



# ENHANCING EFFICIENCY AND SAFETY ON ROAD NETWORKS

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**Abstract:** Multiple emergency situations negatively impact highway traffic safety and efficiency. Unexpected traffic jams are usually caused by accidents, the presence of damaged vehicles, or the appearance of emergency vehicles. These scenarios take into account the safety of vehicles involved in emergency situations. However, the impact of these cases on surrounding vehicles is usually limited to traffic flow and efficiency parameters. However, in extreme scenarios, nearby vehicles may be involved in an emergency situation such as a chain-reaction accident. In this article, I would like to first consider some emergencies that can occur on highways. We then study the impact of these cases on surrounding moving vehicles based on the relative position of each vehicle compared to the detected cases, and the moving speed and direction of each vehicle. Third, we introduce recommended protocols that provide an optimal response for each vehicle in the vicinity of the detected emergency. In such scenarios, slowing down/increasing vehicle speed, changing lanes, or stopping the vehicle completely are the most common responses. Experimental results show that the proposed protocol improves traffic fluidity near highway emergency situations. Compared to common highway protocols, it reduces vehicle travel time delays and increases throughput for each lane. In addition, the safety situation of vehicles has also improved, and the proportion of vehicles involved in accidents has decreased.

**Index Terms -**Accidents, Traffic safety, damaged vehicles, Traffic flow, Vehicle speed, Lane changes, Safety conditions.

## I. INTRODUCTION

This study aims to comprehensively investigate the various emergency cases that can occur on highway roads. These emergency cases primarily include accidents, the presence of damaged vehicles, and the appearance of emergency vehicles. By thoroughly understanding these scenarios, we can develop effective strategies for addressing them. Our research endeavours to analyse the effects of these emergency cases on the vehicles in their proximity. This assessment will consider factors such as the relative location of each vehicle concerning the detected emergency case, as well as the speed and direction of movement of each vehicle. This information will shed light on how these emergency scenarios influence the flow of traffic and the safety of neighbouring vehicles. One of the central objectives of this research is to propose a recommendation protocol tailored to respond to various emergency situations. This protocol will provide guidance on the most suitable actions for drivers in the vicinity of the detected emergency case. These responses may include adjusting vehicle speed, changing lanes, or coming to a complete stop. The overarching purpose of this research is to contribute to the enhancement of traffic efficiency and safety on highway roads. By implementing the recommended protocol and strategies, we seek to improve traffic flow, reduce delays in vehicle travel times, and increase the throughput of each lane.

## II. LITERATURE REVIEW

**PAVEMENT CONDITION SURVEY USING DRONE TECHNOLOGY** Lerosé Lane, DingXin Cheng

01 Jun 2023

Timely repairs of pavement defects are essential in protecting both public road and highway systems. Identification of pavement distresses is necessary for planning pavement repairs. This has previously been

performed by engineers surveying the roadways visually in the field. As drone usage has progressed, it has become clear that drones are a valuable tool to enhance visual documentation, improve project communication, and provide various data for processing. The use of drone technology has improved both the speed and accuracy of capturing data. Available software has allowed the data to be processed and analysed in an office environment. This report summarizes the use of drone technology for pavement evaluation for three case studies. Results from this study can be used to deepen understanding of drone use in the process of data gathering for timely repairs for transportation infrastructure.

**ROAD TRAFFIC ACCIDENTS: AN OVERVIEW OF DATA SOURCES, ANALYSIS TECHNIQUES AND CONTRIBUTING FACTORS** Arun Chand, S. Jayesh, Anjana Bhasi 01 Jan 2021

Road traffic accidents are one among the world's leading causes of injuries and fatalities and hence represent an important field of research towards the use of traffic accident analysis and prediction techniques and the determination of the most key factors contributing to road traffic accidents. This paper aims to provide an overview of road accident data sources, data analysis techniques, various algorithms used to build road accident forecasts, and also their suitability to the types of data being examined with the ease of interpretation. The paper also summarizes the operational problems of road traffic, identifies the risk factors, the efficacy of road safety measures when they contribute to the statistical analysis of the severity of motor vehicle accidents and offers an assessment of future methodological approaches. In this review, different gaps in the road traffic accident area were found and further fields of research have been mentioned.

**SYSTEM, MULTI-UTILITY DEVICE AND METHOD TO MONITOR VEHICLES FOR ROAD SAFETY** John Alexander Valiyaveetil 28 Jan 2021

The invention relates to a surveillance method for road safety. In one embodiment, this method includes acquiring multiple data from at least one primary image capturing device and a secondary image capturing device where the image capturing devices are mounted on a vehicle. The acquired data includes object image data and related metadata. The method further includes analysing each acquired data by performing object-detection using machine learning (ML) model on the data, each object including vehicles, lane markings, street lights, potholes, etc.; and determining the type of the analysed object by collecting the data related to all the objects and further filtering of data as per requirements, wherein the type including lane crossing, vehicle analysis, scenery identification, a black box event, behaviour analysis. In responsive to processing by a processor encoded with instruction enabling the processor to process the acquired data to perform one or more functions of surveillance including speed detection, lane detection and lane crossing, vehicle analysis, object detection, scenery identification, and behaviour analysis.

**TRAFFIC SIGNAL DATA TRANSMISSION METHOD AND TRAFFIC SIGNAL CONTROL SYSTEM** Bai Chuandong 07 Aug 2020

The invention discloses a traffic signal data transmission method and a traffic signal control system, and belongs to the technical field of traffic signal control. According to the technical scheme, the traffic signal control system comprises a traffic annunciator, a traffic flow monitoring module, a wireless

communication unit, a traffic flow proportion pre-setting module and a base station centre, and the output end of the traffic flow monitoring module is connected with the input end of the wireless communication unit. With the arrangement of a traffic flow analysis system, a traffic flow proportion pre-setting module and a signal lamp intelligent adjusting system, during system runtime, the transverse and longitudinal traffic flow proportions of a crossroad can be well calculated in real time, when the traffic flow proportions are approximately equal, the traffic signals can be switched according to a pre-set mode, and the system can adjust the switching time of the transverse traffic light and the longitudinal traffic light in real time when the difference between the transverse traffic flow proportion and the longitudinal traffic flow proportion is larger, thereby well deploying the switching of the traffic signal device in real time according to the traffic conditions, and improving the real-time performance and robustness of traffic deployment.

### III. METHODOLOGY

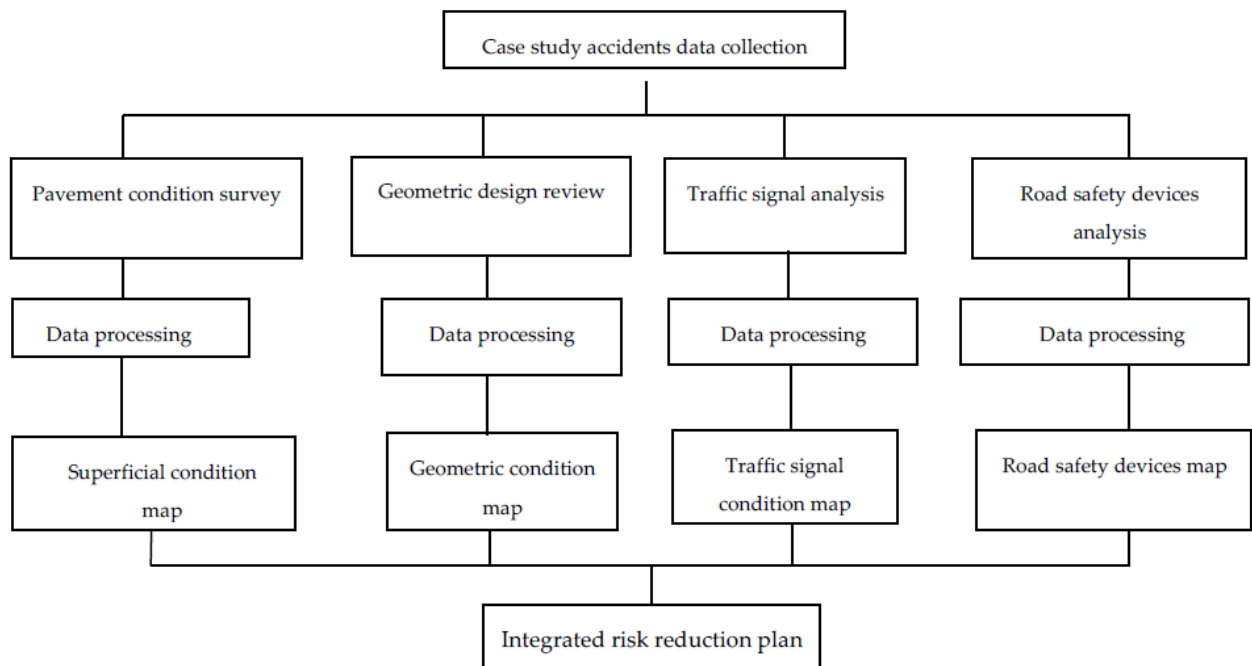
#### Study Area

Vijayawada is located at a Latitude of 16° 31' North and Longitude of 80° 37' East. Vijayawada is one of the thirty-five metropolitan cities in the country, is the second largest city in the state of Andhra Pradesh after Visakhapatnam, located on banks of river Krishna. Vijayawada has historically, culturally, politically, socially and educationally active place in Andhra Pradesh State. The municipality was upgraded to a corporation in 1981. With the merger of Gunadala, Patamata and Bhavanipuram village panchayats, and two villages Payakapuram and Kundavari Kandrika in the corporation in 1985, the total area of the corporation went up to 58 sq. km. The city is divided into 59 political wards. An elected body headed by the Mayor performs the administration of the Corporation.



Fig: Study area location

## Methodology



## IV. RESULTS AND ANALYSIS

The first step in our analysis involved conducting exploratory data analysis (EDA) to gain a comprehensive understanding of the dataset. This EDA revealed some intriguing patterns and trends. Firstly, there was a noticeable seasonal variation in the number of accidents, with a spike during the winter months. This could be attributed to adverse weather conditions, such as snow and ice, making road surfaces more hazardous. Additionally, accidents were more prevalent in urban areas compared to rural regions, suggesting the need for targeted safety measures in cities.

The results from the pavement surface condition in 2017, show that the most deteriorated road section is the descending one, because 28% of this section is in poor condition, mainly in the mountainous area where there are a considerable curve system and steep slopes. Likewise, the first kilometres in the urban area present the aforementioned condition. On the other hand, the ascending road section presents good conditions in 70% of its route, 29% is in fair condition and only 1% is in poor condition.

### PAVEMENT CONDITION SURVEY

Pavement condition survey is a crucial assessment conducted to evaluate the quality and condition of road surfaces, ensuring safe and efficient transportation infrastructure. The survey typically involves visual inspections, measurements, and analysis of various pavement distress types such as cracks, potholes, rutting, and surface deterioration. Highly trained professionals, often equipped with specialized equipment, conduct these surveys to gather accurate data on pavement conditions. Utilizing advanced technologies like laser scanning and pavement condition rating systems, engineers can assess the severity and extent of pavement distresses, allowing for informed decision-making regarding maintenance, repair, and rehabilitation strategies. The data collected from pavement condition surveys are essential for prioritizing road maintenance projects, allocating resources effectively, and maximizing the lifespan of transportation assets. By regularly conducting pavement condition surveys, transportation agencies can identify deterioration trends, anticipate maintenance needs, and implement proactive measures to ensure

the safety, durability, and sustainability of road networks for the benefit of communities and economies alike.

### **GEOMETRIC CONDITION**

The results and discussion related to geometric conditions in mountainous zones emphasize the critical role of these conditions in shaping the safety, efficiency, and aesthetic appeal of roads in challenging terrains. Through the proper application of geometric conditions in mountain road design, the inherent challenges of elevation changes, steep slopes, and winding curves can be met with strategies that enhance driver safety and overall travel experience. The discussion highlights that in the mountainous context, geometric conditions are not merely a set of guidelines but a means of harmonizing transportation with nature's grandeur. As such, they serve as a testament to the intricate dance between engineering and the environment, ensuring that the journey through mountainous zones is not just a passage but a memorable experience.

### **TRAFFIC SIGNAL AND SAFETY DEVICES CONDITION**

The evaluation of traffic signal and safety device conditions highlights several critical findings. First and foremost, the functionality of traffic signals, encompassing aspects such as pedestrian walk signals and countdown timers, is paramount in regulating traffic flow and enhancing safety. Well-maintained signals ensure smooth traffic operation, whereas malfunctioning or inadequately maintained signals can lead to confusion and an elevated risk of accidents. Similarly, the presence and condition of road signage, including regulatory, warning, and informational signs, is essential for driver awareness and adherence to traffic rules. Clear and well-maintained signs contribute to safety, while faded, damaged, or missing signs can result in confusion and traffic violations. Furthermore, the quality and condition of road markings, such as lane lines and pedestrian crossings, play a significant role in guiding drivers and enhancing safety. Maintained road markings improve driver awareness and reduce the risk of accidents, while faded or missing markings can lead to lane deviation and reduced visibility.

### **ROAD SAFETY DEVICES ANALYSIS**

Road safety devices play a crucial role in mitigating risks and reducing the severity of accidents on roadways. These devices encompass a wide range of equipment and infrastructure designed to enhance safety for motorists, pedestrians, and cyclists. Common road safety devices include guardrails, crash cushions, traffic barriers, rumble strips, reflective signs, and traffic signals. Each device serves a specific purpose, such as redirecting errant vehicles, alerting drivers to hazards, or regulating traffic flow. Advanced technologies like intelligent transportation systems (ITS) and automated enforcement systems further improve road safety by providing real-time information and monitoring traffic behavior. Regular analysis of road safety devices involves evaluating their effectiveness, durability, and compliance with safety standards..

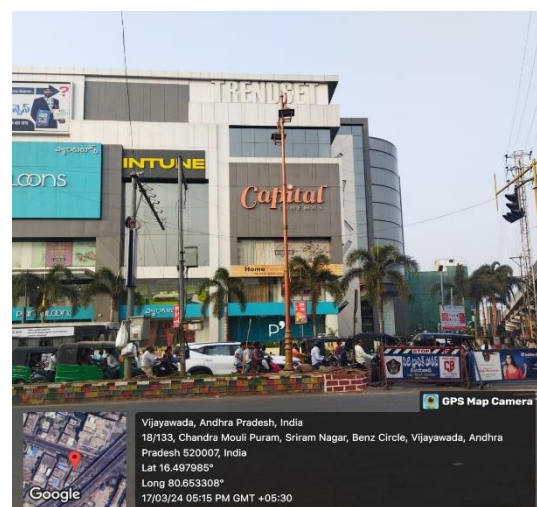
### **INTEGRATED RISK REDUCTION PLAN**

ArcGIS is indispensable in road design, offering a suite of tools and capabilities that streamline the process and enhance its efficiency and effectiveness. With its geospatial data integration and analysis features,

ArcGIS allows engineers and planners to make informed decisions. It aids in site selection, terrain analysis, and traffic assessment, helping to identify optimal road routes and ensure safety. Environmental impact analysis is simplified, promoting the creation of eco-conscious road networks. Moreover, ArcGIS supports land use planning, 3D visualization for public engagement, and encourages collaboration among stakeholders, enhancing transparency. Its decision support tools assist in selecting the most efficient and sustainable road designs. In summary, ArcGIS plays a pivotal role in modern road design by improving data-driven decision-making, fostering safety, and considering environmental and societal factors in the planning and construction of road infrastructure.

**Table. Integrated risk reduction plan**

S.no	Risk Level	Risk Factor	Risk Reduction Strategies
1	Very High	Area of junction	Road widening at junction
2	Very High	At Petrol bunk	Change the location of the petrol bunk
3	Very High	At Trend set mall	Avoid parking near the mall
4	Medium	At bus stand road	Providing zebra crossing for pedestrians
5	Medium	Free left	Develop free left for safe transportation
6	Very High	Geometric	Maintenance required
7	Medium	At Temple	Proper parking should be allotted
8	Very High	Drainage Optimization	Redesign the drainage channel
9	Very Low	Operative and Driver behavior	Enforcement of traffic laws and car accident prevention technology



## V. CONCLUSION

We are observed the study area and we are identified the accident cause factors on the location of study area. The study area is NH and the junction area is less when compared to traffic ratio. The surroundings of the junction (study area) are surrounded with malls, petrol bunk, temples as well as the restaurants and shopping malls. This will cause to congestion on the road and moreover some accidents are occurred due to lack of traffic indications and signals.

We are suggesting the risk factor solutions to what we observed in surveys.

1. Road widening towards JNBS
2. Zebra-crossing at traffic signal lights
3. Footpath towards JNBS and Patamata road
4. Sign Boards at internal junctions.

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