



EFFECTIVE MANAGEMENT OF A PUBLIC-PRIVATE INFRASTRUCTURE PARTNERSHIP:

A CASE STUDY

**Highway 401/407 Interchange
(East of Trafalgar Road in the Region of Halton)**

**Ramp from Westbound Highway 407 to
Westbound Highway 401**

FINAL REPORT

August 6, 2008

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Abstract

Highway 407, Canada's first privately owned fully electronic toll highway located in southern Ontario intersects with the Province's 400 Series Highways in a number of locations. Respective roles and responsibilities between the Province and the Concessionaire, 407ETR Concession Company Limited, are outlined in the Highway 407 Concession and Ground Lease Agreement (CGLA).

Managing the individual interests of the Province and 407ETR, while ensuring compliance with the CGLA, requires both parties to be fully committed to the relationship in order to realize the mutual benefits of the public-private partnership. This paper examines the issues the province dealt with during the problem identification, design development and construction implementation phases with its partner 407ETR.

This paper focuses on one particular operational issue that was affecting the flow of traffic on both the Provincial Highway 401 and the privately owned Highway 407. The problem area centered on the interchange ramp carrying Highway 407 westbound traffic onto Highway 401 westbound. The volume of traffic on the identified ramp was forming significant queues on both highways during peak afternoon hours. A high level of co-operation was required between the government and 407ETR before a detailed examination of the existing geometric issues that were the root cause of the queues could begin. In the spirit of co-operation, both parties acknowledged the shared responsibility for finding a solution, and the shared responsibility for the implementation of the possible geometric improvements.

This paper contains a brief outline of the innovative traffic modeling that was jointly undertaken to resolve the geometric deficiencies. Also discussed will be the role of the Independent Auditor, as specified in the Highway 407 sale agreement, to ensure that the focus on safety standards was upheld throughout the design and construction phases.

Following the various perspectives, the paper includes some of the lessons learned at various operational phases of the Highway 407 project, and offers insight to improve future management of similar privatization relationships.

1. INTRODUCTION

Highway 407, Canada's first privately owned electronic toll road in Canada has, been a tremendous success story for the construction of the first new 400 series highway in southern Ontario in decades. The highway currently stretches 108 kilometers, includes 41 interchanges and accommodates over 374,000 trips per work day. The construction timeframe was breathtakingly rapid yet no leeway was allowed for compromising roadway design standards. The final result is also one of the safest highways in North America.

Now the work begins

Those involved in the planning and design of roads and highways can attest to the axiom: "construction is the easy part". Modern construction technology and techniques have dramatically reduced the length of time needed to construct major roadway projects. Yet, for all the advancement of construction technology, advancements in environmental awareness, sustainable growth and public accountability have also dramatically altered the effort required to plan, design and operate new or improved highways.

One outcome of the increased public accountability is the governance structure put in place to oversee the partnership with 407ETR. 407ETR, the operator of Highway 407 in a Public Private Partnership with the Province of Ontario, is governed by extensive contractual obligations including:

- The Highway 407 Act (1998)
- The Share Purchase Agreement
- The Concession and Ground Lease Agreement (CGLA)

The agreements define the terms and conditions of the concession and lease agreement between the two parties, and also identify the obligations and rights of both parties. There are a number of provisions that govern the obligations of the concessionaire concerning congestion relief and safety issues over the span of the 99-year lease agreement. The CGLA contains great attention to future re-construction and expansion of Highway 407, as well as a number of deferred interchanges; however, 99 years is a very long time from a roadway-planning horizon.

The first decade of the partnership between the province and 407ETR has already presented a number of issues that were not explicitly addressed in the CGLA. To provide additional clarity to the CGLA, a number of amending agreements have been negotiated between the province and 407ETR. One of the recent items has been the co-ordination of highway expansion between the province and 407ETR at the westbound connection between Highway 407 and Highway 401 (Exhibit 1).

2. PROBLEM IDENTIFICATION

By 2004, Highway 407 westbound traffic volumes had reached levels that were causing vehicles destined for Highway 401 to form queues over 1 km long and were causing serious safety issues as the queues backed-up onto mainline 407 westbound lanes.

Exhibit 1: Study Area



In response to the growing traffic growth and potential safety issues, 407ETR provided additional ramp storage capacity by widening the subject ramp. The westbound ramp was widened from one lane to two lanes, with the second lane dropping back to single lane prior to merging on to Highway 401 Westbound.

Although the improvements provided a measure of short-term congestion relief, attention then focused on the long-term capacity of the ramp to accommodate future growth and also the performance of the ramp in response to additional expansion of Highway 407. Under the terms of the Settlement Agreement between the province and 407ETR in March 2006, 407ETR agreed to commence the expansion of Highway 407 between Highways 401 and 404.

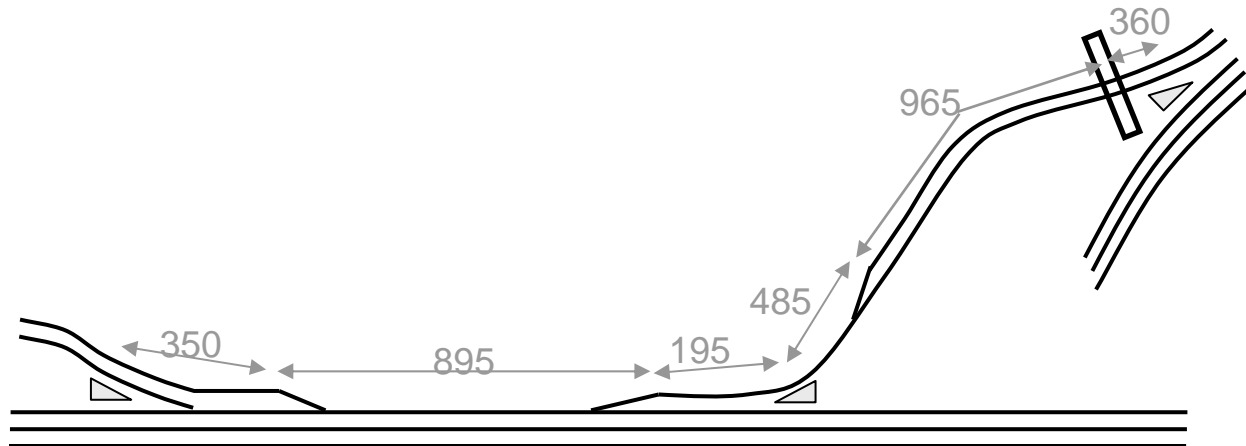
In the subject area, both Highway 407 and Highway 401 had 6-lane cross-sections. The ramp from Highway 407 westbound to Highway 401 westbound was nominally a 2-lane ramp, although the outside lane began to taper out about 500m upstream of the bull-nose at Highway 401 and the second lane tapered out about 250m downstream of the bull-nose. Approximately 1,500m west of the bull-nose for the ramp from Highway 407 is the bull-nose for the off-ramp to Trafalgar Road. This ramp is configured with a developed must-exit lane and an either/or exit lane. (Exhibit 2)

Following a series of meetings between 407ETR and ministry staff to discuss the general arrangement for the 2-lane Hwy 407 exit ramp, it was recognized that it might be beneficial to both the ministry and 407ETR if the Highway 407 ramp was extended along Highway 401 as a single lane widening all the way to the Trafalgar Road interchange.

Additionally, it was agreed that a traffic study for the extension of construction work to the Trafalgar Road Off-ramp should be undertaken to confirm the potential benefits to

the public highway. The modeling would help the ministry prepare a business case for sharing the costs with 407ETR associated with the design and construction of the undertaking.

Exhibit 2: Existing Situation - Dimensions



It was expected that the proposed extension to Trafalgar Road would improve merging opportunity for traffic going to Trafalgar Road and hence improve safety on Highway 401 as it is anticipated that the majority on the subject ramp would be going to Trafalgar Road.

It was agreed that traffic Micro-Simulation using VISSIM, would be undertaken for the following cases based on existing traffic figures:

- (a) Do nothing (serve as the base case for comparison)
- (b) Extension of the exit ramp by 900m to conform with Ministry of Transportation of Ontario (MTO) Standard (Compliance Case)
- (c) Extension of the construction work to Trafalgar Road

The traffic planning horizon to consider in the traffic modeling was significant in light of the ministry's long-term plans for improvements to Highway 401 in the area. The proposed improvements would provide immediate benefits to Highway 401 in the immediate vicinity of Trafalgar Road, but the proposed widening needed to be weighed against the ministry's long-term plans.

The ministry needed to protect for potential expansion of Highway 401 and also protect for potential extension of High Occupancy Vehicle (HOV) Lanes on Highway 401.

It was agreed that traffic counting to determine the number of vehicles from westbound Highway 407 leaving the Trafalgar Road off-ramp to be taken for the PM peak hours on Wednesday and Thursday on the 2nd week of January, 2007.

The ministry's Highway Engineering Office provided general arrangements for potential Highway 401 expansion to accommodate three (3) general-purpose lanes with one (1) HOV lane for information. The analysis was divided into two stages, the first addressing

the existing 6-lane mainline cross-section for Highway 401, and the second addressing the future situation with an 8-lane mainline cross-section.

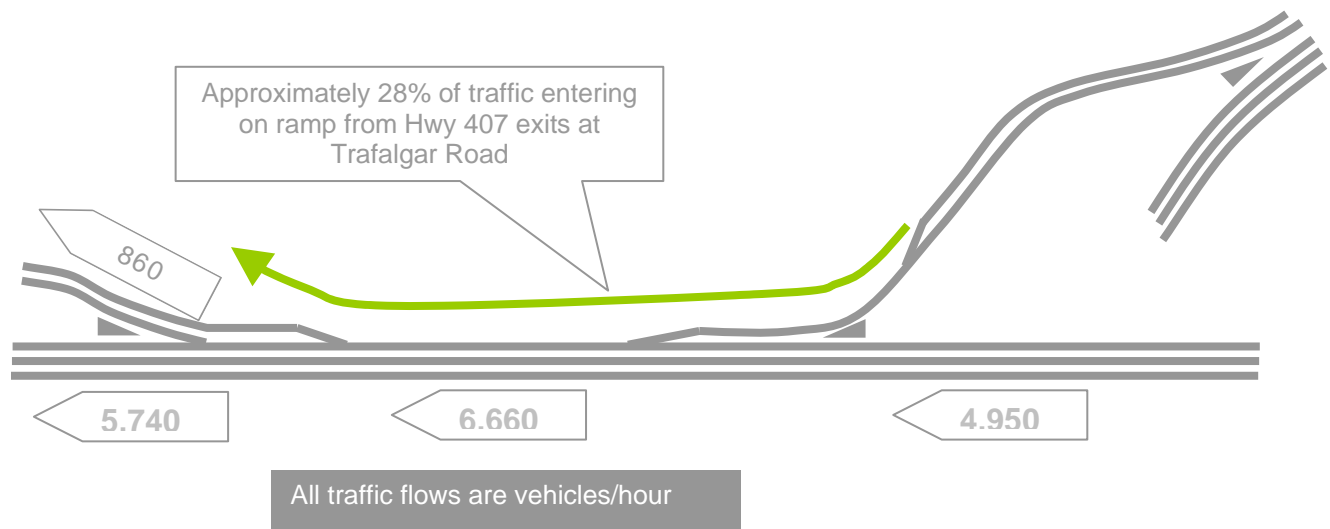
MTO Traffic Office provided traffic flow figures on this section of Highway 401 and the Trafalgar ramp terminal for the same time period for the purpose of traffic analysis.

It was agreed that the traffic evaluation for the three cases was to be completed by early February 2007 with review by 407ETR prior to submission to MTO for their review.

Traffic Flows

A balanced set of traffic flows was assembled for the afternoon peak hour from the available data. The afternoon peak hour was the critical time period with respect to westbound traffic. The flows tended towards the high side for the critical movements, particularly the flow on the subject ramp, which seemed to be highest for a Friday count in October 2006. The timing of the peak was generally in agreement with the perceptions of 407ETR staff. Other flows were balanced to this control flow but major adjustments, more than 5-10%, were unnecessary. The proportion of traffic on the ramp from Highway 407 that exited at Trafalgar Road was estimated to be an average value of 28%, which was used in the analysis. (Exhibit 3)

Exhibit 3: 2006 Baseline Traffic Flows (Peak Day) and Peaking Characteristics

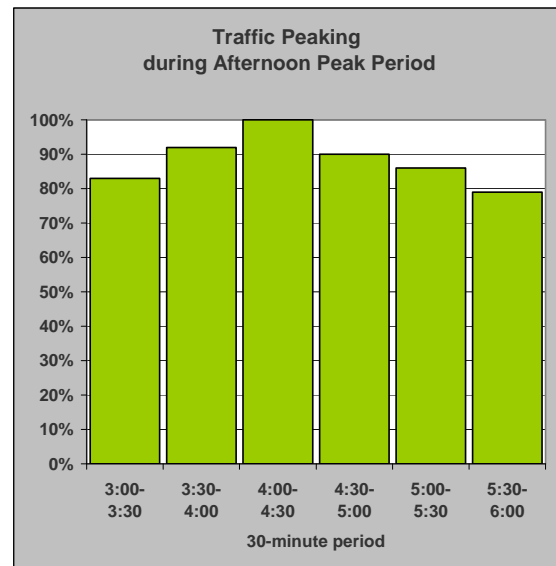


Commercial vehicle flows were estimated from the available data. It was found that medium and heavy trucks constituted about 4-9% of all vehicles in the study area from Highway 407, while the proportion on Highway 401 ranged from 10-15% during the afternoon peak period. Heavy trucks as a proportion of total medium plus heavy trucks averaged about 80% on Highway 401 and 40-60% on Highway 407.

Exhibit 4

Peaking factors were developed as a composite estimate from the available data, the “shoulder” hours before and after the peak hour being assigned 92% and 87% of peak-hour traffic, respectively.

The resulting “baseline” pattern of existing traffic flows is summarized on Exhibit 4, which also shows the variation in traffic levels across the afternoon peak period.



Future Traffic Flows

To assess the proposed ramp modifications up to ten years into the future, the development of 2016 volume estimates was tackled next. A trend analysis based on Average Annual Daily Traffic (AADT) indicated consistent growth over the past decade for both Highway 407 and Highway 401. Based on those trends, traffic on the subject ramp 407 would increase by 63% over 10 years while the corresponding increase for Highway 401 would be 28%.

Traffic Modeling

A micro-simulation model was developed using VISSIM for the study area network. The model included the westbound lanes as shown in the study area (Exhibit 1), including the on and off-ramps on Highway 401 upstream of the ramp from Highway 407. The time period modeled was from 3 pm to 6 pm, with the 30-minute period between 4:00 and 4:30 pm being the period of peak demand. Separate origin/destination matrices were developed for autos (including light trucks), medium trucks, and heavy trucks. Other vehicle types (buses) were so few in number that modeling these separately was not warranted.

Initial validation/calibration of the model was based on our observations of peak-hour operation and on 407ETR staff perceptions that at peak times, the queue on the ramp from Highway 407 to Highway 401 extended to approximately the toll gantry. As it turned out, only minimal adjustments to the model were required, mainly in the way of traffic lane allocation on Highway 401 upstream of the ramp from Highway 401 (some “through” traffic being re-allocated to the median and second lanes on Highway 401 to accommodate merging traffic from Highway 407). For each scenario, five runs were conducted with different random seed values. The results shown as “speed contour plots” were based on the most representative (average) of the five runs. The “lane-by-

lane” plots were based on the worst 4-minute “slice” from the representative speed contour plots.

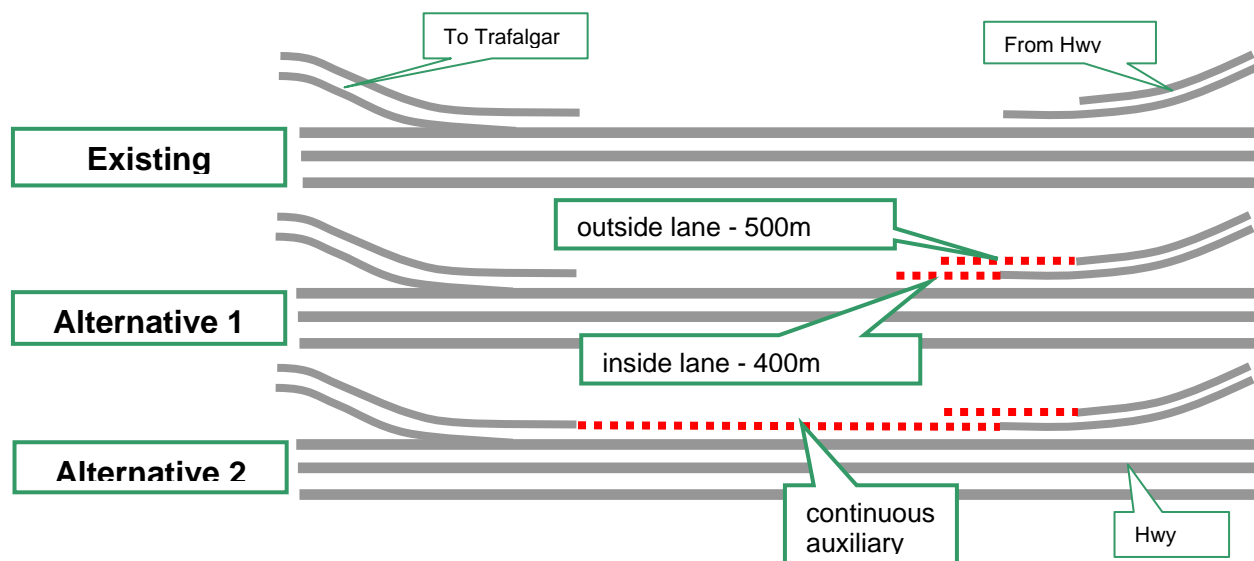
It is cautioned that calibration is an approximate exercise, particularly in congested or “border-line” congested conditions. However, it is believed that the model developed and used for this analysis provided a reasonable representation of existing conditions on a typical busy day. Furthermore, it provided an acceptable basis for relative comparison of the performance of alternative improvement configurations.

3. ALTERNATIVES EVALUATED

Two alternative improvements were evaluated based on the existing 6-lane Highway 401 configuration (Exhibit 5):

- The first alternative involved extensions of the existing ramp lanes. The shoulder lane, which tapers out just upstream of the existing ramp bull-nose, would be extended by 500m to the west, while the second lane would be extended by some 400m. The proposed configuration was in accordance with the terms of the concession agreement concerning Highway 407.
- The second alternative builds on the first by further extending the second lane as a continuous auxiliary lane to become a “must-exit” lane at the Trafalgar Road off-ramp.

Exhibit 5: Alternatives 2 and 3 – based on existing 6-lane Highway 401 mainline



Joint Design Considerations

Negotiating cost sharing had the potential to be challenging. This challenge was due to two key factors, the history of our relations with 407ETR, and also the probability for disagreement concerning the tangible benefits that either party would receive from the project.

All areas of consideration were jointly evaluated during the design process. To ensure that each party was satisfied with the findings of the consultant, regarding traffic flow improvements on MTO and 407ETR's respective facilities, joint project management and decision making was adopted. This joint effort formed the basis of successful cost sharing arrangement.

Establishing this joint design management allowed design solutions to be reached that reflected the interest of both parties. These considerations included:

- Accommodating 407ETR's long term two lane connection with the Highway 401
- Ensuring that upon the completion of construction the solution to the Highway 407 ramp would enhance rather than deteriorate traffic operations on the Highway 401
- The solution did not preclude future plans to upgrade and widen Highway 401
- Minimized future throw-away costs

Evaluation of Alternatives

Utilizing speed contour plots and lane-by-lane plots (Appendix A) it was concluded that:

- In terms of the operation of the ramp from Highway 407 to Highway 401, comparison indicated that in either case, queuing on the ramp would be eliminated under the traffic flow conditions tested. There was no appreciable difference between the two options in terms of ramp operations.
- In terms of the operation of Highway 401, there was a distinct improvement provided by the first alternative. The peak-hour queuing upstream from the bull-nose for the ramp from Highway 407 would have been significantly reduced in terms of both extent and duration. The second alternative appeared to lead to virtual elimination of this queuing.
- Common to all alternatives was some disturbance in traffic flow and reduced speed on Highway 401 just upstream of the Trafalgar off-ramp. This was due to lane-changing at this location. It appeared from the speed contour plots and was confirmed by the lane-by-lane speed plots (worst case conditions), that the disturbance was marginally worse with the improvements in place. This was likely due to the fact that more traffic would be getting through on Highway 401 at

the Highway 407 on-ramp as conditions improve, leading to a heavier loading at the Trafalgar off-ramp. However, it appeared to be a relatively minor difference.

On balance, both alternatives would have addressed the queuing issue on the ramp from Highway 407 to Highway 401 under existing “high day” traffic conditions. Alternative 1, with the extended ramp lanes, markedly improved the operation of Highway 401 in the vicinity of the ramp bull-nose, but it introduced a minor impact on Highway 401 as traffic approached the Trafalgar Road Interchange. Alternative 2, with the continuous auxiliary lane, improved operations at the subject location to an even greater extent and improved downstream flow on Highway 401.

Development and Evaluation of Future Scenarios

To assess the proposed ramp modifications up to ten years into the future, the development of 2016 volume estimates was considered. A trend analysis based on Average Annual Daily Traffic (AADT) indicated consistent growth over the past decade for both Highway 407 and Highway 401. Based on these trends, traffic on Highway 407 would increase by 63% over 10 years while the corresponding increase for Highway 401 would be 28% (see graphs below).

However, there are several constraints that make it unlikely that the calculated growth will be achieved:

- The current westbound flow on Highway 401 between the on-ramp and Trafalgar Road exceeds the theoretical capacity of 6,600 pce/hr (pce is a Passenger Car Equivalent – heavy vehicles are converted into equivalent cars at a rate of about 1.7 for generally level terrain). With the additional auxiliary lane of Alternative 2, the capacity of this section would be increased and some growth could be accommodated.
- Highway 401 west of the Trafalgar Road off-ramp, there is currently about a 5-10% capacity surplus. This is still insufficient to accommodate the projected increase of about 28%. The surplus is slightly greater east of 9th Line.
- Highway 401 at the Credit River, to the east of the study area, afternoon peak-hour and peak-period (3 hours) data was examined. It was found that peak flow levels were reached in 2001 and that traffic flows have been lower and somewhat variable since then (2004, 2006 Cordon Count data). Given that the 2001 flow levels exceeded the theoretical capacity and that daily traffic levels have been steadily increasing, this probably indicates that, since 2001, Highway 401 has been operating with demand greater than capacity and that the turbulent flow conditions have reduced the throughput. Overall, this capacity constraint to the east (unless the highway is widened) will limit the traffic entering the study area. We note also that the traffic flows at the Credit River are virtually identical over the entire 3-hour peak period, this peak spreading confirming the presence of congestion.

- On Highway 407, there is currently a capacity surplus of about 25 to 30%. However, it is insufficient to accommodate the estimated 63% growth over the next 10 years.
- The capacity of a ramp is approximately 1,500 to 1,900 per lane, although higher flows have been observed on high-design ramps in Toronto. With improvements, the ramp should be able to accommodate the estimated 63% increase in demand and should not act as a constraint.
- There is some potential for additional peak spreading to fill in the “shoulder” periods before and after the peak hour (92% and 87% of the peak hour as noted previously) but the earlier observation with respect to peak spreading at the Credit River eliminates this as a real possibility.

4. DESIGN AND CONSTRUCTION TIMELINE

The timeline was remarkably rapid for this project. Formal contact between 407ETR and the ministry regarding the subject ramp was initiated in December 2006. A joint venture was proposed, and at 407ETR’s sole expense, initial subsurface investigations and existing condition topographic surveys for the area were initiated.

The ministry granted 407ETR the necessary encroachment permits in order to carry out the initial site investigations, and in conjunction with the field works, discussions also took place to select an experienced traffic consultant that would be capable of undertaking the micro-simulation modeling discussed above.

By March 2007, at shared expense, the ministry and 407ETR had entered into a partnered arrangement to retain the necessary engineering services, and had developed design options to address the ministry’s objectives of protecting for long-range improvements to Highway 401.

To satisfy environmental requirements, 407ETR held a Public Information Session and filed a Design and Construction Report with the Ministry of the Environment in June 2007. Environmental clearance was obtained after a 30-day public review. With all the necessary design and approvals in place, 407ETR commenced construction activities in early August and the reconstructed ramp was opened to traffic before the end of September 2007.

During this period of negotiations, both parties continued to uphold all the contractual obligations of the CGLA, which included the process of subjecting the design and construction to the scrutiny of the ministry’s Highway 407 Audit Team, and Highway 407 Safety Steering Committee (Section 9 of Schedule 20 “Safety and Standards Protocol” of the CGLA).

The audit process was another key to ensuring the highest standards of safety were met before any new portion of highway was opened to traffic. Rather than potentially being a source of dispute and conflict between the ministry and 407ETR, both parties recognized the value of impartial independent scrutiny.

The pre-opening audit involved the assembly of a panel of experts from the ministry that reflected all aspects of the engineering and construction disciplines involved. The team conducted a field review when the project was substantially complete in early September 2007. The team recorded its findings to 407ETR, and 407ETR acted promptly to correct all deficiencies identified.

Once satisfied that all deficiencies had been corrected in accordance with ministry standards and the CGLA requirements, the Ministry's Safety Steering Committee recommended that the Minister of Transportation authorize the opening of the new ramp and auxiliary lane.

The timeline from initial proposal to highway opening was roughly 9 months. It is difficult to underscore the extraordinary speed of this timeline. For conventional ministry led projects for a 400 series highway, the process of justifying a project and then securing funding for design and construction and engineering services, is an onerous one. The public process is not without merits, as it serves to ensure infrastructure funding is directed to meet provincial priorities. However, to satisfy all stakeholders it would not be uncommon for such a project to span several years from initial proposal to final construction.

5. PARTNERSHIP BENEFITS AND NEXT STEPS

The introduction to this paper brought to light the lack of explicit direction on issues related to the expansion of Highway 407 and its effects on adjacent Provincial highways. However, both parties involved were able to demonstrate that an understanding of the partnership principles between the province and 407ETR was the key to resolving new and emerging issues.

The partnership founded on the recognition of first principles of our core business, which is to supply a transportation system that is integrated, and provides for the safe and efficient movement of people and goods.

In this particular case, the monetary scale of the project was very small relative to the scale of the ministry's annual roadwork budget; however, this particular project represented a major shift in relations between the two parties. After a number of tension-filled years, it signalled the successes possible when both parties communicate without prejudice and focus on finding win-win solutions.

Looking forward, the ministry and 407ETR are now working together to achieve similar success for improvements to the QEW / 403 / 407 Interchange in Burlington, the

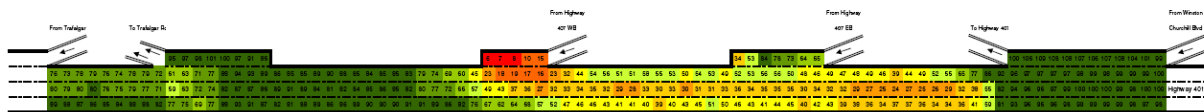
Highway 400 / 407 Interchange in Vaughan, several new municipal bridge structures crossing Highway 407, and further expansion of the Highway 407 / 401 Interchange.

As touched upon earlier in this paper, once construction of a project is complete and traffic starts flowing on an improved roadway, the strength of the partnership is fundamental as work begins anew to look ahead to future improvements in a continuous quest to address emerging issues.

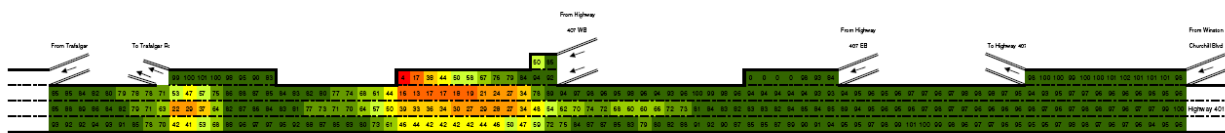
APPENDIX A

Lane-by-Lane Speed Plots for Highway 401 Westbound

Existing Configuration



Alternative 1 (extended ramp lanes)



Alternative 2 (continuous auxiliary lane)

