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Assessing Heavy Goods Vehicle Driver's Behavior at Signalized Intersection via Risk Assessment Model

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Abstract

The large measurement and dense mass of heavy good vehicle (HGV) contribute massively of an impact with another vehicle. Every year many people are killed in road accidents in Malaysia. Most of these cases are car driver and motorcyclists, killed in collision involving trucks and other type of HGV and some of these fatalities were at signalized intersection. The aim of this paper is to identify the problem of HGV driver behavior at signalized intersection. Signalized intersections are likely to guarantee safety by providing the right way for traffic flow and movement. However, the current signalized facility and specification may not guarantee road safety according to some factors such as traffic destruction and risky signal phasing. Past study showed there was a relationship between the driver's attitude and behavior towards road safety. The failure to properly recognize and understand driver's behavior at signalized intersection design can contribute to operational and safety problem. The method that will be used in this paper to identify the risk is via risk assessment model, simulation software, also via observation and interview for the driver's behavior. The significant of this paper is to find a gap by analyzing the behavior of HGV driver and risk assessment at signalized intersection. In conclusion, this paper can help researchers and practitioners to understand HGV driver's behavior at signalized intersections and for the authority to develop better amenities for HGV driver's safety by adding on the existing safety practices for road transport over various aspects especially in Heavy vehicle operation.

Keywords: Heavy Goods Vehicle (HGV), Signalized Intersection, Driver Behavior, Risk Assessment Model

Introduction to Heavy Vehicle

Sun (2017) mentioned that HGVs can be defined as Freight trucks which are categorized by the alignment of the truck and trailer(s), the numbers of axels that the HGV have and by the type of trailer. A single unit truck is a truck in which

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the load or cargo carrying capability is integral to the body of the vehicle. A truck tractor is a power-unit that pulls semi-trailer or trailer units. The truck tractor itself does not have any load or cargo carrying capability without attached trailers. Both single unit and truck tractors can be attached to a single-trailer or to multi-trailers (double or triple). The total number of axles on the truck alignment includes those of the truck and any trailers. It can range from 2 or 3 axles for a single unit or bobtail (truck tractor without a trailer) to 7 or more for units with three trailers.

Based on the Global Truck Study 2016, from 2004 to 2015, sales in the total truck market for heavy good vehicle raised at an average annual rate of 2.7%, but the growth was tremendously unstable, ranging from -18% to 37%. HGVs remain to be the leading segment in the market, with a share of 63%. Between 2014 and 2024 the worldwide truck market is likely to continue increasing at a fairly low rate of 3.1% per year. The Indian market will be the key driver (Schiller et.al, 2016). As HGV industries continues to grow within Malaysia, crash rates relating heavy vehicle at dengerous state, and the risk of injury and fatality remain to extend to all road users (Huzaifah, 2010). According to Ministry of Transport (MOT), the number of registered license in 2016 for lorry driver is 13,394 (A and C class) remains high each year considering many people are having a certification to drive trucks and it can contribute to the increasing number of trucks on road. Yet, in the situation of Malaysia, the high percentage of heavy good vehicles (HGV), based on the statistics by MiROS, 28,817 heavy vehicles are registered in 2016 (increasing 2%) which is a rate higher compared to other countries such as Thailand and Singapore (S.P.A.D, 2016). Based on Table 2, its highlighted that the number of new registered HGV license is remain high.

Heavy Goods Vehicle and Safety

The safety of HGV and also towards other vehicle has been main societal concern because of the vast development of the truck business and it contributed to high crash rates including in Malaysia industries. Crash compatibility is the main factors that contributes to high level of harshness in heavy vehicle crashes. The

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huge and heavy mass of these heavy vehicles contribute extremely to the severity of an impact with another road user (Mark, 2010). Heavy vehicles have six or more wheels to be compared with other types of vehicle and have a gross weight more than 10,000 lbs. This has contributed in a harshness when a contact occurs between large trucks and other vehicles which is being demonstrated in an increased rate of fatal crash involving huge trucks (Sarath, 2007). Table 1 shows the critical statistic in terms of safety related to heavy vehicle in Malaysian road.

Table 1: Number of New License of New Registered 2007-2016

JENIS KENDERAAN *Type of Vehicle*	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
BAS *Busses*										
BERHENTI-HENTI *Stage*	540	513	385	259	636	93	330	250	487	296
EKSPRES *Express*	356	389	328	332	142	161	181	176	140	93
MINI *Mini*	11	12	121	18	211	39	24	14	19	13
PEKERJA *Employees*	361	675	255	429	12	431	603	515	506	363
PENGANTARA *Feeder*	-	58	127	66	591	2	7	6	6	44
CATAR *Chartered*	19	378	181	232	12	66	28	9	12	8
SEKOLAH *School*	846	1,423	1,129	1,074	927	853	924	959	881	751
JUMLAH KECIL *Sub Total*	2,133	3,448	2,626	2,410	2,531	1,645	2,097	1,929	2,051	1,568
LORI *Lorry*										
'A'	12,492	14,913	16,152	16,118	14,664	12,992	13,599	13,914	12,584	11,289
'C'	1,746	2,061	2,464	2,614	2,250	2,357	2,987	2,967	2,912	2,645
JUMLAH KECIL *Sub Total*	14,238	16,974	18,616	18,732	16,914	15,349	16,586	16,881	15,496	13,934

Source: Commercial vehicles Licensing Board, SPAD (2016)

Signalized Intersection Scenarios

The effect of intersection features and structures on safety has been examined comprehensively because intersections experience a relatively large amount of motor vehicle conflicts and crashes. Traffic crashes at the urban intersections place an enormous burden on society in terms of injury, death, lost productivity, and property damages. Based on the Fatality Analysis Reporting System (FARS) and National Automotive Sampling System-General Estimates System (NASS-GES) data, in a range of 40% of the estimated 5,338,000 crashes during 2011 in the United States were intersection-related. In this cases relating intersection crashes, about 36% were at signalized intersections. Furthermore, signalized intersections also seem to experience more severe crashes. Injury crashes rate at 33.2% of the

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reported signalized intersection accidents, to be compared rate at 25.2% for non-signalized intersection crashes (Chunjiao, 2014).

Table 2 : Malaysian Accidents Statistics According to Type of Vehicle
Sources: Royal Malaysian Police (PDRM Cawangan Bukit Aman), 2016.

TAHUN *Year*	MOTOSIKAL *Motorcycle*	MOTOKAR *Motocar*	VAN *Van*	BAS *Bus*	LORI *Lorry*	PEMACU 4 RODA *Four Wheel Drive*	TEKSI *Taxi*	BASIKAL *Bicycle*	LAIN-LAIN *Others*	JUMLAH *Total*
2007	111,765	426,941	21,109	10,285	47,696	21,823	8,809	2,690	14,909	**666,027**
2008	111,819	435,665	20,392	9,356	48,250	22,793	8,769	2,463	11,571	**671,078**
2009	113,962	472,307	19,220	9,380	46,724	23,581	8,669	2,486	9,294	**705,623**
2010	120,156	511,861	18,788	9,580	50,438	25,777	9,899	2,178	11,756	**760,433**
2011	129,017	546,702	17,916	9,986	53,078	30,828	11,197	2,033	16,394	**817,151**
2012	130,080	655,813	15,143	10,617	42,158	32,891	11,680	1,310	21,540	**921,232**
2013	121,700	632,602	17,148	10,123	39,276	52,512	11,651	1,370	15,441	**901,823**
2014	125,712	617,578	15,041	9,193	37,481	41,464	10,856	1,275	27,743	**886,343**
2015	123,408	625,758	14,565	8,804	34,942	46,163	9,591	1,119	29,924	**894,274**
2016	135,181	670,935	14,470	9,462	35,064	48,907	8,399	1,318	36,833	**960,569**

Signalized intersections are the common type of junctions found in Malaysia for its expediency in managing traffic flow to and from different methods and approaches. Signalized intersections are not likely to ensure the safety by providing the right way for traffic movement. This is because, the current signalized ability and specification may not promise the safety due to some reasons for example the unsafe signal phasing and traffic violation (Tiwari, Bangdiwala, Saraswat, & Guarav, 2007). To reduce the number of conflicts at intersections and to ensure the traffic safety, intersections are usually equipped with traffic signals. However, inappropriate designed signals facilities, features, and design can unfavorably affect the safety, traffic flow, and mobility (Poders,.et al, 2014). To ensure the placement, design, and operation of traffic signal at intersection is a must. Some cases, the objectives of mobility and safety will be disputed. Intersections are locations that are prone to a crash to occur since they are categorized by many conflicting movements and flow including heavy good vehicle, resulting in difficulty and large variations in interactions towards other

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road users. In all cases, it is vital to understand the degree to which traffic signals are providing safety and mobility for all roadway users. Assuring the well-organized operation of the traffic signal is becoming an imperative issue as many agencies attempt to exploit vehicle roadway capacity to serve the rising demand for travel between HGV and other road users, while preserving a high level of safety. Sinking crashes rates should always be the main objectives whenever the design or operational appearances of a signalized intersection are improved. As stated by the Federal Highway Administration (FHWA, 2014), the "mission is not simply to improve mobility and productivity, but to ensure that improved mobility and productivity come with improved safety".

Driver Behavior Became the Contributor Factor

This is not to say that the fault lies primarily on the heavy vehicles because of the mass and dimension, the drivers' behavior themselves contributed to this factor. A report from traffic Police officer of Mekelle town which is the study area showed that in 2008, there was a total of 313 road traffic accident and crash also in 2009 the total number increased to 353. Besides, the report indicates that 96% of the cases were due to human risk behavior where 4% was because of vehicle breakdown and problem (Mekelle Town Police Commission Office: Report on road traffic accident, 2009). The evidence showed that human behavior is the common factor whereas more than 85% of all traffic crashes (Peden, 2004). Intersections are crash-prone area since they are categorized by many conflicting flow and movements, causing in large variation and difficulty also complexity in interactions between road users (Polders, 2014). Despite the fact is that traffic signals have separate movements in time and space, accidents and crash at these intersections still happened because of road user behavior.

In Malaysia, the rate shows that Malaysia became one of the highest countries contributed to the deadly accident compared to other 17 developed countries. Based on Asian Economic and Social Commission, it showed that the number of a fatal crash has become the highest in the Asia Pacific region for five

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years in a row and even 8 times higher than Finland and Germany (Salleh, 2013). Human factor and behavior have become the dominant factor that contributed 85% to 96% to the road accidents (Sivak, 1980). According to the England Commission (2010), the human error factor has contributed as much as 95% of the road crash. While in Malaysia, 94% of the road accident rate was due to the drivers' behavior and error (Manan, 2012). Therefore, it is proven that driver behavior is the main factor towards road accidents around the globe.

Risk Assessment Model

Risk assessment or risk analysis used for complex system required an investigation of a crash and accident also for its casual factors. Based on the literature, it is found that various kinds of risk assessment tools that are used for road, for example Surrogate Safety Assessment Model, SIDRA Safety Model, Micro Assessment Model also Hazard and Operability Analysis (Hamidun, 2015). Unluckily, intersections is an area that become one of the most complex scenarios out of all traffic related scenarios to measure the risk by using tools or software. This paper requires situation analysis and risk assessment model algorithms which are suitable and accurate for this study. The demonstrator system is needed to examine the intersection scenario and environment with several onboard sensors and to create an appropriate scene model including intentions, behavior and interrelations of Heavy Vehicle also all vehicles in the scene which in this study is signalized intersection. The risk assessment model should be able to forecast the possible individual risks for the vehicle at intersection area.

Petri Nets Software is the Best Model for Risk Assessment

Petri Nets Software is the graphical modelling tool that can be used to assess all complex scenarios of traffic related scenarios. The competence of Petri Nets to capture the complex intersection by their ability to record various timing of isolated events make it very useful to be adopted for traffic network system. Besides, Petri Nets is capable to visualize and analyzed the discrete event system

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behavior using the graphical representation (Dotoli & Fanti, 2006). Signalized intersection became one of the most complex traffic events because of too many conflicting movements including heavy goods vehicle, resulting in difficulty and complexity and huge variations of interactions between other road users. Petri Nets has been adopted and proven as the best tools for modeling the control optimization algorithm for traffic light durations at signalized intersection where the number of vehicles can be counted by using induction loops and represented as an input parameter (Febbraro & Giglio, 2005).

Result and Discussion

Based on study in the literature, the safety of heavy trucks is the main idea and to be concerned because of the vast growth of the truck industry not only in Malaysia also around the globe and these associated to high fatal-crash rates. As heavy vehicle transportation industries growth rapidly within Malaysia, crash rates and cases among heavy vehicle remain high, and the risk of fatality and injury continues to expend to all road users. Road traffic injuries became the ninth most common cause of death while WHO expected that by 2030, they would become the fifth most common cases (World Health Organization 2009). Over 1.2 million people die on the road every year, with 20 to 50 million sorrows from non-fatal injuries. Malaysia is one of the most developing country, has recognized road safety as a crucial problem that should be taken a serious action. In addition, it is proven on literature study that driver behavior became one of the biggest contributor factor toward this problem and not lies primarily with the heavy vehicles. Most of the sources found in the literature noted that human behavior is the main factor resulting more than 85% of all traffic crash and accidents especially at the most complex event on road which is at signalized intersection.

This study sets out to understand the heavy vehicle drivers' behavior during their drive through signalized intersection and also to assess the risk using Petri Nets modelling software. Interestingly, this study does not only focus on HGV, but the possible impact towards other road users since intersections are

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crash prone locations and they are categorized by many conflicting movements including heavy goods vehicle, resulting in dificullties and large variations in interactions between other road users. Some elements will be examined such as the effects of signal timing, truck braking time, driver response time, truck acceleration time and some other factors. This research also sets out to provide crucial information to be combined into new versions of the geometric and traffic control guidelines especially for signalized intersection for heavy vehicles' safety in Malaysia. The improvement in terms of safety at signalized intersection can be achieved through the simulation and visual modelling based on the various risk assessment patterns at intersection using Petri Nets software. Providing proper amenities for HGV drivers' safety may help the government improvise the existing guidelines of "Occupational Safety and Health of Practice for Road Transport" that are provided by Ministry of Human Resource Malaysia over various aspects in Heavy vehicle operation.

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