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ASI Based Identification and Prioritization of Accident Black Spot

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Abstract: The number of motor vehicles on road increased spectacularly which causing major social and transportation problems such as death and economic losses. Eradication of accident blackspots is a crucial part of the road safety approach. So, this issue informed the quest to study and identify the accidental black spot in the context of NH 6. The stretch of 35 km on NH 6 near Pune was considered to identify the black spot. Accident blackspot locations were distinguished through the accident severity index (ASI) method by employing two years of accident data. These identified black spots were prioritized based on their final severity index score. The two most vulnerable black spots out of nine were selected for further analysis and countermeasure process. Conclusively, the accident severity-based framework can effectively correlate the nature of the accident with the type of casualty to provide detailed and accurate black spot location.
Keywords: Black Spots, Accident Severity Index (ASI), Black Spot Prioritization, Traffic Volume, Highway, Countermeasures.

I. INTRODUCTION

The intense growing motorization, population growth and city expansion turn out to be extremely serious obstacles to the safety characteristics of road networks of the entire world. Therefore, this problem attracts the focus of the transportation department and engineers and stakeholders on doing their part for enhancing the safety problem appropriately. Subsequently, several scholars presented research regarding the requirement of safety enhancements on challenging roads by planning different frameworks which incorporate distinct accidental casualty descriptive independent attributes and factors.

The transportation engineers are involved with the accidental analysis of roads and are mostly involved with the management aspects of traffic systems. This can be described further into traffic flow management, highway safety management, and road infrastructure maintenance. The accidental analysis study and its management combine to provide a good function of the road networks and better insight on why road-related accidents happen. The detection of the more accidental prone area is a vital concern of traffic safety programs since safety measures and structure assessment can be prescribed for these locations to achieve effective resource allocation. The finding of the more accidental spot area is an important issue of traffic safety programs as safety measures and assessments may prescribe for those locations to attain efficient resource allocations. These accidental spots are known as "black spots" in road safety works of literature and typically have numerous well-specified processes to discover accident locations. Accident black spot is a term applied in highway safety management to denote a location where highway traffic accident has a historical record of the accident. The prominent organization for road safety in India is the National Road Safety Council (NRSC). The NRSC recommended creating a State Road Safety Council and District Road Safety Committee and execute conferences and meeting regularly to counter the risk of road accidents and prioritized road safety issues.

In the case of Maharashtra State, the state government has established Accident Prevention Committee (APC) in the year 1997 to identify the accidental black spots. As a result, the committee identified 7313 accidental spots on 18027 kilometres of the rural highway (D. Thube et al., 2010). Among 7313 accident-prone spots, 5960 spots were treated with different countermeasures. Despite the initiative and remedial measures taken by the authority, the number of accidents is increased possibly because Black spots are shifted to a new location. Hence, new research on black spot study is warranted to identify the black spots based on different parameters. According to the works of (R. Elvik, 2007), the procedure of removing accident black spots in a roadway is comprised of various activities. This includes identification of the black spot, diagnosis of black spot, outline suitable countermeasures, estimation their effect, set priority, implementation, and finally, follow-ups and evaluation of the result. The aim of eradicating black spots starts with the identification of Black spots and ends at Countermeasures, and this required a holistic approach with several methods and data.

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II. OBJECTIVE OF STUDY

A. To identify and prioritize accident black spots on the 35 km stretch of NH 6.
B. To provide high cost and low-cost countermeasures for prioritizing accident black spots.

III. LITERATURE REVIEW

(Bobade et al., 2015) presented an approach to identify the black spots based on the Accidental severity index (ASI) method, but it can distinguish the nature of accident and casualty factors separately on the selected stretch. It is a more reliable and quick method to identify the black spots based on individual parameters.

(Vivek and Rakesh Saini, 2015) taken the help of the Weighted Severity Index and ASI to find a black spot on a stretch of national highway and some recommendations are made to improve the transportation systems. The ASI methods were adopted which use the scoring system based on numbers and accidental severity of spots in the past couple of years. Overall, the study found that the Weighted Severity Index (WSI) and ASI methods are more effective ways to find the black spots

(Desai and Patel, 2010) established the accident prediction models by using the regression analysis method. This study tried to create accident models on the linear regression technique. The outcome of the accident prediction models delivered a good prediction of success rate.

(Mitiku Dinsamo, 2018) developed an Accident Black Spot Location Detection and Countermeasures by Using Statistical modelling. The accident prediction model was derived from Generalized Linear Model (GLM), specifically from Negative binomial regression analysis using SPSS software packages, version 20 The study concluded that Certain factors possibly not be directly related to road traffic injury and other causes immediate, but they may be supported by medium-term and long-term structural reasons. Detection of the risk factors that lead to road traffic crashes is key in finding that can diminish the risk linked with those factors.

(G. Apparao et al., 2013) tried to identify the accidental black spots for national highways using GIS. It is found that GIS can make analysis less tedious, and it can present a platform to keep and update accidents records database and use it for more detailed analysis.

IV. RESEARCH METHODOLOGY

The Methodology framework for black spot identification 35 km stretch on NH 6 is based on the accident severity index method and it consists of four steps which prominently includes Tagging of black spots, Severity Index method based on Nature of accident and Casualty type, final ASI score-based Blackspot identification, prioritization and ranking. The secondary data was collected from the concerned authority and extract the necessary information consist of the accident location, timing, no. of persons involved, type of severity, etc.

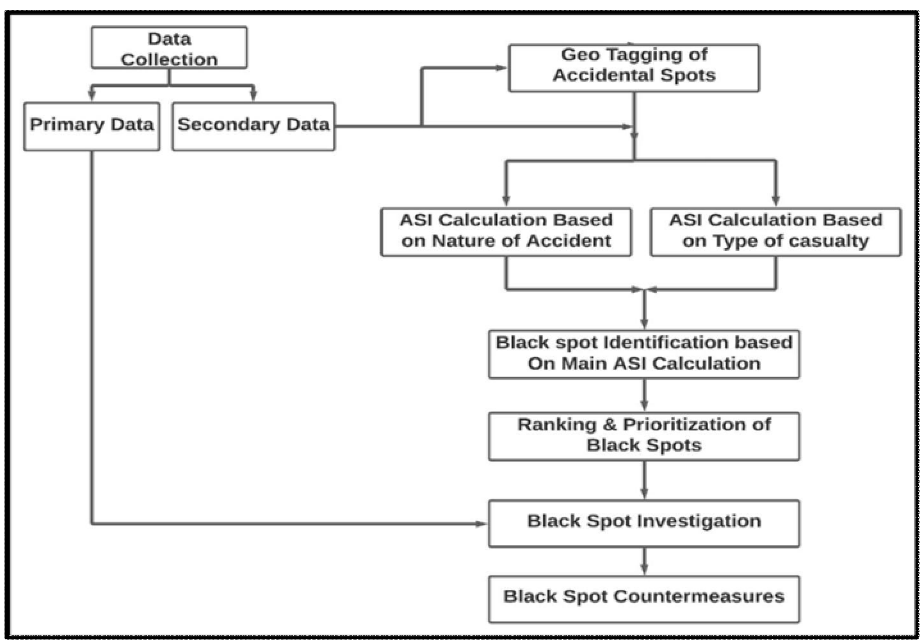

Figure 1: Black Spot Identification Framework

A. Step 1 - Tagging of Black Spots

In the first step, the accident data collected from concern authority for the year 2018 and 2019 were used to locate accidents happened on each spot of 35 KM Pune-Yevat stretch.

Table 1: Accidental spots on Chainage

Sr. No	Chainage (KM)	No. of accidents	Sr. No	Chainage (KM)	No. of accidents
1	1.4	1	20	18.2	1
2	2.2	1	21	18.9	1
3	2.86	1	22	19.5	4
4	3	9	23	19.9	5
5	3.2	3	24	20.2	22
6	4.8	1	25	21	1
7	5.1	1	26	21.4	4
8	5.8	1	27	21.8	1
9	6.1	3	28	22.3	3
10	7.4	2	29	23.6	8
11	8.7	14	30	24.5	3
12	9	1	31	24.9	9
13	10.6	3	32	26.2	1
14	11.6	17	33	27.6	1
15	13.2	12	34	27.8	2
16	13.6	10	35	29	2
17	14.2	4	36	29.6	1
18	15.5	4	37	30.2	1
19	17.9	1	TOTAL		159

B. Step 2 - ASI Calculation Based on nature of the Accident

The accidental severity index was calculated based on different types of nature of accidents recorded on each accident spot. All accidental values for the nature of accident based ASI calculation are taken from secondary data and computed in the Microsoft Excel software. There are 7 types of parameters considered to classify the different nature of accidents and each parameter is assigned with the weightage based on their serious effect on accident casualty. All seven parameters assigned with respective weightage are given as Overturning =7, Head-on collision = 6, Rear-end collision =5, Collision brush =2, Right angle collision = 4, Skidding = 3, Other =1. (Bobade et al., 2015).

The severity score of each accident is based on the assigned weightage of the nature of the accident that occurred at the respective spot. Firstly, the nature of the accident of the respective accident was marked as 'Y' and simultaneously the weightage of the respective marked nature of the accident was assigned in the severity score column. After marking parameters and severity score, the accident severity index was calculated in the given formula: ASI = (Severity score / ΣW) x 100. (Bobade et al., 2015).

For Example, consider Chainage 3.00 from Table 2.

Here, Severity score = 6

$\Sigma W = 7+6+5+4+3+2+1 = 28$

Severity Index (SI) = (Severity score / ΣW) x 100 = (6/ 28) x 100

= 21.43 %.

Finally, all calculated SI values were compared with the Severity Benchmark and if the SI value exceeds or is equal to the ASI benchmark, then the chainage of SI was considered as vulnerable in the context of the nature of the accident. The ASI benchmark was calculated based on the given formula: 100 - [(sum of weightage of top four parameters/ total of all parameters) x 100]. (Bobade et al., 2015).

For Example, summation of the weightages assigned to the top 4 parameters are 7+6+5+4= 22. And weightage of all parameters is = 28. So, Severity Index Benchmark = 100 - [(22/28) x 100] = 21.42.

Table 2: Sample calculation and marking for Nature of accident.

Sr No.	Accident Location (Km)	Nature of Accident								
	A	B								
		1	2	3	4	5	6	7	Severity	SI (%)
1	1.400				Y				2	7.14
2	2.200						Y		3	10.71
3	2.800							Y	1	3.57
4	3.000				Y				2	7.14
5	3.000		Y						6	21.43

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C. Step 3 - ASI Calculation Based on the type of Casualty

The casualty-based severity index indicates all possible vulnerable spots on considered stretch concerning the severity of casualties. Similar to the previous step 2 of marking of nature of the accident, the casualty-based marking was done in this step. All accident casualties are classified into given four types with weightage based on their severity-

1) Fatal accidents (An accident in which one or more persons are killed) = 4
2) Grievous injury accidents (Accidents in which persons were grievously injured) =3
3) Minor Injury accidents (Accidents in which persons received only minor injuries or bruises or sprains.) = 2
4) Non-Injured = 1

The marking of type of casualty occurred at respective accident spot was done and simultaneously respective casualty weightage was assigned in the severity score column. After marking parameters and severity score, the accident severity index was calculated in the given formula: ASI = (Severity score / ΣW) x 100 (Bobade et al., 2015).

For Example, consider Chainage 3.00 from Table 3.

Here, Severity score = 4

ΣW= 4+3+2+1 = 10

Severity Index (SI) = (Severity score / ΣW) x 100 = (4 / 10) x 100

= 40 %.

Table 3: Sample calculation and marking for the type of casualty

Sr No.	Accident Location (Km)	Type of Accident Casualty						Final Severity Index
	A	C						D
		1	2	3	4	Severity	SI (%)	
1	1.400				Y	1	10	17.14
2	2.200		Y			3	30	40.71
3	2.860				Y	1	10	13.57
4	3.000				Y	1	10	17.14
5	3.000	Y				4	40	61.43

Finally, all calculated SI values were compared with the Severity Benchmark and if the SI value is equal to or more than the SI benchmark then it is considered a vulnerable spot. The SI benchmark was calculated as follow - the summation of weightages assigned to the top 2 parameters are 4+3= 7. And Weightage of all parameters is = 10

Severity Index Benchmark = 100 - [(7/10) x 100]

= 30

D. Step 4 – Final ASI score-based Blackspot identification

The black spot was identified based on the Final benchmark of the severity index. The Final benchmark of severity index was calculated by doing a summation of the nature of accident and type of casualty benchmark SI. If the Summation of accident and casualty SI value exceeds the Final benchmark, then it is considered the most vulnerable Black spot.

For instance,

Final Severity Index Benchmark = (SI benchmark for Nature of accident + SI benchmark for Type of casualty)

= 21.43 + 30 = 51.43. The final Severity index benchmark is 51.43.

In this study by using the above method total of nine black spots was identified and among the first black spot identification calculation at 3.00 km is given in table 4.

Table 4: Sample calculation for Final Accidental severity index

Sr No.	Accident Location (Km)	Nature of Accident									Type of Accident Casualty						Final Severity Index
	A	B									C						D
		1	2	3	4	5	6	7	Severity	SI (%)	1	2	3	4	Severity	SI (%)	
1	1.400				Y				2	7.14				Y	1	10	17.14
2	2.200						Y		3	10.71		Y			3	30	40.71
3	2.860							Y	1	3.57				Y	1	10	13.57
4	3.000				Y				2	7.14				Y	1	10	17.14
5	3.000		Y						6	21.43	Y				4	40	61.43
6	3.000				Y				2	7.14			Y		2	40	47.14
7	3.000						Y		3	10.71			Y		2	20	30.71

V. RESULT AND COUNTERMEASURES

A. Prioritization of identified black spots

The Prioritization of black spots is another important stage to select the most vulnerable spot as these black spots are a priority for authorities to reduce accidents in a short duration. Less severe black posts can treat after tackling the most vulnerable black spots. Therefore, the identified nine black spots were prioritized based on their total score of final severity for every location / Chainage. The ranking of nine black spots is provided in table 5 and the top 2 black spots were selected for countermeasures.

Table 5: Ranking of identified Black spots

Accidental Location Chainage (KM)	Total of Final Severity Index	Ranking
3	61.43	6
8.7	120	4
11.6	**283.58**	**1**
13.2	**171.43**	**3**
13.6	55	7
19.9	55	7
20.2	**222**	**2**
23.6	65	5
24.9	120	4

B. Black Spots Investigation and Countermeasures

The detailed investigation of identified black spots is a very critical part before the development of countermeasures. The detailed investigation of identified black spots considered different primary data including Inventory survey, Geometrics survey, Traffic volume study, Spot speed study and road user-local community interview. After investigation of selected two black spots, both high and both low and high-cost countermeasures are suggested based on their suitability.

The low-cost countermeasure is suggested for the black spot at chainage 11.6 km. To prevents the intensity and frequency of severe accidents to a large extent, appropriate channelization is suggested which will increase capacity, improve safety, provide the highest convenience, and driver confidence. As per (IRC SP 41: 1994*)* the first suggested option of conventional channelised Traffic Islands and another one is known as a "seagull intersection or continuous green T-intersection". Some other additional countermeasures are suggested about road conditions improvement, light signal systems, road markings, appropriate road signs according to IRC:93-1985, IRC 35-1997, and IRC 67- 2010 respectively.

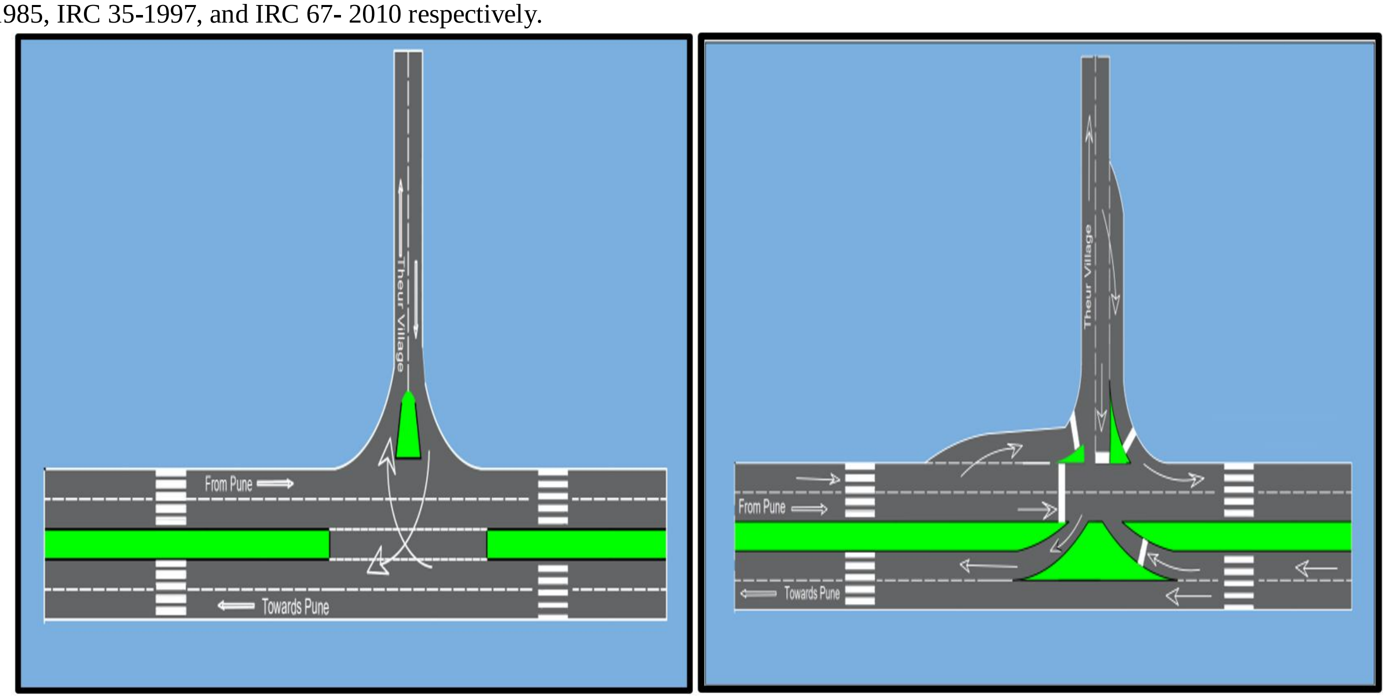

Figure 2: Conventional channelised Traffic Islands (Left) and Seagull Intersection (Right)

High-cost countermeasure is the last option for any decision-making authority as it involved a complex and time-consuming process. However, in this study, the Blackspot at 20.2 chainage intersection was suggested with a high-cost countermeasure based on variously identified justifications and future requirements and appropriateness. In this case, it was ideal to consider flyover on the intersection which can provide several benefits over other suggested low-cost benefits. The flyover model is developed with the help of BIM technology including civil 3D and Infraworks 360. The developed model can be further used for accident and traffic simulation by adding various primary data such as traffic volume count.

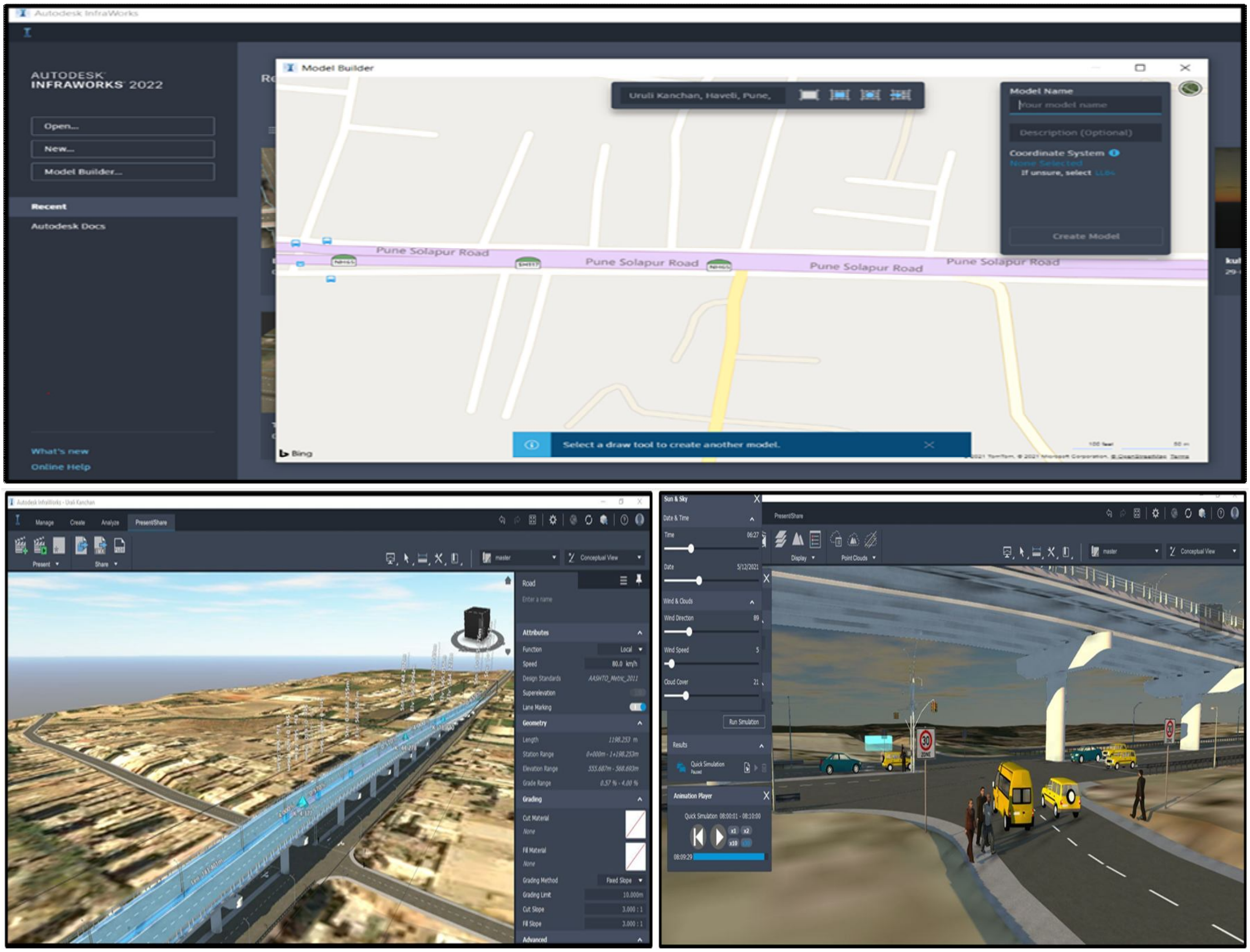

Figure 3: BIM modelling of flyover countermeasure for Blackspot

VI. CONCLUSION

A. The identification of black spots based on ASI methodology by considering the nature of accident and type of casualty independently do not provide a detailed cause of black spot. While considering the Final ASI, the Blackspot can effectively correlate the nature of the accident with the type of casualty. The Ranking of the set of different identified black spots can be prioritised by using ASI methodology with Final ASI were independently calculated ASI was unable to provide Ranking.

B. It is found that the deployment of ASI based method is feasible for a long section of road with minimum data process by using a spreadsheet. Further, it can be utilized in the Accident density method of GIS-based applications such as ArcGIS or QGIS for graphical representation of a wide category of blackspot related statistical data.

C. The case study on Pune to Yevat road section discovered that a total of 30 vulnerable spots are identified based on individual ASI methods. However, the final ASI concluded 9 Black spots.

D. Lack of proper warning signs, road markings, signals, inadequate illumination on footpaths and cycle tracks, poor emergency response capability and injustice in the implementation of traffic laws are the main causes of road accidents.

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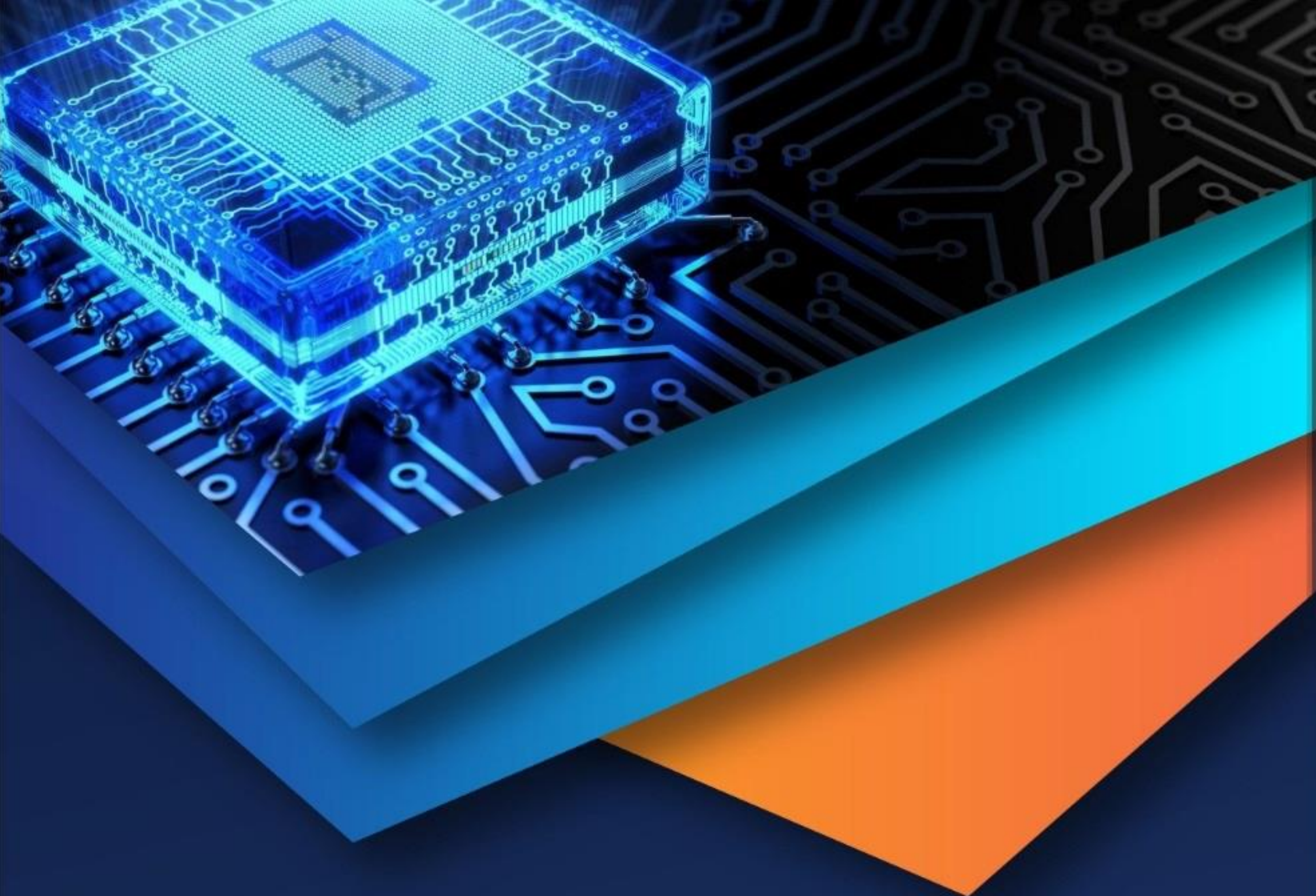

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