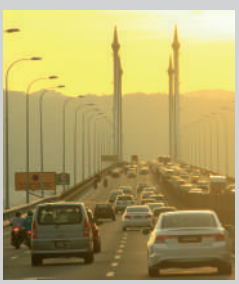
MRR No. 369



Research Report

Development of a VKT Index for Commercial Vehicles

Ho Jen Sim
Azzuhana Roslan
Nurulhuda Jamaluddin
Sharifah Allyana Syed Mohamed Rahim

MIROS
MALAYSIAN INSTITUTE OF ROAD SAFETY RESEARCH
ASEAN ROAD SAFETY CENTRE

Development of a VKT Index for Commercial Vehicles

Ho Jen Sim
Azzuhana Roslan
Nurulhuda Jamaluddin
Sharifah Allyana Syed Mohamed Rahim

MIROS
MALAYSIAN INSTITUTE OF ROAD SAFETY RESEARCH
ASEAN ROAD SAFETY CENTRE

Published by:
Malaysian Institute of Road Safety Research (MIROS)
Lot 125-135, Jalan TKS 1, Taman Kajang Sentral,
43000 Kajang, Selangor Darul Ehsan, Malaysia.

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

Ho, Jen Sim
Development of a VKT Index for Commercial Vehicles / Ho Jen Sim,
Azzuhana Roslan, Nurulhuda Jamaluddin, Sharifah Allyana
Syed Mohamed Rahim.
(Research Report; MRR No. 369)
ISBN 978-967-2988-00-7
1. Commercial vehicles--Research--Malaysia.
2. Traffic safety--Research--Malaysia.
3. Motor vehicles--Research--Malaysia.
4. Government publications--Malaysia
I. Azzuhana Roslan. II. Nurulhuda Jamaluddin.
III. Sharifah Allyana Syed Mohamed Rahim.
IV. Title. V. Series.
343.094809595

Printed by:
VISUAL PRINT SDN BHD (186281-A)
No 47, 47-1, Jalan Damai Raya 1,
Alam Damai, 56000 Cheras,
Kuala Lumpur

Typeface: Calibri
Size: 11 pt.

Contents

List of Tables

List of Figures

Acknowledgements

The authors/committee would like to express their appreciation to the former Director-General of the Malaysian Institute of Road Safety Research (MIROS), Professor Dr Wong Shaw Voon and the former Director of Road Engineering and Environmental Research Centre, Dr. Jamilah Mohamad Marjan for providing the grant to conduct this project, entitled “Development of a VKT Index for Commercial Vehicles” (No. Grant: RE103044) and extending their support to produce this report. Their gratitude also goes out to all the stakeholders involved, partners, reviewers, relevant agencies/companies, research participants, and to PUSPAKOM who have worked hard, contributed their invaluable ideas, input, energy and time towards the production of this report. The authors would also like to express special thanks to the team members and research assistants for their help and contribution towards completing the project.

Abstract

Vehicle Kilometers Travelled (VKT) is the total kilometers travelled by motor vehicles on any particular road system during a given period of time. VKT is an indicator commonly used to measure road safety performance in a particular country and also serves as an indicator for international traffic safety comparison purposes.

The vehicle kilometer study has been conducted in Malaysia since year 2005. However those studies were not without flaws. Many problems such as low response rate, inadequate sample or insufficiently comprehensive due to the involvement of limited types of vehicles or that the studies were only carried out at certain states. Therefore, this study was formulated to acquire the odometer readings when vehicles went for their periodic inspection at PUSPAKOM service centres.

For this study, there were 20,896 data entries with the frequency of each category ranging between 5 units to 7302 units. The samples were further divided into four main clusters namely: heavy vehicles, taxi, bus and rent vehicles A total of 16,350 heavy vehicles that were included in this study recorded 459,411,958 km travelled over the 6-month period. In this cluster, the smallest sample size was 5 units of vehicles which were from rigid agriculture lorry and window van. The biggest sample size consisted of 7,302 units with an average of 18,726 km distance travelled. The express bus had the longest average distance travelled of 97,165 km while the least was the school bus/factory bus with an average of 13,595 km in the 6- month period.

A total of 2,505 taxis were included in the analysis with a recorded distance travelled of 69,510,493 km in the study period. Motorcar type of taxi comprised 98.8% of the samples. Of note is that noted that the window van was preferred over the motorcar for longer distance travel with the mean distance travelled being about 36% higher. Lastly, there were 715 commercial motorcars in this study. The average distances travelled for the jeep was 22,618 km.

It must be admitted that this study encountered some deficiencies in terms of accuracy of data. Efforts have been made to improve data recording and the respective PUSPAKOM service centers are committed to ensuring high quality data for future studies.

1. Introduction

Vehicle Kilometers Travelled (VKT) is the total kilometers travelled by motor vehicles on any particular road system during a given period of time. VKT is an indicator commonly used to measure road safety performance in a particular country and as an indicator for international traffic safety comparison purposes. This parameter provides additional information about the crash risk in terms of exposure for certain groups of road users. For instance, drivers who travel long distances have a higher risk of being involved in an accident compared to those who make shorter trips.

In Malaysia, the vehicle kilometre study was first conducted in year 2005 in the form of an interview survey in Selangor. The results from the first survey were not promising due to the limited number of respondents; moreover it only covered motorcycles and cars. In year 2007, another approach using postcards was adopted. In this study, a total of 40,000 postcards were sent to new vehicle owners (motorcycle and car) nationwide. However, the response was not favourable as only 17% of the postcards were returned.

The third survey commenced on 25 December 2010. Postcards bearing a questionnaire were sent to 25,000 respondents nationwide where the data was provided by Road Transport Department. The targeted respondents (all vehicle users) were those who renewed their licences from January – November 2010 and a sample of 25,000 respondents were selected randomly. The data collected from this survey provided information on the distance travelled on the road by different types of vehicles in Malaysia and on the road users' socio-economic background. However, several concerns were raised in relation to obtaining accurate data when collecting the odometer readings for commercial vehicles. Problems faced in acquiring the odometer readings included:

- The recipients of the postcards were not operating the vehicles.
- The vehicles were used by other branches or had travelled to other states.

- Some of the lorries were only used at sites.

Given the many deficiencies encountered in obtaining odometer readings for commercial vehicles through the postcard survey, it was thus decided to acquire the odometer readings from the periodic inspection at PUSPAKOM service centres. The results can be used for the allocation of funds for road maintenance, development of traffic safety intervention measures and evaluation of the effectiveness of road safety programs.

1.1 Objectives of the Study

The general objective of this study is to develop VKT values for commercial vehicles in Malaysia. It is also the goal of this study to:

i. Determine the travel distances (odometer readings) for commercial vehicles;
ii. Identify the VKT by state and type of vehicles; and
iii. Establish the VKT for commercial vehicles in Malaysia.

2. Literature Review

The number of vehicles in Malaysia has grown exponentially over the last few decades. To date, there are about 22.6 million vehicles on the roads. Of these, 92% are motorcycles and motorcars while the other 8% constitute bus, taxi, rental cars, goods vehicles and others. Table 1 presents the registration of different types of vehicles by state.

Table 1 Distribution of registered vehicles by state as of 2012 (*Source*: PDRM, 2012)

State	Motorcycle	Motorcar	Bus	Taxi	Rental vehicles	Goods vehicles	Others	Total
Perlis	66,414	20,902	208	199	5	1,862	1,429	91,019
Kedah	770,224	291,255	3,323	3,739	779	36,202	20,089	1,125,611
Pulau Pinang	1,222,127	994,567	6,113	3,930	497	68,122	20,850	2,316,206
Perak	1,186,408	683,619	4,978	4,518	74	66,171	38,973	1,984,741
Selangor	1,145,822	1,049,723	7,753	11,438	238	161,284	81,750	2,458,008
Wilayah Persekutuan	1,529,316	3,309,854	20,009	39,293	15,668	221,910	152,383	5,288,433
Negeri Sembilan	480,055	307,728	2,854	2,155	15	41,758	8,198	842,763
Melaka	401,472	301,827	2,068	1,839	51	25,378	6,677	739,312
Johor	1,567,600	1,304,367	10,515	12,418	120	130,625	54,202	3,079,847
Pahang	497,727	344,087	2,096	2,673	21	40,272	14,958	901,834
Terengganu	319,055	265,544	2,053	2,007	12	26,671	8,275	623,617
Kelantan	450,370	182,464	1,178	1,097	16	20,273	7,509	662,907
Sabah	273,305	566,351	6,889	5,132	1,275	107,200	59,349	1,019,501
Sarawak	634,683	671,736	3,240	2,381	585	81,133	62,566	1,456,324
Total	10,544,578	10,294,024	73,277	92,819	19,356	1,028,861	537,208	22,590,123

2.1 What is a Commercial Vehicle?

A commercial vehicle is any kind of vehicle that is used for business or commercial purposes. A vehicle that is used to carry freight or other commercial goods, or any vehicle that is used in the course of any business activity, is referred to as a commercial vehicle. A commercial vehicle could be a big truck (semis, tractor trailers), a commercial bus, a van, or any other type of automobile used for commercial purposes.

2.2 Overview of Commercial Vehicle Accidents

Records from the Royal Malaysian Police (PDRM, 2012) show that of the 878,568 vehicles involved in crashes in 2012, heavy vehicles and commercial vehicles accounted for about 10.5%. In most of the cases (over 90% of the 6,917 fatalities that occurred in year 2012), the victims were vulnerable road users such as motorcyclists, pedestrians, cyclists and private car drivers. Very often, accidents involving commercial vehicles tend to be more tragic compared to other types of accidents. This is attributed to the size of the typical commercial vehicle compared to the size of the average car or motorcycle.

Various studies in United States and Europe have identified that the major factor in this significant over-involvement of commercial vehicles is the incompatible and aggressive design of heavy vehicles, a feature aggravated by their much greater mass. A study conducted by Rechnitzer (1998) identified that the current design of heavy vehicle continues to be virtually unregulated in regard to reducing its harm potential to other road users. A major design feature of heavy vehicles identified as significantly exacerbating the injury risk to pedestrians, cyclists and vehicle occupants is the high stiffness and aggressiveness of the front structure of the vehicles.

Figure 1 below shows the number of commercial vehicles involved in road crashes in 2012. The biggest contributors to the crashes were lorries (2,562 cases) and jeeps (1,149) followed by van (644) and special duty vehicles (includes ambulance, fire engine, police and crane) with 516 cases.

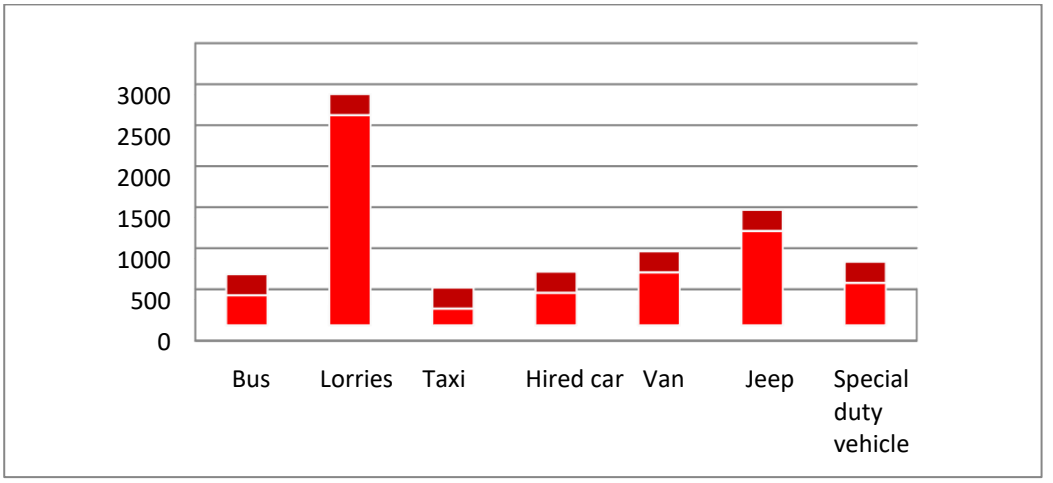


Figure 1 Number of vehicles involved in road crashes (2012)

Though the number of buses involved in road crashes is lower than special duty vehicles, the total number of bus casualties is higher (Table 2). The table also shows that lorries contributed a higher number of deaths (194) followed by jeep (159)). This is followed by the van with 86 deaths, special duty vehicles 57 deaths, hired car 55 deaths and bus 32 deaths. However, the trends are somewhat different for minor casualties. The number of minor casualties for the bus is higher (146) compared with special duty vehicles (107), hired car (86) and taxi (62).

Table 2 Number of casualties from crashes involving commercial vehicles (2012)

Type of vehicle	Type of casualties			
	Death	Serious	Minor	Total
Bus	32	36	146	214
Jeep	159	132	219	510
Special duty **vehicle**	57	34	107	198
Lorries	194	141	236	571
Taxi	35	33	62	130
Van	86	85	168	339
Hired **car**	55	33	86	174
Total	618	494	1,024	2,136

2.3 Exposure

In traffic accident analysis, risk and exposure are always used to assess the performance of road safety (Hakkert & Braimaister, 2002). According to the World Health Organization (WHO), risk is a function of four elements in road traffic: exposure, the probability of a crash, the probability of injury and the outcome of the injury. According to Rumar (1999), the relationship between safety, risk and exposure can be expressed as follows:

$$\text{Safety (Severity)} = \text{Risk (trend)} \times \text{Exposure (trend)}$$

Risk is defined as the probability of a crash occurring (Hauer, 1982). In 1986, Haight suggested that the definition of risk would be more useful if one considers the severity of the outcome of an event. The two definitions convened into a popular perception which related risk to both the chance of a hazardous event for someone to get involved in a particular activity and the severity of the outcome (Hakkert & Braimaister, 2002). Nevertheless, another question arose to debate the basis of comparison due to different probabilities and consequences. Hence, the exposure measure is used to rationalise the comparison of different consequences.

Exposure is a measure of the number of chances for crashes or injuries to take place (Cameron & Oxley, 1995) which is usually related to the amount of travel. Several research workers have used various forms of the following definitions (Chapman, 1973).

Exposure: The number of opportunities for accidents of a certain type in a given area (i.e. it is the possible number of accidents of that type which could occur in that time in that area).

Propensity: The conditional probability that an accident occurs given the opportunity for one.

Cameron and Oxley (1995) suggest the use of two different frameworks for the measurement of exposure in road safety research. Firstly, measurements of site exposure must consider the type of road, road conditions, road geometry and the

environmental conditions. Secondly, driver exposure measures must examine the number of opportunities a driver has to crash when driving on the road network.

Different methods have been used to measure exposure but there is considerable disagreement in the literature as to which exposure measures are most desirable to use and how they should be collected (Wolfe, 1982). Furthermore, some of the most easily obtained exposure measures are not always the most appropriate ones for developing meaningful crash rates. Choosing the appropriate measure of exposure depends on the intended use of the data and the population studied. The two main methods of collecting road safety exposure data are surveys of travellers (population based) that rely on self-reported travel behaviour from household surveys and surveys of traffic (vehicles) through on-road vehicle counts or observational surveys. In addition, studies on traffic conflicts and control observations at crash sites can provide exposure data.

2.4 Vehicle Kilometres Travelled (VKT)

Vehicle kilometres travelled (VKT) is the most widely used accident exposure indicator that describes vehicle activity level on the road. The VKT is usually used by various authorities for planning purposes, highway infrastructure fund allocation, environmental monitoring, road safety performance analysis and estimation of vehicle emissions. WHO and the Organisation for Economic Co-operation and Development (OECD) have been using VKT as a proxy for international traffic safety comparison purposes.

VKT for a country can be calculated by multiplying the total distance travelled with total number of vehicles. In this term, several assumptions are applied i.e. a kilometre travelled by a car is the same as a kilometre travelled by a heavy truck (BITRE, 2011) and geographical and land use factors have no influence in the travel distance. The VKT is expressed as:

$$\text{Total VKT} = \text{Total Distance Travelled x Total Number of Vehicles Registered}$$

2.5 Methods of Obtaining Odometer Readings

VKT, as described earlier, refers to total kilometres travelled by all the vehicles on the roads. The most accurate data is obtained through odometer readings for two different periods of time. However, it is not an easy task as it involves extensive work and resources; thus VKT is usually estimated based on data collected.

Several techniques have been developed to collect and estimate VKT data. There are four basic methods for road VKT estimation (Leduc, 2008; Azevado & Cardoso, 2009). Figure 2 shows the schematic diagram of the methods.

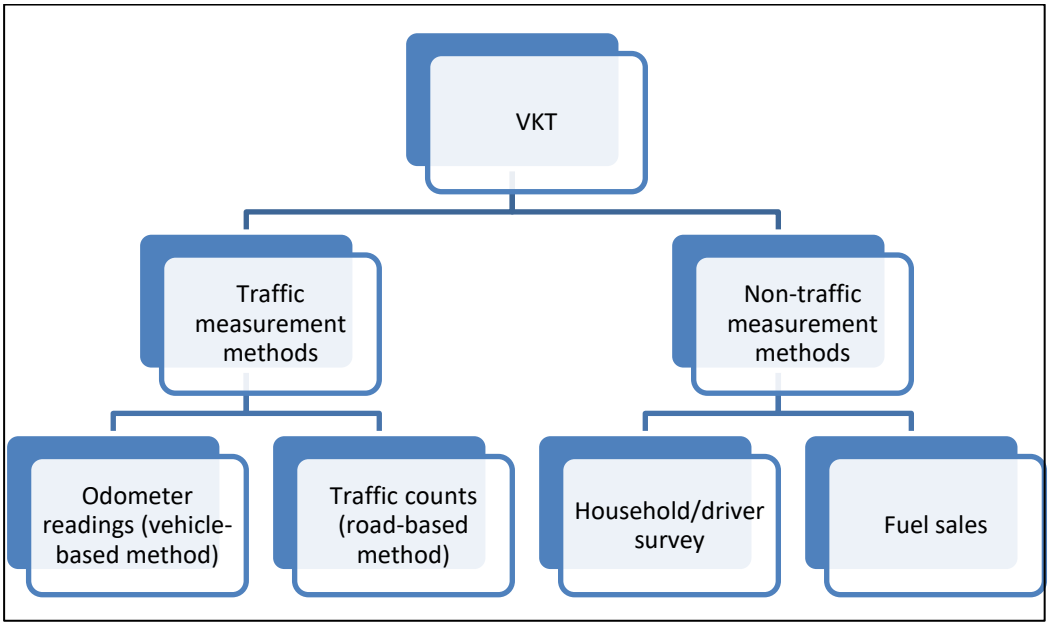


Figure 2 Methods of obtaining VKT (*Source*: BITRE, 2011)

2.5.1 Odometer Readings

Odometer readings of vehicles are the most accurate source of VKT. Advantages and disadvantages of this method are shown in Table 3.

Table 3 Advantages and disadvantages of odometer readings

Advantages	Disadvantages
• More accurate • More comprehensive as it covers all types of vehicles	• Involves extensive resources • Not able to relate to geographical data (origin and destination)

2.5.2 Traffic Count

The traffic volume count is obtained only on a sample of road sections and the VKT is then estimated for the entire road network. This is usually done by translating the volume, Annual Average Daily Traffic (AADT), and multiplying with the length of the road section. Yearly VKT is estimated by multiplying with number of days in a year. Advantages and disadvantages of this method are shown in Table 4.

Table 4 Advantages and disadvantages of traffic counts

Advantages	Disadvantages
• Classification of VKT by type of road, vehicle types, time of day and area	• Only on a sample of roads • Not able to relate to number of trips made by the same vehicle

2.5.3 Household Survey

In this method, a questionnaire or travel diary will be sent to the selected households. The respondents are required to provide data such as number of kilometers travelled for every trip made during the survey period. This method is very informative but involves huge investment on resources. With the data, the VKT model can be developed and the model can be used to forecast midterm/long term VKT by updating some of the variables such as population size and number of licensed drivers. Advantages and disadvantages of this method are shown in Table 5.

Table 5 Advantages and disadvantages of household surveys

Advantages	Disadvantages
• Have persons as a unit (possible to compare groups of persons). • High level of data disaggregation by person, vehicle, socio-economic background, vehicle ownership • Individual trip characteristics	• Sample-based • Self-reporting – error prone data • Target respondents and owner of vehicles might be different • Less commitment/low response rate • High implementing cost

2.5.4 Fuel Sales

Fuel sales have been used to estimate the VKT in USA for more than five (5) decades (Kumapley, 1994). In this approach, the volume of traffic is estimated from fuel supply and fuel consumption data where the estimated kilometers driven per litre of fuel for each type of vehicle is calculated. Advantages and disadvantages of this method are shown in Table 6.

Table 6 Advantages and disadvantages of fuel sales

Advantages	Disadvantages
• No travel distance data required. • Estimated model can apply to the whole nation • Able to give yearly data	• Model developed based on several assumptions • Inaccuracy in fuel sales data • Inconsistent fuel efficiency figures due to fleet age mix, driving habit, weather, condition of the vehicle

3. Methodology

This chapter describes the methodology for estimating VKT for commercial vehicles in Malaysia. The main source of data was the odometer readings provided by PUSPAKOM. Other descriptions in this chapter include data cleaning, problems pertaining to the data and site visits to PUSPAKOM service centres.

3.1 PUSPAKOM Inspection Centres

PUSPAKOM was founded in 1994 and is the only vehicle inspection company appointed by the Malaysian government. In Malaysia, it is mandatory for all commercial and public vehicles to be inspected by PUSPAKOM every six (6) months. Besides, all private vehicles for hire-purchase financing, ownership transfer and insurance matters are also required to be inspected and to obtain approval from PUSPAKOM.

To date, there are a total of 55 inspection centres and 28 mobile inspection sites nationwide. With the facilities and expertise, PUSPAKOM provides inspection services to more than 3 million commercial and public vehicles a year. Several branches were visited during the conduct of this study to obtain an overview of inspection centres. Figure 3 and 4 show images of PUSPAKOM inspection centres at Kota Kinabalu taken during a site visit. Table 7 lists the PUSPAKOM inspection centres around Malaysia.

Figure 3 Inspection lane, PUSPAKOM Kota Kinabalu

Figure 4 Vehicle inspection at PUSPAKOM Kota Kinabalu

Table 7 PUSPAKOM branches

Central region	Northern region
PUSPAKOM Wangsa Maju, Kuala Lumpur	PUSPAKOM Alor Setar, Kedah
PUSPAKOM (HPI) Taman Bukit Maluri, Kuala Lumpur	PUSPAKOM Mak Mandin, Pulau Pinang
PUSPAKOM Cheras, Kuala Lumpur	PUSPAKOM (HPI) Batu Maung, Pulau Pinang
PUSPAKOM Glenmarie, Selangor	PUSPAKOM Teluk Kumbar, Pulau Pinang
PUSPAKOM Bangi, Selangor	PUSPAKOM Arau, Perlis
PUSPAKOM Banting, Selangor	PUSPAKOM Sungai Petani, Kedah
PUSPAKOM (HPI) Batu Caves, Selangor	PUSPAKOM Langkawi, Kedah
PUSPAKOM (HPI) Jalan Tandang, Petaling Jaya, Selangor	PUSPAKOM Gopeng, Perak
PUSPAKOM Padang Jawa, Selangor	PUSPAKOM Taiping, Perak
PUSPAKOM (HPI) Pandan Mewah, Selangor	PUSPAKOM Ipoh, Perak
PUSPAKOM Shah Alam, Selangor	PUSPAKOM Teluk Intan, Perak
PUSPAKOM Sungai Besar, Selangor	PUSPAKOM Manjung, Perak
PUSPAKOM Seremban, Negeri Sembilan	PUSPAKOM (Mobile Unit) Gerik, Perak
Eastern region	**Southern region**
PUSPAKOM Kuantan, Pahang	PUS PAKOM Alor Gajah, Melaka
PUSPAKOM Raub, Pahang	PUSPAKOM Batu Pahat, Johor
PUSPAKOM Temerloh, Pahang	PUSPAKOM Johor Bahru, Johor
PUSPAKOM Pekan	PUSPAKOM Kluang, Johor
PUSPAKOM (HPI) Pengkalan Chepa, Kota Bharu, Kelantan	PUSPAKOM Segamat, Johor
PUSPAKOM Kota Bharu, Kelantan	PUSPAKOM Muar, Johor
PUSPAKOM (Mobile Unit) Kuala Krai, Kelantan	PUSPAKOM Pasir Gudang, Johor
PUSPAKOM (Mobile Unit) Gua Musang, Kelantan	PUSPAKOM Skudai, Johor
PUSPAKOM Kuala Terengganu, Terengganu	PUSPAKOM (HPI) Taman Daya, Johor Bahru, Johor
PUSPAKOM (Mobile unit) Dungun, Terengganu	
Sarawak region	**Sabah region**
PUSPAKOM Bintulu	PUSPAKOM Labuan
PUSPAKOM Kuching	PUSPAKOM Beaufort

PUSPAKOM Miri	PUSPAKOM Keningau
PUSPAKOM Sarikei	PUSPAKOM Kota Kinabalu
PUSPAKOM Sibu	PUSPAKOM Kota Marudu
PUSPAKOM Sri Aman	PUSPAKOM Lahad Datu
	PUSPAKOM Sandakan
	PUSPAKOM Tawau

3.2 Classification of Commercial and Other Vehicles

Commercial and public vehicles are generally categorised into three basic categories based on what they carry: moving people, moving goods and providing services. For PUSPAKOM, the commercial and public vehicles are classified by body code and usage code. There are 50 and 117 categories under body code and usage code classifications, respectively.

The common types of commercial and public vehicles are:

- School bus, school van
- Local bus, shuttle bus, chartered bus, express bus, factory bus
- Rental vehicles
- Package, product and food deliveries
- Warehouse deliveries and urban freight distribution
- Construction transport
- Public service vehicles: Federal, state, local councils safety vehicles: ambulance, fire truck etc.
- Utility vehicles: garbage pickup, water etc.

In this study, vehicle usage code was first used to categorise the vehicle types. For some vehicle types, the body code was further used to differentiate the travel purpose. Threshold travel values based on survey results by Nurul et al. (2014) were established for each type of vehicle. Table 8 shows the threshold values for each type of vehicle.

Table 8 Threshold values for each type of vehicle

Usage code	Body code	Threshold value
Ambulance		36,000
Articulated vehicle		252,000
Bus	*Perkhidmatan awam – bas persiaran/bas catar*	70,000
	Bas ekspress	252,000
	Perkhidmatan awam – bas sekolah/bas pekerja/bas kilang	36,000
	Perkhidmatan awam – bas mini/bas berhenti-henti	125,000
Jeep	*Psdn-jip/van/bas/kvn sykt*	80,000
	Barangan rigid/brg-rigid decon 950 – 5000 kg	80,000
	P.awam – kereta sewa pandu/kereta sewa	55,000
Tow jeep		36,000
Rigid lorry – agriculture		80,000
Rigid lorry – general cargo		80,000
Rigid lorry – concrete mixer		125,000
Rigid lorry – dumper/tipper		125,000
Rigid lorry – animal carrier		125,000
Rigid lorry – luton/kotak		125,000
Rigid lorry – mobile services		60,000
Rigid lorry – refrigerated		125,000
Rigid lorry – garbage		80,000
Rigid lorry – tow truck		80,000
Rigid lorry – vehicle carrier		125,000
Lorry tanker rigid – petrol/diesel		152,000
Lorry tanker rigid flour		152,000

Motorcar	*Perkhidmatan awam – teksi/limusin*	55,000
	P. awam – kereta sewa pandu/kereta sewa	55,000
Prime mover		252,000
Pick-up		80,000
Semi trailer – general cargo		252,000
Semi trailer – luton/box		252,000
Semi trailer		252,000
Semi trailer – low loader		252,000
Window van	*Psdn-Jip/van/bas/kvn sykt*	80,000
	Barangan rigid/brg-rigid decon 950 – 5000 kg	80,000
	Perkhidmatan awam – bas mini/bas berhenti-henti	125,000
	Perkhidmatan awam – bas sekolah/bas pekerja/bas kilang	36,000
	Perkhid. awam – bas persiaran/bas catar	70,000
	Perkhidmatan awam – teksi/limosin	55,000

3.3 Odometer Readings for Commercial and Public Vehicles

It is not mandatory that the odometer reading be taken in order to pass the inspection. However, in collaboration with the PUSPAKOM, the vehicle examiner is required to take note of the odometer reading and record it in the database system to achieve the objectives of the study. Figure 5 shows a sample odometer on a lorry as well as the certificate-of-fitness issued by PUSPAKOM.

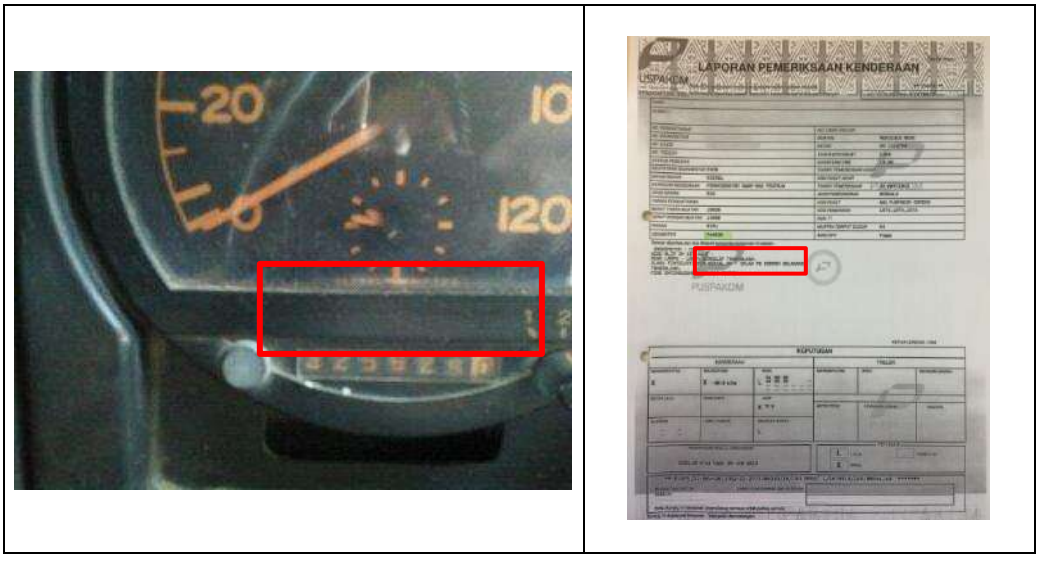


Figure 5 Example of an odometer on a lorry and certificate issued by PUSPAKOM

In this study, PUSPAKOM provided one-year odometer readings for all the commercial and public vehicles that had been inspected at their nationwide service centres between September 2012 and September 2013. Other information such as vehicle registration date, type of vehicle, usage code, body code, inspected date and branch were also provided by PUSPAKOM. A total of 1.2 million entries were provided by PUSPAKOM. Figure 6 shows the database provided by PUSPAKOM.

BRANCH	LOCATION	DATE INSPECTION	CHASSIS NO	REGN NO	ENGINE NO	BODY CO	BODY DESCR	USAGE CODE	USAGE DESCR	VE ID	ODOMETER
A01	PUSPAKOM GOPENG	2013-09-28 12:44:47.025838	NPR72L-7401399	AGX7863	4HJ1-534196	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	2805	408550
A01	PUSPAKOM GOPENG	2013-09-28 12:37:35.412148	V57A-79573	ACB7742	563386	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	2999	135888
A01	PUSPAKOM GOPENG	2013-09-28 12:35:43.347429	JDA00V11600A02247	AFB948	14B1737944	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	1873	75120
A01	PUSPAKOM GOPENG	2013-09-28 12:33:46.931855	LH80-0069923	BEL3409	2L-9247073	BF	BRG-RIGID DECON 950-5000KG	LRL	LORI RIGID - LUTON/KOTAK	2867	609454
A01	PUSPAKOM GOPENG	2013-09-28 12:30:25.740133	PM2L250S002017816	BKS7266	J78A57B	AI	SEKOLAH MEMANDU-MOTOKAR	MKR	MOTOKAR	2999	54654
A01	PUSPAKOM GOPENG	2013-09-28 12:25:25.740145	PN8VPC22JTCA47146	BJA4272	A15-C077883	BF	BRG-RIGID DECON 950-5000KG	VAS	SEMI-PANEL VAN	2867	225130
A01	PUSPAKOM GOPENG	2013-09-28 12:20:11.481459	SG221L-10780	NAP4745	J08C-B16719	BA	BARANGAN-PENGERAK UTAMA	PGU	PENGGERAK UTAMA	1873	236010
A01	PUSPAKOM GOPENG	2013-09-28 12:14:39.570382	V54-90118	MP8555	DG-166743	BH	BARANGAN-KENDERAAN TUNDA	LRT	LORI RIGID - TUNDA	2867	929791
A01	PUSPAKOM GOPENG	2013-09-28 12:06:01.71682	C22ASN-D359161	ADX1569	4G15PGJ0872	DA	PERKHIDMATAN AWAM-KERETA SE	MKR	MOTOKAR	2999	32125
A01	PUSPAKOM GOPENG	2013-09-28 12:03:50.387233	PML60CL2R5P010684	AFJ4136	4HF1139141	BF	BRG-RIGID DECON 950-5000KG	LRL	LORI RIGID - LUTON/KOTAK	2805	688351
A01	PUSPAKOM GOPENG	2013-09-28 12:00:47.565353	PNDYU41H55T056113	PGU9829	FD46-028211	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	2805	7337196
A01	PUSPAKOM GOPENG	2013-09-28 11:55:21.172223	PNDYU41T5AT051810	AFJ2628	TD42-515271T	BF	BRG-RIGID DECON 950-5000KG	LRL	LORI RIGID - LUTON/KOTAK	1873	31399
A01	PUSPAKOM GOPENG	2013-09-28 11:50:02.225544	NPR71L-7419512	AGK9289	4HG1-618185	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	2805	5213305
A01	PUSPAKOM GOPENG	2013-09-28 11:46:25.892814	BF22-A13000	ABC2479	Z16-037465W	BF	BRG-RIGID DECON 950-5000KG	PIC	PICK-UP	2867	125558
A01	PUSPAKOM GOPENG	2013-09-28 11:42:24.767457	FP510D-510026	AGS5589	6D40-282682	BA	BARANGAN-PENGERAK UTAMA	PGU	PENGGERAK UTAMA	1873	541222
A01	PUSPAKOM GOPENG	2013-09-28 11:39:14.012021	V57A74251	WCE2869	550345	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	2999	564588
A01	PUSPAKOM GOPENG	2013-09-28 11:37:38.981361	CD45CVN-01233	AGM5624	PF6-301107B	BB	BARANGAN RIGID	LRD	LORI RIGID - DUMPER/TIPPE	1873	810009
A01	PUSPAKOM GOPENG	2013-09-28 11:35:47.228697	HDJ101-0016836	ML8585	1HD-0186663	BF	BRG-RIGID DECON 950-5000KG	JIP	JIP	2867	369328
A01	PUSPAKOM GOPENG	2013-09-28 11:33:49.59507	PNDYU41T58T051179	AGT8618	TD42-513035T	BF	BRG-RIGID DECON 950-5000KG	LRL	LORI RIGID - LUTON/KOTAK	1877	117927
A01	PUSPAKOM GOPENG	2013-09-28 11:25:21.642534	FE444E-A76627	ADD3642	4D31-884237	GB	JENTERA BERGERAK	MAP	MOBILE AERIAL PLATFORM	1873	167010
A01	PUSPAKOM GOPENG	2013-09-28 11:15:52.170307	V57A-75604	ABW4013	553353	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	2999	356218
A01	PUSPAKOM GOPENG	2013-09-28 11:13:31.024913	FR1KZD-10903	AHU588	K13CTG13475	BB	BARANGAN RIGID	LRD	LORI RIGID - DUMPER/TIPPE	1877	194676
A01	PUSPAKOM GOPENG	2013-09-28 11:11:33.481181	LH80-0061735	ACM6148	2L1865075	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	2867	514907
A01	PUSPAKOM GOPENG	2013-09-28 11:08:57.950044	YU41H5-053431	AEY8128	FD46-021624	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	2805	697963
A01	PUSPAKOM GOPENG	2013-09-28 11:07:01.970425	CT141-0005961	ACR5065	2C-3368970	DA	PERKHIDMATAN AWAM-KERETA SE	MKR	MOTOKAR	2999	654
A01	PUSPAKOM GOPENG	2013-09-28 11:01:21.858364	SZDFVP16313	ADJ283	C104207	BF	BRG-RIGID DECON 950-5000KG	LRA	LORI RIGID - KARGO AM	1877	343524
A01	PUSPAKOM GOPENG	2013-09-28 10:56:25.458476	KM36-9022309	WJC2208	5K9039345	BF	BRG-RIGID DECON 950-5000KG	VAN	WINDOW VAN	2867	295233

Figure 6 Sample of information provided by PUSPAKOM

3.3.1 Data Cleaning and Analysis

Before the data was used for developing the VKT index, it was cleaned to exclude erroneous data. Data with no odometer readings or repeated readings were removed from the dataset. Several discussions were conducted with the PUSPAKOM management to understand the causes of the erroneous data and it was found that the problem was mainly due to negligence of the vehicle examiners and faulty odometers. The odometer readings were either not taken or any value was simply keyed into the computer system as they were under the impression that the odometer readings have no impact on the safety of the vehicle. No readings or similar readings for a pool of vehicles at the same branch were observed to have given rise to faulty data.

This problem has been brought to the attention of the management of PUSPAKOM and several measures have been taken to resolve the problem such as constant notifications of the deficiency and sending memorandums to all the respective branches for an immediate course of action.

Therefore only vehicles inspected in the month of December 2012 were identified as the sample for analysis. The dataset was expected to be more accurate after all the corrective measures had been taken. The sample was then matched with the vehicles inspected in June 2014 by assuming all the commercial and public vehicles would have been sent for periodic inspection half yearly. Thus, vehicles that failed to turn up for the next scheduled inspection were removed from the sample.

4. Results

The database provided by PUSPAKOM contained a total of 117 categories in terms of usage codes. However, only 26 categories (as shown in Table 9) were included in the analysis as the data provided were either invalid or not promising to represent the travel distance for the particular type of vehicles. The 26 categories were further grouped into four (4) main clusters based on the nature of usage that is taxi, bus, rental vehicles and heavy vehicles. There were 20,896 data entries with the frequency for each of the categories ranging between 5 units to 7302 units. Figure 7 shows the proportion of vehicles with dada entries. Heavy vehicles comprised 78%, taxi 12%, bus 6% and rental vehicles 4%.

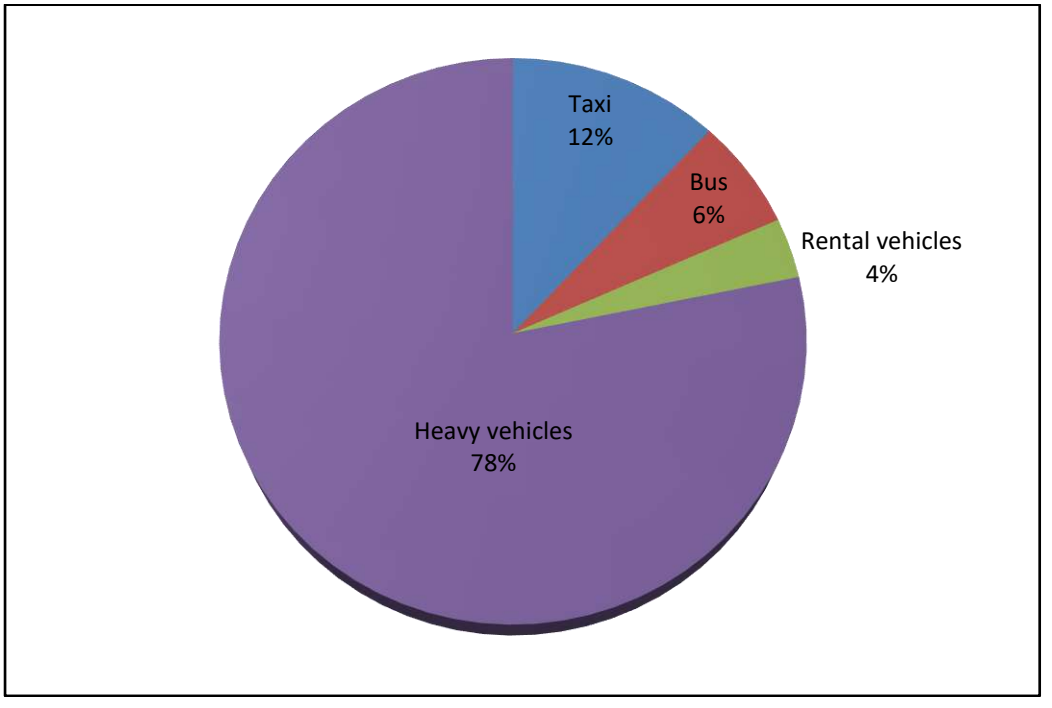


Figure 7 Breakdown of the sample

Table 9 Categories of vehicles in this study

Cluster	Vehicles	Usage code	Usage description
Heavy vehicles	Ambulance	AMB	
	Articulated vehicle	AVE	
	Jeep	JIP	Psdn – Jip/Van/Bas/Kvn sykt,
	Tow jeep		Barangan Rigid/Brg-Rigid Decon 950 – 5000 kg,
	Rigid lorry – Agriculture		
	Rigid lorry – General cargo		
	Rigid lorry – Concrete mixer		
	Rigid lorry – Dumper/Tipper		
	Rigid lorry – Animal carrier		
	Rigid lorry – Luton/Box		
	Rigid lorry – Mobile services		
	Rigid lorry – Refrigerated		
	Rigid lorry – Garbage		
	Rigid lorry – Tow truck		
	Rigid lorry – Vehicle carrier, Lorry tanker		
	Rigid – Petrol/Diesel, Lorry tanker		
	Rigid – Flour		
	Prime mover		
	Pick-up		
	Semi-trailer – General cargo		
	Semi-trailer – Luton/Box		
	Semi-trailer – Contena		
	Semi-trailer – Low loader		
	Window van		Psdn – Jip/Van/Bas/Kvn sykt,
			Rigid/Brg-Rigid Decon 950 – 5000 kg
Bus	Bus		Bas persiaran/bas catar, Bas express

		Bas sekolah/bas pekerja/bas kilang,
		Bas mini/bas berhenti-henti
	Window van	Bas mini/bas berhenti-henti
		Bas sekolah/bas pekerja/kilang
		Bas persiaran/bas catar
Taxi	Motorcar	
	Window van	
Rental vehicles	Jeep	Kereta sewa pandu/sewa
	Motorcar	Kereta sewa pandu/sewa

As the travel distance of the commercial vehicles is highly dependent on the nature of company business and geographical factors, the magnitude of the kilometre travelled was estimated based on the types of vehicles. The findings of the study conducted by Nurul et al. (2014) were used as a reference for the number of trips made and distance travelled in a week for each type of commercial and public vehicle.

Tables 10 to 13 present the findings of odometer readings by main clusters. The results show that for heavy vehicles, a total of 16,350 vehicles had recorded 459,411,958 km travelled over a six-month period. In this cluster, the smallest sample size was 5 units of vehicles which were from rigid agriculture lorry and window van. The biggest sample size consisted of 7,302 units with an average of 18,726 km distance travelled.

Bus and window van used as bus were grouped under bus cluster. There were seven (7) subcategories of buses such as tour bus/chartered bus, express bus, school bus/factory bus, mini bus/stage bus, minivan/stage van, school van/factory van, tour van/chartered van. The express bus had the longest average distance travelled of 97,165 km while the least was the school bus/factory bus with an average of 13,595 km in the 6-month period.

A total of 2,505 taxis were included in the analysis with a recorded 69,510,493 km distance travelled in the study period. Motorcar type of taxi comprised of 98.8% of the sample. It was also noted that the window van was preferred over motorcar for longer distance travel with the mean distance travelled being about 36% higher.

There were 715 commercial motorcars in this study. The average distances travelled for the jeep was 22,618 km while the mean kilometre travelled for the motorcar type of jeep was 21,232 km.

Table 10 Average threshold values developed based on previous study

Usage code	Threshold values	Frequency	Total readings	Mean	Std. deviation	Minimum	Maximum
Ambulance	36,000	8	108876.0	13609.5	10544.3	1711.0	33494.0
Articulated vehicle	252,000	56	5004494.6	89366.0	80491.5	2669.0	252220.0
Jeep	80,000	279	3446218.2	12352.0	13235.6	1001.0	77643.0
Tow jeep	36,000	9	140726.0	15636.2	11397.1	3849.0	36254.0
Rigid lorry – agriculture	80,000	5	127629.0	25525.8	26467.3	3000.0	69701.0
Rigid lorry – general cargo	80,000	7302	136740966.5	18726.5	18131.7	1000.0	80038.0
Rigid lorry – concrete mixer	125,000	141	4997542.3	35443.6	38243.7	1134.0	125351.0
Rigid lorry – dumper/tipper	125,000	2257	72428979.3	32090.8	33572.6	1000.0	125234.0
Rigid lorry – animal carrier	125,000	59	2789519.3	47280.0	36479.9	3187.0	120546.0
Rigid lorry – luton/kotak	125,000	2814	79092580.9	28106.8	29676.8	1006.0	125154.0
Rigid lorry – mobile services	60,000	6	38638.0	6439.7	3571.8	1047.0	11616.0
Rigid lorry – refrigerated	125,000	317	10721337.2	33821.3	31490.0	1408.0	124570.0
Rigid lorry – garbage	80,000	155	3725001.4	24032.3	19579.3	1057.0	79403.0
Rigid lorry – tow truck	80,000	44	902975.0	20522.2	17681.5	1276.0	78321.0
Rigid lorry – vehicle carrier	125,000	93	3365448.0	36187.6	33308.7	1137.0	124514.0
lorry tanker Rigid – petrol/diesel	152,000	43	2102041.0	48884.7	6220.9	1468.0	144760.0
lorry tangker Rigid – flour	152,000	7	297902.0	42557.4	45601.0	1452.0	136537.0
Prime mover	252,000	1224	101562916.8	82976.2	74597.8	1038.0	252110.0
Pick-up	80,000	952	15646481.1	16435.4	17083.8	1000.0	80511.0
Semi-trailer – general cargo	252,000	39	5287078.1	135566.1	75145.2	9190.0	246324.0
Semi-trailer – luton/box	252,000	9	1564110.0	173790.0	50358.2	82259.0	235440.0
Semi-trailer – contena	252,000	12	1537455.0	128121.3	99601.4	3022.0	250857.0

Semi-trailer – low loader	252,000	8	774011.0	96751.4	103843.3	5268.0	245488.0
Window van	80,000	5	78733.0	15746.6	18887.0	1728.0	47421.0
	80,000	493	6636253.7	13461.0	15647.8	1007.0	80477.0
Total		16350	459411958.4				

Table 11 VKT for bus

Usage code	Threshold value	Frequency	Total readings	Mean	Std. deviation	Minimum	Maximum
Bus	70,000	141	4617423.0	32747.7	16352.4	2936.0	70017.0
	252,000	148	14380459.0	97165.3	48167.6	1273.0	241157.0
	36,000	316	3971794.6	12569.0	8000.3	1010.0	36065.0
	125,000	95	3969900.5	41788.4	28258.5	1000.0	125112.0
Window van	125,000	59	2615312.0	44327.3	31704.4	3251.0	125767.0
	36,000	496	6743394.0	13595.6	7981.0	1230.0	36901.0
	70,000	71	2103664.0	29629.1	15464.2	1674.0	68716.0
Total		1326	38401947.1				

Table 12 VKT for taxi

Usage code	Body code	Frequency	Total readings	Mean	Std. deviation	Minimum	Maximum
Motocar	55,000	2476	68424026.0	27634.9	11829.7	1008.0	51964.0
Window van	55,000	29	1086467.0	37464.4	11972.2	11446.0	55043.0
Total		2505	69510493				

Table 13 VKT for the commercial motorcar

Usage code	Body code	Frequency	Total readings	Mean	Std. deviation	Minimum	Maximum
Jeep	55,000	13	294045.0	22618.8	4548.8	2881.0	53630.0
Motocar	55,000	702	14904876.0	21232.0	13188.9	1006.0	55534.0
Total		715	15198921				

To better understand the distribution of the data, the odometer readings were plotted using the box plot. Figures below illustrate the results of the box plots. Based on Figure 8, it can be seen that the readings for Articulated Vehicles (AVE) are widely distributed while the profile for Bus CB (Express Bus) is fairly distributed.

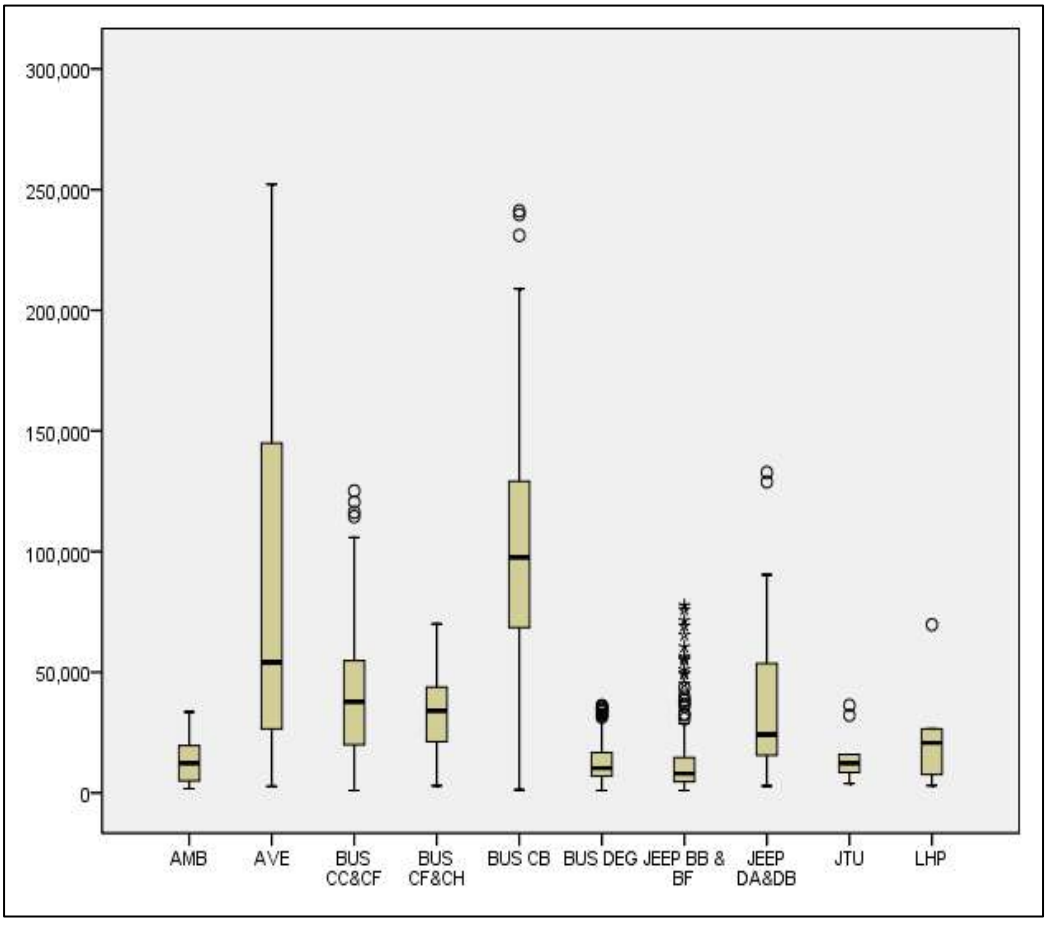


Figure 8 Box plots for AMB, AVE, bus, jeep, JTU and LHP

Figure 9 describes the vehicle kilometre travelled profiles of the rigid lorry. In general, most of the distributions are skewed to the right which indicates that the means were larger than the median values. Outlier data were observed for the lorry such as LRA

(General Cargo), LRD (Dumper), LRL (Luton), LRR (Refrigerated), LRS (Garbage), LRT (Tow).

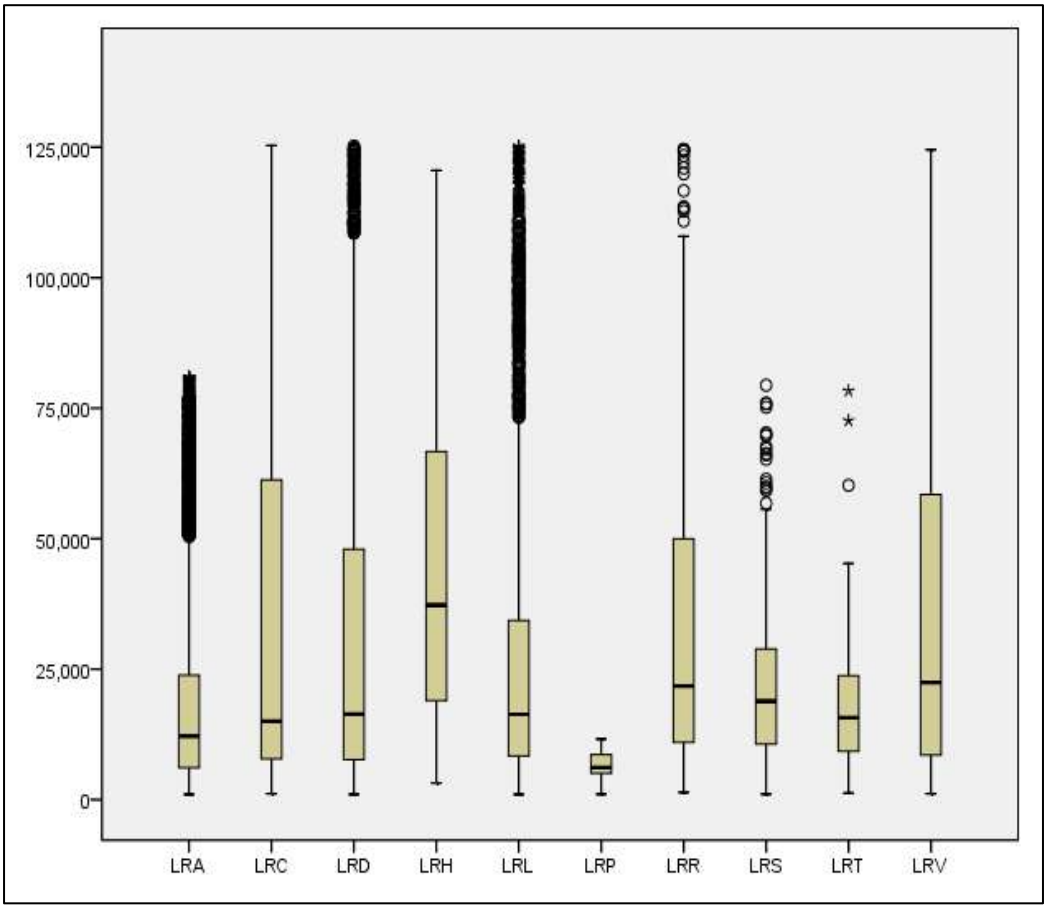


Figure 9 Box plots for LRA, LRC, LRD, LRH, LRL, LRP, LRR, LRS, LRT and LRV

Figure 10 shows the distribution of data for semi-trailers and prime movers. The data for the semi-trailers (cargo, container and low loader) and PGU were found to be widely dispersed. The distribution for SKA and SKO was skewed to the left while for PGU and SLL, it was skewed to the right. A few outliers were recorded for pick up (PIC).

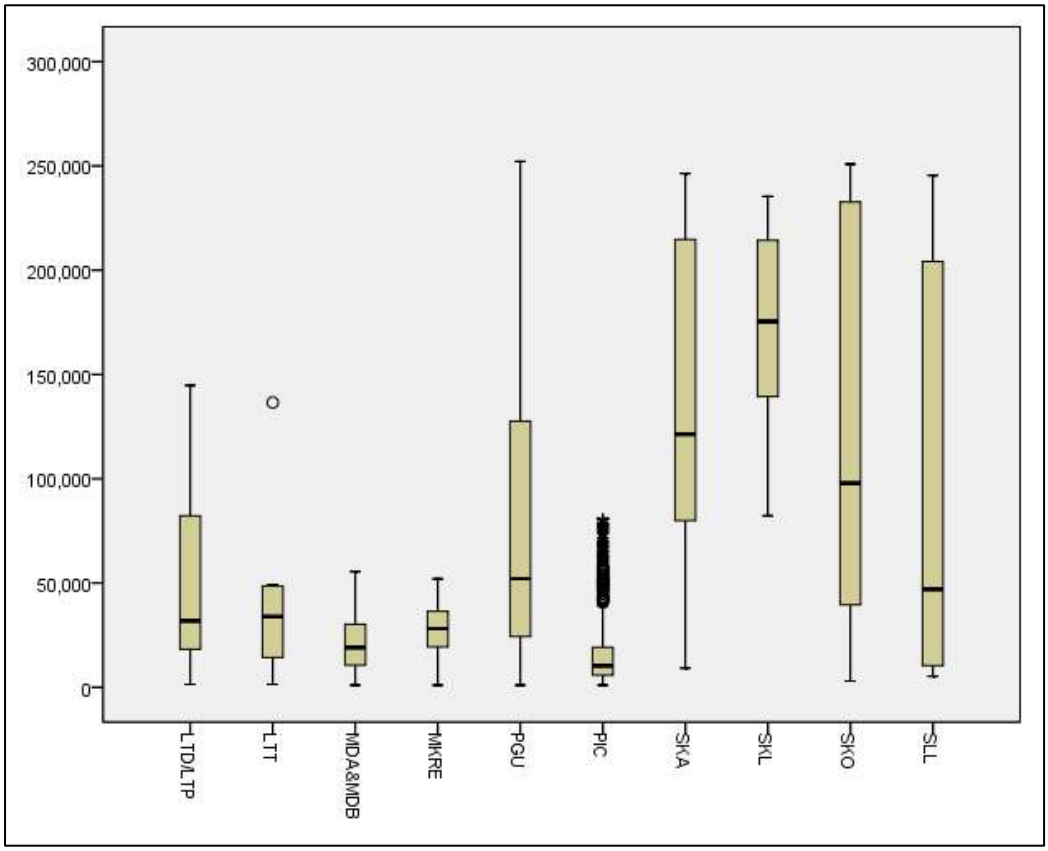


Figure 10 Box plots for LTD, LTT, MDA, MKR, PGU, PIC, SKA, SKL, SKO and SLL

Figure 11 presents the distribution for van categories. Substantial outliers were observed for the category of window van carrying goods. The distribution for vans that served as stage bus (CA&CC), factory and school bus (CD, CE, CG) and tour bus was slightly skewed to the right while the reverse was true for the van that served as taxi.

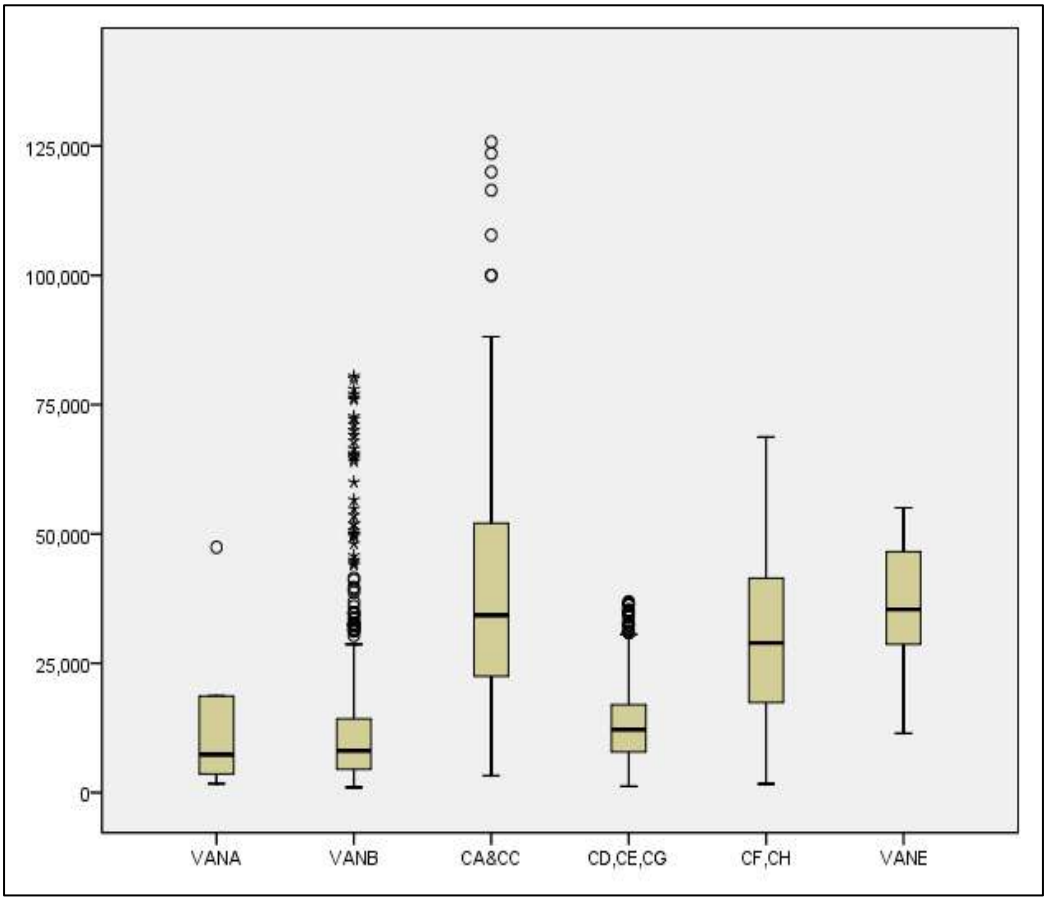


Figure 11 Box plots for different types of vans and buses

Further analysis of distance travelled by categories of vehicles produced travel patterns as shown in Figures 12 to 15. Figure 12 illustrates the 6-month travel distance for taxi and it is noted that the exposures are normally distributed. The median travel distance was 28,195 km while the mean was 27,748 km. About 30% of the taxi travelled 20,000 – 30,000 km. Less than 2% of the taxi travelled more than 50,000 km.

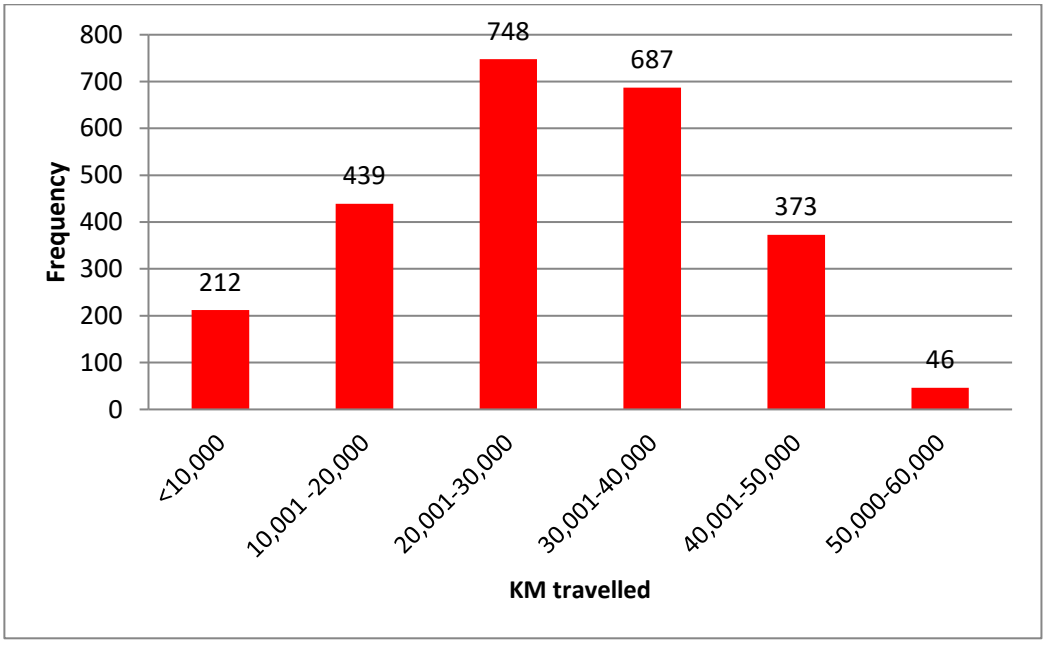


Figure 12 Profile of kilometres travelled for taxi

Skewed patterns were observed for bus, rental vehicles and commercial vehicles (as shown in Figure 13). The majority recorded a travelled distance of less than 30,000 km. For instance, about 71% of the buses reported less than 30,000 km distance travelled over a 6-month period. Similarly, it was also noted that nearly 75% of rental vehicles and 72% of the heavy vehicles had travelled less than 30,000 km over the past six months.

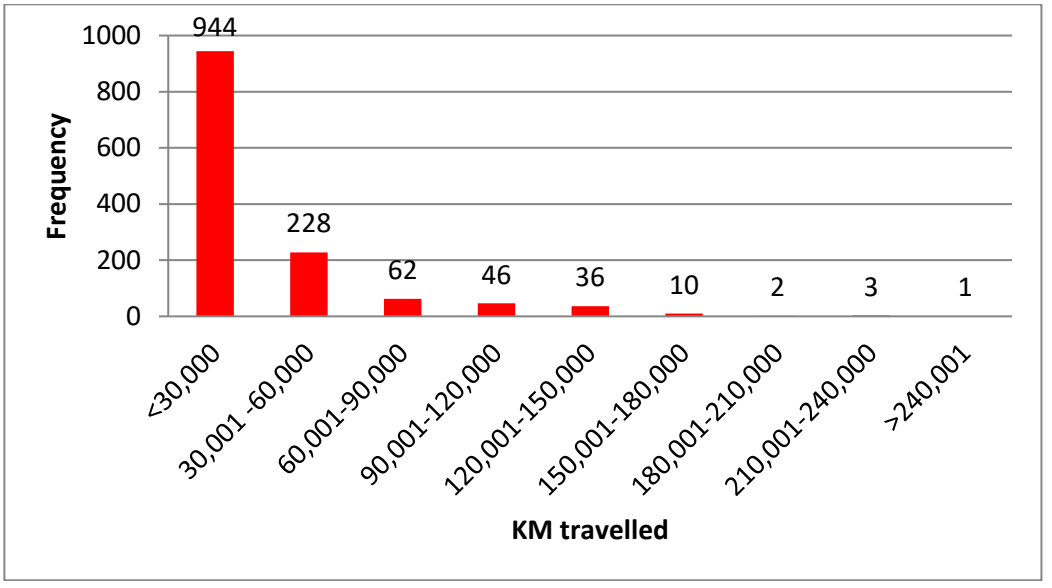


Figure 13 Profile of kilometres travelled for buses

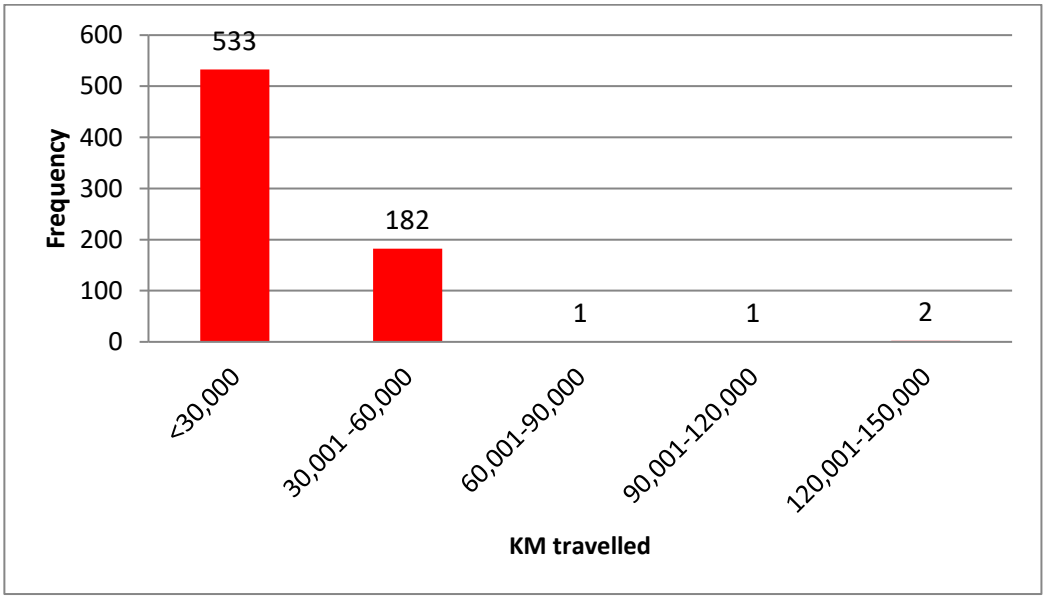


Figure 14 Profile of kilometres travelled for rental vehicles

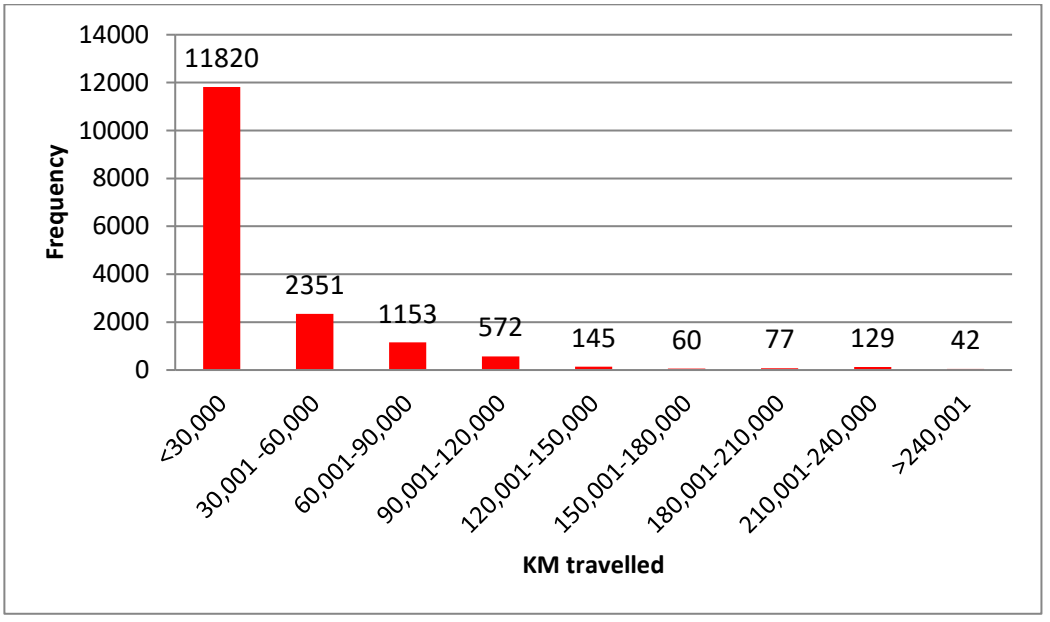


Figure 15 Profile of kilometres travelled for heavy vehicles

4.1 Annual Vehicle Kilometre Travelled

Based on odometer readings, the annual vehicle kilometres travelled was estimated. The estimation of annual distance travelled was disaggregated by the nature of vehicles as shown in Table 14. The bus had the highest estimation of annual vehicle kilometres travelled with 57,921 km, followed by commercial vehicles at 59,197 km per annum. The taxi was estimated to have 52,644 km travelled in a year.

Table 14 Estimation of VKT for commercial vehicles, buses and taxi

Type of Vehicle	Frequency	Total odometer readings	Half yearly VKT	Annual VKT
Commercial vehicles	16350	459411958.4	28098.6	56197.2
Bus	1326	38401947.1	28960.7	57921.5
Taxi	3207	84415369.0	26322.2	52644.4

5. Discussion

This project aimed to establish the vehicle kilometers travelled (VKT) for commercial vehicles in Malaysia. The VKT was estimated based on the odometer readings obtained by PUSPAKOM Service Centres during their periodic inspection of all vehicles.

The key problem identified in this project was the inconsistency of the data recording. This has raised the issue of accuracy of the dataset which can affect the value of the VKT index for Malaysia. Efforts have been taken to resolve the problems by holding numerous meetings with the management of PUSPAKOM. Several on-the-ground visits were conducted to understand the root cause of the problems in the dataset. The main reasons were found to be faulty odometers and the reluctance of the vehicle examiners to record the correct odometer readings. The vehicle examiners were briefed on the importance of the data in contributing to the national road safety plan. Thus, it is hoped that the joint effort between MIROS and the management of PUSPAKOM can help improve the accuracy of the data.

No attempt was made to establish the risk of commercial vehicle accidents as only 26 out of the 117 categories of vehicles were included in the analysis of this study. About 10% of accidents annually involve commercial vehicles (as described in Section 2.2) with the vulnerable road users (motorcyclists, bicyclists and pedestrians) being often the victims. This is attributed to the size of the typical commercial vehicle as compared to the size of the average car or motorcycle.

Also, no attempt was made to explore the relationship between the exposure characteristics of the commercial vehicle drivers and the accidents. Several studies indicate that sleepiness and fatigue are among the factors leading to crashes. The human body clock is programmed to sleep at night (1.00 am – 6.00 am) and 2.00 pm – 4.00 pm in the afternoon (Stutts et al., 1999). Aspects such as age and competence are also other major concerns in the logistics industry.

It will be useful if VKT can be established for each state of Malaysia where it can indicate the usage and loading of the road network in a particular state. The information can serve as a reference for relevant authorities to determine the allocation of budgets. However, due to the limited sample size of this study, the VKT for each state could not be calculated. Besides, the VKT of commercial vehicle is closely related to land use, nature of business and type of vehicles, for instance vehicles such as prime mover, semi-trailer are long haulage vehicles and they travel around the country mainly via expressways. Further exploration on the usage of commercial vehicles on the different types of road networks is essential.

6. Conclusion and Recommendations

The VKT is usually used by various authorities for planning purpose, highway infrastructure fund allocation, environmental monitoring, road safety performance analysis and estimation of vehicle emissions. WHO and OECD have been using VKT as a proxy for international traffic safety comparison purposes.

In Malaysia, the development of VKT has been undertaken since 2005. However, the studies have not been considered comprehensive as they covered only limited areas and limited types of vehicles. This study was undertaken to complement the existing studies which collect the odometer readings for private vehicles and motorcycles in Malaysia and also as part of the continuous efforts to develop the VKT index for Malaysia.

Some deficiencies in the dataset are acknowledged. Nevertheless, the problem has been rectified and the respective PUSPAKOM service centres are expected to ensure high quality data.

6.1 Recommendation for Future Studies

The information contained in this study would be of use to improve the commercial vehicle road safety scenario in the country. Hence, it is of interest to:

i. explore the relationship of the exposure of different types of commercial vehicles with accident characteristics, for instance, the length of a journey and the severity of the accident;
ii. investigate the relationship of driver characteristics to VKT,
iii. examine the business operator's compliance to periodic inspections.

References

Azevedo, C. L., & Cardoso, J. (2009*). Estimation of annual traffic volumes: A model for Portugal*. The Young Researchers Seminar 2009, Torino, Italy, 3 – 5 June 2009. www.ectri.org/.../Azevedo_C_Cardoso_J_Session1_Traffic(1).pdf).

Bureau of Infrastructure, Transport and Regional Economics (BITRE). (2011). *Road vehicle kilometers travelled: Estimation from state and territory fuel sales*. Canberra ACT.

Cameron, M., & Oxley, J. (1995). *Investigation of improved exposure data for the assessment of road safety*. Clayton Victoria: Monash University Accident Research Unit.

Chapman. (1973). The concept of exposure. *Accident Analysis and Prevention, 5*, 95 – 110.

Hakkert, A. S., & Braimaister, L. (2002). *The uses of exposure and risk in road safety studies*, No.R-2002-12. Leidschendam, The Netherlands: SWOV Institute for Road Safety Research .

Hauer, E. (1982). Traffic conflicts and exposure. *Accident Analysis and Prevention, 14*(5), 359 – 364.

Kumapley, R. (1994). *Estimating statewide vehicle-miles traveled in Indiana*. Unpublished Master's Thesis, School of Civil Engineering, Purdue University.

Leduc, G. (2008). *Road traffic data: Collection methods and applications.* Joint Research CommitteeTechnical Notes (JRC 47967), European Commission, Seville, Spain.

Rechnitzer, G. (1998). Road crashes. In *the Inquest Handbook*, Ed. Hugh Selby. *The Federation Press, Australia***,** pp. 80 – 103.

Rumar, K. (1999). *Road safety and benchmarking*. In Proceedings of the Paris Conference on Transport Benchmarking, November 1999, Paris, France.

Wolfe, A. C. (1982).The concept of exposure to the risk of a road traffic accident and an overview of exposure to data collection methods. *Accident Analysis and Prevention*, *14*(5), 337 – 340.

Wundersitz, L. N., & Hutchinson, T. P. (2008). *Identifying and improving exposure measures.* Centre for Automotive Safety Research. The University of Adelaide, Australia.

World Health Organization. (2004). World Report on Road Traffic Injury Prevention. Geneva. Retrieved from http://www.who.int/violence_injury_prevention/publications/road_traffic/world_report/chapter3.pdf?ua=1

Research Report

Development of a VKT Index for Commercial Vehicles

Designed by: MIROS

MIROS
MALAYSIAN INSTITUTE OF ROAD SAFETY RESEARCH
ASEAN ROAD SAFETY CENTRE

Malaysian Institute of Road Safety Research
Lot 125-135, Jalan TKS 1, Taman Kajang Sentral
43000 Kajang, Selangor Darul Ehsan
Tel: +603 8924 9200 **Fax:** +603 8733 2005
Website: www.miros.gov.my **E-mail:** dg@miros.gov.my

ISBN 978-967-2988-00-7
9 789672 988007