A COMPARATIVE ACCIDENT ANALYSIS MODEL ON 2013 GENTING HIGHLAND BUS CRASH AT GENTING HIGHLAND – KUALA LUMPUR ROAD USING SELECTED SYSTEMIC ACCIDENT MODELS

BY

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ABSTRACT

Road traffic accidents are increasingly recognised as a serious public health concern. Each year road traffic accidents cause 1.2 million deaths worldwide and the number is expected to increase by 65 percent in 20 years. One of the challenges to solving this issue is that many accident investigation studies employed methods that gave less emphasis on systemic factors of road traffic accidents such as enforcement and government policies but rely on a direct cause-effect chain to analyse an accident causation process. By contrast, more contemporary approaches of investigating accidents are based on systemic accident models that can be used to analyse the interactions between various components of a sociotechnical system. Different systemic accident models, however, can lead to different analyses and subsequently different conclusions. As such, this study sought to compare three different systemic accident models, namely, the Driving Reliability and Error Analysis Method (DREAM), System-Theoretic Accident Model and Process (STAMP), and AcciMap in analysing the accident causation process of the 2013 Genting Highlands Bus Crash, which was the deadliest road traffic accident in Malaysia. Using DREAM, this study found that most of the contributing factors originated from maintenance errors and road design issues. On the other hand, STAMP identified inadequate controls and flaws within the road transportation system as contributing factors while AcciMap indicated various direct and indirect factors across different levels within the system. Findings of this study suggest that DREAM can present the accident factors in a succinct graphical representation by using a classification system thus making it easy to carry out and simple to understand. In addition, although both AcciMap and STAMP analyse road traffic accident across different system levels, STAMP is more comprehensive and flexible. However, because STAMP is time consuming and complex, it is more suitable for analysing major road traffic accidents.

خلاصة البحث

تعتبر حوادث المرور مصدر قلق على الصحة العامة بصورة متزايد في جميع أنحاء العالم حيث يبلغ عدد الوفيات حوالي 1.2 مليون نسمة في السنة، ومن المتوقع أن يزداد بنسبة 65٪ خلال 20 عامًا القادمة . ومع ذلك فإن أحد التحديات في حل هذه المشكلة هو محاولة العديد من الدراسات لتحديد العوامل الرئيسية لحوادث المرور ولكن باهتمام ضئيل،من ضمنها العوامل النظامية لحوادث المرور مثل التفاعل بين بيئة الطريق وتطبيق القوانين والسياسات الحكومية، والت تؤدي إلى تسبيب الحوادث كسلسلة مباشرة من الأسباب والآثار .ونتيجة لذلك تم تطوير طريقة حديث للتحقيق في حوادث المرور لتحليل التفاعل بين مختلف المكونات المتعددة لهذا النظام الاجتماعي التقني .هذه الطريقة الحديثة لها القدرة على تحليل الحوادث من أوجه مختلفة، وقد أجريت دراسات لتحديد ما إذا كانت هذه الأوجه تحدد نفس عوامل الحادث .ولذلك سعت هذه الدراسة إلى تحليل العمليات التي تسبيب الحوادث المرورية الكبير باستخدام ،(DREAM) ثلاثة نماذج لحوادث نظامية مختلفة وهي :الطريقة الموثوقية للقيادة وتحليل الأخطاء كانت دراسة الحالة .ACCIMAP و ،(STAMP) نموذج وعملية نظريات النظام للحوادث المستخدمة هي حادثة تحطم حافلة مرتفعات جنتنج في عام 2013، والذي يعد أكثر الحوادث المرورية تستخدم نظام تصنيف لتحديد العوامل المساهمة DREAM دموية في ماليزيا .ووجدت الدراسة أن في الحوادث كالتي تنتج بسبب أخطاء في الصيانة ومشكلات في تصميم الطريق .من ناحية أخرى حدد عدم كفاية السيطرة والعيوب داخل نظام النقل البري كالتي ساهمت في حادثة الحافلة . STAMP إلى أن أن الحوادث تقع بسبب عوامل مختلفة مباشرة ACCIMAP على النقيض من ذلك أشار قادر DREAM وغير مباشرة عبر مستويات مختلفة داخل النظام.تشير نتائج هذه الدراسة إلى أن على بيان عوامل الحادث في تمثيل رسومي موجز باستخدام نظام تصنيف، مما سهّل تنفيذه وبسّط فهمه . بتحليل STAMP و ACCIMAP بالإضافة إلى ذلك على فعلى فبالرغم من قيام كل من أكثر شمولية ومرونة .ومع ذلك اعتبر STAMP حوادث المرور على مستويات مختلفة من النظام، كان مناسبا أكثر لتحليل الحوادث المرورية الكبيرة لأنها معقدة وتستغرق وقتا طويلا STAMP

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Health Sciences

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I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Concern on the road traffic accident dates many decades since the early invention of motorised cars as a mode of transportation. The first recorded road traffic accident was tracked back to 1771 in France which involve a steam-powered vehicle (Vivoda and Eby, 2011). Though no one was injured or killed, it set up the issues of road traffic accident. Decades after, road traffic accident found its first road traffic fatality in 1869 at Irish Midland. This time, a respected astronomer and microscopist, Mary Ward fall off from the vehicle when the steam vehicle took a turn on a street corner (Fallon and O'Neill, 2005). Since then, the numbers of road traffic accident increase, whether in terms of the severity of the accident, number of passengers involved, and in the numbers of vehicles involved with crash from hundred to millions in numbers (World Health Organisation [WHO], 2015). In addition, the current state of the road traffic accident become worsen as it is estimated that 50 million people are injured due to road traffic accident with 1.2 million deaths per year are associated with road traffic accidents (Peden *et al*., 2004). The numbers are not going to stop; it is estimated that by 2020, half of the global injuries and deaths are causes by road traffic accident (WHO, 2015).

The increasing trend in road traffic accident are found probably to be associated with the increasing advancement of technology on the transportation sector. While the earlier mode of transportation for human civilisation were simple by using animal-powered transport, it has now become motorised, replacing the traditional

animal transportation method (Eckermann, 2001). The technology advancement on motorised vehicle at the moment does not showing any sign that it is going to stop. Although the advancement of technology in transportation sector is going to help human to reach farther destination in short period of time, the task of driving however required various input of information and understanding. This information and understanding not only limited to the interaction between driver and the vehicle but also consider the surrounding environment as well (Regan *et al*., 2008). For example, a driver may need to aware with the weather condition, road condition, traffic conditions, and the activity of other road users while at the same time have to remain a safe driving process. Considering that driving is a both physical and mental process (Anstey *et al*., 2005), this create a complexity in the driving process as more elements need to be considered while driving. Thus, due to this complexity, there is more factors of road traffic accident being exposed to the driver, hence increasing the risk of road traffic accident (Larsson *et al*., 2010).

Hence, under those circumstances, road traffic accident at the modern world has no longer associated with the simple cause and effect as seen with first recorded road traffic accident. In the accident, the first ever motorised vehicle was speeding at recorded 2 miles per hour before it hit a wall. It was believed that the cause of the crash is due to speeding (Vivoda and Eby, 2011). Although, the speeding was considered as too slow for the current speed standard of the modern wold, the accident still occurs and damaging the vehicle. This show that road traffic accident can happen anytime and at any moment, even though some factors seems to be illogical for the road traffic accident to occur.

The causes of the road traffic accident were later then varied as seen in the case of Mary Ward. The speed is not a cause in this road traffic accident, but rather the jolted vehicle when turning around the corner is what cause the accident (Fallon and O'Neill, 2005). Returning to the modern world, speed and road corner incident are still associated with the causes of road traffic accident, but the causes has become more diverse and no longer associated with only the vehicle and the road condition. For example, causes of the road traffic accident has now been associated with the factors from pedestrian, human factors, environment factors, time factors, distraction while driving, and driving under influence of drugs and alcoholic drinks (Beshah and Hill, 2010; Mishra *et* al., 2010; Zhang *et al*., 2013; WHO, 2015).

Interestingly, there is also evidence that technology, organisation factors, and inadequate enforcement of regulations and guidelines contribute to the road traffic accidents (Salmon and Lenne, 2009; Habibovic *et al*., 2013; Thomas *et al*., 2013; WHO, 2013; WHO, 2015). With this in mind, it reflects on how the transportation sector of had changed throughout time since the first road traffic accident in 1771 France where there are many factors that are associated with either contributing to road traffic accident or minimise the impact, depending on how it was used (Vivoda and Eby, 2011). For example, a normal driver will have to handle out the vehicle user interface, pressing and depressing the pedal to drive or brake, and gear shifting. At the same time, a driver would also require a legal driving license in order to drive the vehicle where various road safety regulations, including road signs, road conditions that are needed to be understood. Occasionally, certain driver will need assistant from the Global Positioning System (GPS) which are made available from smartphone technology (Jensen *et al*., 2010). Considering all this, multiples activities were incorporated to the driving activities in order to aid the driving process of the driver.

All these, will increase the number of factors associated with road traffic accident (Peden *et al*., 2004). Technology and modernisation is to help people in their daily life, but the risks and factors of road traffic accident also rises in parallel.

Although extensive research has been carried out to solve the issues with road traffic accident, identifying the root cause remain the focus of solving the road traffic accident. The purpose of identifying the root cause for road traffic is to eliminate the cause in hope that the similar road traffic accident would not occur in the future (Thomas *et al*., 2013). However, this may cause other factors to be overlooked. Instead, the outcome of the investigated road traffic accident will justify that the root cause identified is the main cause of the road traffic accident. Because of that, this create an oversimplification of the accident factors thus lead to blaming culture (Leveson, 2011). This will often, lead the person, or the group of people involved with the road traffic accident being put into blame. Issues of hindsight bias could also influence the finding for the cause of road traffic accident (Leveson, 2012). For this reason, to solve the problems with the road traffic accident, the accident should be perceived to be originated from multiple interaction of factors for road traffic accident (Qureshi, 2007). By using this concept, analysing the accident, the road traffic accident will able to present that it does not occur from a single cause, thus the right approach to prevent similar road traffic accident could be achieved.

Considering that the factors of road traffic accident had become diverse, it is also worth to note that the number of road user had increased too. There are two types of road user that are associated with the road traffic accidents. The first is the non-motorised vehicle road user such as cyclist and the pedestrians. The second is the motorised vehicle road users. The second types could be classified into private motorised transport such as personal car and personal motorcycle while the second is

and the public motorised transport (Eckermann, 2001). such as buses and taxis. Despite the essentiality of these motorised transport to make transportation easier, road traffic accident involving with these transport cause a great accident cost such as the medical costs, legal costs, and the property costs eventhough the private transport cause a lesser cost than private transport (Jakob *et al*., 2006).However, this is only applicable to high-income countries as low and middle income countries frequently surround with various problems even though the public transport was considered as very safe and a better approach to reduce road traffic accident (Peden *et al*., 2004; Chimba *et al*., 2010; WHO, 2013). Poor regulations, poor law enforcement, and struggle with economic funding to provide a safe public motorised transport is always issues to these countries (WHO, 2013).

1.2 STATEMENT OF THE PROBLEM

Bus, one of the public motorised transport always found as a preferred choice of transport despite any inefficiencies for instance, bus may experience poor service quality particularly on the system configurations and the engineering services (Govender, 2014). In addition, due to this, road traffic accident involving bus such as side-swipe accident, rear end bus accident, bus-to-bus accident and roll-over accident are found to be common particularly due to the weakness of the roof strengths and the structural integrity of the bus body (Rahman *et al*., 2011; Li *et al*., 2012; Goh *et al*., 2014). Considering that bus carry more passengers for land public transport than any other motorised transport, any accident involving bus would cause more injuries and fatalities (Kareem, 2003; Chu, 2014). As previously mentioned, the problem with public motorised transport are often found on low and middle-income countries (Peden *et al*., 2004). As a middle-income country, the same issues were also faced by

Malaysia on the public motorised transport involving bus (Rahman *et al*., 2011; The World Bank, 2017). Despite the number of registered bus and number of accident related to bus was considered as low in Malaysia, the severity of the road traffic accident should not be neglected (Rahman *et al*., 2011; WHO, 2013). Often, road traffic accident in Malaysia involving busses will become a public attention due to its rare occurrence but with severe impact (Solah *et al*., 2013). For many years, road traffic accident involving bus in Malaysia always associated with many injuries and fatalities such as the 1996 Genting Highland Bus Crash with 17 casualties (Aini *et al*., 2001), 2007 Bus Accident with 22 casualties, 2011 Genting Bus Disaster (Aini and Fakhru'l, 2013), 2013 Genting Bus Crash (Ministry of Transport, 2014), 2016 Genting -Kl Bus Crash (Channel News Asia, 2016), and 2016 Pagoh Bus Crash (Astro Awani, 2016). Interestingly, based on the previously mentioned cases, express bus service was mostly associated with the bus accident in Malaysia. In addition, bus accident with high number of casualties often occurs at the Genting Highland road. At the moment, the highest number of causalities regarding bus accident was recorded in the 2013 Genting Highland Bus Crash (referred as 2013 Genting Crash afterwards) with 37 passengers are dead including the driver. 16 passengers were badly injured. The bus itself fall into the ravine on the scene of the accident. It was considered as the worst ever road traffic accident involving bus in Malaysia to date (Ministry of Transport, 2014). The finding of the accident reveal various factors of the accident with speeding was selected as the main cause. The finding, however, present each of the factors as an individual outcome rather than considering it as a system entity. Thus, the causal relationship between the factors and the system component of the 2013 Genting Crash could not be established hence limited the explanation of non-linear complexity of the socio-technical system of the road traffic accident (Underwood and Waterson, 2013).

In addition, this miss out the opportunity to learn important lesson from the system safety point of view of road traffic accident as interactions between the system component were not considered.

1.3 PURPOSE OF THE STUDY

This research sought to identify the causes of the road traffic accident from the concept of systems theory by using the systemic accident analysis model. The system theory is defined as the laws, principles, and model that are in need in order for the complex interactions and the interdependencies of the system component to work in a complex system (Fan *et al*., 2015). Hence, a better approach that can consider all this to describe the accident causation process using this concept is by using the systemic accident analysis model. The study focused on analysing the accident of the 2013 Genting Bus Crash. The crash attracts a lot of public attention and cause an inquiry is made to investigate in depth the cause of the accident (Ministry of Transport, 2014). The official inquiry report makes details on the reason for the 2013 Genting Crash, but lack of emphasis was given on how the factors of the accident interact with each other and cause the accident. Indeed, the factors and causes of the accident are presented in the report, however systemic accident analysis model will able to present the accident in a systematic approach and able to provide alternate recommendation option to prevent similar occurrence of accident in the future. In this study, three different systemic accident analysis models are used to analyse the accident. The systemic accident analysis model used in this study are Driving Reliability and Error Analysis Model (DREAM), Systems-Theoretic Accident Model and Process (STAMP), and AcciMap (Warner *et al*., 2008; Leveson, 2012; Branford *et al*., 2009). Each of the systemic accident analysis model being used in this study will focus on different

aspect of the accident, thus providing different recommendations (Katsakiori *et al*., 2009) particularly on the system safety for improving the road safety in Malaysia.

1.4 RESEARCH OBJECTIVES

The study aimed to achieve the following objectives:

1- To analyse the causes of the 2013 Genting Crash through the systemic accident analysis models known as DREAM by analysing the accident on the causal relationship between the critical events and the contributing factors of the accident.

2- To analyse the causes of the 2013 Genting Crash through the systemic accident analysis model known as STAMP by analysing the accident on the violation of system safety constraints and the inadequate controls enforce on the sociotechnical system of the road safety domain.

3- To analyse the causes of the 2013 Genting Crash through the systemic accident analysis model known as AcciMap by analysing the accident on the combination of causal factors of the accident across the organisational work level of the road safety system.

4- To compare the outcome of DREAM, STAMP, and AcciMap on the 2013 Genting Crash by comparing certain characteristic of the systemic accident analysis models including the graphical presentation, the sequences of accident, the domain of use, the levels of detail and analysis, and the usability of the systemic accident analysis model.