An Accident Statistics-driven adoption framework for ADAS in India

Santhosh Kumar G, Rajkamal S, Avinash Chavan, Guruprakash Rao

Abstract

Road infrastructure and vehicle technology in India have significantly advanced in recent years, improving road mobility. However, road traffic accidents and fatalities continue to rise despite ongoing efforts. In developed countries, Advanced Driver Assistance Systems (ADAS) have played a crucial role in reducing accidents. In regions like Europe, ADAS technologies have been gradually integrated alongside infrastructure improvements, awareness programs and stricter enforcement, all of which has boosted their effectiveness. Directly adopting ADAS in India, without considering local road conditions, could be problematic due to the diversity of Indian roadways and the lack of supporting factors, such as enforcement, awareness, and infrastructure. Therefore, a thorough analysis of road accident data is essential to understand the prevalent accident scenarios and to assess the relevance of ADAS technologies for India. This paper examines road accidents in India, focusing on their causes and severity, to guide the adoption of appropriate technologies to improve road safety.

Keywords: Road infrastructure, Vehicle technology, Advanced Driver Assistance Systems (ADAS), Road traffic accidents, Road safety

I. INTRODUCTION

Road transport is crucial for India's economic growth, but its increased use has led to a rise in road accidents, with fatalities doubling from 0.79 lakh in 2000 to 1.7 lakh (1,70,000 fatalities) in 2022. The Government of India, infrastructure developers, and the automobile industry must collaborate to address human-, infrastructure-, and vehicle-related issues. Advanced Driver Assistance Systems (ADAS) are gaining considerable attention in today's automobile market, with manufacturers eager to incorporate this technology into their vehicles to maintain competitiveness. However, a key question remains: are all ADAS technologies truly suited to India's unique road conditions and challenges?

India's diverse road conditions, varied driving behavior, and inconsistent infrastructure raise concerns about the immediate effectiveness and relevance of these technologies. Moreover, the limited level of public awareness further complicates the implementation of such technologies.

It's important to note that ADAS is not a single technology, but rather a suite of technologies designed to assist drivers. Not all ADAS technologies may be suitable for Indian roads, therefore a holistic approach is needed to identify which technologies would be most beneficial for the country.

To determine ADAS technology's adaptability for India, it is essential to evaluate the country's specific in-depth road accident data. This includes analyzing road accident types, the influence of human, vehicle and infrastructural factors and how different ADAS technologies could address these challenges. A thorough assessment will help identify which ADAS features offer the most potential for improving road safety in the Indian context.

Santhosh Kumar G is Senior Manager at Integrated Safety Centre ,TATA MOTORS Passenger Vehicle Limited
Rajkamal S is Senior Manager at Integrated Safety Centre ,TATA MOTORS Passenger Vehicle Limited
Avinash Chavan is Deputy General Manger at Integrated Safety Centre ,TATA MOTORS Passenger Vehicle Limited
Guruprakash Rao is General Manager at Integrated Safety Centre ,TATA MOTORS Passenger Vehicle Limited
Santhosh Kumar G (Mobile: 91 9566752265, email: skg740524@tatamotors.com) is Senior Manager at Integrated Safety

II. METHODS

This paper analyses passenger car accidents from RASSI (Road Accident Sampling System - India), a comprehensive accident database in India, and correlates with Ministry of Road Transport and Highway (MoRTH) data for conclusions. The analysis focuses on two key variables: pre-crash scenarios and contributing factors. Not possible to prioritise all accident types for prevention measures, and so it is necessary to create an analysis methodology to prioritise a specific set of accident scenarios. The intended analysis procedure is carried out in four steps: data gathering, data analysis, findings, and countermeasures. The purpose of this method is to comprehensively analyse the accident contributing factors against the frequency of pre-crash accident scenarios and their severity in order to identify the most severe pre-crash scenarios. The below Process Flow Chart provides a visual representation of the analysis methodology carried out in this study.

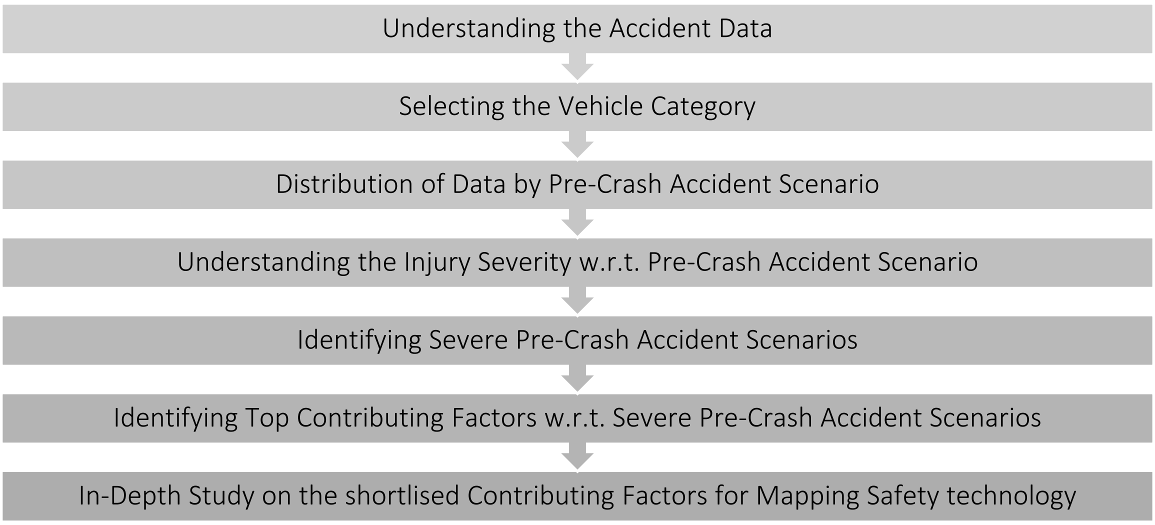


Fig. 1. Process Flow Chart.

Passenger Car Accident Analysis (M1 Category)

As per the intended analysis procedure, M1 accident contributing factors are distributed into human, vehicle, and infrastructure categories. The findings suggest that the contributing factors often involve a mix of categories, highlighting the need for a multifaceted approach.

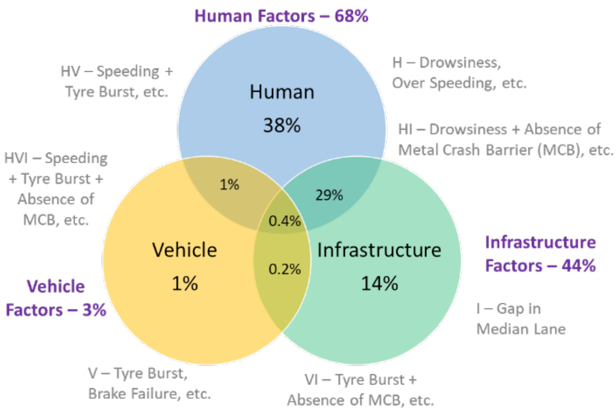


Fig. 2. Pre-Crash Contributing Factors.

As per the intended analysis procedure, M1 category accidents are analyzed based on their pre-crash scenarios, considering both frequency and severity.

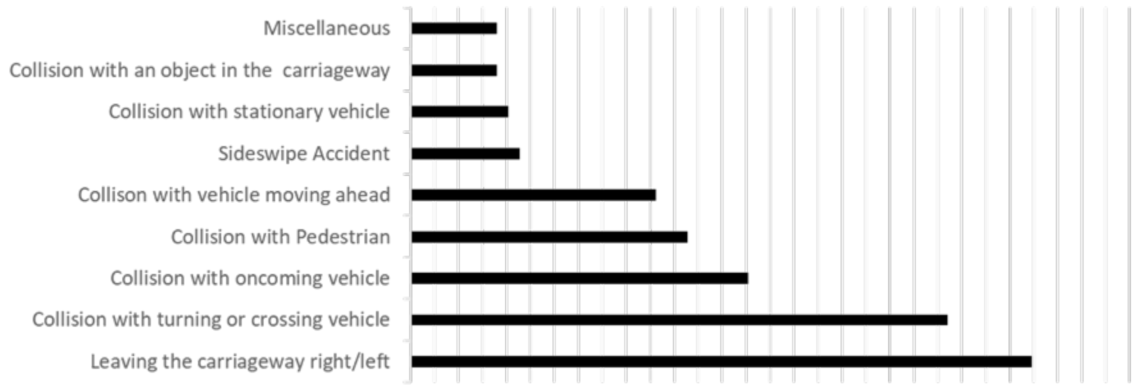


Fig. 3. Frequency of Pre-Crash Accident Scenarios.

Severity % is calculated by dividing the sum of serious and fatal injuries by the total number of injured persons.

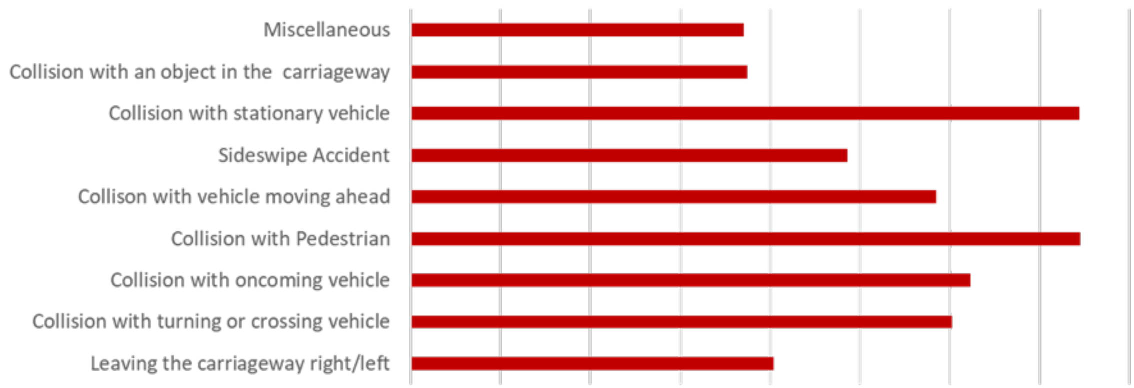


Fig. 4. Severity of Pre-Crash Accident Scenarios.

To identify the severe Pre-Crash Accident Scenario, it is vital to consider both frequency and severity together rather than considering either one of the two. Hence, we considered a 3 x 3 risk matrix, with frequency and severity in the X- and Y-axis. This approach simplified the process of identifying the severe Pre-Crash Accident Scenarios.

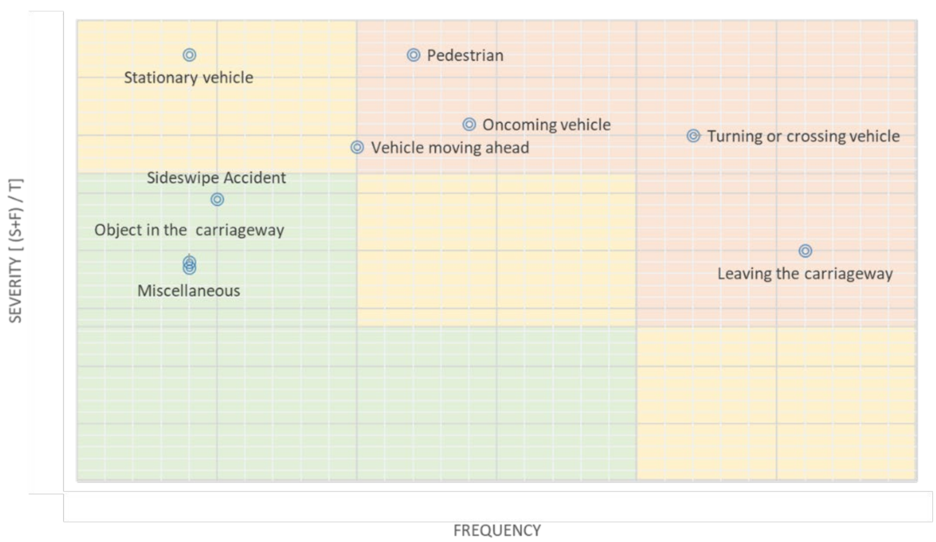
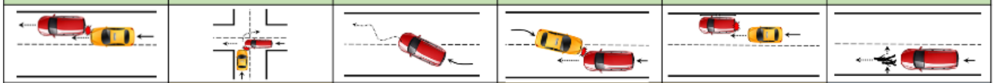


Fig. 5. Pre-Crash Accident Scenarios by Frequency and Injury Severity.

III. RESULTS

The analysis identified the most frequent and most severe accident scenarios. After categorizing these scenarios, the key contributing factors for each were determined. These factors were thoroughly examined to understand the underlying causes. The results of the analysis revealed that the primary causes of these accidents were a mix of driver errors and road infrastructure issues. The insights from this analysis can help in prioritizing ADAS technologies.

TABLE I
MAJOR CONTRIBUTING FACTORS OF PASSENGER CAR ACCIDENTS

Accident Scenarios					
Moving ahead	Turning or Crossing	Leaving the carriageway	Oncoming Vehicle	Starting or Parked Vehicle	Pedestrian
					
Driver - Drowsiness	Intersection	Driver - Drowsiness	Undivided Road	Parked vehicle on road	Vehicle Blindspot
Driving too slow for condition	Turning suddenly or without indication	Over - Speeding	Poor road marking or signage	Parked vehicle off road	Driver - Distraction
Improper lane change/ usage	Over - Speeding	Sharp road curvature	Overtaking in undivided road	Driver - Drowsiness	Improper Backing
Over - Speeding	Poor road marking or signage	Defective Brake	Improper lane change/ usage	Absence of Reflector	Poor road marking or signage
Driver - Distraction	Disobeyed Traffic Signal	Poor road marking or signage	Illegal road usage	Improper lane change/ usage	Poor street lighting

Human Factors | Infrastructure Factors | Vehicle Factors

Mapping ADAS features

The effectiveness of any ADAS technology to mitigate an accident will depend on multiple factors and on the pre-crash scenario. For example, features like Forward Collision Warning (FCW) and Autonomous Emergency Braking (AEB) are targeted to be effective in frontal collision scenarios. However, oncoming vehicles are generally not considered for any warning or braking activations in such scenarios for FCW and AEB. Similarly, for any ADAS feature there are certain combinations of pre-crash scenarios and contributing factors where the features can be considered effective in an ideal scenario. Now the question arises as to which participant vehicle, equipped with which ADAS feature, should be considered to evaluate the effectiveness of crash avoidance.

In our study, we have considered an ADAS feature to be 100% effective in accidents if any of the vehicles equipped with it deliver a change to the accident that leads to lower impact speeds or injury reduction. It must be highlighted that this is an ideal assumption since other factors also play a role, such as the movement of surrounding participants, the position of surrounding infrastructure, and driver reaction times, among other things. A crash reconstruction exercise with the pre-crash data, including surrounding participants, would need to be carried out for an accurate assessment of crash-avoidance effectiveness with the ADAS features. Some ADAS features are directly aimed at preventing the occurrence of a contributing factor that is either vehicle-, human-, or infrastructure-related.

ADAS technologies are designed to enhance vehicle safety by addressing specific accident scenarios and contributing factors. For instance, over-speeding-related accidents, such as collisions with stationary vehicles or with vehicles moving ahead, can be effectively mitigated by technologies like Speed Assistance (SA), Forward Collision Warning (FCW), Automatic Emergency Braking (AEB), and Adaptive Cruise Control (ACC). These systems not only ensure the vehicle maintains a safe speed but also alert the driver to potential hazards and, if necessary, automatically apply the brakes to avoid or reduce the severity of a collision.

Similarly, by mapping various ADAS technologies to specific accident scenarios and contributing factors, we can assess the likelihood of accidents that can be prevented or mitigated. This approach helps identify the most impactful ADAS features, providing valuable insights into their potential to enhance safety. Ultimately, this methodology helps in prioritising those ADAS technologies that can significantly improve road safety and reduce accidents and fatalities in India.

IV. CONCLUSION

This methodology provides a structured approach to identifying the potential benefits of ADAS technologies in the Indian context. Analyzing accident data and assessing pre-crash scenarios helps to priorities the relevant technologies, ensuring they are not adopted generically but instead tailored to the unique road conditions and safety challenges. This framework offers a more informed, data-driven, and strategic approach to integrating ADAS technology into vehicles, rather than adopting it indiscriminately. Furthermore, these technologies must be customized to align with Indian driving behaviors and road conditions. Without customization, there is a risk that the ADAS warnings may become overly frequent or intrusive, leading drivers to disable the systems. To ensure the adoption and long-term effectiveness and of ADAS, it is essential to ensure that these features are user-friendly, contextually relevant, and effective in preventing accidents, ultimately reducing the number of accidents and related serious injury and deaths.

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VI. REFERENCE

1. National Crime Records Bureau, “Accidental Deaths and Suicides in India”, Ministry of Home Affairs, reports for years 2022.
2. Transport Research Wing, “Road Accidents in India”, Ministry of Road Transport and Highways, India, 2022.
3. Puthan, P., Thalya, P., Lubbe, N. (2018) Active and passive safety passenger car technologies:
4. Potentials to save lives in India. Proceedings of IRCOBI Asia Conference, 2018, Lonavala, India.
5. Penumaka, A., Ghosh, P., Kalakala, V., Bakker, J., Buerkle, H. 2017. “Assessing the Potential Benefits of Autonomous Emergency Braking System Based on Indian Road Accidents” ESV Paper no. 17-0399, 17th ESV Conference, Washington D.C., June 5-6, 2017