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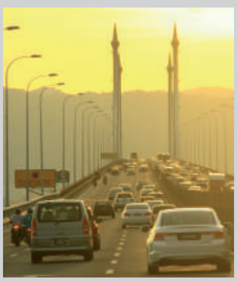
Contribution of Commercial Goods Vehicle Volumes in the iRAP Risk Model



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Abstract

As the demand for heavy vehicles continues to increase in Malaysia, the number of registered commercial vehicles had also seen tremendous growth over the years. Unfortunately, the risk of traffic accidents associated with commercial vehicles was also growing in the parallel upward trend. In-depth crash investigation by MIROS on 550 fatal crashes which involved light vehicles and commercial goods vehicles (where the number of fatalities was three or more and at least one, respectively by vehicle type) pointed out that head-on and rear-end crashes had almost constituted three-quarter of the total investigated crashes.

On the other hand, one (1) of the national efforts to promote road safety is the adoption of iRAP programmes. iRAP is a non-profit organisation aims to save lives through evidence-based approach; utilising road survey methodology in the identification of road condition and environment. Presently, the iRAP model considers four (4) modes of road users: car occupant, motorcyclist, pedestrian and pedal cyclist, whilst the crash type included in the analysis are run-off, head-on, and intersection-type crashes. Within the Malaysian road context, the non-representation of commercial vehicles or heavy vehicles, as well as other crash type calls for further study on the feasibility of the existing model. Thus this study aims to evaluate the substantiality of run-off and rear-end crash for commercial vehicles to be included in the current road assessment programme.

The bulk of data used in this study is secondary data obtained from the Malaysian Highway Authority (LLM) from the year 2013 to the year 2014. A total of 9152 and 10032 accidents year 2013 and 2014, respectively have been utilised in this study. Though the number of commercial vehicles involved in the crashes had increased, the proportion of involvement had decreased. Run-off accidents had the highest scores which constituted half of the total accidents (51.3% – 52.7%) while the second highest type of accident was

rear-ended collision which reported about 28.8% to nearly 30% of the total collisions. Chi-square analysis revealed that rear-ended collision is 1.3 – 1.7 times more likely to involved in KSI as compared other collision. Commercial vehicles are 1.9 – 2.2 times more likely involved in rear-end collision as compared to other collision. In both cases, the reverse is true for run-off collision.

1. Introduction

As the demand for heavy vehicles continues to increase in Malaysia, the number of registered commercial vehicles had also seen tremendous growth over the years (see Figure 1). Unfortunately, the risk of traffic accidents associated with commercial vehicles was also growing in the parallel upward trend. Crashes involving commercial vehicles (bus and lorries) were observed to have increased more than 25% for five-years from the year 2000 till 2005 (MIROS, 2009). In terms of crash rates per 10,000 vehicles, it was found that the crash rates for lorries were about 2 times of the private vehicle crash rates. In brief, an average of 1280 lorries was involved in fatal road crashes annually between the year 2006 to 2011 (Syukri et al., 2012). Of these crashes, rear-end, head-on and run-off fatalities comprised of about three-quarter of the total fatalities. This is indeed alarming as the smaller car drivers/passengers were usually the victims. Figure 2 illustrates the accidents by type of vehicles.

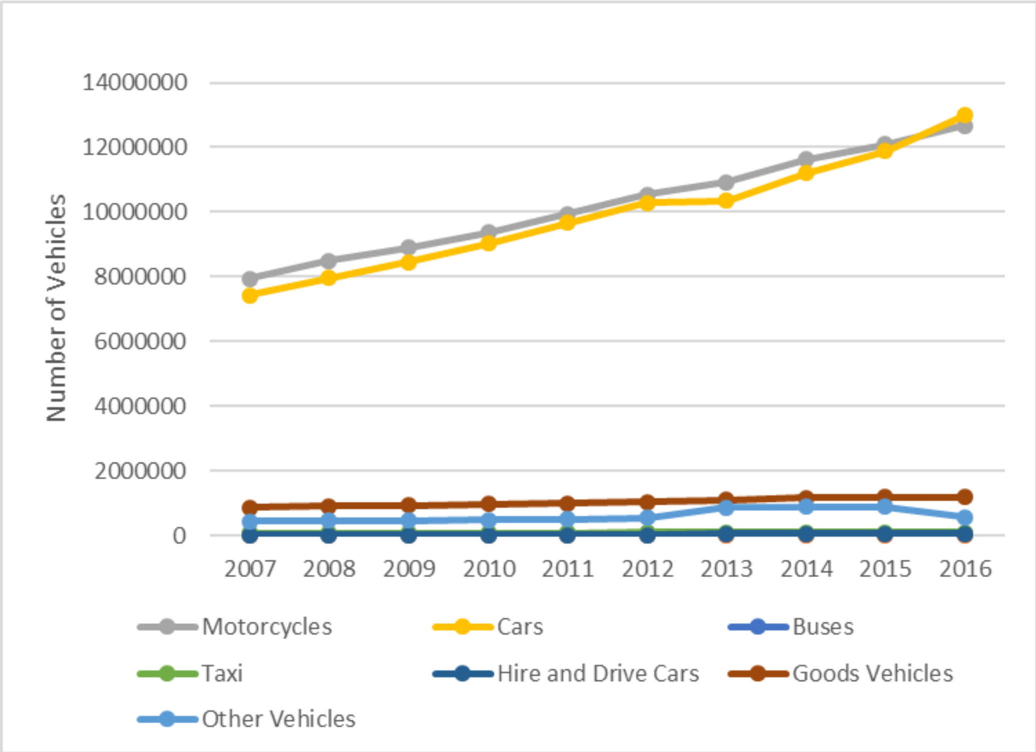


Figure 1 Registered vehicles over the years from 2007 – 2016 (*Source:* PDRM, 2016)

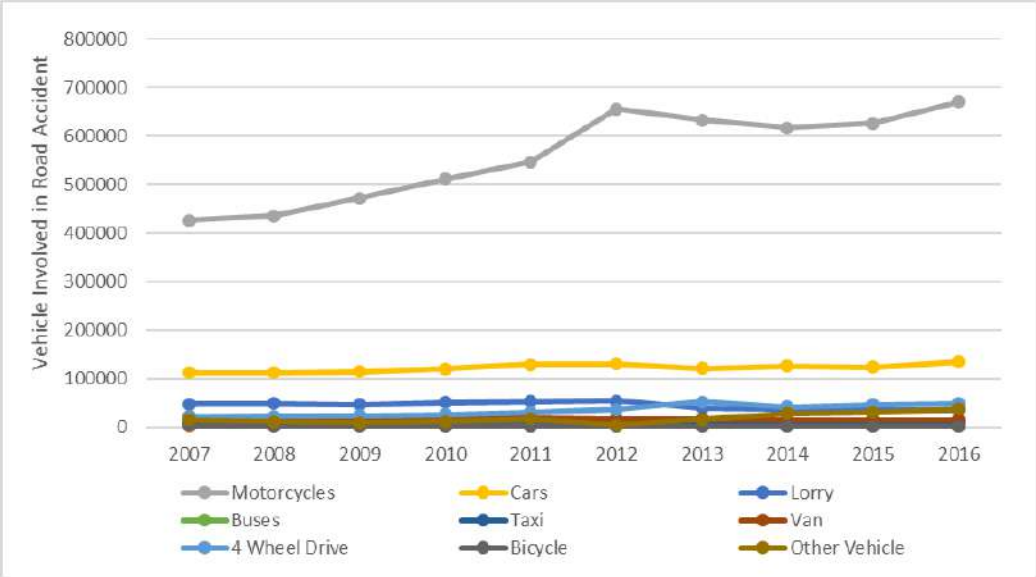


Figure 2 Number of vehicle involved in accidents (*Source:* PDRM, 2016)

Between year the 2007 to 2012, MIROS had carried out in-depth crash investigation on 550 fatal crashes which involved light vehicles and commercial goods vehicles (where the number of fatalities were three or more and at least one, respectively by vehicle type). Of these investigation cases, head on crashes were over-represented with about 33% (Syukri et al., 2012). When segregated the head-on crashes by type of heavy vehicles, it was found that most of the cases involved rigid lorries. Post mortem of the crashes revealed that risky driving was the main contributor to the head-on crashes. Risky driving in this context refers to overtaking at curves, overtaking at non-passing zones, not providing signal indicator while turning, etc. In the event of an accident, all the motorcyclists died and three-quarter of the drivers in the passenger cars were dead. Of the accidents, it was also noted 62% of the passenger cars were at fault in causing the accidents.

On the other hand, rear-end crashes were over-represented were about 37% of the fatalities were due to rear-end crashes (Syukri et al., 2012). The analysis illustrated that for rear-end crashes, there was no distinction of the occurrence between the two periods of the day (day or night time). It is surprising to note that 94% of the crashes were with non-stationary heavy vehicles and in the event of an accident, more than 85% of motorcycle occupants died. It was also noted that crashes with stationed lorries on federal and expressway occurred on flat stretches while the reverse is true for the similar accident on the state roads.

A lot of studies have been conducted to understand the underlying factors contributed to the traffic accidents in Malaysia of which MIROS being the pillar of national road safety research institute. Though few studies have been conducted on commercial good vehicles in Malaysia (Amir et al., 2015; Syukri et al., 2012), there is very little knowledge on traffic risk prediction related to commercial goods vehicles crashes especially head-on crashes. Traffic risk prediction model is of use in providing the likelihood of an accident to occur that the decision-makers can use to strategize specific target or intervention countermeasures to the maximum benefits of lives saving.

iRAP (International Road Assessment Program) is one of the proactive programs to enable the risk of fatal and serious injury to be predicted and rank the cost-benefit ratio should a potential countermeasures program was applied. The iRAP has been adopted in Malaysia since 2007 however, no attribute on commercial good vehicles was considered in the iRAP model. There is an urge to include the traffic risk of commercial goods vehicles looking at the alarming state on the crashes involving these particular vehicles. All in all, there is a need to establish additional evidence on whether this attribute to be included in the iRAP model in terms of the Malaysian context. The ultimate aim of this study is to assess the suitability of the rear-end, run-off & head-on accidents involving commercial vehicles in the iRAP model in the Malaysian context.

1.1 Aims and Objectives

The objectives of this study are:

i. To develop the inventory of rear-end, run-off & head-on accidents on expressway
ii. To evaluate the speed profile of express buses plying the Southern Region routes.

1.2 Scope and Limitation

The scope of this project covers the accidents reported on the expressways. For this project, only data for PLUS North-South Expressway is available and the road survey data based on the International Road Assessment Programme (iRAP) methodology. The accident data used in this study was between the year 2013 and 2014.

2. Methodology

The bulk of data used in this study is secondary data obtained from the Malaysian Highway Authority (LLM). Detailed crash data provided by LLM, from the year 2013 to the year 2014, were processed and incorporated into an existing data set of the road environment and traffic condition. This second set of data is obtained from a MIROS road survey based on the International Road Assessment Programme (iRAP) methodology.

iRAP as a non-profit organisation aims to save lives through evidence-based approach; utilising road survey methodology in the identification of road condition and environment. The iRAP road survey methodology is based on the culmination of experience and knowledge road assessment by developed countries such as Australia (AusRAP), Europe (EuroRAP) and the United States (USRAP).

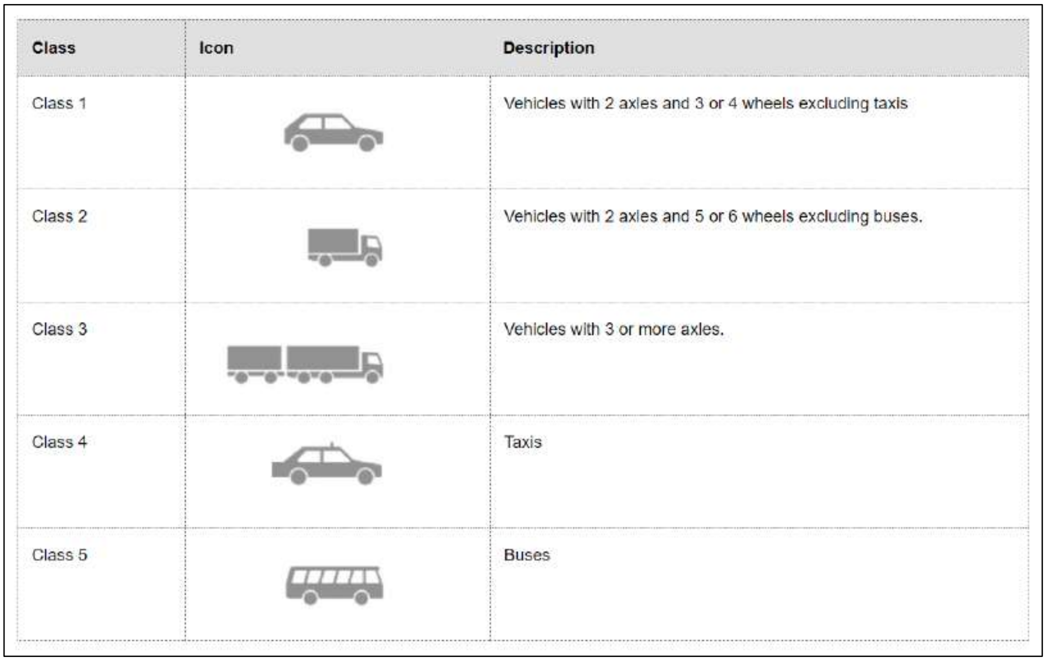
Presently, the iRAP model considers four (4) modes of road users: car occupant, motorcyclist, pedestrian and pedal cyclist, whilst the crash type included in the analysis are run-off, head-on, and intersection-type crashes. Within the Malaysian road context, the non-representation of commercial vehicles or heavy vehicles, as well as other crash types, calls for further study on the feasibility of the existing model. Thus this study aims to evaluate the substantiality of run-off and rear-end crash for commercial vehicles to be included in the current road assessment programme. The attributes of iRAP are described in Table below.

Table 1 Example of factors included in iRAP model

Mode	Accident type	Likelihood factors	Protection factors
Car occupant	Run-off	Speed – likelihood Lane width Paved shoulder width Curvature Quality of curve Delineation Road condition Raised edge marking	Speed – protection Roadside severity
	Head-on	Speed – likelihood Number of lanes Lane width Curvature Quality of curve Road condition	Speed – protection Median type – protection
	Junction	Speed – likelihood Major junction type - likelihood Junction quality Intersection road flow Minor access point density	Speed – protection Major junction type protection
Motorcyclist	Run-off	As car model, except number of lanes and lane width excluded, but a factor for segregated lane or facility added	As car model
	Head-on	As car model	As car model
	Junction	As car model	As car model
Pedestrian	Along road	Speed – likelihood Sidewalk provision – likelihood Side friction	Speed – protection Sidewalk provision – protection
	Crossing	Speed – likelihood Number of lanes Median type – likelihood	Speed – protection Pedestrian crossing facilities – protection

	Pedestrian crossing facilities – likelihood Quality of crossing

Due to unavailability of IRAP data for other federal road and highways, only PLUS North-South Expressway and ELITE highway were included in this study. On the other hand, the traffic volume on the expressway is classified into 5 classes as shown in Figure 3. In this study, commercial vehicles (CV) is the target group which comprised of Class 2 (vehicles with 2 axles and 5 or 6 wheels excluding buses), Class 3 (vehicles with 3 or more axles) and Class 5 (buses).



Class	Icon	Description
Class 1		Vehicles with 2 axles and 3 or 4 wheels excluding taxis
Class 2		Vehicles with 2 axles and 5 or 6 wheels excluding buses.
Class 3		Vehicles with 3 or more axles.
Class 4		Taxis
Class 5		Buses

Figure 3 Vehicle classes according to PLUS highway (*Source:* PLUS website)

2.1 Statistical Analysis

Several statistical analyses were conducted to understand the contributory attributes or the relationship between the type of collision with traffic volume, type of injury and involvement of commercial vehicle (CV) in the accident. The analysis involved t-test, chi-square, Relative Risk and odd ratio.

3. Results and Discussions

3.1 Characteristics of Highway Samples

In this study, only North-South Expressway which spans from Bukit Kayu Hitam to Skudai was considered. The whole expressway was divided into 14 sections as shown in Table 2 and crashes occurred in the year 2013 and 2014 along the study sections were analysed.

A total of 9152 and 10032 accidents have been recorded in the year 2013 and 2014, respectively. Of these sections, the highest number of accidents took place between Sungai Besi – Seremban with 22 cases per km (1033 accidents) and 27 cases per km (1259 accidents) in the year 2013 and year 2014, respectively. Increased of accidents was observed in 2014 (total accidents as well as accidents involving commercial vehicles) as compared to 2013 but the proportion of CV involvement in accidents had reduced. Paired t-test was conducted and it had shown that the changes in accidents between 2013 and 2014 were significant difference.

Involvement of commercial vehicles in the collisions ranged from 19% to 47.42% along the study section whereby section between Ipoh – Bidor had the highest commercial vehicles involvement in 2013. In the year 2014, it had seen some reduction in the proportion of commercial vehicles involved in the total accident which ranged from 15.25% to 31%. The highest decrement of commercial vehicles proportion in the collisions was reported on the section between Sungai Petani – Jawi with a decrease of 44%.

Table 2 Distribution of accident data in year 2013 and 2014 on different sections of the North-South Expressway

No.	Highway section	Section length studied (km)	Accident cases		Change of accident occurrences (%) *	% of CV involved in the collision**		Change of CV involved accident occurrences (%)
			2013	2014		2013	2014	
1	Bukit Kayu Hitam – Alor Setar (S)	52.4	275	276	0.36	25.57	20.65	-19.24
2	Alor Setar (S) – Sungai Petani (S)	60.7	583	572	-1.89	26.19	18.53	-29.25
3	Sg Petani (S) – Jawi	61.2	666	634	-4.80	39.92	22.24	-44.29
4	Jawi – Changkat Jering	59.0	449	501	11.58	42.54	30.54	-28.21
5	Changkat Jering – Ipoh (S)	59.9	657	677	3.04	43.45	26.14	-39.84
6	Ipoh (S) – Bidor	60.7	572	662	15.73	47.42	30.82	-35.01
7	Bidor – Tanjong Malim	64.3	506	622	22.92	38.63	23.47	-39.24
8	Tanjong Malim – Bukit Lanjan	64.5	1097	1095	-0.18	34.93	22.65	-35.16
9	Sungai Besi – Seremban	46.9	1033	1259	21.88	19.01	15.25	-19.78
10	Bandar Baru Nilai – Shah Alam (ELITE)	49.1	771	898	16.47	42.25	28.29	-33.04
11	Seremban – Simpang Ampat	46.6	668	755	13.02	31.24	26.62	-14.79
12	Simpang Ampat – Pagoh	76.2	694	687	-1.01	46.41	31.00	-33.20

13	Pagoh – Machap	70.9	594	674	13.47	36.55	27.82	-23.89
14	Machap – Skudai	66.2	588	711	20.92	43.07	30.38	-29.46

* Statistically significant difference according to t test ($p < 0.05$) in comparing each section of highway between year 2013 and 2014

** Statistically significant difference according to t test ($p < 0.05$) in comparing the change of CV involved accident between year 2013 and 2014

3.2 Analysis of Accident by Type of Collision

Table 3 presents the distribution of accident cases by type of collision for both year 2013 and 2014. Of all the collisions, run-off accidents had the highest scores which constituted half of the total accidents (52.7% and 51.3% for 2013 and 2014, respectively). The second highest type of accident was rear-ended collision which reported about 28.8% to nearly 30% of the total collisions. The two collisions which constituted about 80% of the total collisions indeed required serious attention from the relevant authorities.

Table 3 Number of accidents by type of collision

Type of collision	2013		2014	
	N	%	N	%
Angular collision	95	1.04	107	1.07
Broken windscreen	2	0.02	6	0.06
Cross direction (north/south)	17	0.19	16	0.16
Forced collision	18	0.20	35	0.35
Head-on collision	24	0.26	26	0.26
Hitting animal	80	0.87	113	1.13
Hitting object on road	346	3.78	616	6.15
Hitting pedestrian	13	0.14	21	0.21
Others	363	3.97	410	4.09
Run-off	4821	52.68	5147	51.35
Overturned	294	3.21	265	2.64
Rear-end collision	2690	29.39	2882	28.75
Right angle side collision	109	1.19	97	0.97

Side swipe	280	3.06	291	2.90
Total	9153	100.00	10032	100.00

* Statistically significant difference according to t-test ($p < 0.05$) in comparing each type of collision between the year 2013 and 2014

Additional effort was taken to understand if the commercial vehicles had over-represented in each type of collisions. Table 4 presents the involvement of commercial vehicles in each of the collision. Of this collision, cross direction and other collision had the highest proportion of commercial vehicles in 2013 and 2014. For run-off and rear-end collisions, the proportion of commercial vehicles involved were 16% and 37%, respectively. Nearly one-third of the rear-end collision involving commercial vehicles is an alarming indicator as the impact of this collision is very serious due to the involvement of multiple vehicles in one case.

Table 4 Proportion of CV involved in each type of accidents

Type of collision	2013				2014			
	Total	Single CV involved	Multiple CV involved	No CV involved	Total	Single CV involved	Multiple CV involved	No CV involved
	N	%			N	%		
Angular collision	95	21.05	5.26	73.68	107	29.91	7.48	62.62
Broken windscreen	2	100.00	0.00	0.00	6	0.00	16.67	83.33
Cross direction (north/ south)	17	41.18	11.76	47.06	16	75.00	12.50	12.50
Forced collision	18	22.22	0.00	77.78	35	31.43	0.00	68.57
Head-on collision	24	20.83	4.17	75.00	26	11.54	3.85	84.62
Hitting animal	80	5.00	0.00	95.00	113	2.65	0.00	97.35

Hitting object on road	346	24.86	1.16	73.99	616	17.37	0.81	81.82
Hitting pedestrian	13	0.00	0.00	100.00	21	23.81	4.76	71.43
Others	363	53.17	3.03	43.80	410	48.54	2.44	49.02
Run-off	4821	14.91	0.95	84.13	5147	14.77	0.70	84.53
Overturned	294	45.24	1.02	53.74	265	46.42	1.51	52.08
Rear collision	2690	25.06	11.82	63.12	2882	24.98	10.62	64.40
Right angle side collision	109	27.52	8.26	64.22	97	29.90	11.34	58.76
Side swipe	280	17.14	2.86	80.00	291	23.37	6.19	70.45
Total (N)	9152	1925	407	6820	10032	2072	403	7557

* Statistically significant difference according to ANOVA test ($p < 0.05$) in comparing number of commercial vehicles involved in each type of collision

Additional information was obtained by performing cross-tabulation of the severity accident with the type of collision. Based on Table 5, it was found that of the total run-off accidents, only 11% of the Kill and Serious Injury (KSI) involving commercial vehicles while in the rear-end collision KSI, the proportion for commercial vehicle involved cases was nearly similar to cases not involving a commercial vehicle.

Table 5 Proportion of CV involvement in each of the collision for KSI and non KSI in 2013

2013	KSI-CV	KSI-No CV	Total	Non KSI-CV	Non KSI-No CV	Total
Angular collision	33.3	66.7	100	35.2	64.8	100
Broken windscreen	0.0	0.0	0	100.0	0.0	100
Cross direction (north/south)	44.4	55.6	100	62.5	37.5	100
Forced collision	50.0	50.0	100	31.3	68.8	100
Head-on collision	20.0	80.0	100	42.9	57.1	100

Hitting animal	0.0	100.0	100	5.3	94.7	100
Hitting object on road	13.2	86.8	100	27.6	72.4	100
Hitting pedestrian	14.3	85.7	100	0.0	100.0	100
Others	30.0	70.0	100	57.6	42.4	100
Run-off	11.1	88.9	100	16.8	83.2	100
Overturned	34.0	66.0	100	48.5	51.5	100
Rear collision	47.8	52.2	100	33.6	66.4	100
Right angle side collision	40.9	59.1	100	40.2	59.8	100
Side swipe	14.0	86.0	100	27.4	72.6	100

Almost similar trends for run-off and rear-end collision in the year 2014 with the respective collisions in the year 2013 was observed. 12% of the run-off KSI had commercial vehicles involved while in rear-end KSI collision, 47% involved commercial vehicles.

Table 6 Proportion of CV involvement in each of the collision for KSI and non KSI in 2014

2014	KSI-CV	KSI-No CV	Total	Non KSI-CV	Non KSI-No CV	Total
Angular collision	29.4	70.6	100	42.2	57.8	100
Broken windscreen	0.0	0.0	0	66.7	33.3	100
Cross direction (north/south)	62.5	37.5	100	100.0	0.0	100
Forced collision	16.7	83.3	100	43.5	56.5	100
Head-on collision	10.0	90.0	100	16.7	83.3	100
Hitting animal	0.0	100.0	100	1.9	98.1	100
Hitting object on road	18.6	81.4	100	19.7	80.3	100

Hitting pedestrian	35.3	64.7	100	1.5	98.5	100
Others	20.0	80.0	100	55.4	44.6	100
Run-off	12.1	87.9	100	16.1	83.9	100
Overturned	34.4	65.6	100	47.6	52.4	100
Rear collision	47.2	52.8	100	32.1	67.9	100
Right angle side collision	23.5	76.5	100	40.7	59.3	100
Side swipe	4.3	95.7	100	34.8	65.2	100

Using overturned collision as a reference, relative risk (RR) analysis was conducted to examine the risk of commercial vehicles involved in killed or serious injury (KSI). It was found that rear-end collision involving a commercial vehicle is 1.4 times more likely to result in KSI as compared to overturned collision for an accident in 2013. However, the reverse is true for run-off collision. On the other hand, run-off and rear-end collision involving commercial vehicle were less likely resulted in non KSI as compared to an overturned collision. The similar trend was observed for the rear-end and run-off collision in the year 2014.

Table 7 Relative risk (RR) for the involvement of CV and no CV in each type of collision

Type of collision	**2013**			**2014**		
	KSI-CV	**KSI-No CV**	**RR**	**KSI-CV**	**KSI-No CV**	**RR**
Angular collision	8	16	0.98	5	12	0.86
Broken windscreen	0	0	0.00	0	0	0.00
Cross direction (north/south)	4	5	1.31	5	3	1.82
Forced collision	1	1	1.47	2	10	0.48
Head-on collision	2	8	0.59	1	9	0.29
Hitting animal	0	5	0.00	0	9	0.00
Hitting object on road	5	33	0.39	8	35	0.54

Hitting pedestrian	1	6	0.42	6	11	1.03
Others	12	28	0.88	10	40	0.58
Run-off	85	680	0.33	97	702	0.35
Overturned	18	35	1.00	11	21	1.00
Rear collision	322	351	1.41	311	348	1.37
Right angle side collision	9	13	1.20	4	13	0.68
Side swipe	8	49	0.41	2	44	0.13

3.3 Analysis of Accidents with Traffic Volumes

It is always said that the higher traffic volume the higher accident risk. A correlation test was then taken to understand the relationship between the run-off and rear-end accident with traffic volumes. As described in Chapter 2, Class 1 volume refers to passenger cars, Class 2 is vehicle with 2 axles and 5 or 6 wheels excluding bus, Class 3 defines vehicle with 3 or more axles, Class 4 is taxi and Class 5 refers to bus. Nevertheless, it should be noted that the volumes of the highways were relatively high as compared to the commercial vehicle volumes involved in the run-off and rear-end accidents.

Table 8 shows the correlation results for accidents in the year 2013. It was found that the run-off accidents did not correlate significantly with Class 1 volumes, Class 2 volumes, Class 3 volumes and Class 5 volumes. A significant positive relationship was observed for the commercial vehicles involved in run-off collision with Class 1 volumes, Class 2 volumes and Class 3 volumes. But no significant relationship was observed for all class of volumes with number of commercial vehicles involved in rear-end collisions.

Table 8 Correlation test for run-off and rear-end accidents in the year 2013

	All accident on the highway section	Run-off accident on the section	HV involved in the run-off	Rear-end accident on the section	HV involved in rear-end accident	Class 1 yearly volume	Class 2 yearly volume	Class 3 yearly volume	Class 4 yearly volume	Class 5 yearly volume
All accident on the highway section		**0.652** **0.000**	**0.478** **0.000**	**0.604** **0.000**	**0.461** **0.050**	**0.588** **0.000**	**0.610** **0.000**	**0.611** **0.000**	**0.440** **0.007**	0.315 0.061
Run-off accident on the section			**-0.275** **0.000**	**0.727** **0.000**	**0.584** **0.000**	0.142 0.409	0.271 0.109	0.191 0.266	**0.369** **0.027**	0.073 0.670
CV involved in the run-off				-0.281 0.097	-0.229 0.180	**0.476** **0.003**	**0.356** **0.033**	**0.461** **0.005**	0.009 0.960	0.286 0.091
Rear-end accident on the section					**0.747** **0.000**	0.259 0.128	**0.338** **0.044**	0.244 0.151	**0.444** **0.007**	0.058 0.737
CV involved in rear-end accident						-0.047 0.787	0.081 0.639	0.016 0.924	0.078 0.652	-0.069 0.688
Class 1 yearly volume							**0.961** **0.000**	**0.953** **0.000**	**0.571** **0.000**	**0.622** **0.000**
Class 2 yearly volume								**0.981** **0.000**	**0.637** **0.000**	**0.689** **0.000**
Class 3 yearly volume									**-0.616** **0.000**	**0.760** **0.000**
Class 4 yearly volume										**0.598** **0.000**

Class 5 yearly volume	

0.880 – correlation r value
0.000 – p value
Bold: significant at $p < 0.05$

For all the accidents in the year 2014 (as shown in Table 9), there was no significant association with all classes of volumes except rear-end accidents positively related to Class 5 volumes. It was also found that the CV involved in run-off and rear-end accidents negatively correlated with Class 1, Class 2, Class 3 and Class 4 traffic volumes. The results are contrary to their counterparts in the year 2013 (positive relationship).

Table 9 Correlation test for run-off and rear-end accidents in the year 2014

	All accident on the highway section	**Run-off accident on the section**	**HV involved in the run-off**	**Rear-end accident on the section**	**HV involved in rear-end accident**	**Class 1 yearly volume**	**Class 2 yearly volume**	**Class 3 yearly volume**	**Class 4 yearly volume**	**Class 5 yearly volume**
All accident on the highway section		**0.915** **0.000**	**0.662** **0.000**	**0.911** **0.000**	**0.745** **0.000**	0.039 0.647	0.098 0.254	0.107 0.213	0.058 0.497	0.143 0.095
Run-off accident on the section			**0.701** **0.000**	**0.733** **0.000**	**0.685** **0.000**	-0.049 0.566	0.010 0.907	-0.003 0.969	-0.027 0.749	0.050 0.563
HV involved in the run-off				**0.472** **0.000**	**0.472** **0.000**	-0.113 0.189	-0.022 0.796	-0.017 0.844	-0.068 0.425	0.034 0.696
Rear-end accident on the section					**0.717** **0.000**	0.119 0.163	0.157 0.066	0.156 0.068	0.120 0.162	**0.185** **0.030**

HV involved in rear-end accident		-0.136 0.112	-0.070 0.417	-0.017 0.848	-0.094 0.273	0.064 0.454
Class 1 yearly volume			**0.880** **0.000**	**0.859** **0.000**	**0.963** **0.000**	**0.747** **0.000**
Class 2 yearly volume				**0.884** **0.000**	**0.842** **0.000**	**0.788** **0.000**
Class 3 yearly volume					**0.840** **0.000**	**0.916** **0.000**
Class 4 yearly volume						**0.734** **0.000**
Class 5 yearly volume						

0.880 – correlation r value
0.000 – p value
Bold: significant at $p < 0.05$

Chi-square analysis was further performed to understand whether the type of collisions (run-off and rear-end) were associated with type of injury or commercial vehicles. It should be noted that damaged only accident was not included due to high frequency that leads to an imbalance of data.

From Table 10, it was observed that rear-end collision is 1.3 – 1.7 times more likely to result in KSI as compared other collision. A commercial vehicle is 1.9 – 2.2 times more likely involved in rear-end collision as compared to other collision. In both cases, the reverse is true for run-off collision.

Table 10 Chi-square analysis

Year	2013			2014		
Type of injury	KSI	Minor	Odd ratio	KSI	Minor	
Run-off collision	766	852	0.63*	799	4348	0.62*
Rear-end collision	678	473		659	2223	
Total	1444	1325		1458	6571	
	KSI	Minor		KSI	Minor	
Run-off collision	766	852	0.83*	799	4348	0.79*
Other collision	1715	1592		919	3966	
Total	2481	2444		1718	8314	
	KSI	Minor		KSI	Minor	
Rear-end collision	678	473	1.33*	659	2223	1.71*
Other collision	1715	1592		1059	6091	
Total	2393	2065		1718	8314	
	CV	Non-CV		CV	Non-CV	
Rear-end collision	952	1738	1.87*	1035	1847	2.18*
Other collision	1466	4997		1463	5687	
Total	2418	6735		2498	7534	
	CV	Non-CV		CV	Non-CV	
Run-off collision	745	4076	0.29*	800	4347	0.35*
Other collision	1673	2659		1698	3187	
Total	2418	6735		2498	7534	

* $p < 0.05$, significant at $p<0.05$ level based on the chi-square analysis

4. Conclusions and Recommendation

The main thrust of this study is to examine the feasibility of run-off and rear-end collision involving CV to be included in the iRAP model as it is claimed these two (2) accidents were over-represented. The data used in this study was from LLM and only covers North-South Expressway which spans from Bukit Kayu Hitam to Skudai. A total of 9152 and 10032 accidents in the year 2013 and 2014, respectively was used in this study. Analysis of the data shows the fact that both the collisions comprised of about 80% of the total collisions on the expressway (50% and 30% for run-off and rear-end collisions, respectively) in the year 2013 and 2014. Slight increment of total accidents and commercial vehicles involved accidents were observed from the year 2013 to the year 2014 but the proportion of CV involved in the collision had significantly reduced.

Further distribution of accident data revealed that 16% and 37% of run-off and rear-end collisions involved commercial vehicles, respectively. Nearly one-third of the rear-end collision involving commercial vehicles is an alarming indicator as the impact of this collision is very serious due to the involvement of multiple vehicles in one case. In terms of severity, it was found that of the run-off accidents, only 11 – 12% of the kill and serious injury (KSI) involving commercial vehicles while in the KSI rear-end collision, cases involved a commercial vehicle had nearly similar proportion with the cases not involving commercial vehicles.

Commercial vehicle is 1.9 – 2.2 times more likely involved in rear-end collision as compared to other collision. In terms of severity, rear-end collision is 1.3 – 1.7 times more likely to involved in KSI as compared other collision. In both cases, the reverse is true for run-off collision.

When looking into the relationship of run-off and rear-end collision with traffic volumes, no conclusive findings can be drawn from the two (2) years' accident data as mixed results were obtained. In general, this may be due to imbalance data between accident occurrence and traffic volume.

All in all, the annual involvement of CV in accidents was less than 1% of the total CV volumes on the expressway. Nevertheless, judging from the fact that of the total 80% run-off and rear-end collisions, 16% and 37% of run-off and rear-end collisions involved commercial vehicles; it is, therefore, demanded serious attention to include the CV involved run-off and rear-end collision in the iRAP model in order to provide more extensive evaluation and rating on the safety of the road engineering attributes on the expressway.

In addition, the findings on the commercial vehicles that were 1.9 – 2.2 times more likely to involve in rear-end collision as compared to other collision shed some light to another research direction: where the commercial vehicles the at fault vehicle in rear-end collision, were the commercial vehicles stopped by the shoulder/emergency lane and failed to warn other road users. Besides, it is also suggested to look into whether the speed of the commercial vehicle contributed to the rear-end collision as there is evidence from the previous study by Ho et al. (2017) that the operating speeds of commercial vehicles were significantly different between the middle and slow lanes on the expressway. The lane where rear-end collision took place is also of interest to be further investigated as the heavy vehicle is always suggested to travel on the slow lane. In this respect, the relationship between heavy vehicle/commercial vehicle involved collision and its lane occupancy as well as the travel speed is worth an in-depth investigation as to whether restricting heavy vehicle on slow lane would improve traffic safety.

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Research Report

Contribution of Commercial Goods Vehicle Volumes in the iRAP Risk Model

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