Proceedings of the Eastern Asia Society for Transportation Studies, Vol.12,2019

The Feasibility Study of Determining Blackspots

Ganjargal OSORKHUU[a], Naranbaatar ERDENESUREN, Sarantuya SANGIJANTSAN, Lhagvasuren BAVUUDORJ, Bayarsaikhan BAYASGALAN [b*],

[a] *School of Civil Architecture, MUST,Ulaanbaatar 14191, Mongolia;*
E-mail: ujkaus@yahoo.com
[b*] *School of Mechanical Engineering and Transportation, Mongolian University of Science and Technology (MUST), Ulaanbaatar 36, Mongolia;*
[b*]*E-mail: bayas.bayar@must.edu.mn,*

Abstract: One way of reducing traffic accidents and cases is to identify the hazardous spots or "black spots" of the road traffic accidents which are occurred frequently and to determine causes of the incidents to eliminate them. The hazardous spot or "black spot" is said that the road sections having high risks where traffic accidents are occurred many times (Statistics about traffic accidents in Mongolia, 2018; Geurts and Wets, 2012; Karl-Olov *et al.*, 2001). It is possible to define a correlation between numbers of traffic accidents on the black spots and their factors which influenced on traffic accidents occurred frequently on those road sections. Aim of this paper is develop some methods how to define some factors of Driver-Vehicle-Road-Environment system, determine the "black spots" by traffic intensities, accident rates on the intersections and traffic rows which are influenced on the traffic accidents.

Keywords: Black spots, Traffic accidents, Safety of traffic patterns, Accident rates

1. INTRODUCTION

The total population of Mongolia in 2017 was 3.2 million, increased by 1.0 million or 47.6 percent compared with year of the 1990. Territory of Mongolia is 1564.1 thousand square kilometers. In 2017, the population density was 2.0 persons per square kilometer on the national level, while it is 311.3 persons per square kilometer in UB city. In Mongolia, the number of vehicles was increased by 6.5 times in 2000-2017, 212.2 million passengers were ridden by vehicles in 2017counted more than once increased by 2.4 times or 123.8 passengers comparing to 2000 so that it is impossible to reach to above the growth by coordinating traffic and engineering movements (Current situations of traffic accidents, 2017). On March 2017, 244 indicators were defined by the 48th Session of the United Nations Commission of Statistics to assess Implementation of the Sustainable Development objectives and death rates caused by traffic accidents were risen by 16.4 % throughout the country per 100 000 population, it was increased by 0.6 comparing to previous years (Statistics about traffic accidents in Mongolia, 2018). According to the information of the World Health Organization (https://unstats.un.org/unsd/statcom/48th-session/documents/; Health Static Index 2012-2015, 2016; Information Brochure of Preventing Roadside Accidents and Injures, 2010), Mongolia has been ranked the 75th place out of 183 countries with mortality rates per 100,000 people.

1.1 Analyses of Traffic Accidents in Mongolia

In Mongolia, 507 people were died because of traffic accidents in 2017. 77.9% of those people were died on the local roads (Statistics about traffic accidents in Mongolia, 2018). In addition, 42.1% of the traffic accidents referred to the speed over, 41.0 % of traffic accidents which were caused by driven cars when they used alcohol on the local roads. Developing methods for determining the black spots, study some factors of Driver-Vehicle-Road-Environment system which are influenced on forming "black spot" frequencies of traffic accidents are significant for Safety of Traffic Patterns to take some urgent measures on time and eliminate them. The core reason of the huge jump is number of fleet has been increased. Due to the increased number of vehicles number of accident is increased.

Table 1. Key indicators of the traffic accident in Mongolia

Years	Traffic Accidents	Ups/downs (%)	Damages	Ups/Downs (%)	Deaths	Ups/Downs (%)
1990*			609		272	
1995**	3259		865	42.0	294	8.1
2000	5991	83.8	1619	87.2	338	15.0
2005	5042	-15.8	1046	-35.4	355	5.0
2010	8809	74.7	933	-10.8	320	-9.9
2015	45161	412.7	1382	48.1	429	34.1
2017	36591	-19.0	4712	241.0	507	18.2

*in 1990, no registration; **- 1997 year's data;

The table 1 shows the main impacts of Traffic Accidents in the Traffic Accidents relative indicators referred to the deaths per 100 traffic accidents and the traffic accidents per 10000 vehicles, and the table 2 shows the victims per 10000 people. Consequences of the traffic accidents or 30 deaths from 100 victims; 5 deaths per 100 traffic accidents; 440 traffic accidents per 10000 vehicles; 62 victims per 100000 people are shown in the table 2.

Table 2. Relative Indicator of traffic accident in Mongolia

Years	Consequences of the traffic accidents	The number of deaths per 100 traffic accidents	The number of traffic accidents per 10000 vehicles	The number of victims 100000 people
1990*	44.7			
1995*	34.0	9.0	541.3	38.6
2000	20.9	5.6	505.9	67.4
2005	33.9	7.0	306.3	41.0
2010	34.3	3.6	308.7	33.8
2015	31.0	0.9	571.9	45.2
2017	10.8	1.4	406.5	148.3
Mean value	30	5	440	62

In the table 2 we have covered from 1990 to 2017 and consequence of the traffic accident and the number of deaths per 100 traffic accidents are trends to decrease. However, the number of traffic accidents per 10000 vehicles is relatively constant, and the number of victims 100000 people is trends to increase.

1.2 Reasons of the Traffic Accidents

In Mongolia, 97.5% of the traffic accidents were registered in 2017 because of drivers' faults, 2.4 % of them based on pedestrians' wrong acts, 0.1% of them caused by road conditions increased by 0.2 due to driver's faults and decreased by 0.2 referred to pedestrians' wrong acts comparing to previous years and rates of traffic accidents caused by road conditions remained as same as previous (Statistics about traffic accidents in Mongolia, 2018).

Table 3. Traffic Accidents registered based on drivers' faults

Ulaanbaatar (Urban) Areas	Rural (Local) Areas
Did not adapt side lane spaces -48.6%	Participated in traffic without attentions- 0.2%
Did not follow the rules of accessing intersections -16.5%	Did not take stops - 16.3%
Placed on the wrong rows- 16.5%	Did not adapt side lane spaces -9.9%
Reverse actions were incomplete -8.3%	Speed limit over-9.1%
Did not take stops -2.1%	Reverse actions were incomplete -9.0%
Participated in traffic without attentions-2.0%	Drove Vehicles while were drunken-8.5%
Others-6.0%	Others-27.0%

2. RESEARCH PROCESSES OF DETERMINING BLACK SPOTS

Safety Traffic Provisions are concepts that supply the Driver-Vehicle-Road-Environment System reliabilities (Yavolev and Divacov, 1982; Potenberg, 1986; Dugeree *et al.*, 2006; Enkhbold, 2007). Moreover, there aren't not enough researches relating to the "black spot" determination even though there are plenty of traffic accidents' cases in Mongolia. Also, principles of determining the "black spot" and techniques haven't been standardized yet and there are very different methods in each country (Geurts and Wets, 2012; Oyunbileg *et al.*, 2011; Elvik, 2008). Hauer (1996) and other researchers made researches on rate methods of the traffic accidents (the number of accidents per vehicle or kilometer) on certain locations, methods of accident frequencies (the number of accidents during a certain time and length of certain roads) using above two methods together.

Australian Regional Economics and Road Transportation Committee (2001) defined rates of risks on certain areas of "black spots" and classified the area each traffic accident based on existing possibilities. According to works of researchers (Geurts and Wets, 2012; Oyunbileg *et al.*, 2011), Sayed and Abdelwahab (1995), there are three factors influenced on the numbers of traffic accidents of "black spot" locations. Here:

1) Road environment;
2) Traffic patterns using Road Systems;
3) People's skills and physical manners who use the road.

Above the patterns explains that accidents are caused by drivers' skills, road environment or vehicle's specifications and losing sub-system operations. The road environment refers to the following factors such as traffic flows of vehicles, road conditions and geometrical scales.

For the research work relating to the "black spot", the certain pattern of accidents was chosen to analyze traffic accidents. For example, Saccomanno (1989), Saccomanno ба Buyco (1988), Jovanis and Delleur (1983) and Mountain (1998) selected to research certain locations of "black spot" like straight roads and intersections. Other researchers such as Saccomanno (1989), Saccomanno and Buyco (1988), Jovanis and Delleur (1983), Blower (1993), and Miaou (1994), Chirachavala and Cleveland (1985), Glauz and Harwood (1985), Wood, Simms (2002) and Valent (2002) explored dynamic features of vehicles, especially, they highlighted accidents of trucks. A few researchers made researches relating to the patterns of accident involvements. For instance, Shankar (1995), Persaud (1990), Hadi (1995), Wood, Simms (2002) and Valent (2002) analyzed all types of vehicles. This research work was designed for defining "black spot" using the above methods adapting in conditions of own country, such as making choices to apply required information and facts for uses of the patterns and developing mathematical models to estimate the number of accidents in advance where traffic accidents are occurred frequently around " black spot" locations.

Furthermore, there are some methods for discovering "black spot" on the certain sections of the roads and providing with occupational safety. Here:

1) A method based on analysis of information about traffic accidents;
2) A method of road sections and safety of elements' coefficient;
3) A method of safety of road section's coefficient;
4) A method of assessing road traffic organizations;
5) A method of assessing intersections on the roads which are used for the occupational safety assessments (Bazarragchaa *et al.*, 2017; Ganbat *et al.*, 2014; Ganbat and Ganjargal, 2015).

It is necessary to continue the study in the context of Mongolia's special case of variables to identify the black spot. To identify the "black spot" locations, it's more suitable to use the Severity Index Method because some required facts aren't registered in Mongolia while using the Model and Accident rate method which were used by the researchers to determine "black spot".

This method is calculated total number of serious, light and deadly injuries and appropriate weighs multiplied by these numbers to index. The following formula is used to calculate safety.

$$P = X + 3 \cdot Y + 5 \cdot Z \tag{1}$$

where,

X : total number of light injuries;
Y : total number of serious injuries;
Z : total number of deadly injuries.

If the index is more than 15, the location is "black spot" (Geurts and Wets, 2012).

3. RESEARCH WORK FINDINGS OF DETERMING BLACK SPOTS ON SOME INTERSECTIONS IN UB USING THE PTV VISUM MODEL

Ulaanbaatar is the most populated city in Mongolia. In Ulaanbaatar, the number of cars per 100 km^2 was increased by 7226 in 2016 and the number of cars per 100 persons was increased by 23.9.

The project "Predictive Model of Transport Demand" (Jia Hao Wu, 2016) was sponsored by Asian Development Bank in 2016 implemented in order to support programs of road investment in Ulaanbaatar, strength city transport capacity and aid some technical supports.

The Model of Transport Demand Strategy referred to travel needs, workplace researches in Ulaanbaatar to observe operations and places were developed by the project based on the three researches to accomplish the model confirmation and technical guideline of adjustment. Here:

1) Collect information related to traffic zones, demographics, land use information, road networks, transit lines, parking lots, personal family survey results, detailed records, traffic counts, transit sizes, photos and videos;
2) The modeling curriculum, the implementation of the training program's satisfaction survey, the outcome of the survey of the private household survey, the modeling of foreign travel training and research results;
3) Aim and reference of strategic models, model validation, test and adjustment, development of future models, guidelines for traffic flow, data, development guideline and tips.

3.1 Modeling Results of Traffic Flows in UB

The traffic flow modeling in Ulaanbaatar hasn’t been done well before and some required facts haven’t been collected so that a very few researches were made in Mongolia (Ganzorig, 2010). To calculate the traffic flow modeling in Ulaanbaatar, road networks in Ulaanbaatar was uploaded into geographical data using the VISUM program and divided into 209 zones. The advantages of the PTV VISUM traffic modelling software are to investigate and predict the effects of traffic volumes on UB major intersections as black spot. These zones were divided into several small sections in Ulaanbaatar Districts (Figure 1) where traffic flows are more than other zones (Public and State organizations located near Chinggis Square) to give possibilities to estimate the certain zones accurately.

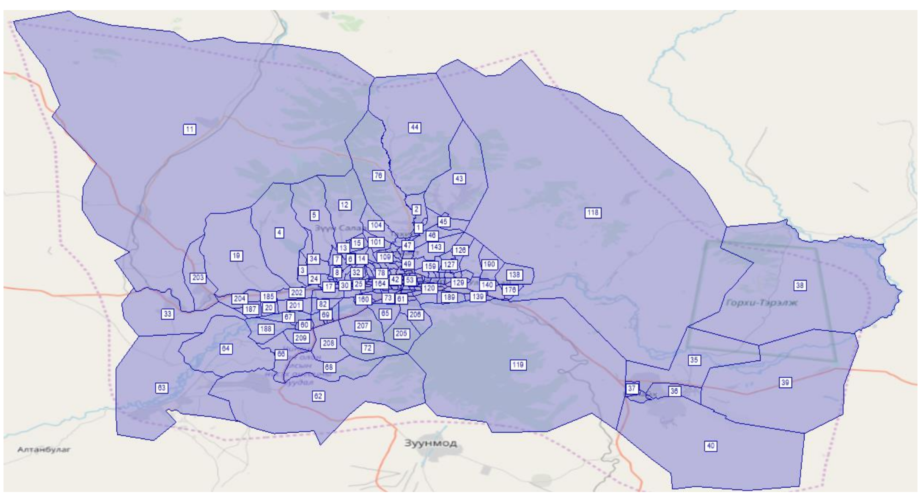

Figure1. 6 Districts and their micro districts in Ulaanbaatar

The geographical data is consisted of intersections, links or roads between intersections including 6428 links and 2631 intersections or node of road network. There are 6 types of road.

Table 3. Types of road

Arterial	Roads in Micro Districts
4 lanes	4 lanes
3 lanes	3 lanes
2 lanes	2 lanes

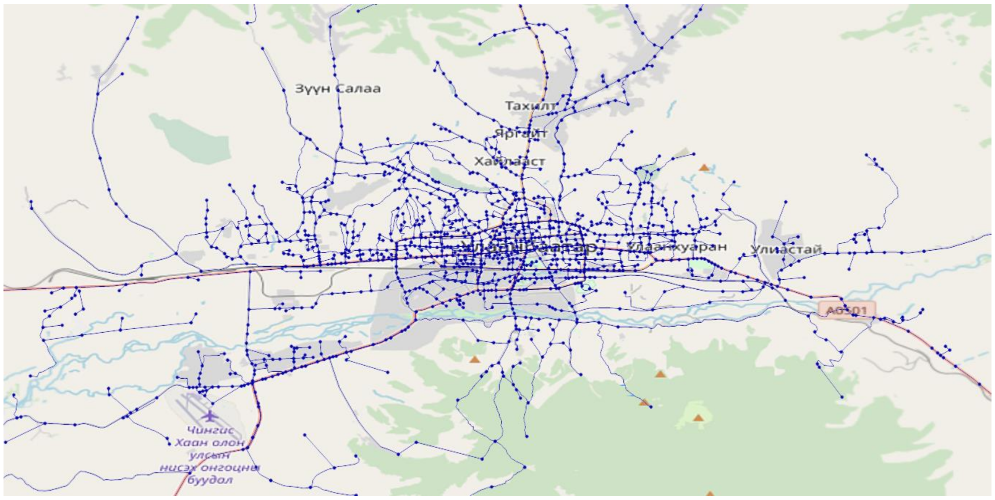

Figure 2. Auto road networks in Ulaanbaatar

Roads' capacity depends on the numbers of traffic lanes. For example, the four-lane- arterial has penetrated capacity for 3200 traffic per hour. The highest speed limit on arterial is 60kmh, but 20kmh on the roads in micro districts. The intersection also has the penetrated capacity to have a turn and adjusts the turnaround. Adjusting function of the turning directions on the intersection is shown on the Figure 3.

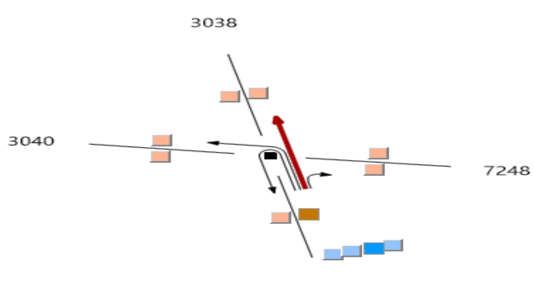

Figure 3. The turning directions on the intersection

Adjusting turning on lighting frequency and time on the intersections with traffic lights that restricts internal resistance of the road or traffic flow speed and gets closer to reality of traffic flow calculation. The adjustment was made on the PTV-VISUM default intersection model with reflection of real intersection design in UB city road network.

Data of public transportation is uploaded into development of traffic flow modeling which plays a main role. In Ulaanbaatar, buses, trolleybuses and micro buses are in service of the public transportation with 72 routes. Therefore, quantities, times and routes of public transportation and other factors are uploaded from the data of City Public Transportation Agency. Based on the input data such as public transportation route, number of the vehicles and its speed the model can predict the flow of the major intersections. Uploading information into the auto road networks in Ulaanbaatar is shown on the Figure 4.

Figure 4. Uploading Public Transportation Routes into VISUM program

Traffic flow modelling was created based on amount of population among districts using "Four-stepped method". The four-stepped method is made up the following steps. Here:

1) Trip generation is to commute from a particular point to participate in road network having a trip with individual and official purposes;
2) Trip distribution is to determine the final and middle points of the trip generation (using gravity modelling etc.,) ;
3) Mode choice is define that a passenger starts from generating point to final and middle points to take a trip using traffic form and a passenger participate in traffic or pedestrian road networks in the traffic form. There may be many forms of traffic (private cars, public transportation, bicycles and carts /chariots/ … etc.,);
4) Assignment is an algorithm to choose the route by selected modes in order to achieve the target destination.

Trip generation. There are two main parameters that will arise from each zone and the destination of each zone in the trip generation step**.** The production *(Q_i)* is determined by the following equation.

$$Q_i = \sum_g a_g SG_g(i) \tag{2}$$

where,

$SG_g(i)$: i sum of the structural factors of the zone number;

a_g : trip production.

To calculate traffic flow (Z_j), sum of zone trip gravity equals sum of trip production. Other words, Trip sums to zones comes to trip sums from zones.

$$\sum_i Q_i = \sum_j Z_j \tag{3}$$

Trip distribution. To complete the traffic flow modelling, the gravity modeling was used which based on a number of population of districts and micro districts in Ulaanbaatar. The gravity modelling expresses a correlation of places (home, office, kindergarten, school … etc.,).

Places involve trip generation or starting point, trip end or final point considering their correlations including trip time, trip length, fare and other factors. The gravity modeling is generally in the following form.

$$T_{ij} = K_i K_j T_i T_j f(C_{ij})$$
$$\sum_j T_{ij} = T_i\,; \sum_i T_{ij} = T_j$$
$$K_i = \frac{1}{\sum_j K_j T_j f(C_{ij})},\ K_j = \frac{1}{\sum_i K_i T_i f(C_{ij})}, \tag{4}$$

where,

T_{ij} : number of trip generation and trip end points;
T_i : trip generation point;
T_j : trip end point;
C_{ij} : i and j trip fare K_i, K_j- equilibrium coefficients calculated repeatedly;
f : impact of distance dispersion.

(4) Using the equation, calculate the gravity of each zone, the table 4 shows in short. As we have already mentioned, the UB road traffic model estimates the UB road network broken into 209 zones. Using the equation (4), the table 4 was developed and full table was too long to include to the paper, therefore table 4 is sampled from full table.

Table 4. Trip distribution

Zone	1	2	3	4	5	6	7	8	...	209
1	16.3289	13.5616	26.1906	29.9518	26.8175	19.3314	34.7753	15.6394	...	21.4353
2	13.5616	11.8475	21.9144	25.0615	22.4389	16.1751	29.0974	13.0859	...	17.9355
3	26.1907	21.9144	49.4327	50.6144	44.5466	32.1130	57.8531	26.0720	...	35.8177
4	29.9518	25.0615	50.6143	84.0549	50.9437	36.7246	66.1612	29.8161	...	40.9614
5	26.8174	22.4388	44.5463	50.9436	48.3974	32.8437	59.0826	26.5520	...	36.4174
6	19.3313	16.1751	32.1128	36.7245	32.8437	24.5809	42.6386	19.1533	...	26.2697
7	34.7751	29.0973	57.8528	66.1610	59.0826	42.6386	78.2162	34.4834	...	47.2957
8	15.6394	13.0859	26.0719	29.8160	26.5520	19.1533	34.4834	16.5058	...	21.3445
...	...	...	...	...	...	...	...	...	...	...
209	21.4352	17.9354	35.8175	40.9612	36.4174	26.2697	47.2957	21.3445	...	29.6335

Mode choice. It is one step of four-stepped methods that allocates passenger flows to which vehicle travels. Basically, there are two kinds of modes classifying into private vehicles and public transportation. The private vehicles involve all cars and trucks… etc., for their own purposes.

To calculate the passenger flows, considering unified modes" walking steps" in the passenger flows of public transportation. In general, choices of costumers who choose public transportation or private vehicles depending on living levels of a certain household calculated from household research. Alternatively, it is calculated by using the following formula comparing to a number of city population and total private vehicles.

$$U_{ijm} = \sum_g \beta_g c_{ijmg} \tag{5}$$

where,

c_{ijmg} : i from the zone number j to the zone number m travel expense by which type of vehicle;

From here, it can be used from several types of distribution functions required to perform this modeling. In general, the Logit model is calculated.

$$p_{ijm} = \frac{e^{c \cdot U_{ijm}}}{\sum_k e^{c \cdot U_{ijk}}}$$
$$T_{ijm} = p_{ijm} T_{ij} \tag{6}$$

where,

T_{ij} : number of total ride for the flow;

T_{ijm} : m ridden number by which type of vehicle.

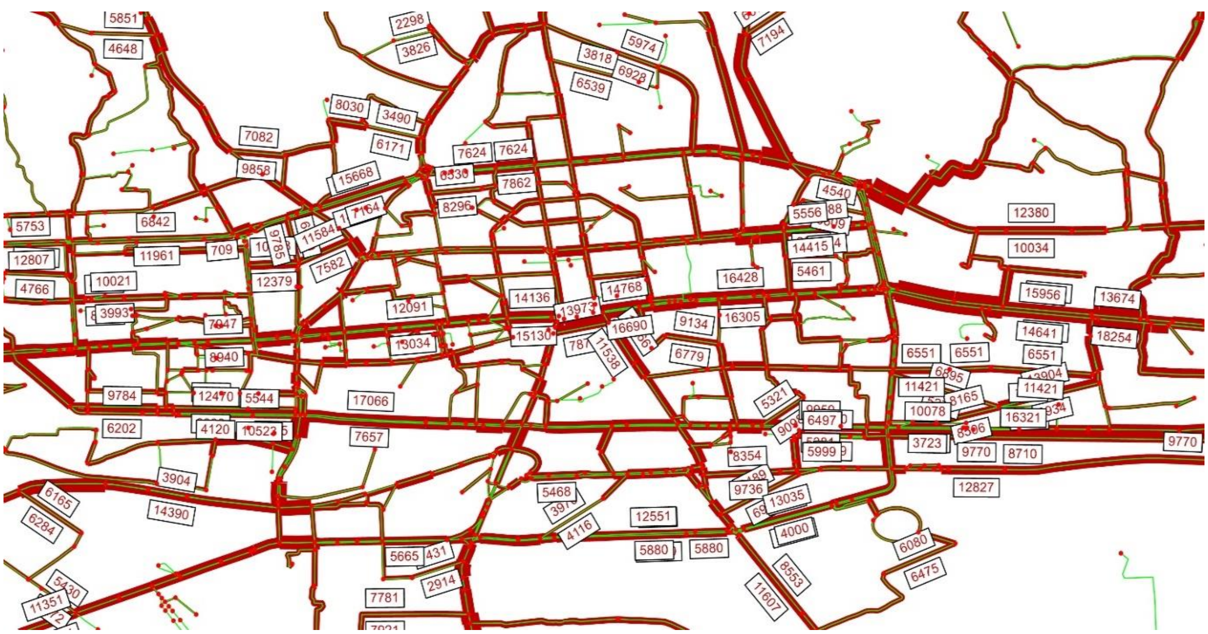

Figure 5.Modeling Results of Traffic Flows in Ulaanbaatar

From here, in order to determine "black spots" on the largest intersections in Ulaanbaatar, it is considered traffic lanes, traffic intensities, coefficients of threat levels and other factors.

3.2 Research Findings of Determining "black spots" on the Largest Intersections in Ulaanbaatar

The UB city traffic flow model was developed with the assistance of PTV VISUM program, and the traffic lanes, traffic flows, traffic lights, and coefficients of threat levels on the 36 largest intersections in Ulaanbaatar were identified. Moreover, geometrical scales of intersections and traffic organizations, other factors and the black spot correlations on the intersections were emitted. The Fig. 6 shows the normalized values of the 36 major intersection's data and total 8 variables as well as in the table 5.

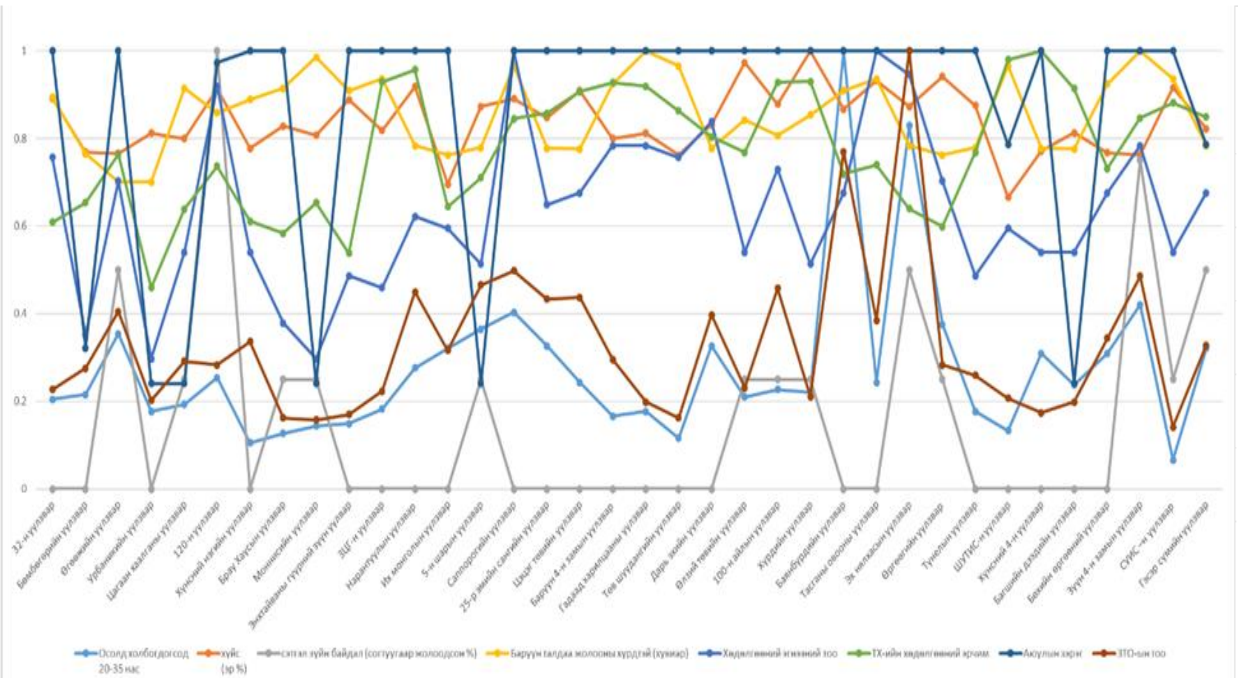

Figure 6. The threat levels, number of lanes and on the 36 largest intersections in UB which has a correlation between number of above the traffic accidents and "black spots" (Weighted average indicator)

It is assumed that the traffic flows, threat levels of intersection and traffic lanes can be influenced on traffic accidents in a way so that some factors have been chosen. The coefficient of threats on the intersections of the road networks in Ulaanbaatar was calculated by the following equation 7 (Babcov, 1993).

$$M = 5m_1 + 3m_2 + m_3 \tag{7}$$

where,

M : threat level;

m_1 : number of the crossing (number of collision point of traffic direction) in the intersection;

m_2 : number of the merging (number of merging point of traffic direction) in the intersection;

m_3 : number of the diverge point (number of diverge point of traffic direction) in the intersection.

Data of road intensities was developed using the PTV VISUM program taken from traffic flow modeling in Ulaanbaatar, the number of lanes was counted and used in the calculation. The selection of the major 36 intersections is based on its flow rate and it is listed in the table 5.

Table 5. Values of traffic safety factors on the 36 intersections in Ulaanbaatar (2017-2018)

№	Locations	Drivers			Vehicles	Roads	Environment	Threat levels	The number of traffic accidents
		Ages 20-35	genders (male %)	psychological situations (drunken)	Position of the drum	The number of traffic lanes	Traffic intensities of Vehicles		
1	Intersection of the 32	37	89.1	0	83.7	28	4248.5	112	56
2	Intersection of the Bumbugur	39	76.9	0	71.7	13	4563.6	36	68
3	Intersection of the Uguuj	64	76.6	2	65.6	26	5332.75	112	100
...	Intersection of the Urbanic	32	81.2	0	65.6	11	3210.5	27	50
36	Intersection of the Geser Temple	58	82.2	2	73.4	25	5930.4	88	81

These factors referred to the intersections and spots where occurred traffic accidents in a way so that the correlation coefficients were defined.

Table 6. Correlations of factors on the 36 largest intersections in Ulaanbaatar

Casuals aged 20-35	Gender (male %)	Psychological situations (drunken %)	The drum on the right side (%)	The number of traffic lanes	Traffic intensities of Vehicles	Threat levels
0.0866	0.1310	0.1043	0.1857	0.2601	0.6448	0.2503

From the table 6, the road intensity influenced on traffic safety strongly, but correlations between the threat level and number of lanes were less, but it's obvious that don't leave them. The correlations of people' ages, genders and psychological situations were very weak (less than 0.2) so that they were discarded from the mathematical equation. Independent variables are chosen based on hypothesis and its correlation value of the correlation analysis. The variables that strongly related to the dependent variables are selected. In our equation (8), there is a weak correlation between driver's age, gender, psychological status and right or left hand wheeled to the traffic accidents or black spot, but the intensity of traffic and danger is strongly related. We can see the number of lane and intensity of the traffic is interrelated.

From here, the model was developed by using the regression method how to correlate road threat level, traffic intensity and the number of lanes which had strong influences.

$$y = 0.1927 + 0.0096 \cdot X_1 + 0.625 \cdot X_2 + 0.082 \cdot X_3 \tag{8}$$

where,

X_1 : traffic flow;
X_2 : threat level;
X_3 : number of lanes.

Based on annual traffic accident statistics our mathematical model of the prediction of black spot analysis is developed. Results from the developed model, average squared error was 0.62. Therefore, the model matched 62 % with conviction level in real situation.

In our equation (8), there is a weak correlation between driver's age, gender, psychological status and right or left hand wheeled to the traffic accidents or black spot, but the intensity of traffic and danger is strongly related. We can see the number of lane and intensity of the traffic is interrelated.

Table 7.Results of Regression Mathematical Model with Many Factors

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.650010739					
R Square	0.622513961					
Adjusted R Square	0.368374645					
Standard Error	0.114805521					
Observations	36					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	3	0.308585202	0.102861734	7.804198333	0.0004771	
Residual	32	0.421769841	0.013180308			
Total	35	0.730355044				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.19276653	0.117032258	-1.64712307	0.10931961	-0.43115344	0.045620375
X Variable 1	0.009634015	0.082934372	0.116164318	0.004348276	-0.15929777	0.178565802
X Variable 2	0.625194269	0.145253634	4.304155787	0.000097958	0.329322299	0.921066239

X Variable 3	0.082185712	0.127529809	0.644443153	0.005181209	-0.17758400	0.341955433

From the table 7, the hypothesis of the initial variation of the regression mathematical model's critical value P is 0.0043 correlated statistically and the second variable P is 0.00009, and the third variable P is 0.00518 which expressed weak statistical correlation. The confirmation of the estimation regression model is shown in the table 7 as ANOVA analysis. For example, p-value of the X Variable 1, X Variable 2, X Variable 3 are lower than 0.05 which the model is reliable.

4. CONCLUSIONS

1) The DVRE (Driver-Vehicle-Road-Environment) system that determines the road traffic accidents causes the drivers of their age, sex, experience, and psychological state based on the current situation of traffic in Mongolia; Vehicle aging, position of the steering wheel, classification and technical state; road pavement, maintenance and number of traffic ramps; A methodology for identifying "black spots" was developed based on factors such as weather, traffic intensity, geometry of intersections, traffic signs, notes, and threat level.
2) The mathematical model was developed which could determine the "black spots" by the factors correlated with the Driver-Vehicle-Road-Environment System strongly. Traffic intensity of vehicle x_1, threat level x_2 on the intersection, traffic lanes x_3 on the 36 largest intersections in Ulaanbaatar were identified and the number of traffic accidents at the "black spots" was estimated using the regression method.

$$y = 0.1927 + 0.0096 \cdot X_1 + 0.625 \cdot X_2 + 0.082 \cdot X_3$$

   Results from the developed model, average squared error was 0.62. Therefore, the model matched 62 % with conviction level in real situation.
3) The threat levels of the 36 largest intersections in Ulaanbaatar were determined that give researchers some possibilities to make research work for short time and can make a summary.
4) Our guidelines can be used in any institutions that have responsibilities for transportations issues, law enforcement agencies and private sectors for their work.

REFERENCES

General Police Department Road Police Agency (2018). *Statistics about traffic accidents in Mongolia*, 13-14. (in Mongolian)

Geurts, K., Wets, G. (2012) *Black spots analysis methods: Literature review*. Kennis Verkeersonveiligheid, 7-19.

Karl-Olov Hedman, Kent, S., Hans, Ek. (2001) *Black spots manual*. Traffic safety project, Ankara, 5-81.

Current situations of traffic accidents (2017) National Statistics, 6-7. (in Mongolian) https://unstats.un.org/unsd/statcom/48th-session/documents/

Health Static Index 2012-2015 (2016) Health Center, Ulaanbaatar, Mongolia. 48. (in Mongolian)

Information Brochure of Preventing Roadside Accidents and Injures (2010) Millennium challenge corporation (MCA) in Mongolia, 96-97.

Yavolev, N.A., Divacov, N.V. (1982) *Theory of Automobile*. Higher Education. Moscow. 70-75.

Potenberg, R.V. (1986) *Fundamentals of the reliability of the system Driver-Car-Road-Environment*. Moscow, 71-78.

Dugeree, D., Bayambaa, Sh., Batmunkh, B., Bayarsaikhan, B. (2006) *Safety of traffic accidents, ecology of auto transportation.* UB, 61-62. (in Mongolian)

Enkhbold, A. (2007) *Safety of traffic*. UB, 247-249. (in Mongolian)

Oyunbileg, J., Demberelsuren, J., Jargalsaikhan, Ch., Gankhuyag, S., others (2011) *Research on hazardous spots on the autoroads*. Health Project of Millennium Challenge Fund. Social Health Institution,11.

Elvik, R. (2008) *A Survey of operational definitions of hazardous road locations in some European countries*. Accident analysis and prevention, Vol 40, 1830-1835.

Bazarragchaa, I., Bayarsuren, B., others (2017). *Assessment of traffic safety in the UB-Darkhan road project developed by MCPCgr*, UB, 7-8. (in Mongolian)

Ganbat, N., Ganjargal, O. (2014) Impact on the reliability of the car and auto-sub-system in the Safety of traffic. *EASTS Mongolia*, *Scientific Research proceedings*, 92-103.

Ganbat, N., Maygmarjav, J., Ganjargal, O. (2014) Vehicles - Traffic safety. *EASTS Mongolia, Scientific research proceedings*, №10/14.

Ganbat, N., Maygmarjav, J., Ganjargal, O. (2015) Vehicles - Traffic safety. *Safety of Traffic international conference*. Mongolian National Chamber of Commerce and Industry, UB.

Jia Hao Wu (2016) *Travel Demand Forecasting Modelling and Calibration Guideline*. Final Report, v2.

Ganzorig, D. (2010) *Some issues of dynamic modeling of traffic flow*. Dissertation abstract, MUST, 20-29.

Babcov, V.F. (1993) *Road conditions and traffic safety: a textbook for universities*. Moscow, Academia, 188-192.