Heavy Truck Conflicts at Expressway On-Ramps – Part 1

Posting Date: 7-Dec-2016; Revised 14-Dec-2016

Figure 1: Every day vast numbers of large and long trucks must enter smoothly into high speed truck traffic on major expressways without causing a crash. This is a delicate procedure that requires the skill, cooperation and attention of all drivers involved.

An assessment of what factors exist during heavy truck traffic conflicts at expressway on-ramps requires the gathering of data about the status of those factors. Gorski Consulting has engaged in an observational (naturalistic) study of westbound heavy truck traffic on Highway 401 at the on-ramp from Elgin Road (Highway 73), just south-east of London, Ontario. This data was collected via multiple video cameras that were set-up at the test site on the afternoon of November 15, 2016.

1.0 Historical Views of Site

The testing site was photographed for several years prior to the testing. These views show the history of traffic volume in the area over the four years prior to this testing. Figures 2 through 13 show the site from eastbound and westbound views commencing from April 25, 2012.

Figure 2: View looking west from April 25, 2012.

Figure 3: View looking west from May 2, 2013.

Figure 4: View looking east from December 1, 2014

Figure 5: View looking east from March 19, 2015.

Figure 6: View looking west from October 22, 2015.

Figure 7: View looking east from November 20, 2015

Figure 8: View looking west from November 20, 2015.

Figure 9: View looking west from April 29, 2016.

Figure 10: View looking east from June 13, 2016.

Figure 11: View looking west from July 10, 2016.

Figure 12: View looking west from October 18, 2016.

Figure 13: View looking east from November 15, 2016.

2.0 Testing of November 15, 2016

Figure 14 is an aerial view of Highway 401 showing the positions of the nine video cameras used in this analysis. Camera 1 was positioned, facing west, on top of the overpass of Elgin Road.

Camera 2 was placed at the west end of the overpass, facing south so as to capture trucks in the right lane as they passed a reference point (end of a hatched, white, lane line).

Cameras were placed along a 400 metre distance of the westbound on-ramp between Camera 4 (at Zero) and Camera 9 (at 400 metres). Thus Cameras 4, 6, 8 and 9 were all facing south and captured westbound traffic as it passed reference points (traffic cones) placed on the road edge. Camera 6 was at 100 metres while camera 8 was at 200 metres

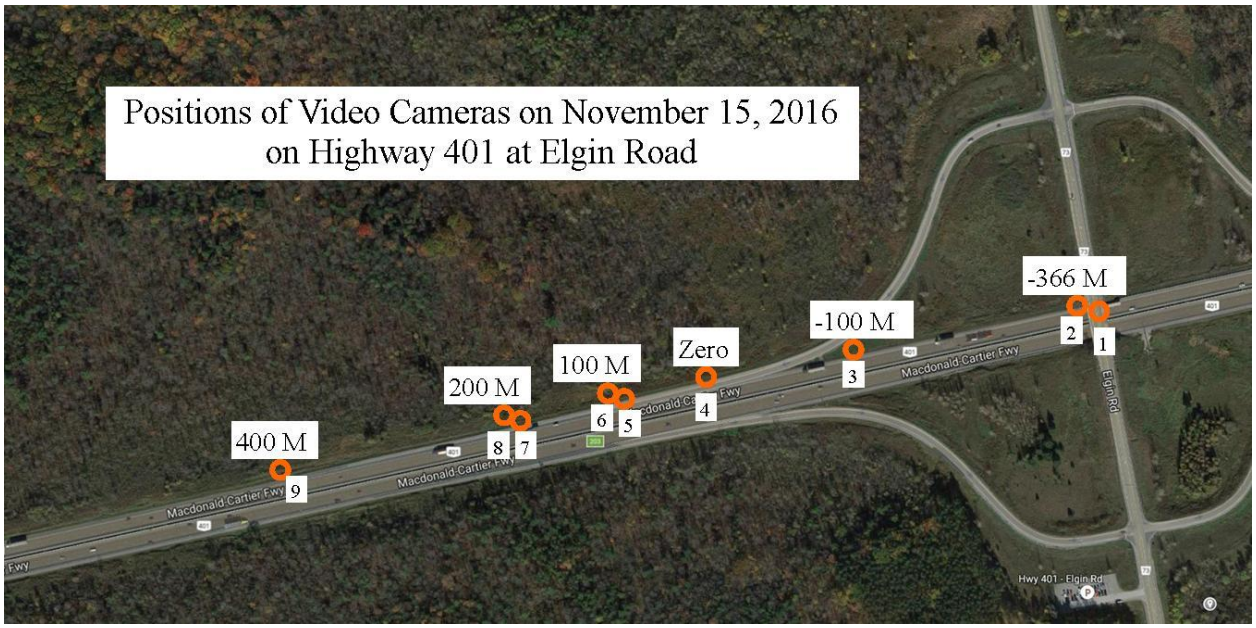

Figure 14: View of Highway 401 showing the positions of the nine video cameras.

Camera 5 was placed at 100 metres and Camera 7 was placed at 200 metres however both of these cameras were facing generally west and this captured the taillights of the trucks while also documenting their westward progress.

Camera 3 was placed within the island between the westbound on-ramp and the westbound right lane. This camera was positioned 100 metres east of Camera 4 (or -100 metres). This camera was pointed in the westward direction thus it allowed the observation of the rear ends of trucks from both the on-ramp and the right westbound lane of Highway 401.

The distance from Camera 2 (at the west edge of the overpass) and Camera 4 (at Zero) was 366 metres.

The total distance from Camera 2 to Camera 9 was 766 metres.

This set-up allowed for capture of the average speed of heavy trucks over four distances:

a) Between -366 and Zero metres (i.e. between Cameras 2 & 4)
b) Between Zero &100 metres (i.e. between Cameras 4 & 6)
c) Between 100 metres & 200 metres (i.e. between Cameras 6 & 8)
d) Between 200 metres & 400 metres (i.e. between Cameras 8 & 9)

The following are the results of the study.

A typical tractor-trailer travelling along Highway 401 may have a total length of 23 metres (75 feet) and weigh up to 36,000 kilograms (80,000 pounds). A Canadian B-train, tractor and double trailer combination, can be as long as 27.5 metres (90.2 feet) and its fully-loaded weight can approach 62,500 kilograms (137,800 pounds).

Average speeds of heavy trucks were obtained along the four segments noted above. Along the westbound right lane the average speeds were as follows:

-366 to Zero Metres = 100.35 km/h

Zero to 100 Metres = 98.59 km/h

100 Metres to 200 Metres = 98.46 km/h

200 Metres to 400 Metres = 99.07 km/h

Along the westbound on-ramp the average speeds were as follows:

Zero to 100 Metres = 65.50 km/h

100 Metres to 200 Metres = 69.65 km/h

200 Metres to 400 Metres = 76.08 km/h

Westbound heavy truck traffic on Highway 401 at Elgin Road was found to be almost exclusively made up of road tractor semi-trailer combinations. Traffic merging into the Highway from the westbound Elgin Road on-ramp was much more diversified including 25% dump trucks and 12 % B-trains.

The total westbound traffic in all 3 lanes of Highway 401 was comprised of just 33% heavy trucks. However, when looking exclusively at the right (slow) lane, the percentage of heavy trucks was 89 %.

The frequency of heavy truck traffic in the right lane was explored in more detail by placing a video camera (Camera 2) at a reference point located at the west edge of the Elgin Road overpass. As the front end of a truck passed the reference point the elapsed time was obtained until the front end of the next truck passed the same reference point.

This time gap excluded the small percentage of vehicles in the right lane that were not heavy trucks. It was found that a heavy truck passed the reference point every 7.93 seconds. Maximum time gaps were just over 25 seconds. However, in 18% of the cases the time gap was below 3.0 seconds and in 6% of the instances the time gap was below 2.0 seconds.

Similarly, time gaps were obtained for trucks entering the Highway via the westbound on-ramp. It was found that a heavy truck passed through the on-ramp every 45 seconds.

Following a truck too closely is a particular safety concern at an older over-pass such as the one at Elgin Road. Figure 15 shows a heavy truck travelling past a similar overpass on Highway 401. The concrete wall of the overpass restricts the view of the on-ramp to the right and the right side of the truck trailer prevents a driver from seeing vehicles on the on-ramp to the left. Thus there could be traffic within the on-ramp ahead of the truck but the driver behind would not be aware of its presence.

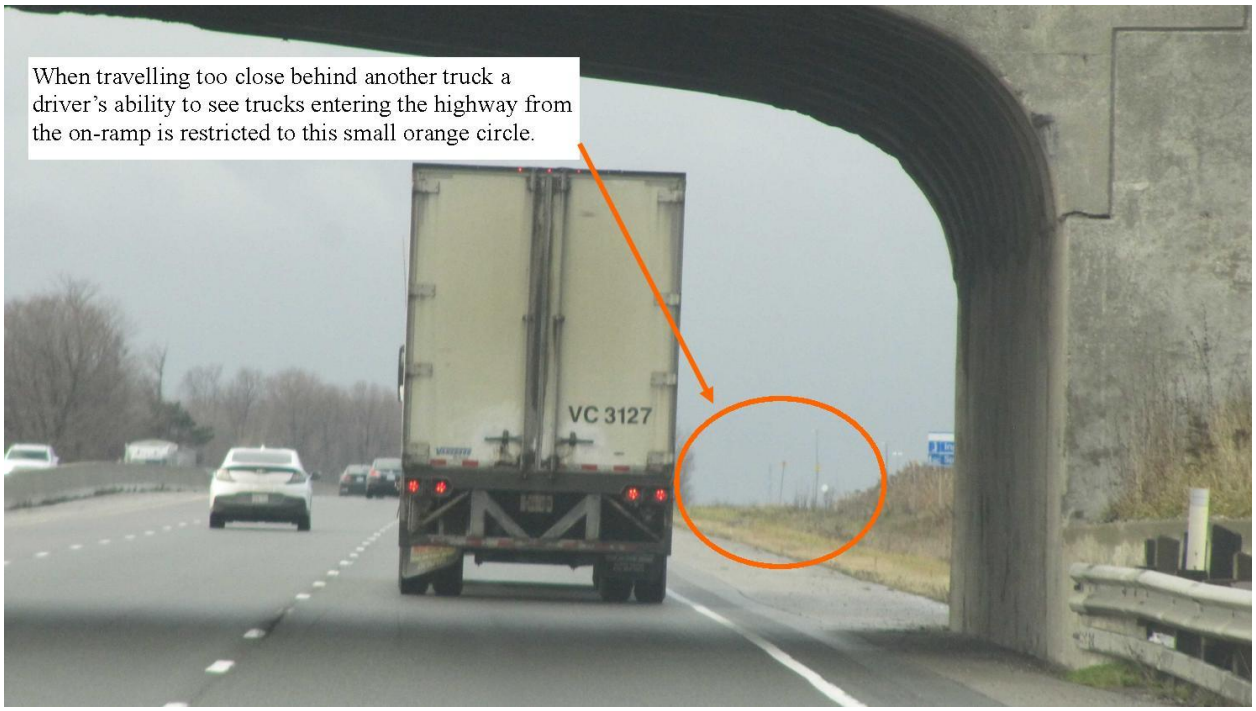

Figure 15: View of a westbound truck passing an older overpass and the minimal view available to see traffic entering the highway from an on-ramp.

The analysis also examined those instances where there was likely conflict between trucks in the westbound right lane of Highway 401 and those entering the highway via the westbound on-ramp. This conflict could reveal itself in several ways however the most obvious (and easiest to detect) were those instances where the approach speed of the truck in the right lane was altered, thus suggesting that this alteration was due to the presence of the truck in the on-ramp entering that right lane.

Based on 100 observations of westbound, heavy trucks, Figure 16 shows the speeds of the 8 observations exhibiting the highest changes in speed as they passed by the video cameras. Similarly, Figure17 provides the specific speed differentials of those 8 trucks across the four segments of roadway. The details of what occurred in these 8 instances is discussed in a companion article, Part II, of this research.

		1	2	3	4
Obs #	Type of Truck	366 M to Zero M	Zero to 100 M	100 M to 200 M	200 M to 400 M
14	Tractor & Semi-Trailer, Day Tripper	101.59	93.02	94.74	99.59
18	B-Train with two orange trailers	99.29	99.17	96.51	91.14
30	Tractor & Flat Bed Semi Trailer, Long Hauler	97.60	90.68	83.72	79.73
32	Tractor & Semi-Tanker Trailer, Long Hauler	92.79	93.02	92.31	98.63
33	Tractor & Semi-Trailer, Long Hauler	98.33	91.60	79.47	71.50
37	Tractor & Semi-Trailer, Long Hauler	95.69	103.75	104.96	103.90
38	Tractor & Semi-Trailer, Long Hauler	103.75	100.00	97.30	97.69
45	Tractor & Semi-Trailer, Long Hauler	103.50	98.09	95.49	91.95
	Average =	**99.07**	**96.17**	**93.06**	**91.77**

Figure 16: Table of the 8 observations of heavy trucks exhibiting the highest speed differentials.

Speed Diff Betw 1 & 2	Speed Diff Betw 2 & 3	Speed Diff Betw 3 & 4	Speed Diff Betw 1 & 4
-8.57	1.71	4.85	-2.00
-0.12	-2.66	-5.38	-8.15
-6.92	-6.96	-3.99	-17.87
0.23	-0.72	6.32	5.84
-6.73	-12.13	-7.97	-26.83
8.06	1.21	-1.06	8.21
-3.75	-2.70	0.40	-6.05
-5.41	-2.60	-3.54	-11.55
-2.90	**-3.11**	**-1.30**	**-7.30**

Figure 17: Difference in speed (km/h) exhibited by 8, westbound, heavy trucks.

As an example, Figures 18 through 21 show a view from Camera 1, looking west, from atop of the Elgin Road overpass, and looking at the scenario unfolding in Observation 14.

Looking at the table in Figure 16 we note in Observation #14 that a westbound tractor trailer is observed to be travelling at an average speed of 101.59 km/h in the distance of -336 metres to Zero metres. This tractor-trailer is not yet visible in Figure 18 however it becomes visible in Figure 19. In Figure18 we see a tractor-trailer with its left turn signal activated as the driver intends to cross into the middle lane due to the presence of a truck on the westbound on-ramp which will be merging into the right lane.

Figure 18: View of a tractor-trailer in the westbound right lane of Highway 401 with its left turn signal activated, indicating that the driver wants to cross into the middle lane. In the background a road tractor hauling a gravity trailer is seen on the on-ramp.

Figure 19: Our interest is in the second tractor-trailer in the right lane of this view as this truck is positioned close to the rear end of the lead truck and therefore the following driver's line of sight could be obstructed for objects ahead.

Figure 20: View of the lead, westbound vehicle making a lane change well in advance of the location of where the merging truck will enter the right lane of the highway.

Figure 21: View showing that the lead tractor trailer has almost completed its lane change and the driver of the following truck has ample opportunity to see the merging truck and take action by braking or also changing lanes if necessary.

In Figure 19 we observe a second tractor-trailer has become visible riding closely behind the rear of the first and it is this second truck that is the subject of our interest. The time gap between the front end of the first truck and the front end of the second truck is only 1.53 seconds therefore the time gap between the rear of the forward truck and the front of the following truck would be shorter in consideration of the length of the first truck. One can observe in Figure 19 that the visibility of the merging truck in the on-ramp could be obscured to the driver of the westbound, following truck. Because of the short distance between the two westbound trucks the following driver's view ahead is blocked by the larger area of the rear of the truck in the driver's field of view.

If the truck in the on-ramp is travelling relatively quickly then the problem is not as great because that vehicle on the on-ramp would be further back and to the right with respect to the following driver's field of view. However, if the truck on the on-ramp is travelling very slowly then its position would be much further forward in the field of view, its presence would be blocked by the leading truck and its existence may not be detected by the following driver.

Figures 20 and 21 show how the driver of the leading, westbound tractor-trailer has begun to change lanes well in advance of reaching the location where the merging truck will enter the right lane. However, in the scenario where the leading truck driver makes a rather abrupt and late lane change, the following driver could have very little time to detect the merging truck and a collision could occur.

Avoiding collisions may not always involve braking and/or changing lanes. In some instances westbound drivers can avoid a conflict by accelerating. This is likely why, in the tables of Figures 16 and 17, the drivers in Observations 32 and 37 sped up.

A heavy brake application likely occurred in Observation 33 where the initial speed of 98.33 km/h was reduced by almost 27 km/h. Such large changes in speed can cause problems to surrounding drivers who may not expect or appreciate why the braking occurred. This is particularly so when the large size of heavy trucks can block the view of many drivers in the vicinity. For example, in Figure 19, the change of lanes by the leading truck has led to the illumination of the braking lights in both of the two passenger cars in the middle lane. The drivers of those two passenger cars might not have detected the presence of the truck on the on-ramp because their view could have been blocked by the presence of both of the trucks in the right lane. This blockage is more complete when the two trucks are close together such that the drivers of the passenger cars cannot see to the right between the gap of the two trucks.

The end of the on-ramp was located just west of the 400 metre marker at Camera 9. Thus the total distance from the overpass at Elgin Road to the end of the on-ramp was about 766 metres. At a speed of 100 km/h (27.8 metres per second) that distance can be travelled in about 27.5 seconds. Thus, once a truck driver passes the wall of the overpass there can be a considerable amount of time to detect and react to the presence of a heavy truck entering on the on-ramp. However, even before reaching the overpass truck drivers can be cognizant of what is likely to occur ahead and plan for it. Thus while travelling in the right lane the driver needs to be aware of the position of

traffic around the truck, particularly with respect to traffic in the middle lane and whether there will be an opportunity to travel into that lane if that action becomes necessary. In some instances that lane change may not be possible due to the traffic volume. In that case the driver can expect that a brake application may be necessary to allow a merging truck to enter the right lane.

It may also be acceptable that an increase in speed may achieve the result of travelling ahead of the merging truck thus avoiding a conflict. However Ontario's Provincial government has required that speed governors be attached to heavy trucks such that their maximum speed is in the vicinity of 105 km/h. While touting this legislation as an improvement in safety it narrows a truck driver's alternatives as an increase in speed to avoid a conflict is removed from the options.

Drivers of heavy trucks entering the highway on the on-ramp have limited options to avoid conflicts. They must accelerate as quickly as possible to the speed of highway traffic but that is generally not possible, especially when the truck is fully-loaded or hauling a more massive cargo in a train of two trailers. Given the typical slow rate of acceleration such heavy trucks will generally enter the right lane at a speed substantially slower than the traffic in the right lane. As indicated earlier, the average speed of such merging trucks, near the end of the end of the on-ramp was observed to be only 76 km/h whereas average speeds of heavy trucks travelling straight through were in the range of 100 km/h. A driver on the on-ramp also has a difficulty estimating the speed of traffic when looking to the left and behind through the available mirrors. Once committed to enter the right lane there is little opportunity to abort the motion except to drive onto the shoulder. Alternatively, a driver travelling straight through in the right lane can observe the merging truck while looking generally forward through the windshield. Such a straight through driver has a much better opportunity to estimate the merging truck's speed, estimate where the merging truck might enter the right lane and to consider avoidance options. Therefore it requires the cooperation of drivers travelling straight through in the right lane of an expressway to make the majority of adjustments either through changing speed or changing lanes. These straight-through drivers must also pay attention to their environment before reaching an overpass and to increase their spacing from any vehicle ahead such they have a greater opportunity to detect vehicles that might otherwise become blocked from view by the truck ahead when travelling too close to that truck.

In a companion article, Part II, a closer look is taken at specific heavy truck conflicts and the status of factors that led to them.