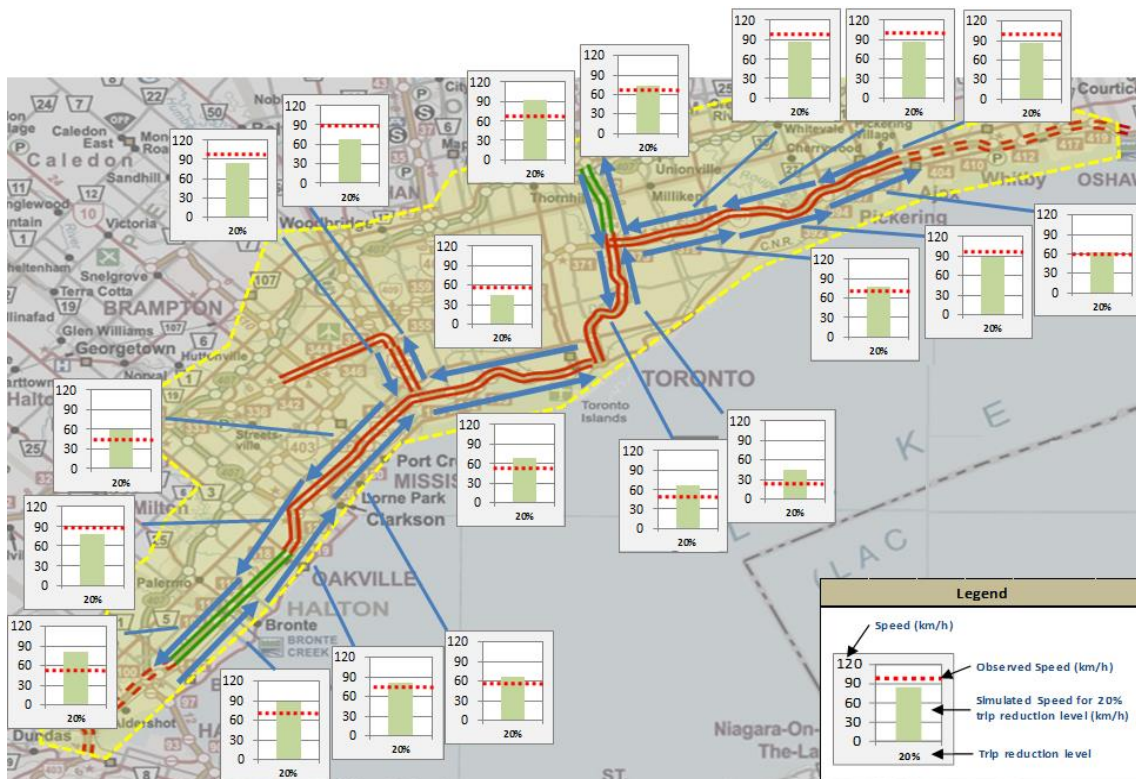

Figure 5: <u>Speed</u> comparison on <u>GPLs</u> in the PM peak (5-6 pm), observed vs. planned (targeted 20% TDM)
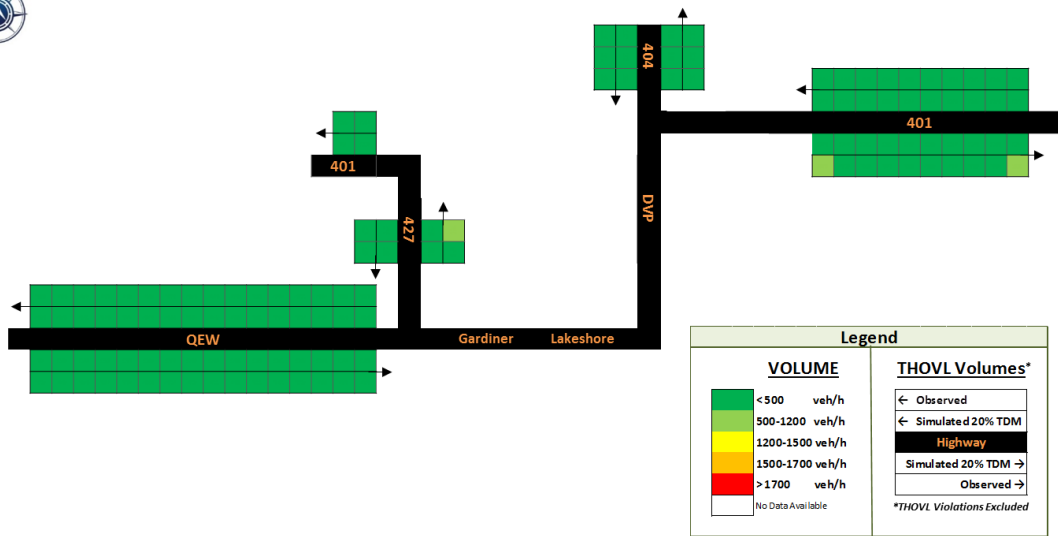
Figure 6: Volume comparison on THOVLs in the PM peak (5-6 pm), observed vs. planned (targeted 20% TDM)
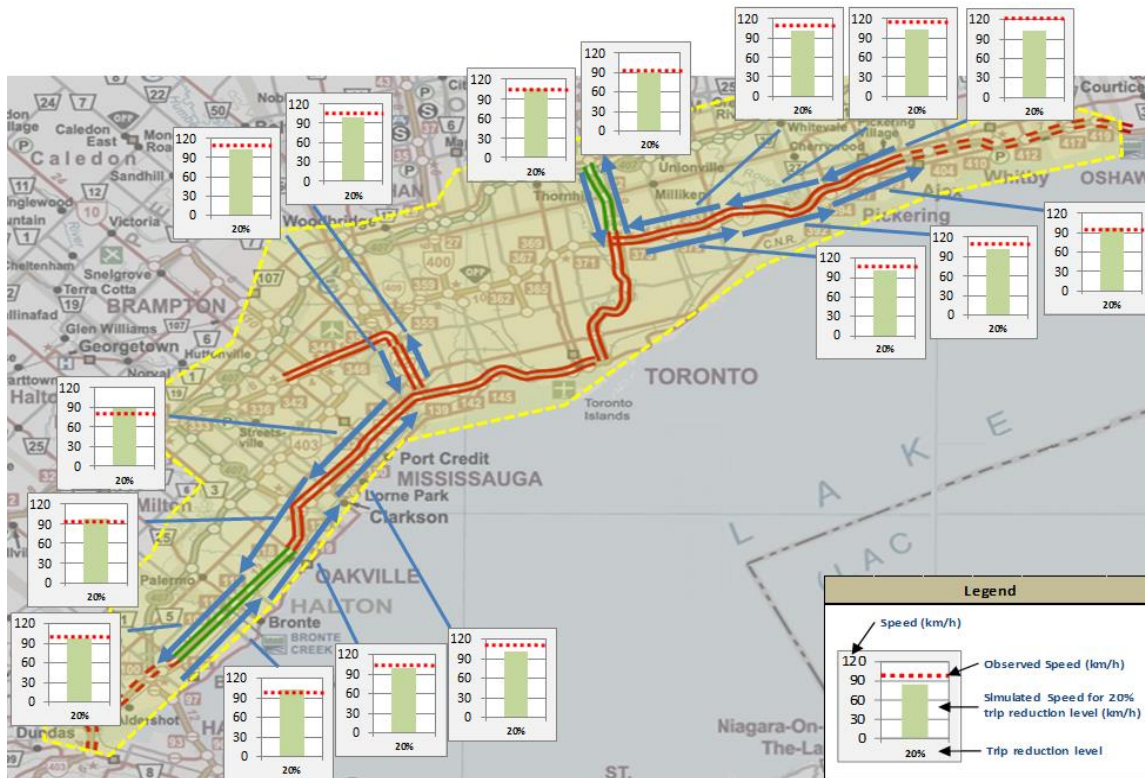

Figure 7: Speed comparison on THOVLs in the PM peak (5-6 pm), observed vs. planned (targeted 20% TDM)

The previous figures show a few locations with the simulation model overestimated traffic volumes for GPLs – e.g. WB direction of QEW, near the Town of Oakville – which resulted in

lower speeds along that section. However, the overall planned volume and speed data along both the GPLs and THOVLs are close to the observed data for most of the highway corridors. It should be noted that the above graphs show the comparison results for the sections along the Gardiner Expressway, Lakeshore Blvd. and DVP where observed traffic data was available.

An additional performance measure used to evaluate the simulation model included estimated travel times along highway corridors. Observed travel times during the Games, collected via Bluetooth during July 20th to July 22nd during the PM peak period (17:00 - 18:00), were compared against simulated travel time results from the simulation. The average speed along each corridor was calculated based on observed/simulated travel times and the length of each segment. The results showed that for most of highway corridors the observed corridor travel time and speed falls between the estimated results from simulation scenarios with 0% and 10% TDM. This indicates that the initial assumption of 20% TDM used for planning purposes might have been an over estimation with a lesser percentage of general traffic being diverted from highways.

4   THOV lane compliance

4.1   Business as usual (before the games) vs. during the Games

Compliance on the existing HOV lanes (before the games) and the THOV lanes during the Games was evaluated by manually observing traffic at select highway corridors. The data was collected for separate weekdays in June, July, and August 2015 when HOV3+ and HOV2+ policies were in effect on each day (i.e. HOV2+ before the Games, HOV3+ during Pan Am and HOV2+ during ParaPan Am Games).

Compliance/violation on the existing HOV lanes along QEW and Highway 404, where the HOV2+ policy was in effect before the games, are summarized in Figure 8.
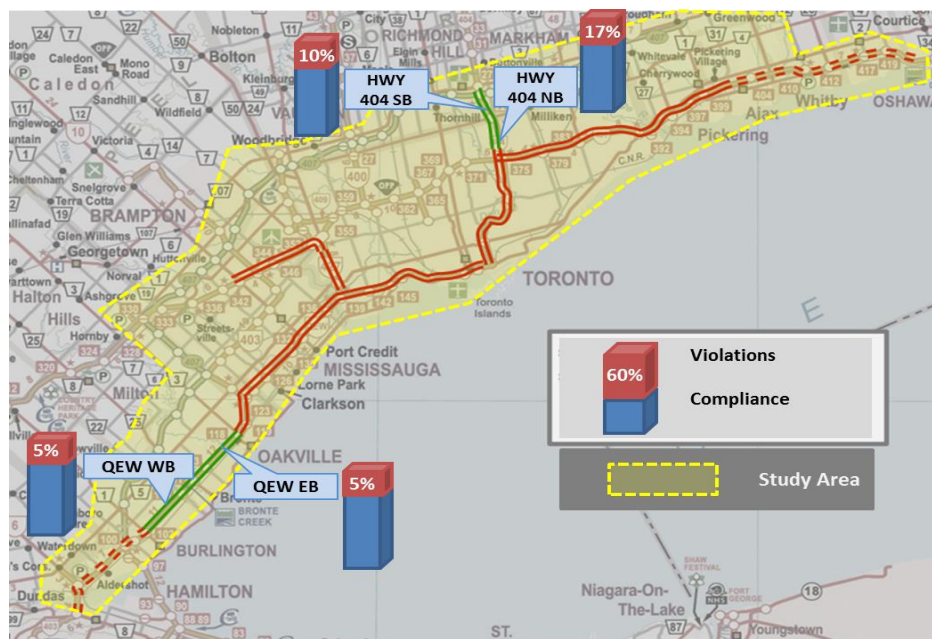

Figure 8: HOV lane compliance under underlinedexisting HOV2+ policy (before the Games)

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Figure 9 and Figure 10 show the compliance/violation percentage for each direction of highway corridors within the THOVL network under HOV3+ and HOV2+ policies.
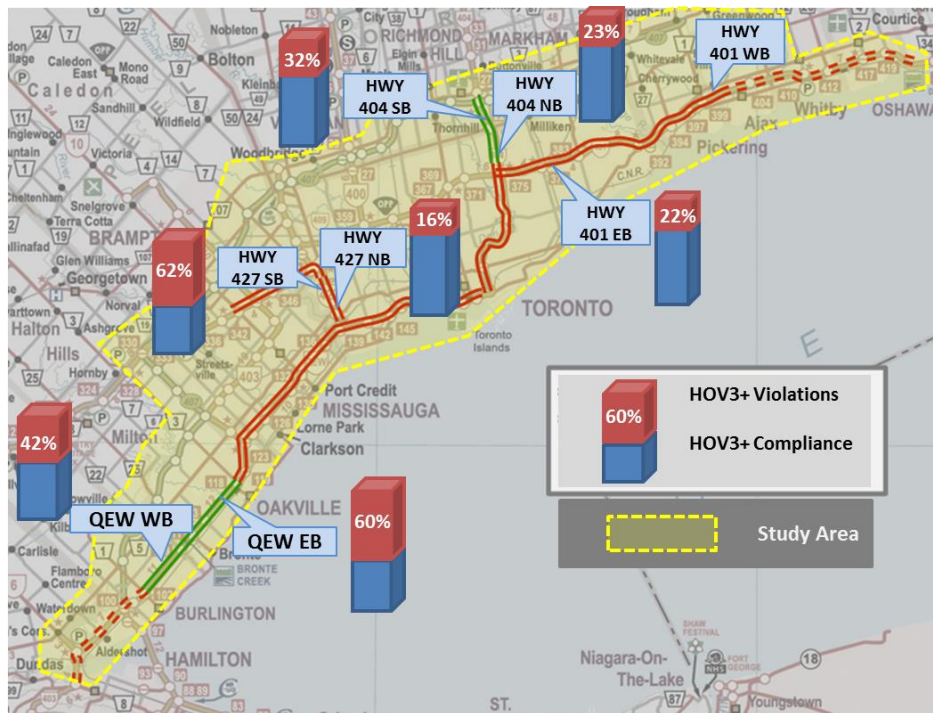

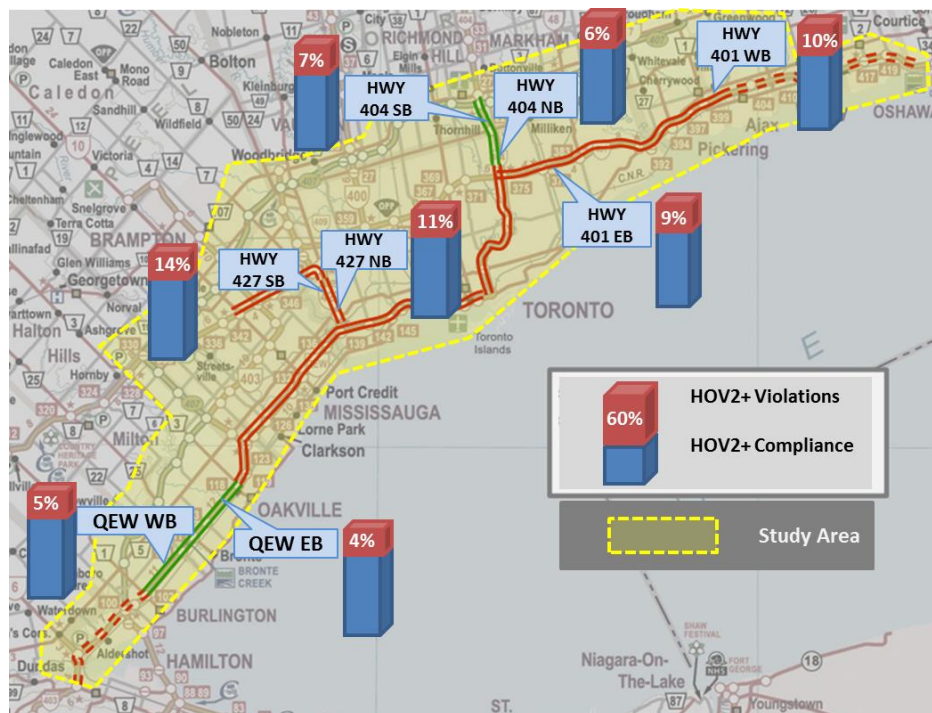**Figure 9: THOV lane compliance under HOV3+ Policy (during Pan Am Games)**

Figure 10: THOV lane compliance under HOV2+ policy (during Parapan Am Games)

As can be seen in the above figures, during the Pan Am Games where the HOV3+ policy was in effect, violations were higher on all the highway corridors in comparison to before the Games period. The increase in percentage of violations was significant on the WB and EB directions of the QEW (42-60% vs. 5%) and the SB direction on Highway 427 comprising more than half of the total traffic travelling in the THOV lane on each corridor. The percentage of violations during the ParaPan Am Games, with HOV2+ policy in effect, remained the same for the QEW while the Highway 404 data shows more HOV compliance during the ParaPan Am Games compared to the before period (6-7% vs. 10-17%).

4.2 Observed vs. planned

The violation rates assumed in the AIMSUN simulation model were:

- HOV2+ scenario: 5%
- HOV3+ Scenario: 10%

The results presented in the previous section show that the violation rate for most of the highways within the simulation model were under estimated in the HOV2+ and HOV3+ scenarios when compared to the observed values. This has been considered in the post evaluation analysis conducted in this study.

5   THOV lane utilization: Pan Am vs. ParaPan Am

The THOVLs were used by athletes and officials to travel from the village to Games' venues. Observed village-to-venue travel times were estimated using vehicle trajectory data collected by GPS units onboard Games-related buses. Extensive GIS analysis was conducted for data cleaning and querying travel times along the THOVLs. Travel times were calculated based on available trajectories between 3 – 7 pm and were averaged over a 3-day period (July 20-22 for Pan Am and August 11-13 for ParaPan Am Games). Figure 11 shows the calculated travel times from village to venues during each of the above mentioned periods are categorized according to the effective HOV policy during each period (i.e. HOV3+ during Pan Am and HOV2+ during ParaPan Am Games). It should be noted that travel times are calculated from athletes' village to the exit point from the THOVL network.
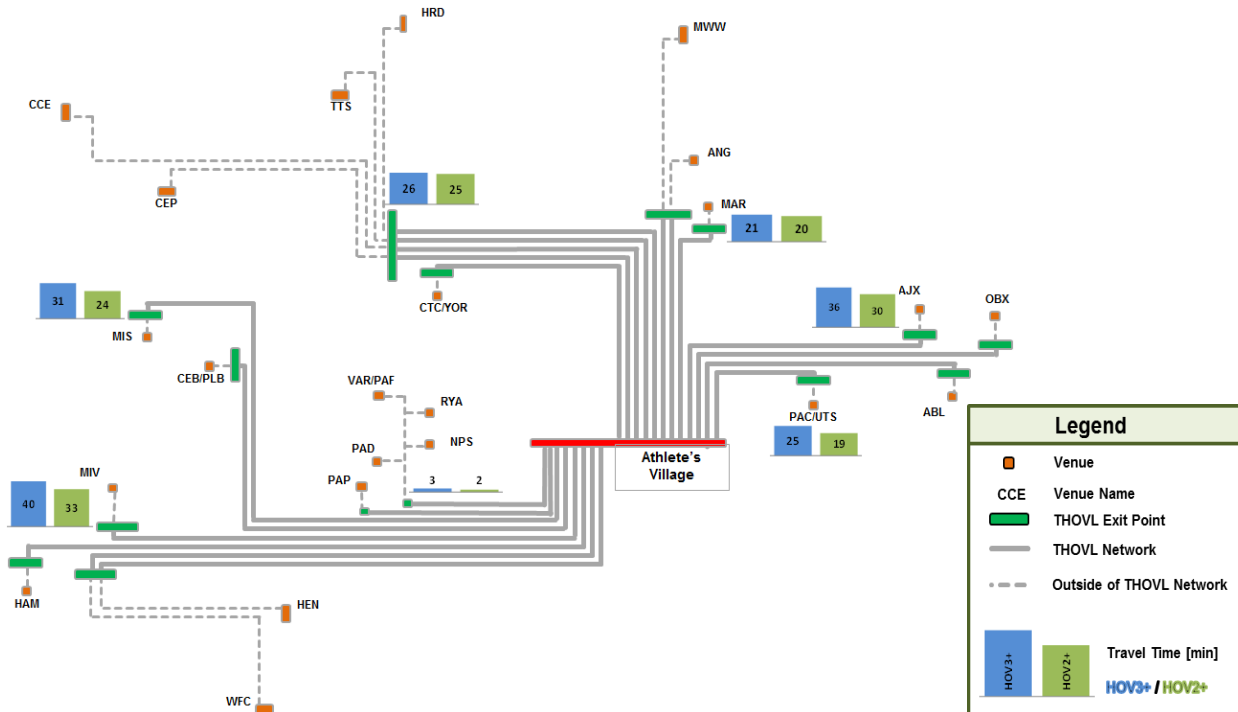
Figure 11: Village-to-venue travel times under <u>HOV3</u>+ and <u>HOV2</u>+ policies (Pan Am and ParaPan Am)

The calculated village-to-venue travel times within the THOVL network during ParaPan Am Games under the HOV2+ policy seems to be similar and, in a few cases, lower than those estimated during the Pan Am Games. This could be due to shorter delays experienced by Games' vehicles when leaving THOV lanes to take exit ramps. In the case of trips under the HOV3+ policy, higher traffic volume were expected in the adjacent GPLs which could have made the transfer slower than trips under the HOV2+ policy.

The collected data during the Games (Pan Am and ParaPan Am) was used to compare the observed speed and volume data on the THOVLs and GPLs under the HOV3+ and HOV2+ policies. Observed data along highway corridors show that traffic volume and speed on GPLs under HOV2+ and HOV3+ scenarios was similar across most sections. One exception is the EB direction of Highway 401, near Toronto, where the GPLs volume seems to be higher under HOV2+, as compared to HOV3+. This could be due to the lower number of HOV violations during this period.

A similar comparison was done for speed and volume data on the THOV lanes. As expected, the collected data show higher volume (and lower speeds) on the THOVLs under HOV2+ policy compared to the period when the HOV3+ policy was in effect.

6   Trip reduction, route diversion and time shifts

To evaluate any travel shifts due to the Pan Am Games and/or the THOVL network, data collection for several planned screen lines were conducted in the month of August. Collected data included 24-hour traffic counts on each direction along the planned arterials parallel to the

highway corridors within the THOVL network. Figure 12 shows the location of screen lines within the network.

Figure 12: Screen line arterials (source: Google Earth©)

Traffic volumes for the peak period (5-6 pm) and shoulder hours (2 hours before/after) for a weekday before and during the Games (August 6th and 13th) were summarized for select highways and their related parallel arterials. The observed traffic volumes were summarized in separate tables for before and after the Games. Samples of the collected data for Highway 401 near Toronto are presented in Table 1 and Table 2.

Table 1: Screen line volumes [veh/h], before the Games – Highway 401 Toronto

Before the Games	Sheppard Ave		Hwy 401 (Toronto)		Ellesmere Rd		Kingston Rd	
Direction	EB	WB	EB	WB	EB	WB	EB	WB
Shoulder (3-4 pm)	851	702	7,877	4,886	427	254	1,474	916
Shoulder (4-5 pm)	935	650	8,091	5,148	482	267	1,819	959
Peak Hour (5-6 pm)	**1,055**	**730**	**7,923**	**5,145**	**583**	**257**	**1,785**	**1025**
Shoulder (6-7 pm)	919	748	7,006	5,365	484	284	1,718	927
Shoulder (7-8 pm)	792	609	6,534	4,343	360	227	1,275	786

Table 2: Screen line volumes [veh/h], during the Games – Highway 401 Toronto

During the Games	Sheppard Ave		Hwy 401 (Toronto)		Ellesmere Rd		Kingston Rd	
Direction	EB	WB	EB	WB	EB	WB	EB	WB
Shoulder (3-4 pm)	846	666	7,798	5,946	414	286	1,479	961
Shoulder (4-5 pm)	950	686	8,284	5,616	483	298	1,953	1,005
Peak Hour (5-6 pm)	**1,124**	**710**	**7,836**	**5,665**	**566**	**322**	**1,933**	**1,028**
Shoulder (6-7 pm)	1,022	790	7,177	5,512	546	273	1,472	977
Shoulder (7-8 pm)	871	642	6,807	4,937	400	282	1,516	858

It should be noted that the screen line data for arterials parallel to DVP and Gardiner Expressway were also collected but due to the lack of traffic demand for these two highways, the analysis was only conducted for MTO highways. Travel shift analysis was conducted using the following criteria:

- If overall total (all arterials and all hours) has decreased, suggests an overall trip reduction (mode shift, occupancy shift, shift in trip out of corridor trip elimination) and % decrease suggests % trip reduction – otherwise, no trip reduction;
- If highway (peak hour or total period) has decreased but arterials have increased, suggests route diversion (Diversion out of the corridor is not accounted for but the screen lines were designed to minimize that possibility); and
- If peak hour has decreased but shoulder hours have increased, suggests time-shifting of travel. If it appears that the whole peaking pattern has been "delayed" or only the hours after the peak hour have increased, may also reflect effect of congestion/delay.

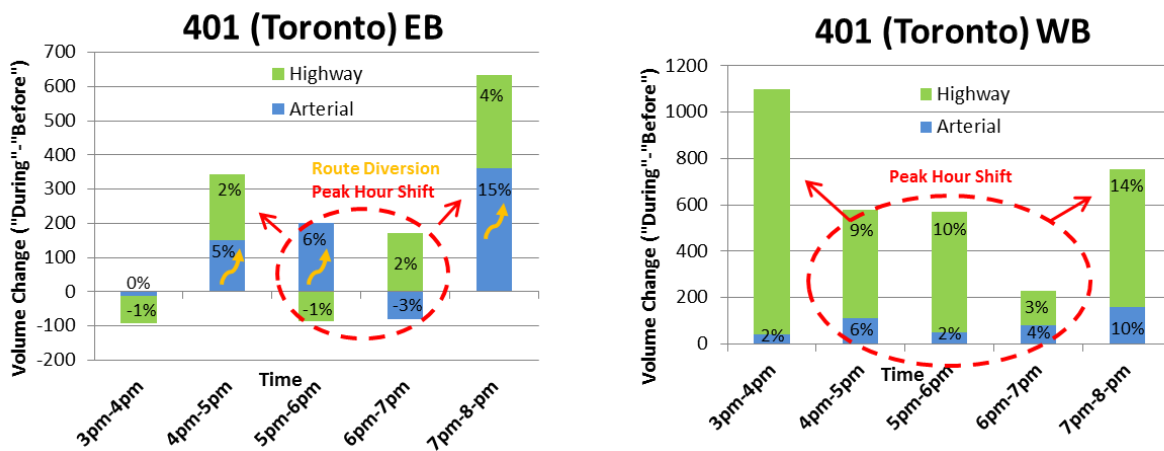Figure 13 to Figure 15 show the results of trip shift analysis for select highways.

Figure 13: Volume comparison (peak and shoulder hours) – <u>HWY 401 Toronto</u>: before and during the Games
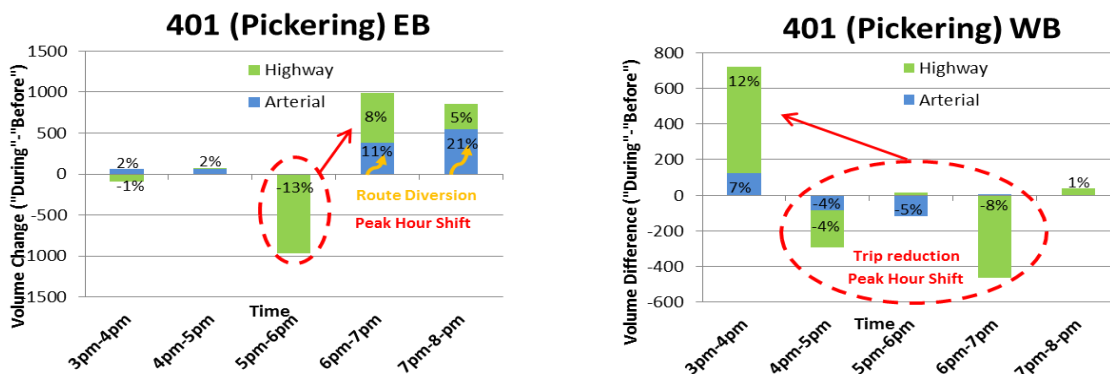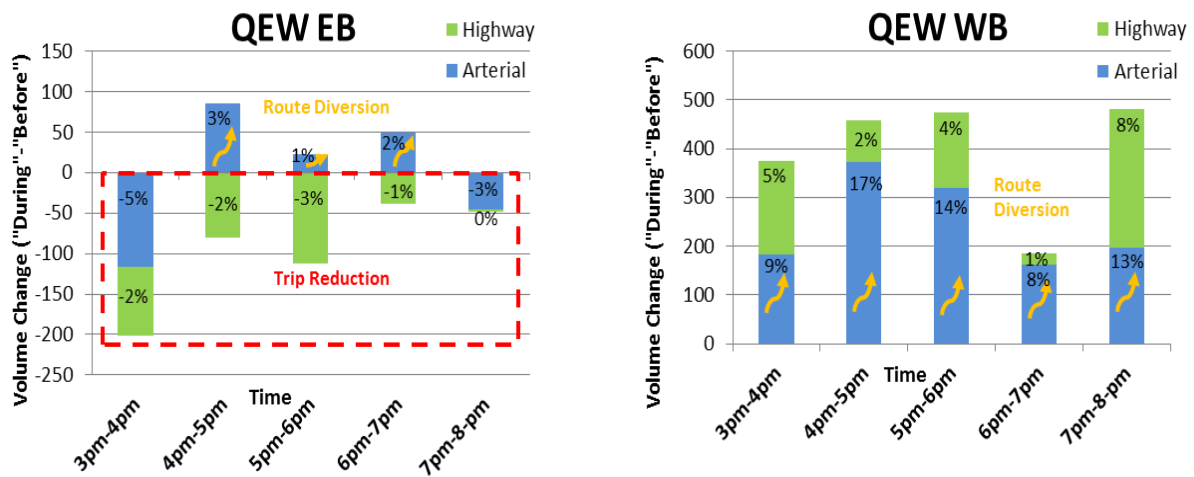

Figure 14: Volume comparison (peak and shoulder hours) – <u>HWY 401 Pickering</u>: before and during the Games

Figure 15: Volume comparison (peak and shoulder hours) – <u>QEW Burlington</u>: before and during the Games

The following observations can be made from the results for each highway corridor/direction:

- Highway 401 (Toronto) EB
  - 5-6% route diversion to arterials during the early PM peak (4-6 pm)
  - 15% route diversion to arterials during the 7-8 pm
  - Time shift from peak period (5-7 pm) to shoulder hours (4-5 pm and 7-8 pm)
- Highway 401 (Toronto) WB
  - Time shift from peak hours (4-6) to shoulder hours (3-5 pm and 7-8 pm)
  - No significant diversion to arterials during the PM peak
- Highway 401 (Pickering) EB
  - Route diversion to arterials (average 16%) during the PM peak (5-8 pm)
  - Time shift from peak hours (5-6) to shoulder hours (6-8 pm)
- Highway 401 (Pickering) WB
  - Time shift from peak hours (4-7) to shoulder hours (3-4 pm)
  - Overall trip reduction during the PM hours (3-8 pm)
  - No significant diversion to arterials during the PM peak
- QEW (Burlington) EB
  - Overall trip reduction during the PM hours (3-8 pm)
  - Average 2% route diversion to arterials during the PM period (4-7 pm)
- QEW (Burlington) WB
  - Average 12% route diversion to arterials during the PM period (3-8 pm)

7   Conclusions and lessons learned

The analysis conducted in this study has led to the following conclusions:

- Generally successful implementation in terms of expected conditions (as planned) vs. observed conditions;
- Games did not cause traffic Armageddon as feared beforehand;
- Average route diversion for select highways was between 2% and 12%;
- 93% of Pan Am and 82% of Parapan Am trips were within targets;
- Observed compliance rates were higher than expected especially during Pan Am Games; and
- Most routes experienced minor delays compared to before the games.

The planning and implementation of the temporary HOV lane network, and the experience gained through its operation, will provide useful insights to the MTO as its policies with respect to managed lanes (HOV lanes, HOT lanes, or other managed lanes) are developed, updated, and implemented. Lessons learned during the Pan Am/ParaPan Am Games will be applicable to a wide spectrum of future Ministry endeavours in this area.

8   Acknowledgements

9   References

Pringle R. and Nikolic G. 2015. "Get Me to the Track On Time! – Traffic Management for the 2015 Panam/Parapan Am Games in the Greater Toronto Area". Presented at the *2015 Conference of the Transportation Association of Canada*, Charlottetown, PEI

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