Mapping of Blackspots Accident Area at North South Expressway to Produce Expressway Advisory System

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Abstract. The study was carried out to produce an advisory system based on the blackspot accidents mapping at the North-South Expressway (NSE). Blackspots are location where the road traffic crashes have historically concentrated by type of accident in which the accident caused fatalities, severe injuries, minor injuries and damage. This research aims to identify accident blackspot and plotting accident data into a digital map of the study area to produce advisory systems for highway users. The software used in this study namely Google Earth Pro, ArcMap and ArcGIS online. Results showed that blackspot location are known in the form of mapping where it can be performed online. In addition, the path with high number of accident points weightage location were identified and prioritized. By applying Google Earth Pro and ArcGIS software, the advisory system was created, and these blackspot locations can also be easily accessed by highway users. Therefore, the advisory system helps in facilitate the users for trip planning base on the accident status locations as a precautionary measure and initiative to reduce the rate of road accident in expressway.

1. Introduction
This paper will present about an advice system where can locate accident blackspots area along North-South Expressway (NSE). From this study, people can determine the location of blackspots area. In this era of globalization, the transportation system has become an important element for a country to compete with other developed and developing countries. However, the increasing number of vehicles due to increasing the demand for central business and economic activities [1]. The expressway is a necessity for the inhabitants of the world as it connects cities with cities and between rural and urban areas. Furthermore, the scope of this research study covers the entire North-South Expressway with an overall length of 772 kilometres. The North-South Expressway connects the north and south of the Malaysian peninsula across eight states connecting major cities to the west of the Malaysian peninsula. At an altitude of 772 kilometres, the highway is considered the longest highway in Malaysia. The study area ranges from Bukit Kayu Hitam, Kedah to Johor Bharu, Johor. With the rapid development of the transportation system, apart from contributing to the positive, it can also contribute to the negative such as road accidents. Also, there are many factors that affect traffic accident. According to Soehodho [2], traffic accidents are usually caused by three different types of factors namely human factors, vehicle factors and external factors including roads. Human factors have the strongest influence, which is agreed by worldwide country. This can be also attributed to a study by Malaysian
Institute of Road Safety Research (MIROS) which believes that human negligence is the biggest contributor leading to 86.0% of accidents in Malaysia [3].

Shafabakhsh et. al. [4] says generally, road accident statistics have been considered as an index of evaluation to assess the probability of road traffic accidents. Refer to statistics of road accidents by the Royal Malaysian Police (PDRM) in 2017 shows in table 1 and figure 1, found over a period of 20 years, from 1997 to 2016, a total of 7,164,210 road accident cases were reported throughout Malaysia with a total of 128,279 fatal accident cases. From the total number of accidents reported, an average of 358,211 road accidents occur each year while the average road accident rate in the country is 981 cases per day. To be more relevant with this study, accident statistic comparison line graph of Malaysia and the expressways under the supervision of the PLUS Expressways Berhad are shown in figure 2. The line graph illustrates the total number of accidents from 2013 to 2018. The lowest number of accidents happened in PLUS expressways was in 2013 and the number of accidents is 11,052 over 477,204 in Malaysia with the percentage of 2.4%. While the critical point for these six years was in 2015 with the number of accidents in PLUS expressways is 14,210 over 489,606 in Malaysia and the percentage is 2.9%. This clearly shows that the number of road accidents in Malaysia is increasing every year as the network of roads and vehicles increases.

Table 1. Accident statistics in Malaysia.

| Year | Total Road Crashes | Road Deaths | Serious Injury | Slight Injury | Damage |
|------|--------------------|-------------|----------------|---------------|--------|
| 1997 | 215,632            | 6,302       | 14,105         | 36,167        | 159,058|
| 1998 | 211,037            | 5,740       | 12,068         | 37,896        | 155,333|
| 1999 | 223,166            | 5,794       | 10,366         | 36,777        | 170,229|
| 2000 | 250,429            | 6,035       | 9,790          | 34,375        | 200,229|
| 2001 | 265,175            | 5,849       | 8,680          | 35,944        | 214,702|
| 2002 | 279,711            | 5,891       | 8,425          | 35,236        | 230,159|
| 2003 | 298,653            | 6,286       | 9,040          | 37,415        | 245,912|
| 2004 | 326,815            | 6,228       | 9,218          | 38,645        | 272,724|
| 2005 | 328,264            | 6,200       | 9,395          | 31,417        | 281,252|
| 2006 | 341,252            | 6,287       | 9,253          | 19,885        | 305,827|
| 2007 | 363,319            | 6,282       | 9,273          | 18,444        | 329,320|
| 2008 | 373,071            | 6,527       | 8,868          | 16,879        | 340,797|
| 2009 | 397,330            | 6,745       | 8,849          | 15,823        | 365,913|
| 2010 | 414,421            | 6,872       | 7,781          | 13,616        | 386,152|
| 2011 | 449,040            | 6,877       | 6,328          | 12,365        | 423,470|
| 2012 | 462,423            | 6,917       | 5,868          | 11,654        | 437,984|
| 2013 | 477,204            | 6,915       | 4,597          | 8,388         | 457,304|
| 2014 | 476,196            | 6,674       | 4,432          | 8,598         | 456,492|
| 2015 | 489,606            | 6,706       | 4,120          | 7,432         | 471,348|
| 2016 | 521,466            | 7,152       | 4,506          | 7,415         | 502,393|
Figure 1. Accident statistics in Malaysia.

Figure 2. Accident statistics in Malaysia and NSE.

Accident blackspot or blackspot area is a place with high concentration of accident historical. Wen Cheng and Simon [5] defined the blackspot as a problematic location of the transport system and impacted by the frequency of accidents related elsewhere. In other words, accidents can be observed in both places that are safe and unsafe. In Malaysia, the introduction of blackspots has been practiced since the early 1990s. The identification process was simplified in 1992 when the Royal Malaysian Police (PDRM) began using a standard form called POL 27 to collect accident information. In 1998, guidelines for identifying blackspots and road safety measures were introduced by the Malaysian Road...
Engineering Association (REAM) and the Department of Public Works [6]. The guidelines state that blackspots can be a site, street section or phenomenon throughout the area. The traditional approach for identifying blackspot locations is to identify sites with higher than average accidents [7]. Therefore, an advisory system has been put in place to facilitate the expressway users. To perform this advisory system to locate blackspots area along the NSE, researcher using Geographical Information System (GIS). GIS is a technology for the creation, representation, management, search, analysis and sharing of geospatial information. GIS manages data in movies called layers. Layers consist of position information and attribute information.

2. Methodology
The North-South Expressway is divided into two sections E1 and E2 where E1 refers to the northern route while E2 refers to the southern route [8]. The E1 expressway begins at the Bukit Kayu Hitam checkpoint in Kedah and ends at Bukit Lanjan in Selangor while the E2 expressway begins at Sungai Besi checkpoint in Kuala Lumpur and ends at Pandan in Johor Bahru for kilometre Zero (also written KM 0). The NSE route map of E1 and E2 are shown in figure 3.

![Figure 3. North-South Expressway route.](image)

The Malaysian Highway Authority has given the accident data for all type of vehicles with their accident severity that is fatalities, severe injuries, minor injuries, and damage only. As such, the data obtained has been processed in Microsoft Excel and applying ranking by accident point to identify the location of the blackspots area. According to the Malaysian Highway Authority's annual report in...
2018, blackspots area can be identified by the type of accident in table 2. The total weightage points above 15 points will be defined as accidents blackspots area.

| Type of accident | Point |
|------------------|-------|
| Fatalities       | 6     |
| Severe injuries  | 4     |
| Minor injuries   | 2     |
| Damage only      | 1     |

This procedure that required information to provide decision makers in order to prevent and reduce road accidents. The process by which data obtained from Microsoft Excel is summarized as a point for all accidental blackspot locations within the Google Earth Pro application based on latitude and longitude. At this stage, data management is very important because if there is a slight error it will affect the results of the data. The data will be stored in the file '.kmz' before transferring the data into the system.

Google Earth Pro software is created by google company which is a map showing application that can identify the location directly. The feature of this software is generating live location points and the image are rasterized in high resolution. From this software, researchers can create files offline and secure way to share information with other users. Using this software, researchers were able to plot blackspot accident locations along the NSE. Figure 4 shows display of study area which is located at North-South Expressway (NSE).
ArcGlobe is to show 3D maps to the world that can connect to the internet. Next, ArcScene is capable of processing and displaying maps in 3D. The last application is ArcToolbox, which is a collection of various tools for analyzing space.

Using ArcGIS software researchers can arrange the location of the data in this software based on data provided by the Malaysian Highway Authority. Figure 5 shows display of study area in ArcMap.

![Figure 5. Display of study area in ArcMap.](image)

3. Results and discussion

This study only uses blackspot area data to show the historically concentrated of prone areas. The accident data given by Malaysian Highway Authority are occurred in North-South Expressway from 2017 to 2019. The total number of weightage points for blackspot area for these three years was 2161. Of these, fatal accidents accounted for 186 points, equivalent to 8.6%, 856 (39.6%) were from serious accidents, 342 (15.8%) were from minor accidents and 777 (36.0%) were from broken or damage accidents. The objective of the researcher has been achieved by plotting accident data showing the blackspot location along the NSE.

Based on the total number of weightage points from 2017 to 2019, E1 area has the highest total number of weightage points at kilometres 257 (KM 257.0) to kilometres 443.8 (KM 443.8) for northwards and at kilometres 399.4 (KM 399.4) to kilometres 460 (KM 460.0) for southwards. At E2, the highest total number of weightage points at kilometres 250 (KM 250.0) to kilometres 310.1 (KM 310.1) in both directions. This shows highway users to be more careful when dealing with this blackspot locations route.

Figure 6 shows the total number of points across three years from 2017 to 2019. For northwards, it is found that 467 points (21.61%) percent are in E1 and 586 points (27.12%) percent are in E2. While for southwards, 654 points (30.26%) percent are in the E1 and 454 (21.01%) percent are in the E2. Thus, the bar chart illustrates that the southward has highest weightage for E1, but it is different for E2 because the highest weightage is northward.
Figure 6. Total weightage from 2017 to 2019.

Figure 7 shows the total number of weightage points from 2017 to 2019 in kilometre post on the E1 section of the North-South Expressway. It shows that the highest point on the northwards was KM443.8 (46) points while the number of points on the southwards was KM446.5 (60) points. This result is in line with Shariff et al [11], where the highest frequency of accidents of E1 section happen between Tanjung Malim (KM 400) to Bukit Lanjan (KM 460) with highest number of blackspot locations. This shows that number of accidents influence in number of blackspot locations.

Figure 8 shows the total number of weightage points based on the years from 2017 to 2019 in kilometre post on the E2 section of the North-South Expressway. It was found that the highest point on the northwards was KM296.5 (96) points while the number of points on the southwards was KM267.2 (80) points. This finding also matched with Manap et al [8], where the highest number of accidents between this locations which normally occurred at interchange, exit ramp, slip road, rest area or lay by area.
Figure 8. Total weightage points at E2.

Table 3. Total weightage at North-South Expressway.

| Total weightage | Fatal | Severe Injury | Slightly Injury | Broken/damage |
|-----------------|-------|---------------|-----------------|---------------|
| 2161            | 186   | 856           | 342             | 777           |

As shown in table 3, the NSE obtained accident data of 2017 to 2019 has the highest point of weightage for severe injury of 856 points, followed by 777 points, 342 points and 186 points with damage, slightly injury and fatal, respectively. Therefore, the severe injury types have the effect of the density of total weightage points of the NSE.

The figure 9 shows that the findings of this study, where the total number of accidents blackspot location was 82 locations with 2161 of weightage points. This data has covered up a total of 1194 accidents. The closer the distance of each point showing the critical area of accidents location with the highest tendency for accidents to happen at the locations.

Output and rendering are the ultimate GIS function that enables data to be displayed for reporting and visualization purposes. Based on Dereli and Erdogan [12], GIS also used as provision of road safety especially in determine blackspot of accidents, road defects, and the necessary road improvements. Researchers use ArcGIS online where the resulting data can be displayed in their respective device.

This advisory system was created using the ArcGIS online website. The mapping data within ArcMap must be shared first before it can be uploaded to the ArcGIS online website. After doing some editing, the maps that researchers produce can be shared with the public. Figure 10 shows the QR code generated and accessible to the public with a mobile device and other device. Besides, figure 11 and figure 12 show the displays feature by using monitor and device.

In addition to generating the QR code, researchers also provided a link to display a map of the blackspot locations of the North-South expressway.

https://gisukm.maps.arcgis.com/apps/webappviewer/index.html?id=46779fa265aa46a791708ae467720604
Figure 9. Map of blackspots location.

Figure 10. QR code.

Figure 11. The displays on monitor.
Figure 12. The displays on device

The public can view the accident data and the amount of weightage points by pressing the accident location. The advisory system can be in-vehicle warning system that improves driver behaviour over time [13]. Thus, this advisory system helps in facilitate the users for trip planning base on the accident status locations as a precautionary measure and initiative to reduce the rate of road accident in expressway.

The organized identification, analysis, and precaution of hazardous blackspot locations are the best answer in reducing road accident and fatality rates in Malaysia. In order to create a sustainable transportation system, Malaysia must low in rates and causes due to traffic accidents and fatalities especially from motor vehicle accidents [14]. Research has shown that identification hazardous road or blackspot locations by means of the GIS and advisory system approach gives more reliable results for expressway users.

4. Conclusion
In this study, the GIS system was used to mark the location of the accidents blackspots area along the North-South Expressway with a length of 772 kilometres. Once the mapping is ready in ArcMap then the advisory system can be launched through the online ArcGIS website. This advisory system is accessible to everyone who owns a mobile device and also other device. Therefore, the expressway users can identify accident blackspot locations.

In addition, the result was found the total number of accident blackspot locations was 82 locations and a total of 2161 weightage points. This data has a total number of 1194 of accidents. This study also conclude that the higher frequency of traffic accident is not that mean that area labelled as blackspots area without considering the accident weightage. Further analysis can be done to determine the factor that affected accident at blackspots area with labelling the area by density of accidents weightage.

5. References

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