# Safety Implications of Mandated Truck Speed Limiters

**Frank F. Saccomanno**[1], Professor, Ph.D., P.Eng.
E-mail: saccoman@uwaterloo.ca

**David Duong**[1*], Research Assistant
E-mail: dqduong@uwaterloo.ca

**Flávio Cunto**[1], Research Assistant, M.Sc.
E-mail: fjccunto@uwaterloo.ca

**Bruce Hellinga**[1], Associate Professor, Ph.D., P.Eng.
E-mail: bhellinga@uwaterloo.ca

**Chris Philp**[2], P.Eng.
E-mail: cphilp@itransconsulting.com

**Pierre Thiffault**[3], Senior Research Analyst, Ph.D
E-mail: THIFFAP@tc.gc.ca

**1.** Department of Civil and Environmental Engineering
University of Waterloo
200, University Street West
Waterloo, ON, Canada N2L 6P6
Tel: (519) 888-4567 x. 6596
Fax: (519) 888-5221

**2.** iTRANS Consulting Inc.
100, York Blvd., Suite 300
Richmond Hill, ON, Canada L4B 1J8
Tel: (905) 882-4100 x. 5365
Fax: (905) 882-1557

**3.** Road Safety and Motor Vehicle Regulation
Motor Carrier Division
Transport Canada
275, Slater, 17th floor
Ottawa, ON, Canada K1A ON5
Tel: (613) 993-8552
Fax: (613) 998-2913

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*Corresponding author

## ABSTRACT

This paper presents the results of a study funded by Transport Canada to investigate the safety implications of mandated truck speed limiters. The study adopted a microscopic simulation approach that was applied to a number of maximum speed control strategies including 105km/h. The sensitivity of safety performance with respect to changes in geometric and traffic scenarios was investigated. The study found that truck speed limiters produced positive safety gains for different assumed volumes and percentage trucks and different compliance levels. Under certain conditions such as high volumes and high percentage of trucks, speed limiters produced a reduction in safety, especially at on and off-ramp segments of freeways.

## INTRODUCTION

Several jurisdictions in North America (national and state) are currently considering the introduction of mandatory speed limiters to reduce energy costs and crash risks. A speed limiter, also called a governor, is a built-in microchip that limits the maximum revolutions that an engine can achieve, hence restricting the vehicle's maximum speed.

The primary intent of mandated truck speed limiters is to reduce energy consumption and lower vehicle emissions. In Ontario, for example, a recently mandated 105 km/h truck speed rule is expected to produce fuel savings of up to 10,500 litres per truck per year, or a total of over 50 million litres of fuel savings annually province-wide. This can have a significant effect on reductions in green house emissions (estimated at about 140 kilo tones per year).

Unfortunately, the safety implications of mandated truck speed limiters are not well understood and this has led to a divergence of views on their possible effectiveness. The Ontario Ministry of Transportation (MTO) has taken the position that mandated truck speed limiters (set at 105 km/h) will reduce the incidents and severity of crashes involving large trucks (*1*). This position is supported by a number of industry and regulatory agencies in Canada, such as, Ontario Trucking Association (OTA), Canadian Trucking Alliance (CTA), Canada Safety Council and the Canadian Lung Association.

On the other side, a number of groups have taken the position that mandated truck speed limiters can lead to the unintended outcome of increased crash risk in terms of both frequency and severity. The Truck Owner-Operator Business Association in Canada (*2*) has suggested that mandated speed limiters could make it more difficult for trucks to merge, pass or keep up with other presumably faster moving vehicles, especially in those instances where the posted speed limits on highways exceeds the value mandated for trucks. Opponents of speed limiters have argued that mandated maximum speeds for trucks can increase the likelihood of crashes due in large part to restrictions in over-taking manoeuvres (*3*).

## OBJECTIVES OF STUDY

The basic aim of the study discussed in this paper was to assess the safety implications of mandating speed limiters for large trucks (weight greater than 11,794 kg). A number of maximum speed thresholds (including 105 km/h) and compliance rates were investigated for different freeway geometric and traffic scenarios.

As the basis for measuring safety performance, the study adopted a microscopic traffic simulation platform that was calibrated based on observed vehicle tracking data. The calibration of the traffic simulation model ensures that the estimates of safety performance obtained from the model are accurate and representative of real-world traffic conditions. The calibrated model was applied to different traffic/highway scenarios to assess how safety performance (or potential crash risk) is affected by different speed control strategies and different road and traffic conditions.

## REVIEW OF PREVIOUS SPEED CONTROL STUDIES

Previous research on the safety impacts of speed limiters has come primarily from European studies dealing with speed control for all types of vehicles [(*4*), (*5*)]. A few field trials have been carried out in Europe for passenger cars suggesting some improvements in safety [(*6*),(*7*)]. Toledo et al (*8*) and Johnson and Pawar (*9*) investigated safety implications arising from the use of speed limiters and differential posted speed limits, but found their results to be inconclusive. As a result the authors recommended additional research.

Logically, we would expect a reduction in crashes would follow a reduction in the maximum speed limit where the reduction is applied uniformly to all vehicles in the traffic stream, and there is 100% compliance. The challenge for this study has been to determine the effect on safety of a speed control strategy that targets one group of vehicles (trucks) and not another (cars). Specifically the study investigated the effect of truck limiters on car/truck speed differentials with resultant impacts on traffic turbulence. Increased turbulence has been identified by a number of researchers as having a deleterious effect on crash risk [(*10*),(*11*),(*12*)].

The interface between traffic speed variance, turbulence and crash risk is complex and requires a thorough real-time treatment of individual vehicle speed and spacing profiles (*13*). If speed controls produce either intentional or unintentional increases in speed differentials or variance between cars and trucks, then there is a chance that both crash frequency and severity could be compromised by the introduction of these controls.

## STUDY FRAMEWORK

A four stage process was adopted in this study for simulating safety performance and for assessing how this would be affected by mandated truck speed limiters:

1. Specification of safety performance
2. Calibration/validation of traffic simulation platform
3. Linking safety performance to observational crash occurrence
4. Estimating safety performance for different road/traffic scenarios and speed limiter control strategies

In this research, VISSIM© (Version 4.3) was selected as the traffic simulation platform for assessing the safety implications. VISSIM© is based on psycho-physical driving algorithms and accounts for four different driving regimes: 1) Un-influenced driving, 2) Closing process, 3) Following process and 4) Emergency braking, and are defined by six human thresholds:

- *AX* - desired distance for standing vehicles (front-to-front distance)

- *ABX* - desired minimum following distance at low speed differences
- *SDV* - perception threshold of speed difference at long distance
- *SDX* - perception threshold of growing distance in following process
- *CLDV* - small speed differences at short, decreasing distance are considered in this perceptual threshold
- *OPDV* - perceptual threshold for recognizing small speed differences at short, but increasing distances

These four driving regimes represent situations where drivers should behave in a similar (but not equal) manner with respect to desired spacing, speed and actions needed to achieve them by means of varying acceleration and deceleration rates (*14*).

In lieu of predicting actual crashes, safety performance measures are commonly used in microscopic simulation to capture high risk driver behaviour in the traffic stream and hence, explain the "potential for crashes". A number of measures of safety performance have been suggested in the literature, such as, "time to collision" (TTC), "deceleration rate to avoid the crash" (DRAC), "post encroachment time" (PET), Time Extended Time-to-collision (TET), Unsafety Density parameter (UD), among others [(*15*), (*16*), (*17*), (*18*)].

To measure safety performance in real-time, Cunto and Saccomanno (*19*) and Saccomanno et al. (*20*) proposed a Crash Potential Index (CPI) expressed as a function of the probability that the vehicle deceleration rate required to avoid a crash exceeds its maximum braking capability. For the traffic stream as a whole this measure can be expressed as the average CPI/veh. This measure provides a basic indicator of the level of turbulence associated with the traffic stream over time, and hence its potential for crashes. Additional measures derived from the CPI/veh indicator include: $85^{th}$ percentile CPI ($CPI85^{th}$), number and percentage of vehicles interacting or in conflict, time exposed to conflict, etc (*21*).

## VISSIM CALIBRATION

The purpose of VISSIM calibration is to establish accurate and reliable safety performance measures for different road geometries and traffic attributes using "best estimate" traffic model input parameters. These parameters should yield simulated safety performance measures that compare closely to those estimated directly from observational vehicle tracking data. In this way, simulated estimates of safety performance are deemed to be accurate and reliable. Without formally calibrating the traffic simulation platform in this manner, its estimates of safety performance may contain some bias or error in relation to what can be expected in the real world.

The observational vehicle tracking data used to calibrate and validate safety performance in VISSIM were obtained from the Next Generation SIMulation (NGSIM) program administered by the FHWA (*22*). The NGSIM vehicle tracking data were extracted for two 15 minute periods at off-ramps and combined on/off-ramp segments of freeway.

The calibration/validation procedure adopted in this study consists of five sequential steps:

1. Heuristic selection of initial model inputs
2. Initial statistical screening of inputs

3. Linear expression relating significant inputs to safety performance
4. Best estimates of model inputs using genetic algorithms
5. Validation of selected inputs based on an independent traffic sample

The first four steps apply to the model calibration, while the 5th step is concerned with validating the transferability of the results obtained from the calibrated traffic model.

Tables 1 and 2 summarize the VISSIM calibration results obtained in this study for two freeway geometric configurations: 1) off-ramp and 2) combined on/off-ramp, respectively.

**TABLE 1 Genetic Algorithm Best Estimate of VISSIM Parameters (off-ramp segment)**

| VISSIM Parameter | Description | Value |
|---|---|---|
| Observed vehicles ahead | Affects how well vehicles predict other vehicle movements and react accordingly | 2 |
| Safety distance factor | Takes effect for; a) the safety distance of the trailing vehicle in the new lane for the decision whether to change lanes or not, b) the own safety distance during a lane change and c) the distance to the leading (slower) lane changing vehicle | 0.46 |
| Desired average speed | Is the standard deviation of the desired speed distribution | 106.80 |
| Maximum look ahead distance | Defines the distance that vehicles can see forward to react to other vehicles in front or beside it on the same link | 114.13 |
| Acceptable deceleration of lane change vehicles | Affects lane change behaviour | -2.25 |
| CC0 | Standstill distance (m), defines the desired distance between stopped vehicles | 2.88 |

**TABLE 2 Genetic Algorithm Best Estimates of VISSIM Parameters (combined segment)**

| VISSIM Parameter | Description | Value |
|---|---|---|
| Safety distance factor | Takes effect for; a) the safety distance of the trailing vehicle in the new lane for the decision whether to change lanes or not, b) the own safety distance during a lane change and c) the distance to the leading (slower) lane changing vehicle | 0.76 |
| Desired average speed | Is the standard deviation of the desired speed distribution | 106.70 |
| Maximum look ahead distance | Defines the distance that vehicles can see forward to react to other vehicles in front or beside it on the same link | 243.97 |
| Acceptable deceleration of trailing vehicle | Affects lane change behaviour | -1.10 |
| CC0: | Standstill distance (m), defines the desired distance between stopped vehicles | 2.44 |
| CC1 | Is the headway time in seconds that a driver wants to keep | 1.09 |
| CC3 | Threshold for entering Following, controls the start of the deceleration process | -6.09 |
| CC5 | Following thresholds control the speed differences during the following state. Smaller values result in a more sensitive reaction of drivers to accelerations or decelerations of the preceding car | 1.88 |

The input parameters summarized Table 1 for the off-ramp case yield a simulated average CPI/veh of $10.48E^{-5}$ slightly higher than the desired target value of $9.92E^{-5}$ from NGSIM. For the calibration data, the percentage error in the CPI/veh was found to be fairly low at about 5.7%.

For the combined freeway segment, the parameter inputs from Table 2 result in a simulated average CPI/veh of $8.27E^{-5}$ slightly lower than the desired target value of $9.53E^{-5}$ from NGSIM. The percentage error in the CPI/veh was found to be approximately 14%. Simulated and observed values of CPI/veh were within acceptable error ranges, suggesting that the simulation model used in this study adequately reflects safety performance as observed in the NGSIM data.

## LINKING SIMULATED SAFETY PERFORMANCE TO OBSERVED CRASHES

As noted by Gettman and Head (*16*) the issue in linking safety performance to crash risk lies not on predicting crashes, but rather on correlating certain traffic/driving attributes to high risk or unsafe situations at a given location and time. Since crashes are bi-products of high risk behaviour, we would expect traffic profiles for a period prior to the crash to be indicative of low safety performance or high crash potential (average CPI/veh). A link between simulated safety performance measures and crash occurrence provides evidence that crashes tend to take place when traffic stream CPI/veh levels are higher than average and consequently that these measures are indicators of potential crash risk.

Cunto et al. (*23*) introduced three tests that can be used to provide insights as to the link between simulated safety performance and crash occurrence:

- Test 1) comparing safety performance measures in aggregated 1 minute increments for a period five minutes prior to the precise time of the crash
- Test 2) comparing safety performance measures in 1 min increments over five minutes preceding the crash and compare this to non crash results for the same location and traffic volumes, and
- Test 3) comparing average safety performance measures to crash rates estimated over a one hour period at the same site.

These tests make use of two integrated data bases: IFTMS (instrumented freeway traffic management system) data extracted from a segment of the Queen Elizabeth Way (QEW) west of Toronto, and the Accident Data System (ADS) that describes crashes compiled from police reports for the same segment. The IFTMS provides real-time loop detector traffic information for each reported crash on the QEW. The QEW segment used in this analysis comprises a stretch of 19 km equipped with 52 loop detector stations. Traffic information is reported at the detector stations in 20 sec time slices.

In this paper, the discussion is focused on Test 1. This test attempts to reproduce in the microscopic environment similar traffic flow patterns observed at loop detector stations 5 minutes prior to the occurrence of each crash. This analysis of crashes between loop detectors is based on a sample of 20 crashes reported on the instrumented QEW segment for the period 1997-2001.

The interval of 5 minutes prior to the time of the crash is assumed to fully encompass expected changes in traffic conditions that could influence the crash. The two principal factors affecting traffic flow are assumed to be: volume (vph) and speed (km/h). Similar traffic flow patterns are established by matching observed and simulated volume

and speed output in one minute intervals for both upstream (US) and downstream (DS) detectors. As discussed by Cunto et al. (*23*) the crash time was estimated to be the time of maximum speed reduction for each crash at the first upstream detector minus an approximate time it takes the crash shockwave to propagate back from the crash location to this detector.

The average CPI/veh was estimated by summing total CPI over all vehicles divided by the number of vehicles in the simulated traffic stream. This average was determined for 10 independent simulations, and the results are illustrated in Figure 1 for the time interval 1 to 5 minutes prior to the crash.

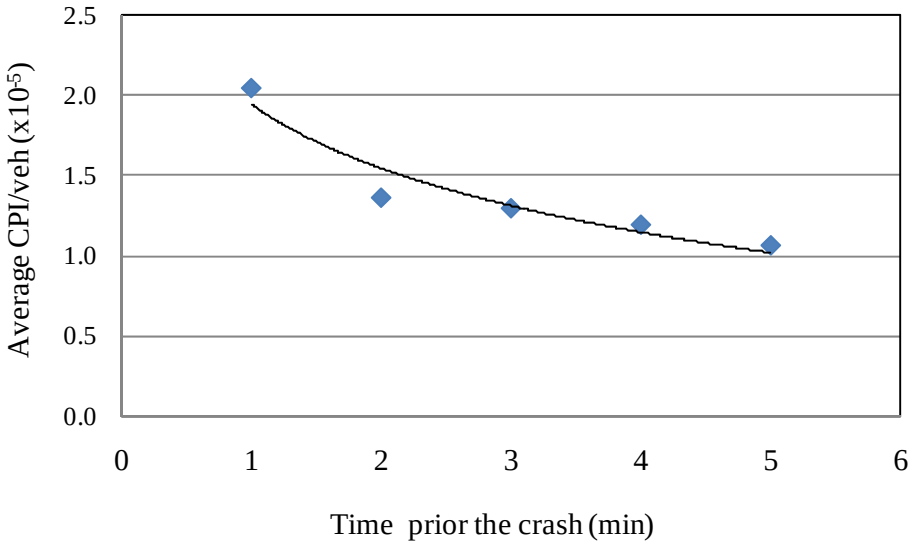


**FIGURE 1 Average CPI/veh *versus* time to crash (20 crash sample).**

For the 20 crashes illustrated in above Figure, a reduction in safety performance (increase in average CPI/veh) was observed with approaching time to crash. This provides some evidence (test 1 only) that the CPI measure used in this analysis reflects increased crash risk as reflected in the observational data. Similar conclusions were obtained for the other two safety performance tests.

## SAFETY PERFOMANCE OF TRUCK SPEED LIMITERS

To assess the safety implications of truck speed limiters, this study considers several freeway geometric and traffic scenarios. As illustrated in Figure 2, the three freeway geometric configurations are: straight, off-ramp, and on-ramp segments.

The relevant traffic scenarios considered in this study are:

- High (2000 vphpl) and low (500 vphpl) freeway volumes
- High (15%) and low (2.5%) percentage trucks in traffic stream
- Mandatory truck limiter compliance rates (75%, 100%)

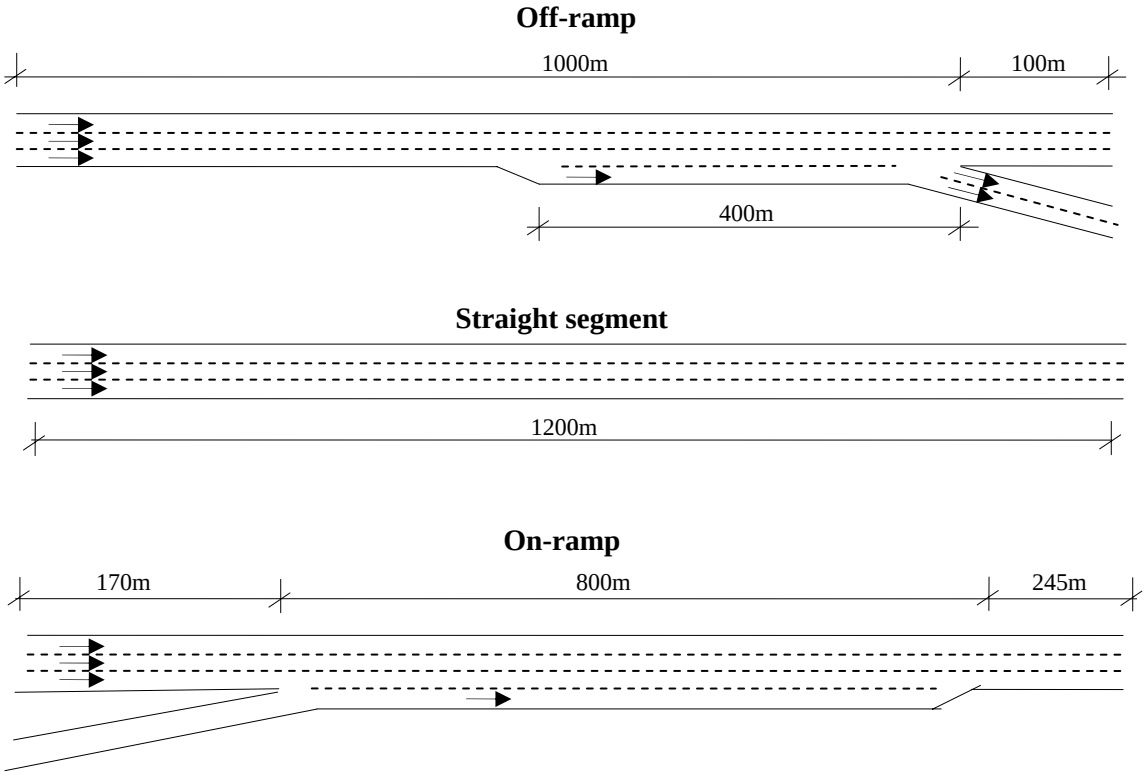


**FIGURE 2 Geometry and lane configuration.**

In addition to these geometric and traffic scenarios, several maximum speed control strategies were investigated for large trucks:

- 110 km/h
- 105 km/h
- 100 km/h
- 90 km/h
- 80 km/h

The first two strategies were adopted to reflect recent Ontario and Quebec speed control regulations. The remaining maximum speed control strategies were selected to provide a measure of the sensitivity of changes in safety with respect to the maximum speed thresholds.

Survey results obtained from a study conducted by McDonald and Brewster (*24*) indicated that 50% of large carriers are currently equipped with limiters compared to 25% for small carriers, regardless of whether they are mandated or not. Accordingly, the base case strategy (no mandatory limiter) assumes that 35% of all trucks are currently equipped on a voluntary basis with speed control devices set at the maximum 105 km/h. For the non-base case strategies the maximum speed on all limiters (voluntary and mandatory) has been set by the regulations as given above.

Different levels of volume, percentage of trucks and compliance rates were investigated, as these factors were assumed to have some effect on the average speed and speed variance, and hence the CPI of individual vehicles in the traffic stream.

**TABLE 3** summarizes the different traffic, lane-configuration and speed control factors used in this investigation of safety performance. A two-level factorial experiment was undertaken to consider all possible interactions between the above scenarios and simulated average CPI/veh.

**TABLE 3 Factorial Analysis Summary**

| Factor | Parameter | Low level (-1) | Centre Points (0) | High level (+1) | Description |
|---|---|---|---|---|---|
| A | Volume | 500 | 1250 | 2000 | Volume in vehicles per hour per lane |
| B | Truck Rate | 0.025 | 0.088 | 0.150 | Truck rate (2.5% to 15%) |
| C | CompRate | 0.750 | 0.875 | 1 | Compliance rate |
| D | NbrLanes | 2 | - | 3 | number of lanes (2 or 3) |
| E | SpeedControl | -1 | - | 1 | Speed limiter: -1 = no control; 1 = speed limit 105 |

The full $2^5$ factorial design requires 32 simulations. Centre points or average values of volume, percentage trucks and compliance rate (as well as number of lanes and maximum speed) were considered. Furthermore, 5 replicates of the entire experiment were carried out to account for random variability in the simulation, and this results in a total of 180 simulation runs (36*5).

A major objective in the factorial analysis is to estimate the effect of independent variables on the average CPI/veh in absence of possible scaling biases introduced by the units of the variables. The factorial experiment also yields a linear expression relating independent variables of interest with the average CPI/veh indicator. Preliminary analysis suggests that the natural log transform of the average CPI/veh yields less variability, and hence is more representative of the underlying relationship.

Table 4 summarizes the results of the n-way ANOVA performed for the factorial experiment at off-ramp locations. For the 105 km/h strategy, the ln(CPI/veh) was found to be significantly affected by the volume (A), percentage trucks (B), number of lanes per direction (D) and the introduction of speed limiters (E). Furthermore, a number of second and third order interactions involving these four factors and compliance rates were found to be significant at the 5% level. These findings suggest that there is statistical evidence for the assertion that the introduction of speed limiters will have an effect on safety. Whether this effect is positive or negative will now be investigated.

**TABLE 4 N-way ANOVA for 105 km/h Strategy (off-ramp)**

| Dependent Variable: Ln(CPI) | | | | | | |
|---|---|---|---|---|---|---|
| Source | Effect | Sum of Squares | df | Mean Square | F | Sig |
| Corrected Model | - | 426.03 | 35 | 12.17 | 11.44 | 0.00 |
| **Intercept** | - | **25253.38** | **1** | **25253.38** | **23732.13** | **0.00** |
| **A** | **1.89** | **142.70** | **1** | **142.70** | **134.10** | **0.00** |
| **B** | **2.22** | **197.67** | **1** | **197.67** | **185.76** | **0.00** |
| C | - | 3.06 | 1 | 3.06 | 2.87 | 0.09 |
| **D** | **0.60** | **10.46** | **1** | **10.46** | **9.83** | **0.00** |
| **E** | **-0.44** | **5.55** | **1** | **5.55** | **5.21** | **0.02** |
| **A * B** | **-0.37** | **5.48** | **1** | **5.48** | **5.15** | **0.02** |
| **A * C** | **0.33** | **4.42** | **1** | **4.42** | **4.15** | **0.04** |
| B * C | - | 3.67 | 1 | 3.67 | 3.45 | 0.07 |
| A * B * C | - | 1.69 | 1 | 1.69 | 1.58 | 0.21 |
| **A * D** | **0.40** | **6.54** | **1** | **6.54** | **6.15** | **0.01** |
| B * D | - | 0.46 | 1 | 0.46 | 0.43 | 0.51 |
| A * B * D | - | 0.09 | 1 | 0.09 | 0.08 | 0.78 |
| C * D | - | 0.06 | 1 | 0.06 | 0.06 | 0.81 |
| A * C * D | - | 0.00 | 1 | 0.00 | 0.00 | 0.95 |
| B * C * D | - | 0.02 | 1 | 0.02 | 0.02 | 0.90 |
| A * B * C * D | - | 0.06 | 1 | 0.06 | 0.05 | 0.82 |
| **A * E** | **0.43** | **7.53** | **1** | **7.53** | **7.07** | **0.01** |
| **B * E** | **0.34** | **4.73** | **1** | **4.73** | **4.45** | **0.04** |
| A * B * E | - | 3.32 | 1 | 3.32 | 3.12 | 0.08 |
| C * E | - | 3.06 | 1 | 3.06 | 2.87 | 0.09 |
| **A * C * E** | **0.33** | **4.42** | **1** | **4.42** | **4.15** | **0.04** |
| B * C * E | - | 3.67 | 1 | 3.67 | 3.45 | 0.07 |
| A * B * C * E | - | 1.69 | 1 | 1.69 | 1.58 | 0.21 |
| D * E | - | 0.17 | 1 | 0.17 | 0.16 | 0.69 |
| A * D * E | - | 0.32 | 1 | 0.32 | 0.30 | 0.58 |
| B * D * E | - | 0.41 | 1 | 0.41 | 0.38 | 0.54 |
| A * B * D * E | - | 0.25 | 1 | 0.25 | 0.23 | 0.63 |
| C * D * E | - | 0.06 | 1 | 0.06 | 0.06 | 0.81 |
| A * C * D * E | - | 0.00 | 1 | 0.00 | 0.00 | 0.95 |
| B * C * D * E | - | 0.02 | 1 | 0.02 | 0.02 | 0.90 |
| A * B * C * D * E | - | 0.06 | 1 | 0.06 | 0.05 | 0.82 |
| Pure Error | | 153.23 | 144 | 1.06 | | |

Note: bolded value indicates variable is significant at the alpha = 5 % level

A linear regression was carried out for the off-ramp scenario relating ln(CPI/veh) to different traffic and compliance attributes with and without limiters (Equation 1),

$$\ln(CPI/veh) = -16.44 + 0.000414\ (V) + 22.71635\ (TR) - 0.07936\ (L) - 0.81935\ (SL) - \\ - 0.00394\ (V)(TR) + 0.00054\ (V)(L) + 0.000447\ (V)(SL) + \\ + 0.027514\ (TR)(SL) - 0.00018\ (V)(CR)(1 + SL) \quad (1)$$

Where:
V= volume (vphpl)
TR = truck rate
L = number of lanes (2 or 3 lanes)
SL = speed limiter (off = -1; on = +1)
CR = compliance rate

Equation 1 provides a good explanation of the variance in safety performance with an R-squared of 0.69. The lack of fit error (181.22) and the pure error of 153.23 were found to lack statistical significance. This expression yields sufficiently accurate results for the variable boundary values used. A residual plot of the fitted model illustrated in Figure 3 indicates that the normality assumption in the residuals (error) is valid.

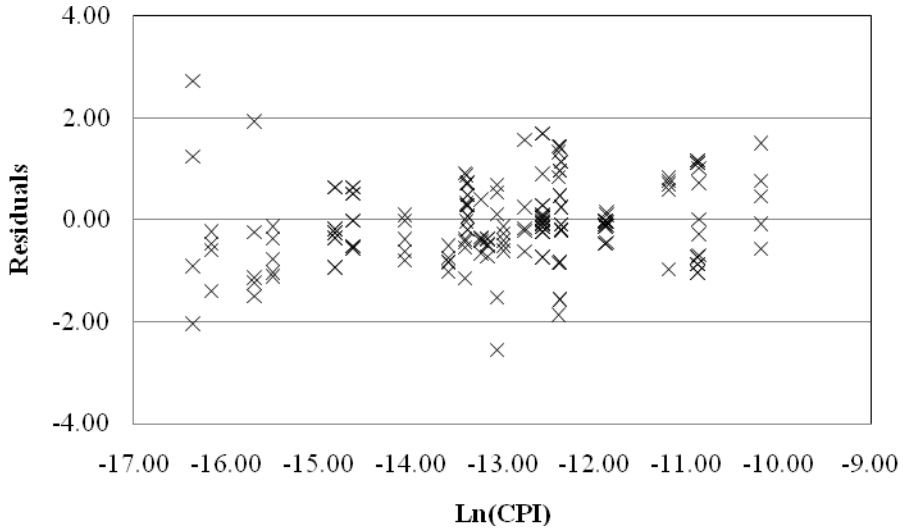


**FIGURE 3 Residual plot for the fitted model (105 km/h strategy).**

The above fitted linear model can be used to investigate changes in the input variables under consideration. Since this analysis is multi-dimensional it can provide a better appreciation of how changes in independent variables affect safety at off-ramp locations.

By evaluating the coefficients from Equation 1 it can be said that as compliance is increased, there is a small corresponding increase in safety for the mandatory speed limiter case. It should also be noted that as volume and percent of trucks increase, the safety gains associated with full compliance are offset by additional traffic turbulence caused by higher volume and percentage trucks.

A graphical analysis of the relationship between CPI/veh, volume and percentage trucks was carried out for 2 and 3 lane freeway segments, with the results illustrated in Figures 4 and 5. The analysis suggests that for the base case (no limiter) the CPI/veh is higher than for the mandatory 105km/h limiter case. This supports the assertion that limiters have positive safety gains. However, this result does not appear to apply to all volumes and percentage trucks. When volume is increased, the difference between the

limiter and non-limiter case becomes less pronounced. In fact for volumes in excess of 1250 vphpl the introduction of mandatory limiters set at 105 km/h can actually have a negative effect on safety (i.e. higher CPI/veh).

It should be noted that this finding holds true for volumes in the uncongested region of traffic flow. Presumably as the volume approaches capacity, the speed of vehicles in the traffic stream will be determined by congestion, and hence the limiter is not expected to have any significant effect on safety. The relationship between increased volume and CPI/veh in the uncongested region appears to be especially pronounced with higher percentage trucks. At different volumes, safety performance is reduced with higher percentage trucks. At certain volumes and high percentage trucks the CPI/veh for the mandatory limiter case is higher than for the base case. Given the volumes and percentage trucks experienced on many freeways in Canada, this result could present some safety challenges for the introduction truck speed limiters.

Figures 6 and 7 illustrates the relationship between CPI/veh and volume for different percentage trucks for 2 and 3 lane configuration at on-ramp and straight segments, respectively.

Similar results were obtained for the on-ramp segment as for the off-ramp. As the volume increases, the CPI/veh also increases, especially for higher percentage trucks. The introduction of limiters set at 105 km/h results in safety gains with respect to the base case (no limiter mandated). We note that as volume increases to levels close to capacity the introduction of limiters can have a negative effect on safety (i.e. higher CPI/veh). This result holds for both 2 lane and 3 lane configurations. Increases in percentage trucks produces pronounced negative safety effects for limiters in comparison to the base case. At very high volumes the CPI/veh versus percentage trucks is lower for the base case strategy. This suggests that for high volumes the introduction of limiters set at 105 km/h could have a negative safety effect for higher percentage trucks in the traffic stream for the on-ramp configuration.

For straight segments the CPI/veh was found to be consistently lower for the mandatory limiter strategy. This suggests that for this configuration where we would expect reduced vehicle interaction, the safety gains of limiters set at 105 km/h can be more pronounced than for segments with on and off-ramps.

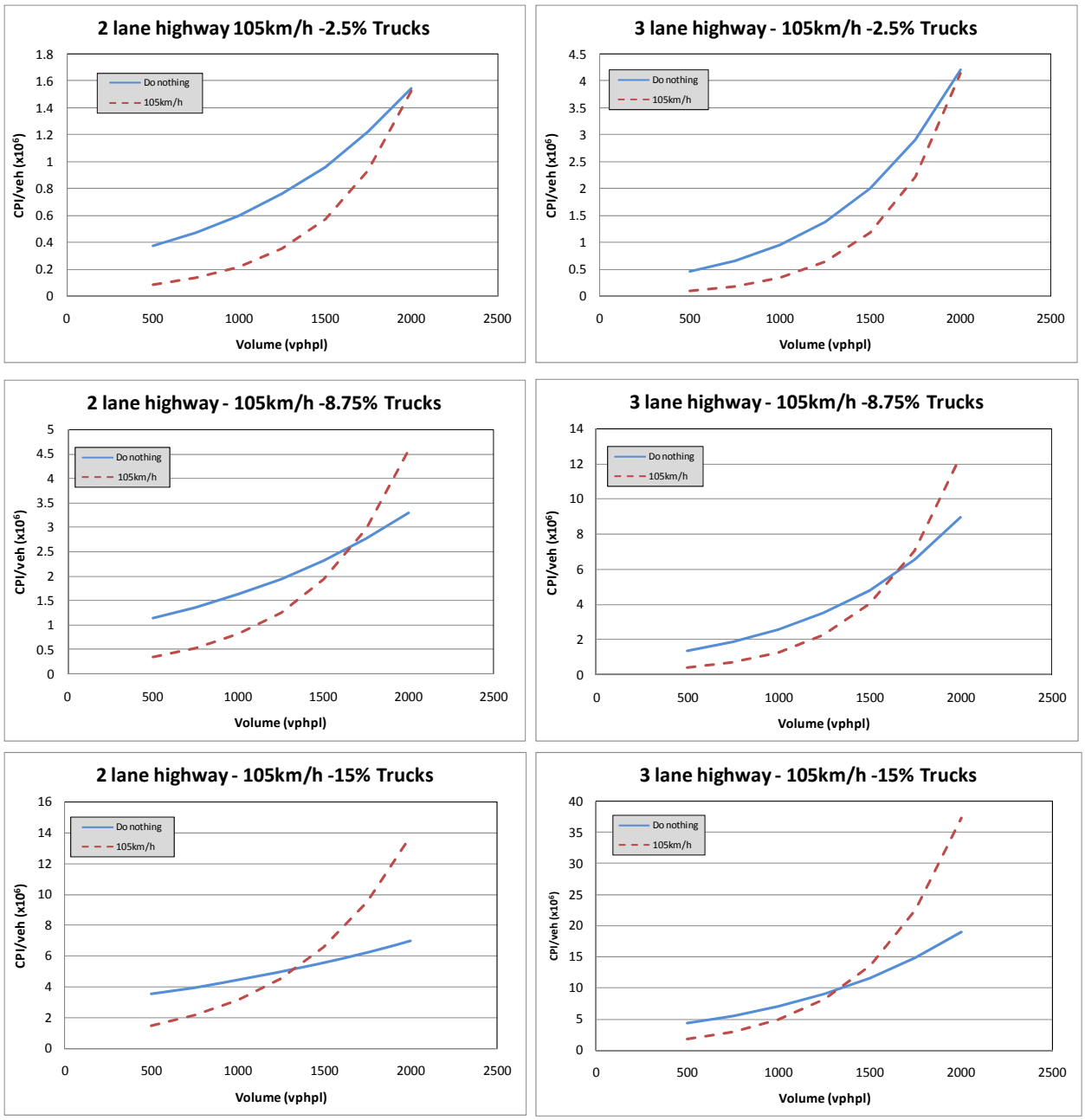


**FIGURE 4 Estimates of CPI/veh as a function of volume for off-ramps.**

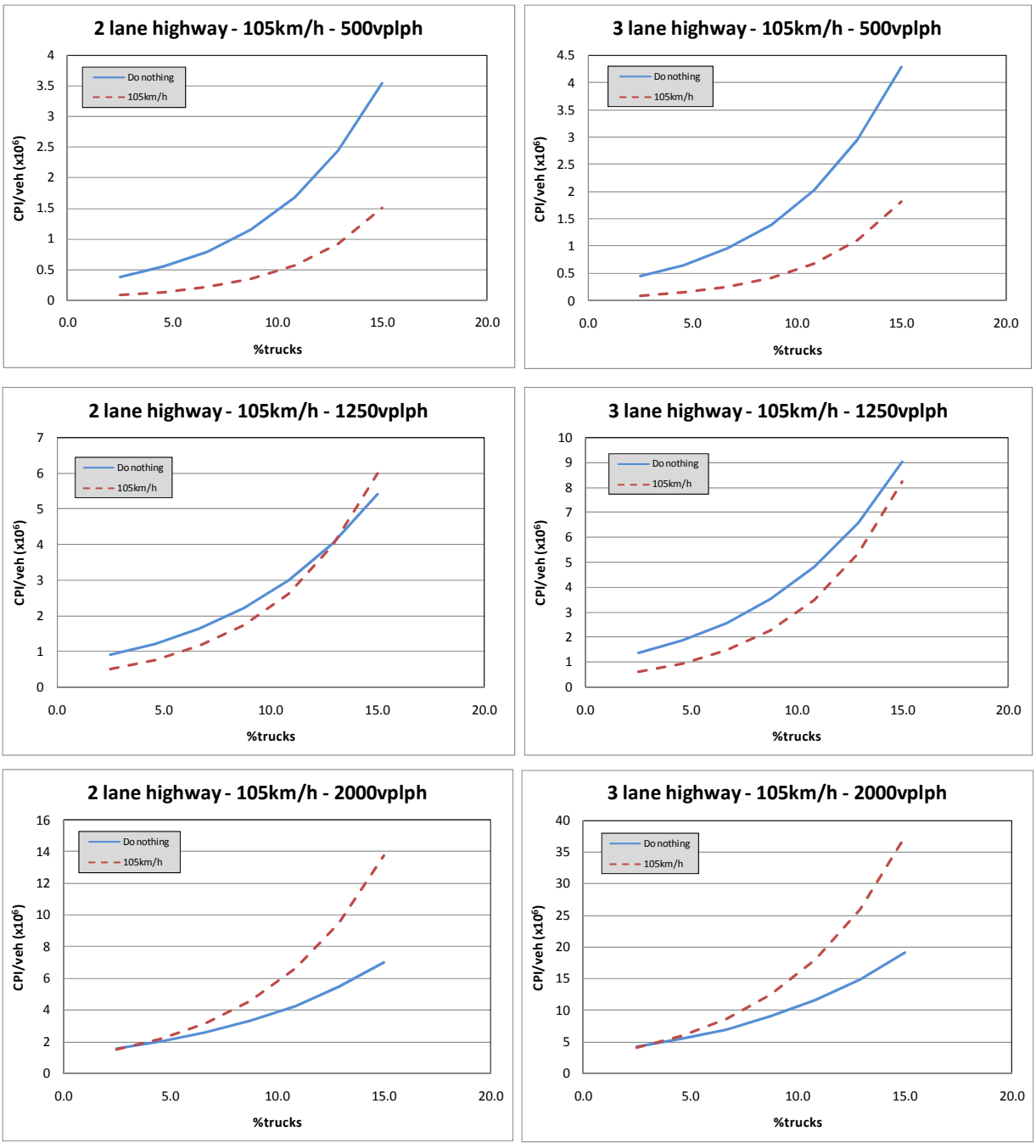


**FIGURE 5 Estimates of CPI/veh as a function of the percentage of trucks for off-ramps.**

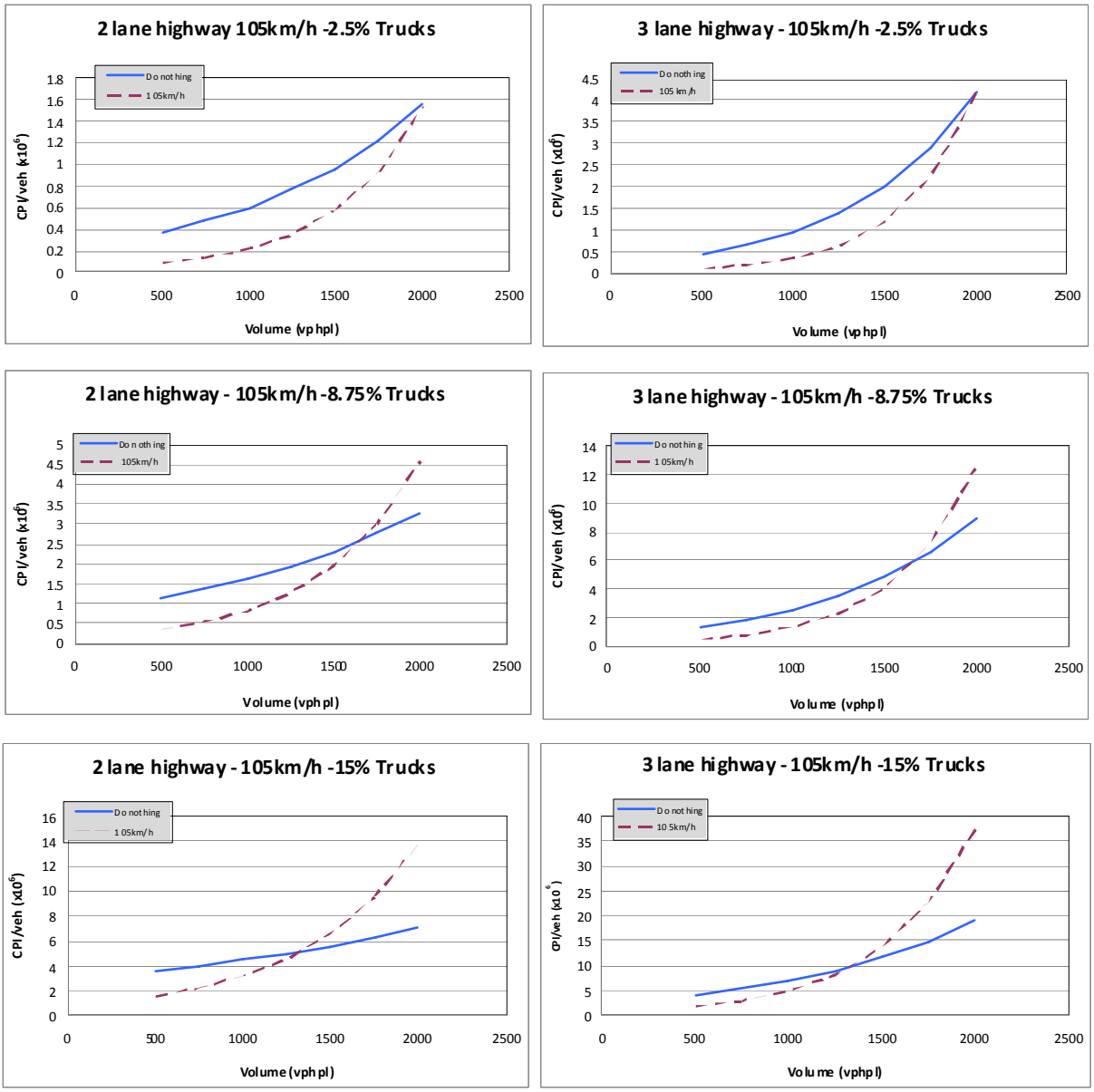


**FIGURE 6 Estimates of CPI/veh as a function of volume for on-ramps.**

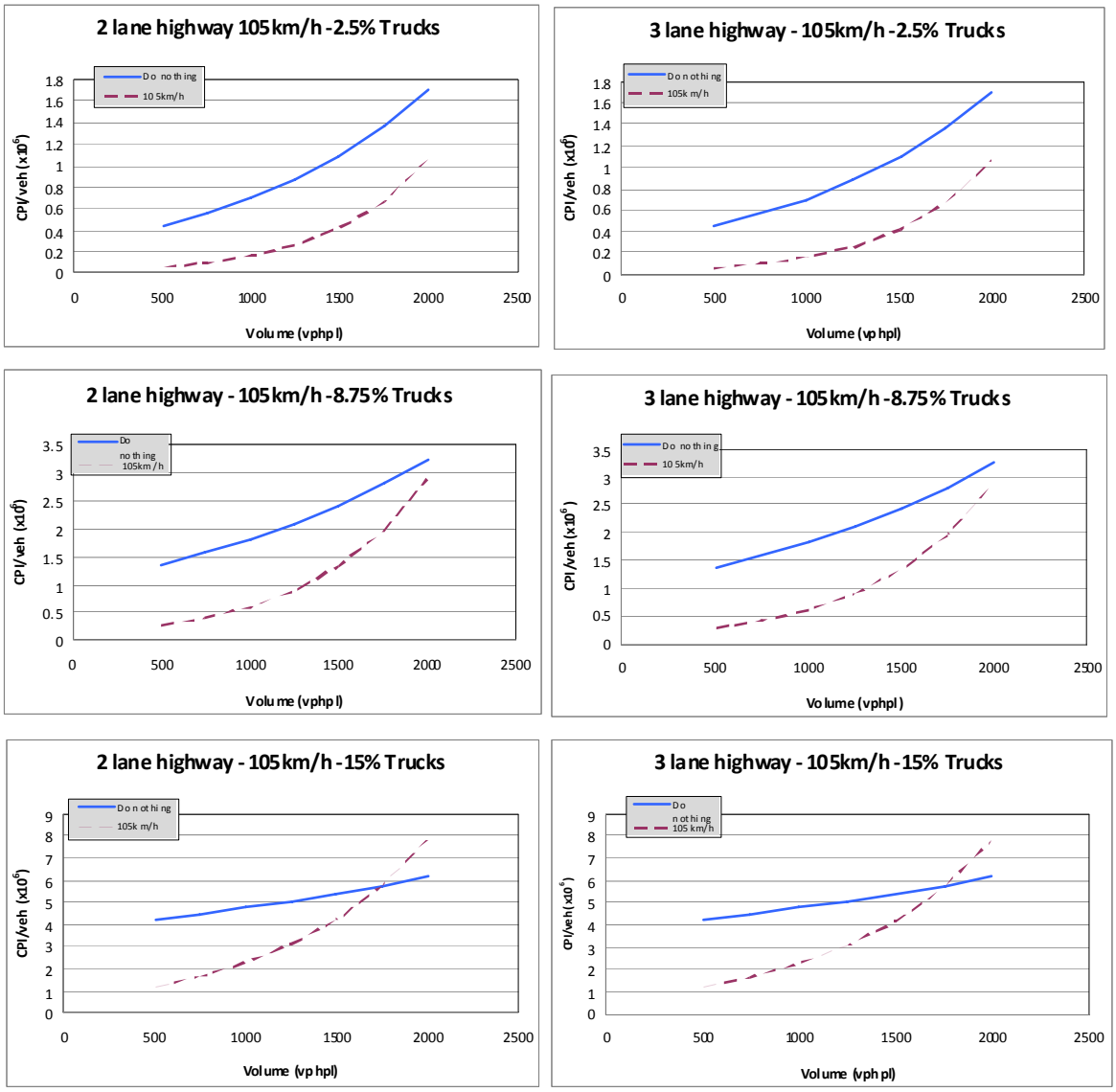


**FIGURE 7 Estimates of CPI/veh as a function of volume for straight segments.**

A sensitivity analysis of safety performance subject to changes in maximum speed limits was undertaken with the results illustrated in Figure 8**.** For this relationship the volume is set well below capacity at 1250vphpl and percentage trucks is set at 8.75%.

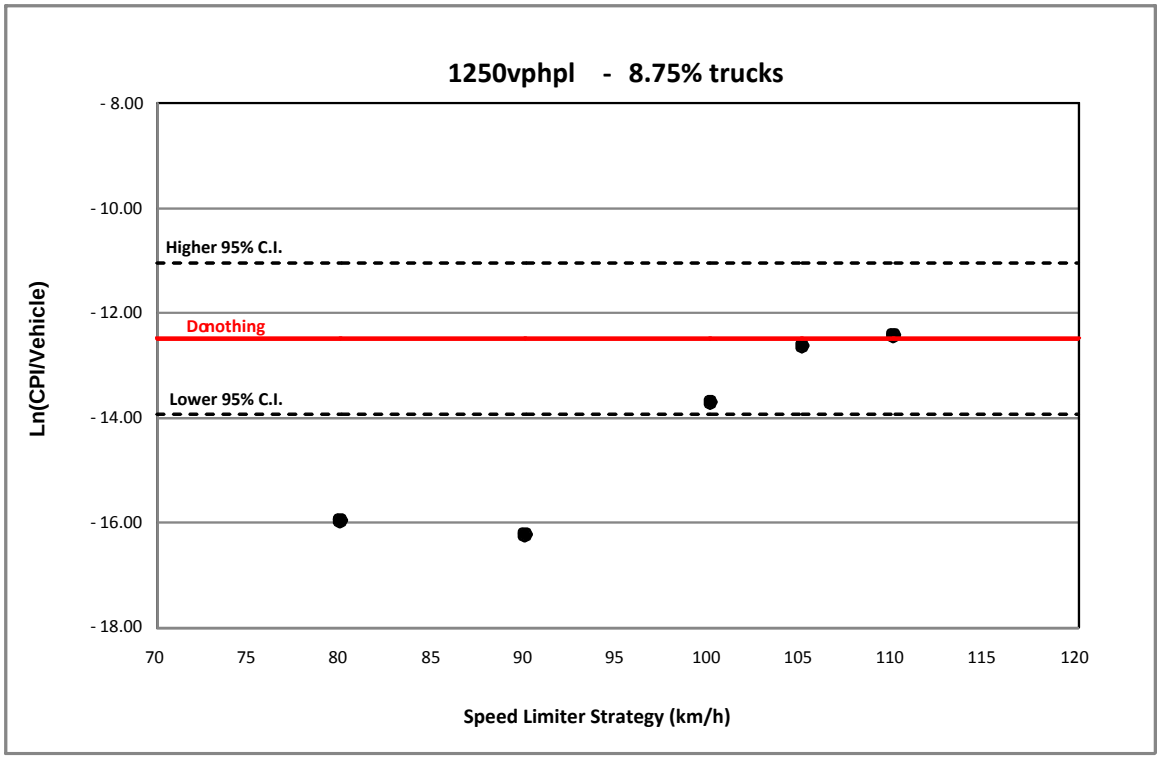


**FIGURE 8 CPI/Veh under different speed limiter strategies.**

The above Figure indicates that the introduction of limiters can enhance safety (lower CPI/veh values) for all maximum speed settings below 105km/h, with the highest safety gains corresponding to a maximum speed set at 90km/h. At a speed of 110km/h or greater the mandatory limiter strategy has no significant effect on safety.

## MAJOR FINDINGS

The simulation of the above scenarios has yielded a number of significant conclusions as to the safety implications of truck speed limiters:

- The introduction of speed limiters set at 105 km/h increases safety in the uncongested region of traffic flow for all geometric configurations studied, especially in the straight segment. As maximum speed is set at 110 km/h the safety gains with the introduction of mandatory limiters become negligible.
- As the volumes and percentage trucks are increased the safety gains associated with mandatory limiters become less pronounced.
- As volume approaches capacity, increased vehicle interactions are expected resulting in reduced safety in areas with more merging and lane-change manoeuvres. This relationship is especially pronounced at on and off-ramp freeway segments.
- As compliance is increased, there is a small corresponding increase in safety for the mandatory speed limiter case. It should also be noted that as volume and percentage of trucks increase, the safety gains associated with full compliance can be offset by the additional traffic turbulence due to higher volume and percentage trucks.
- This results obtained from this study apply specficically to freeways and are not necessarily applicable to two-lane rural highways. Consequently, a more complete

understanding of the safety implications of heavy truck speed limiters must also account for the impacts on all highways types.

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