iRASTE Telangana:

Detailed Project Report

AUGUST
2024

Project
iRASTE
INTELLIGENT SOLUTIONS FOR ROAD SAFETY THROUGH TECHNOLOGY AND ENGINEERING

Study Team

Principal Investigators (PI):

Dr. Anbumani Subramanian, INAI, IIIT Hyderabad
Dr. Chalumuri Ravisekhar, CSIR-CRRI
Dr. C. V. Jawahar, IIIT Hyderabad
Ms. Juby Jose, Intel-India

Co-PIs:

Mr. Govind Krishnan, INAI, IIIT-H
Mr. Prithvi Jonnada, INAI, IIIT-H
Dr. Velmurugan, CSIR-CRRI
Dr. Mukti Advani, CSIR-CRRI
Mr. Dev Singh Thakur, INAI, IIIT-H

Members:

Mr. Varma S. Konala, CEO, IIIT Hyderabad
Dr. Shailaja Tetali, IIPH
Mr. Jitin Kumar, CSIR – CRRI, New Delhi

Students:

Mr. Sundar Gupta, M. Tech student, NIT Surathkal
Ms. Praneetha Gubbala, M. Tech student, VNR VJIET Hyderabad
Ms. B. Vandana, M. Tech student, VNT VJIET Hyderabad
Mr. Abhay Dixit, M. Tech Student, MSR University, Vadodara
Mr. Divyang Akbari, M. Tech Student, SVNIT, Surat

Acknowledgement

Project iRASTE-Telangana team would like to place on record its profound gratitude and sincere thanks to the following respected persons:

1. Hon'ble Shri. Kalvakuntla Taraka Rama Rao, Former Minister for Municipal Administration and Urban Development, Industries and Commerce, and Information Technology, Electronics and Communications, Government of Telangana
2. Shri. Jayesh Ranjan IAS, Special Chief Secretary Dept of IT, E & C, Government of Telangana.
3. Shri. V.C. Sajjanar, IPS – Managing Director (MD) TGSRTC
4. Shri. Dr. V. Ravinder IPS, IGP Retd. – Chief Operating Officer (COO) TGSRTC
5. Ms. Rama Devi Lanka, Director of Emerging Technologies, OSD, IT, E & C, Government of Telangana.
6. Ms. Rushitha M – Head Startup Projects, Emerging Technologies, IT, E & C, Government of Telangana.

Team would like to express sincere gratitude to the members of the Steering Committee for their invaluable contributions and dedicated efforts throughout the entire project. Their insights, comments, guidance, and commitment significantly influenced the successful completion of this endeavour.

Steering Committee Members:

1. Dr. (Mrs.) N. Kalaiselvi, Director General (DG), Council of Scientific and Industrial Research (CSIR), New Delhi.
2. Dr. Manoranjan Parida, Director, CSIR - Central Road Research Institute (CRRI), New Delhi.
3. Prof. P.J. Narayanan, Director, International Institute of Information Technology (IIIT), Hyderabad.
4. Ms. Nivruti Rai, Managing Director of Invest India, Former Country Head - Intel India, VP - Intel Foundry Services, Intel Corporation.
5. Mr. Kishore Ramisetty, Vice President & General Manager, Vertical Solutions and Services Group at Intel Corporation.

Team extends heartfelt thanks to each member for their time, expertise, and unwavering support. Their thoughtful reviews and constructive feedback played a crucial role in shaping the project and ensuring its overall success.

Additionally, the iRASTE Team expresses sincere gratitude for the support extended by esteemed individuals in the field of Transportation Engineering, as well as professionals from Mobility and Road Safety Startups-

1. Mr. Kiran K. Kapila, President Emeritus, International Road Federation (IRF), India
2. Prof. P. K. Sikdar, President ICT and Advisor to IRF, Former Director, CSIR – CRRI
3. Dr. S. Gangopadhyay, Former Director, CSIR – CRRI, Former President to IRF IC
4. Mr. Akhilesh Srivastava, Road Safety Ambassador – IRF, IT Advisor ITDA Uttarakhand
5. Ms. Geetam Tiwari, Professor, Indian Institute of Technology (IIT), Delhi
6. Dr. Ekta Kapoor, Mission Director, NM – ICPS
7. Mr. Harshvardhan Sharma, Nomura
8. Mr. Prasanta Roy, FTI

9. Dr. Srinivas Imandi, PHFI
10. Naresh Kolloju, Program Executive – GMR Varalakshmi Foundation
11. G. Nagakrishna, Corporate Relations Officer - GMR
12. Mr. Mangesh Dakhore, ASEEM INFRA PVT LTD

The team sincerely acknowledges the support provided by –

1. Ministry of Road Transport & Highways (MoRT&H), India
2. National Highway Authority of India (NHAI), India
3. Traffic Police Department, Hyderabad
4. Telangana State Police Department
5. Regional Transport Office (RTO), Hyderabad
6. Faculties and Students of Visvesvaraya National Institute of Technology (VNIT), Nagpur
7. Regional Road Safety Committee, Telangana
8. Intel Onboard Fleet Services (IOFS), Intel – India, Bangalore
9. iHUB - Data, IIIT Hyderabad, Hyderabad
10. Telangana State Road Transportation Corporation (TGSRTC)
11. Indian Institute of Public Health (IIPH), Public Health Foundation of India (PHFI), Hyderabad

Achievements & Awards

ET Government DIGITECH Award 2023

Gartner Case Study

SKOCH Award 2024

Table of Contents:

List of Figures

List of Tables

List of Abbreviations

ABC	Active Bleeding Control
ADAS	Advance Driver Assistance System
AATC	Annual Average Total Crashes
AI	Artificial Intelligence
CRRI	Central Road Research Institute
CAS	Collision Avoidance System
CWSV	Combined Weighted Severity Value
CP	Control Period
CSV	Crash Severity Value
DV	Dependent Variable
DPR	Detailed Project Report
DMS	Driver Monitoring System
EMRI	Emergency Management and Research Institute
EMS	Emergency medical services
FIR	First Information Report
FV	Following Vehicle
FCW	Forward Collision Warnings
GIS	Geographical Information System
GDP	Geometric Design Plans
HMW	Headway Monitoring Warnings
IVs	Independent variables
IIPH	Indian institute of Public Health
IRC	Indian Road Congress
IT	Information Technology
ITS	Intelligent Transportation Systems

iRASTE	Intelligent solutions for RoAd Safety through Technology and Engineering
IOFS	Intel Onboard Fleet Services
LDW	Lane Departure Warnings
LHS	Left-Hand Side
MoRTH	Ministry of Road Transport and Highways
MNL	Multinomial Logit
NH	National Highways
NHAI	National Highway Authority of India
OR	Other Roads
OP	Observation Period
PCW	Pedestrian Collision Warnings
RHS	Right-Hand Side
RTIs	Road Traffic Injuries
SLI	Speed Limit Indicator
SSA	Safe Systems Approach
SW	Safety Wardens
SDI	Safety Driving Instructors
SI	Severity Index
SRL	Setting Reaction Level
SH	State Highways
SV	Subject Vehicle
TGSRTC	Telangana State Road Transportation Corporation
TTP	Telangana Traffic Police
TBMs	Transverse Bar Marking
UT	Union Territory
VRUs	Vulnerable Road Users

INTRODUCTION

1

Introduction

The Indian road network is one of the largest and most extensive in the world (6.671 million km during the year 2023-24) spanning vast distances and connecting remote villages to bustling urban centers. Comprising a mix of National Highways (NHs), State Highways (SHs), and Other Roads (ORs), where ORs include rural roads, major & minor district roads, etc., and these road network serves as the lifeline of the country, facilitating the movement of people, goods, and services across diverse landscapes and regions. Despite significant investments in infrastructure development over the years, challenges persist such as poor infrastructure including maintenance and lack of proper road safety assets, congestion in urban areas that often leads to aggressive driving behaviours, lack of Vulnerable Road Users (VRUs) safety measures, overloaded vehicles, reckless driving practices such as speeding and traffic rule violations, inadequate enforcement of traffic laws, lack of education & awareness about safe driving practices, inadequate vehicle maintenance, and so on, and these factors contribute to a high number of road crashes on Indian roads and unfortunately as per the recent road crash statistics by (MoRT&H 2022, 2023).

India ranked first position in road crashes and fatalities among the other countries of the world and contributed to 11% of fatalities around the world. In India, during the past five years (from year 2018 to 2022) road crashes are always high, contributing to more than 0.45 million road crashes, more than 0.15 million road fatalities, and around 0.45 million injuries every year (considered year 2020 & 2021 as an outlier due to the COVID-19 pandemic). Also, the percentage growth in these road crashes, fatalities, and injuries are increasing year by year. For instance, road crashes from year 2021 to 2022 increased by 11.9%, road fatalities by 9.4%, and injuries by 15.3%. For these road crashes, rapid growth in road networks without taking road safety features such as improper incorporation of the road safety guidelines, no VRUs safety-related parameters, no provision of service roads, improper road safety assets & road furniture, no provision of road user education & awareness, lack of enforcement, etc., inadvertently increase the occurrence of road crashes due to these interconnected factors.

Road crashes in India exhibit significant disparities across the different types of roads, as highlighted by MoRT&H data (2022, 2023). Although NHs make up just 2.1% of the total road network, they account for 32.9% of road crashes, 36.2% of fatalities, and 32.6% of major and minor injuries. Similarly, SH which comprises 2.8% of the road network, contributes to 23.1% of crashes, 24.3% of fatalities, and 24% of injuries. In contrast, ORs which represent the largest share at 95.1% of the road network—are responsible for 43.9% of crashes, 39.4% of fatalities, and 43.4% of injuries in 2022. These statistics are depicted in Figure 1.1 (a) & (b).

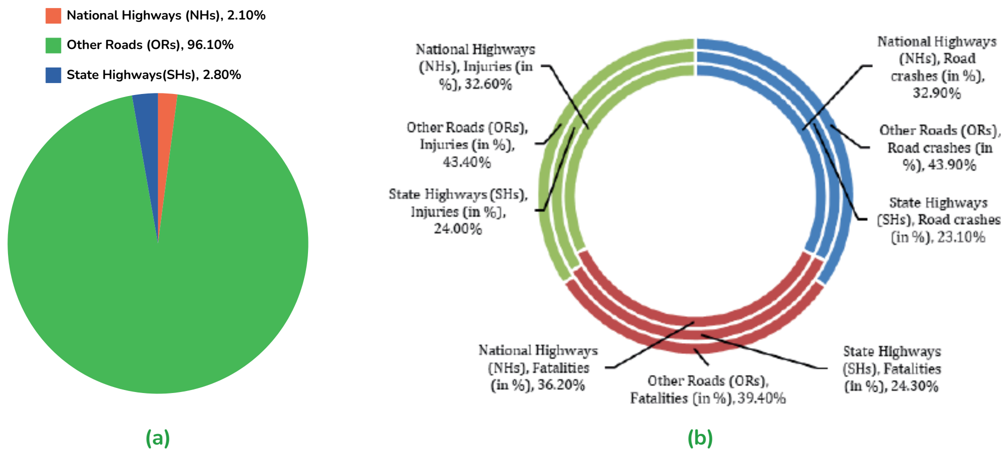


Figure 1.1. Indian roads and their road crash statistics; (a) Percentage share of various Indian roads, (b) Road crashes, fatalities, and injuries at these various Indian roads.

Additionally, road crash statistics from MoRT&H (2022 & 2023) reveal a significant rise in accidents across all road types in 2022 compared to 2021. On National Highways (NHs), road crashes increased by 17.99%, fatalities by 8.98%, and injuries by 22.58%. State Highways (SHs) saw a rise of 10.69% in crashes, 8.03% in fatalities, and 15.02% in injuries. Similarly, Other Roads (ORs) experienced an increase of 8.23% in crashes, 10.73% in fatalities, and 10.59% in injuries. These trends are illustrated in Figure 1.2.

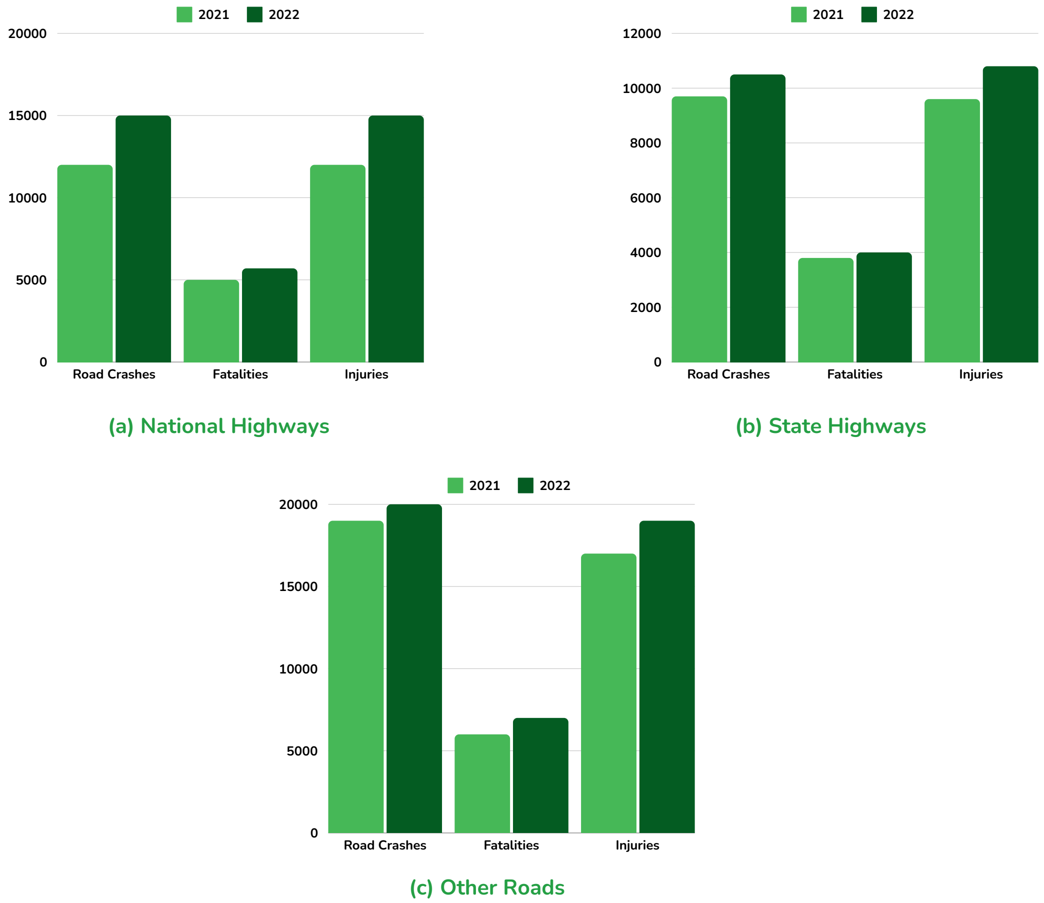


Figure 1.2. Year-wise Road crash statistics of different Indian roads; (a) National Highways, (b) State Highways, (c) Other Roads.

At the same time, in India, Telangana state alone accounted for 21,315 and 21,619 road crashes during 2021 & 2022. As a result of these crashes, 7,557 and 7,559 fatalities happened during 2021 & 2022. Specific to road type, Telangana state accounted for the high number of crashes such as 7,214 and 7,505 in the years 2021 and 2022, thus having the consistent dubious distinction of 8th position in the country in road crashes among the 28 states and 8 U/Ts in the same years. This has resulted in 2,735 fatalities and 3,010 fatalities in the year 2021 and 2022 respectively making it one of the most unsafe states in the country. Figure 1.3 presents the yearly road crash statistics for Telangana's NHs from year 2019 to 2022. Across the four years, there were fluctuations in the number of road crashes, with a peak of 7,505 crashes reported in the year 2022 (MoRT&H 2022, 2023).

In addition to the increase in crashes, there was a corresponding rise in fatalities, reaching a peak of 3,010 deaths in 2022, highlighting a concerning trend in crash severity. While the year 2020 saw a decrease in the total number of crashes compared to 2019, fatalities still increased, indicating that the crashes were more severe despite their reduced frequency. Similarly, although 2021 experienced a slight decrease in crashes compared to 2020, fatalities continued to climb. The number of injuries fluctuated slightly over the years, with the highest recorded in 2019 and the lowest in 2020. Despite these variations, the overall figures remained consistently high, reflecting persistent challenges in road safety management on Telangana's national highways.

These statistics underscore the urgent need for proactive measures to address the underlying causes of road crashes and fatalities. Emphasizing the importance of enhanced infrastructure, advanced technologies, stricter enforcement of traffic laws, and targeted public awareness campaigns, these efforts aim to create a safer road environment for all users. Reducing crash severity requires less conventional measures to mitigate the alarming trends in road safety.

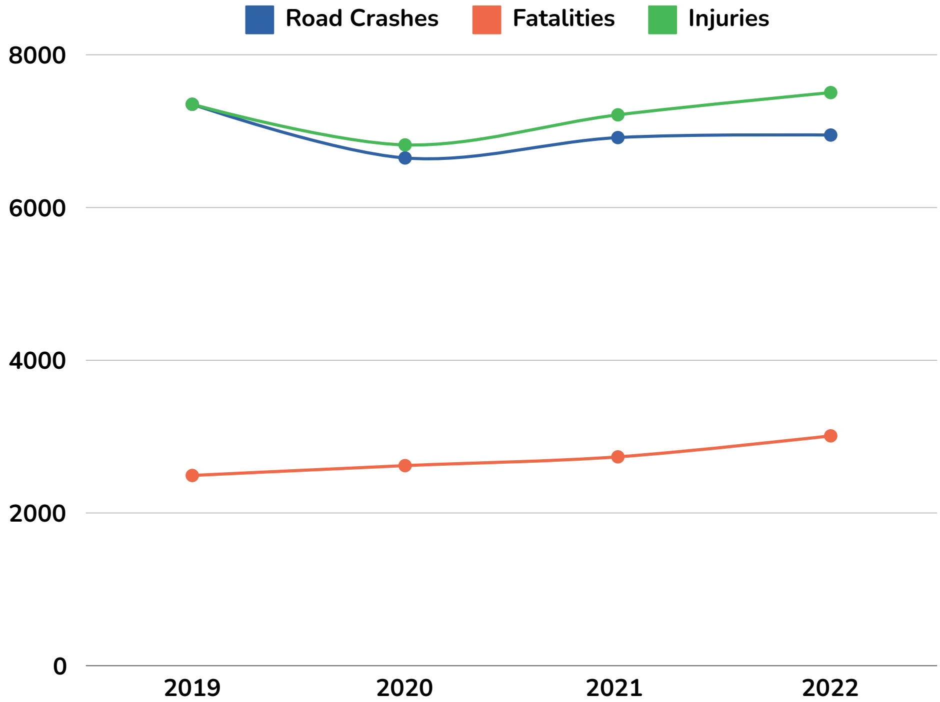


Figure 1.3. Year-wise trend of road crash statistics of Telangana State National Highways.

An analysis of the vehicles and the road users involved in the fatalities & major and minor injuries due to the above road crashes is illustrated in Table 1.1. This table presents the quantitative data on road crash fatalities and injuries categorized by road user type and gender. Overall, males accounted for a significantly higher number of fatalities and injuries compared to females across all categories. Among road user types, pedestrians reported the highest total fatalities and injuries, followed by two-wheelers and car-related vehicles. Two-wheelers showed the highest number of fatalities and injuries, with males comprising the majority. Auto rickshaws, cars, taxis, vans, and trucks/lorries also reported notable figures, predominantly among males. Bicycles, buses, and other non-motor vehicles had lower fatality and injury rates overall. The data underscores the substantial impact of road crashes on male road users across various categories, highlighting the need for targeted interventions to improve their safety.

Table 1.1. Road crashes of Telangana state based on road user type during year 2020.

Road Users	Fatalities		Major Injuries		Minor Injuries		Total	
	Male	Female	Male	Female	Male	Female	Male	Female
Pedestrian	903	245	263	74	1606	577	2772	896
Bicycles	63	0	24	1	122	2	209	3
Two Wheelers	3105	364	1219	127	6432	1400	10756	1891
Auto Rickshaws	272	70	123	47	1075	511	1470	628
Car, Taxis, Vans& LMV	552	106	206	34	1960	582	2718	722
Trucks/ Lorries	416	41	88	6	740	141	1244	188
Buses	72	12	23	0	200	75	295	87
Other Non-motorized Vehicles	124	1	11	0	148	35	283	36
Others	469	67	76	3	552	178	1097	248

Based on the above information, Indian NHs present under the Telangana state boundaries bear a significant burden of road crashes, which underscores the urgent need for comprehensive measures to enhance road safety along the NHs of Telangana state. Improving the road safety status of Telangana state NHs require a multifaceted approach including road safety engineering & management, vehicular engineering, education, enforcement, and emergency care. For this, collaborative efforts involving government agencies, law enforcement, transportation authorities, automobile engineers, technology, and the public are crucial to addressing this pressing issue and ensure that NHs remain safe and efficient conduits for India’s economic growth and development.

To achieve this, a consortium of Telangana government, transportation authorities, road-owning agencies, automobile & public transportation agencies, academic institutes, and Artificial Intelligence (AI) has undertaken an AI-based road safety project i.e., Project iRASTE (Intelligent solutions for RoAd Safety through Technology and Engineering) in Telangana state (India), aimed at the implementation of a holistic Safe Systems Approach (SSA) and ultimately reducing the road crashes / fatalities by 50 % on a couple of inter-urban National Highway (NH) corridors which are falling within the Telangana state boundaries. Incidentally, when a similar project was started for the city of Nagpur, Maharashtra in August 2021 by a consortium coordinated by CSIR – CRRI to address the road safety issues in Nagpur city, the project was coined the acronym iRASTE-Nagpur which is primarily targeting the safety on the urban and peri-urban roads. Taking cue out from the above-referred study, the present study, henceforth referred to as iRASTE-Telangana, is proposed to cover primarily three corridors on inter-urban national highways NH-65 (Hyderabad to Kodad towards Vijayawada), NH-44 (Hyderabad to Pullur towards Bangalore), and NH-44 (Hyderabad to Adilabad towards Nagpur).

Information Technology (IT) minister of Telangana, **Mr. K. T. Rama Rao**, Govt. of Telangana launched this project in July 2022 with the primary objective of reducing up to 50 % on the above selected NHs passing through Telangana state.

It is a established fact that in the present decade, AI-based solutions have shown remarkable results worldwide in enabling safer Mobility and Transportation systems. Accordingly, it was felt that the deployment of AI-based Advance Driver Assistance System (ADAS) tools such as Collision Avoidance System (CAS) and Driver Monitoring System (DMS) can act as a force multiplier in addressing the problems of road safety on India's NHs. Given the above crash statistics, the road crashes involving buses are one of the major areas of safety concern and crashes due to buses leads to high severe crashes due to its big size and bus drivers facing more number of blind spots and Hence this project is attempted by deploying AI-driven solutions in Telangana State Road Transportation Corporation (TGSRTC) public transit buses aimed up to the 50 % reduction of the road fatalities / crashes by 2024 involving buses and it acts as an aid towards achieving the nation's goal i.e., to halve the cases of bus road crashes by the year 2024. To address the above, installation and evaluation of the ADAS in TGSRTC buses was undertaken that includes ADAS devices (as shown in Figure 1.4) by a consortium consisting of, IIIT Hyderabad, Intel-India, CSIR-CRRI, Uber, Aseem Infra, TGSRTC & Telangana government and collectively driven by the INAI – Applied AI Research Center. In this endeavour, TGSRTC and National Highway Authority of India (NHAI) were identified as the beneficiary public transportation and road owning agency respectively who would extend their local logistics support.

It shall be borne in mind that the basic difference between iRASTE-Nagpur and iRASTE-Telangana is that iRASTE-Telangana focuses on reducing accidents on national highways, whereas iRASTE-Nagpur focused on urban / city. In iRASTE-Telangana 10 units of Driver Monitoring System (DMS) was also installed in addition to 190 units of ADAS devices.

Figure 1.4. Installation of ADAS devices in TGSRTC buses.
*TSRTC was renamed to TGSRTC.

This project covers the various aspects of enhancing safety using the AI-based ADAS systems installed in public transit buses of TGSRTC, simultaneous improvement of road infrastructure through the development of geometric design improvement plans for the identified blackspots and the Greyspots (identified based on ADAS and road geometric data) as well as imparting driver training and awareness programs. The strategy deployed in Project iRASTE has been on the application of 4E's conforming to Global Standards. 4E's of Road Safety include Engineering, Education, Enforcement, and Emergency care. In this regard, Project iRASTE has been designed to address the 4 main vectors that connect the 4E's of road safety.

1. **Vehicle Safety** – Improve safety of public fleet leveraging AI. The TGSRTC fleet is used to study the effectiveness of ADAS implementation. ADAS devices installed in the above fleet generates the following alerts / warning namely, Forward Collision Warnings (FCW), Headway Monitoring Warnings (HMW), Lane Departure Warnings (LDW), and Pedestrian Collision Warnings (PCW).
2. **Mobility Analysis** - Application of ADAS data for proactive identification of potential road crash prone locations i.e., Greyspots using the compiled aggregated ADAS and road geometric data and develop Greyspot models.
3. **Infrastructure Safety** - Development of remedial measures i.e., countermeasures for the identified blackspots and continuous monitoring of road assets confirming to IRC: 131 (2022).
4. **Education, Awareness, and Emergency Care** – To educate TGSRTC drivers, safety wardens and safety driving instructors on ADAS and DMS systems and the importance of using technology to reduce road accidents. To train Trystanders near Blackspot locations on Active Bleeding Control (ABC) by working closely with Indian institute of Public Health (IIPH), Hyderabad.

The project is undertaken spread over two phases with focus areas (1) and (2) covered in Phase-1 which encompasses the entire state of Telangana. On the other hand, focus areas No. (3) to (4) was addressed in Phase-2 of the project in Telangana state. This report summarizes the initiatives and results of Project iRASTE-Telangana.

The scope of services for this study is limited to three inter-urban national highway corridors within the regions of Telangana state. The details of study corridors are given in Table 1.2. This table outlines the study corridors within Telangana's boundaries, detailing the routes and lengths of national highways (NH) within the state. The first corridor stretches from Hyderabad to Kodad on the Vijayawada route, covering NH-65 with a length of 150 kilometers. The second corridor runs from Hyderabad to Pullur on the Bengaluru route, encompassing NH-44 with a length of 180 kilometers. Lastly, the third corridor extends from Hyderabad to Adilabad, crossing NH-44 and spanning approximately 303 kilometers. These corridors are crucial transport arteries facilitating connectivity between major cities and regions within Telangana, playing a pivotal role in the state's economic development and transportation infrastructure

Table 1.2. Identified Inter-urban Study Corridors.

S. No.	Route (within TS boundary)		Study corridor (within TS boundary)		NH number	Length of the road (Km)
	From	To	From	To		
1	Hyderabad	Kodad (Vijayawada route)	Malkapuram **(17.280269, 78.796585)**	Kodad **(16.952221, 80.048986)**	NH-65	150
2	Hyderabad	Pullur (Bengaluru route)	Darvesh Masjid **(17.234571, 78.357653)**	Pullur **(15.880352, 78.016547)**	NH-44	180
3	Hyderabad	Adilabad	Medchal ORR Junction **(17.5991795, 78.4925656)**	Penganga Bridge **(19.817265, 78.577524)**	NH-44	303

Further, these considered study corridors were imported into the Geographical Information System (GIS) to visually represent the corridors over the road network of the Telangana state as shown in Figure 1.5.

Figure 1.5. Identified study corridors over the street map of Telangana state in GIS.

Study Methodology

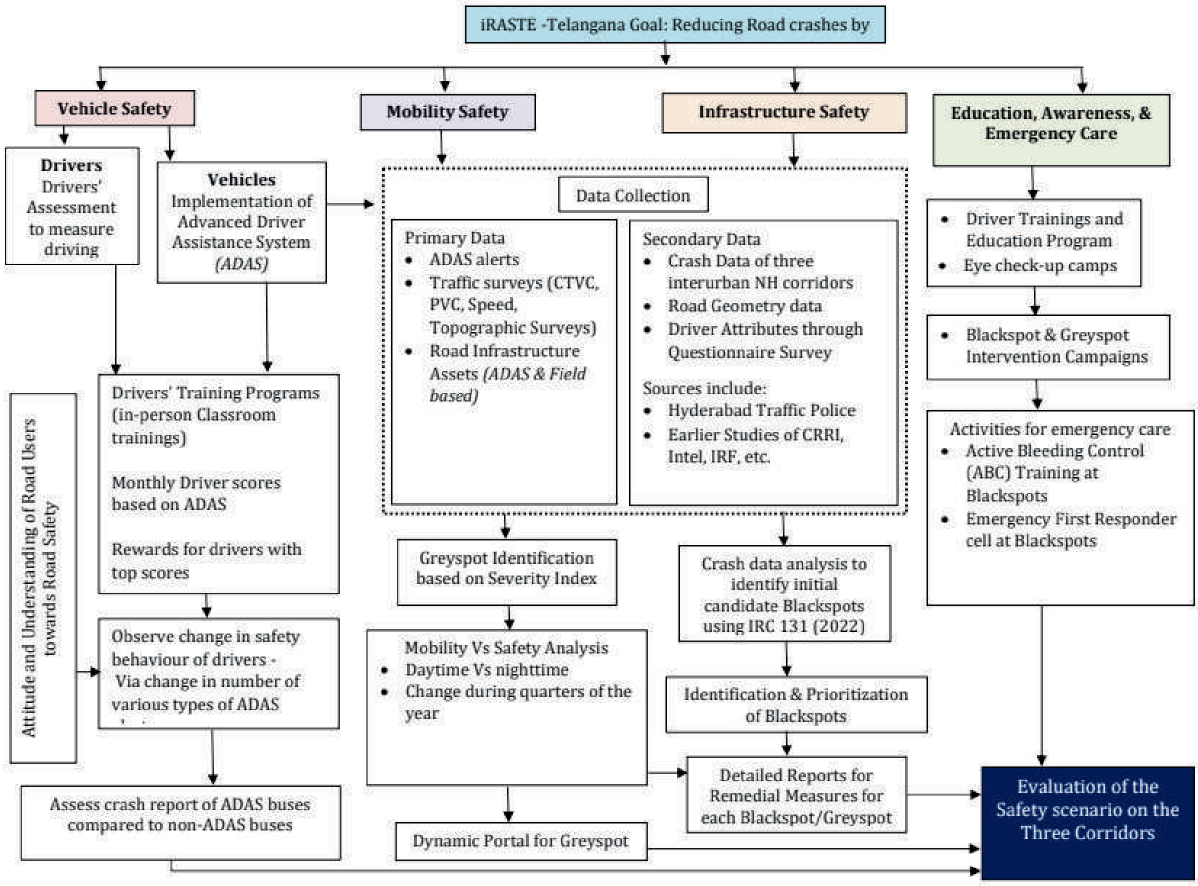


Figure 1.6 Study Methodology

As presented in Figure 1.6, this study involves the installation of ADAS devices in TGSRTC buses that ply on Telangana NH inter-urban corridors. The alerts generated from these devices are stored on cloud and later extracted for further analysis to identify the locations, that can be termed unsafe but do not fall under the category of Blackspots. Eventually, they are termed 'Greyspots' implies thereby the need for undertaking the necessary measures at the identified Greyspots to prevent them from turning into blackspots in the foreseeable future. To accomplish the objectives identified above, the following four major verticals are formulated for reporting purposes.

1) **Vehicle Safety** – This task includes the installation of ADAS devices on fleet (majorly TGSRTC bus fleet), collection, storage, extraction, and collation of data on various alerts generated through device.

2) **Mobility Safety** - Based on the alert data generated by ADAS devices, the Greyspots on the road network traversed by the TGSRTC fleet has been identified which is followed by devising cost effective engineering improvements for possible implementation.

3) **Infrastructure Safety** - This task focuses on the identification of blackspots based on First Information Report (FIR) data and based on field & traffic surveys, a Detailed Project Report (DPR) regarding the rectification of the blackspots is prepared.

4) Driver Education, Training, Emergency Care, and Awareness Campaigns at Blackspots and Greyspots – Parallel and central to the above three vectors are the concerted efforts put forth towards imparting driver's training, education, and awareness towards achieving enhanced road safety. This task also included the categorizing of drivers based on statistical analysis and the relevant analysis to see the level of adoption of ADAS devices among various drivers. Apart from drivers, awareness campaigns imparted amongst the road users and community at large are also covered in this task.

The works accomplished under each of the above-mentioned vectors are discussed in detail in the succeeding sections.

VEHICLE SAFETY

2

2 Vehicle Safety

Road crashes involving large vehicles like buses or trucks cause more fatalities to Vulnerable Road Users VRU's, such as pedestrians or two-wheelers as well as grave damage to public property. The top reasons attributed to such crashes include driver distraction, indiscipline of road users as well as poor road geometrics. Avoiding some of these crash reasons is under the direct control of the driver e.g., driver distraction, whereas some others require the driver to be acutely mindful to external factors on the road. Hence defensive driving by drivers of large commercial vehicles has a major impact on the reduction of road crashes and fatalities in selected project corridors. Recent advances in AI-based vehicle safety technology such as ADAS assist drivers in defensive driving. Alerts from ADAS devices improve driver reaction time by up to 2 times which reduces collision likelihood. Project iRASTE is the first initiative in India to study the impact of AI-based ADAS devices in improving the safety of large, commercially operated fleets in real-world conditions. Nagpur city was the first project corridor selected for implementation of Project iRASTE in Urban part of the city. This was followed by iRASTE implementation roll-out in Telangana state on State Highways.

Project iRASTE is the largest and longest running study of Advanced Driver Assistance Systems (ADAS) for commercial vehicles in India. This report summarizes observations on safe driving behaviour of drivers after introduction of ADAS devices in Telangana. The findings from this project will serve as recommendations for large commercial fleets looking to improve vehicle safety by adopting AI-based safety technology. Furthermore, it will also assist policy bodies and technical standard bodies in India as they formulate regulations for safer vehicles on Indian roads. To accomplish this, the report first provides an overview of ADAS functionality; the second section provides an overview of the TGSRTC Fleet selected for study; the third section explains study methodology; the fourth section discusses study results in detail; the fifth section highlights influence of factors encountered in real-world operations; the final section summarizes conclusions and next steps.

2.1 How does Advanced Driver Assistance Systems (ADAS) help?

AI-powered Advanced Driver Assistance System continuously monitors the road ahead and warns the driver a few seconds before a potential collision. Such real-time warnings improve driver reaction time by up to 2X. This in turn reduces the likelihood of collisions. The alerts warn the driver of risk from other vehicles as well as vulnerable road users like pedestrians or two-wheelers. The alerts also encourage defensive driving practices such as lane discipline and safe headway from vehicles ahead.

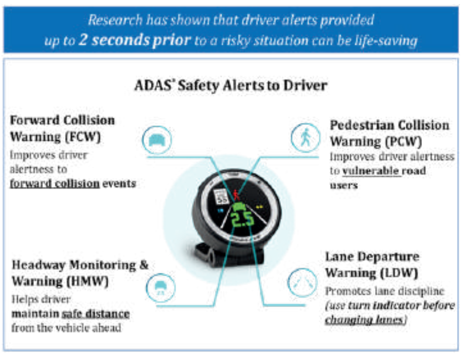


Figure 2.1 ADAS safety alerts delivered to driver via audio and visual alerts. Speed limit indicator (SLI) is provided as a visual display of the ADAS

Table 2.1 details the definition of these ADAS based alerts-

Alerts	Details
Forward Collision Warning (FCW)	FCW alert generates when the Subject Vehicle (SV) approaches the Following Vehicle (FV) closely or experiences sudden braking at high speeds near the FV.
Headway Monitoring Warning (HMW)	ADAS warns the driver when the SV doesn't maintain a 2.5 second headway with the FV. If the headway drops to 0.6 seconds or less, the HMW alert triggers
Lane Departure Warning (LDW)	LDW generates when the SV, traveling at 55 kmph or more, and changes lane suddenly or strays onto lane lines without signalling.
Pedestrian Collision Warning (PCW)	PCW alerts the driver when pedestrians / cyclists are in the vicinity of SV. This alert generates when the speed of SV falls between 7 to 50 kmph.

2.1.1 Illustrations of ADAS-enabled buses and ADAS safety alerts

The main components of an ADAS device include a camera unit focused on the road and a display unit. The single-camera unit has a powerful processor that processes video data locally and uses advanced AI algorithms to detect risk in real time. All computations are done locally which avoids the inefficiency of sending video data to a cloud for processing. Once the camera unit detects imminent risk, the driver is alerted via the display unit fixed at eye-level of the driver. The display unit generates visual as well as audio alerts that captures to attention of the driver. The alert information is also sent to a cloud portal which archives all such events for detailed offline analysis. The ADAS solution used for the study was from Intel Onboard Fleet Services (IOFS), a leading provider of fleet safety solutions.

Figure 2.2 ADAS-enabled bus; the main components of an ADAS devices such as CAS and DMS include a camera unit focused on the road and a display unit.

Figure 2.3 ADAS unit alerts driver with unsafe distance warning for VRUs; Pedestrians and Vehicles, including 2-wheelers are detected; FCW, HMW, LDW, and PCW.

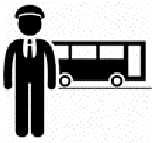
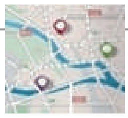
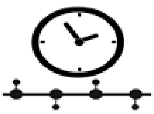
2.2 Overview of study fleets

Project iRASTE was first Implemented in Nagpur city to reduce accidents in an urban location. In every state in India, government operates large commercial bus fleets that offer public transit services. Safety and timeliness of public transit services is an important metrics indicating service quality. Hence Project iRASTE–Telangana's primary focus was to reduce Road Accidents in Highways. Hence, 200 buses of TGSRTC offering inter-city transit services were selected as primary study fleet to assess effectiveness of AI-based ADAS devices.

Project preparation activities started in July 2022. The project then started with ADAS installation on 200 buses of TGSRTC. ADAS installation on all TGSRTC Fleet was completed by Sept 2022. Hence training of the Device and technology has been completed from JAN'23 - MAR'24. Hence, JAN'23 - MAR'24 is considered as the study period for reporting observations.

TGSRTC bus fleet was selected as the primary study fleet. This report provides detailed observations from ADAS-enabled buses of TGSRTC. A deeper focus on one large commercial fleet helps the study to make specific and detailed observations regarding the effectiveness of ADAS in improving the safety of large commercial fleets, especially government operated fleets.

Table 2.2 Key characteristics of ADAS-enabled TGSRTC bus fleet

	**200 ADAS-enabled buses + 10 DMS buses**	ADAS was installed on Buses from 5 main depots (Miyapur-1, BHEL, HYD-1, NZB-1 and NZB-2. During the same period, TGSRTC operated about 200-250 non-ADAS buses in these Depots. This allowed for comparison of road crash statistics of ADAS and non-ADAS buses during the same period.
	**600 drivers**	About 600+ TGSRTC drivers drove ADAS-enabled buses during the study period. Drivers are allocated buses based on a dynamic schedule. 1:1 association is not maintained between a bus and driver. Given longer duration of the study, driver churn was also observed.
	**2 Crore + Kilometers**	ADAS-enabled buses drove 2 Crore + Kilometers during the study period. This mainly covered city routes, though highway roads were also part of the service
	**5 Study Periods**	The study involved observations across 5 observation periods from Jan'23 – March'24, to allow for longitudinal analysis of results

2.3 Study Methodology

The methodology for data analysis is shown in Figure 2.4.

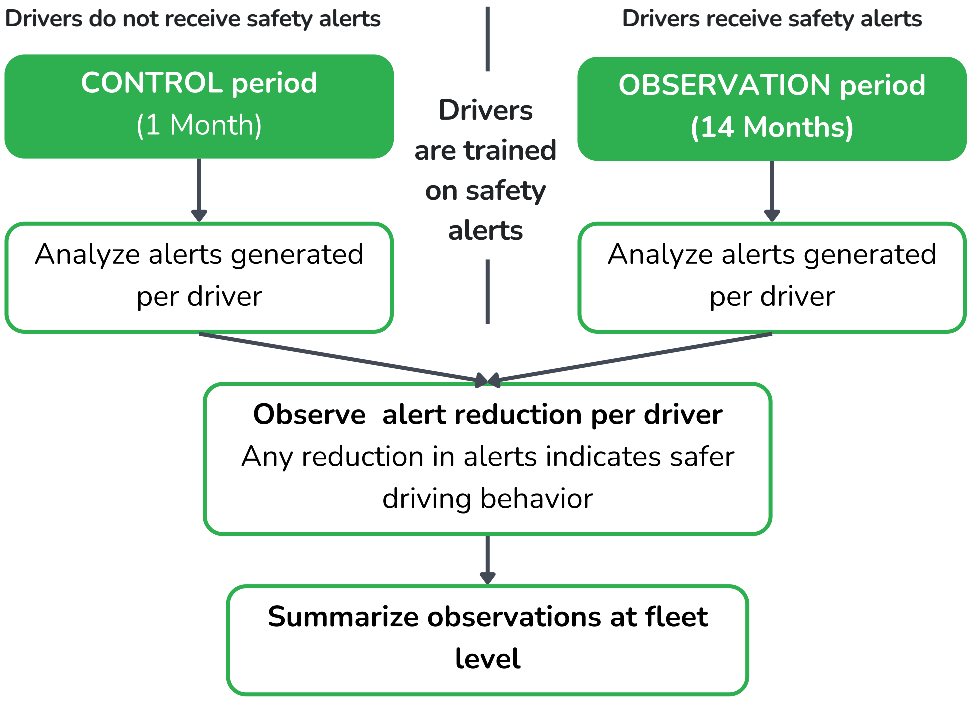


Figure 2.4 Methodology of data analysis

The study started with a Control Period in Oct 2022, spanning a minimum of 1 month. This period is indicated by the acronym, CP in subsequent sections. During the Control Period, drivers do not receive ADAS alerts in-cabin. However, alerts generated by drivers are recorded in the cloud. This data is used to prepare a baseline record of total alerts generated by every driver of ADAS buses. The alerts are then normalized by distance driven to obtain a risk score for the driver. Detailed information on driver risk score is provided in Section 2.4.1.2. At the end of the Control Period, all drivers are trained on ADAS and Defensive driving using ADAS alerts. Now the study enters Observation Period (OP). In this period, drivers receive ADAS alerts in-cabin. This includes audio and visual alerts. A risk score of every driver of ADAS buses is recorded during this period. Every Observation Period span 1 month. A reduction observed in risk score of drivers is an indication of improvement in safe driving behaviour. This analysis has been extended to individual ADAS alerts aimed at assessing improvement in Lane Departure, Safe Headway, Pedestrian collision, and Forward collision alerts. **This study included 1 Control Period (CP) and 5 Observation periods (OP) for the primary study fleet, allowing for longitudinal analysis.**

2.3.1 Challenges

The operational complexity of TGSRTC service doesn't allow fleet managers to maintain 1:1 association between drivers and buses. Drivers are also allocated buses based on a dynamic schedule. Hence all drivers don't drive one fixed route but drive multiple city routes. Due to this, route driven by a driver may influence risk score.

All the Installations in the 200 TGSRTC buses were completed by September 2022. Following this, training was conducted for Depot Management and technicians on the device's technical aspects to stabilize the functioning and prevent it from tampering. iRASTE-Telangana technical team had to visit each and every depot to do this on the ground and make sure all the technical management people part of TGSRTC are trained on the device aspects. iRASTE team had to visit multiple depots and train multiple people who had glitches in their schedules, job timings, etc. Oct'22 - Mar'23 was the period of training all the Depot Management on the technical aspects of the Device.

However, there is a large overlap observed in driver routes. Hence even if drivers are allocated different routes, its effect on risk score is expected to be small. To further minimize the effect of route on risk score of a driver, Control and Observation periods span a large window of 1 month. This allows for sufficient randomness in route assignments such that risk score of a driver is not adversely impacted by route assignment.

Another challenge encountered is in training drivers in ADAS and DMS. ADAS is a new safety technology introduced as part of Project iRASTE. A single training cannot cover all drivers effectively. Due to diverse shift allocations and timings, it was a very challenging task to train all the drivers who were about to drive the ADAS equipped buses (12 groups per day, 20 days of training, 500+ drivers trained). It was important for all the drivers to drive these ADAS equipped buses to know how the technology works and the benefits of using it. Hence the support of TGSRTC Depot Managers were enlisted to conduct periodic ADAS refresher training for drivers during the Observation periods.

2.4 Study Findings

2.4.1 TGSRTC bus fleet

2.4.1.1 ADAS alerts overview

ADAS-enabled TGSRTC fleet was driven more than 2 Crore kilometers during the study period covering the various arterial / sub-arterial road networks as well as national / state highways falling in the state of Telangana across 3 main corridors (refer Figure 2.5).

Figure 2.5 Coverage of Telangana Road network by ADAS buses

Lane Departure warnings (LDW) were the highest recorded alerts in Telangana, followed by Headway Monitoring warnings (HMW). This can be considered as a characteristic of Highways. This distribution of ADAS alerts may change if study corridor comprises other types of roads e.g., Urban Roads.

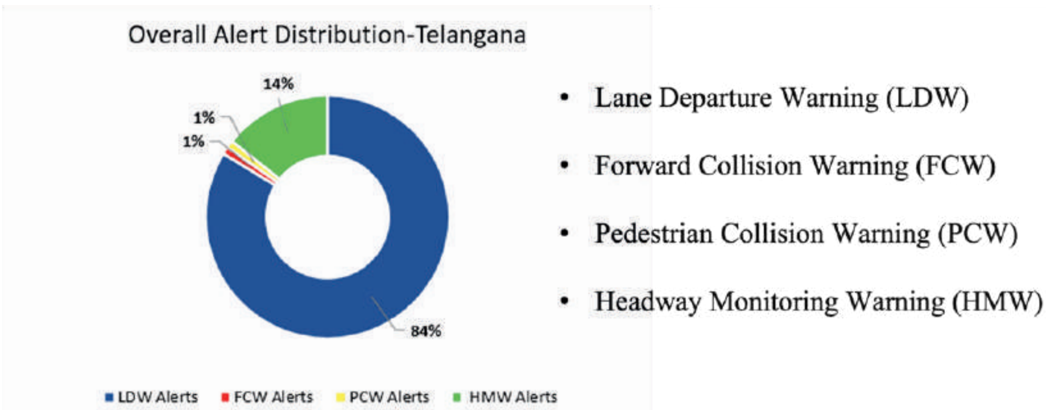


Figure 2.6 Distribution of ADAS alerts in Telangana state (road network comprises primarily interurban highways)

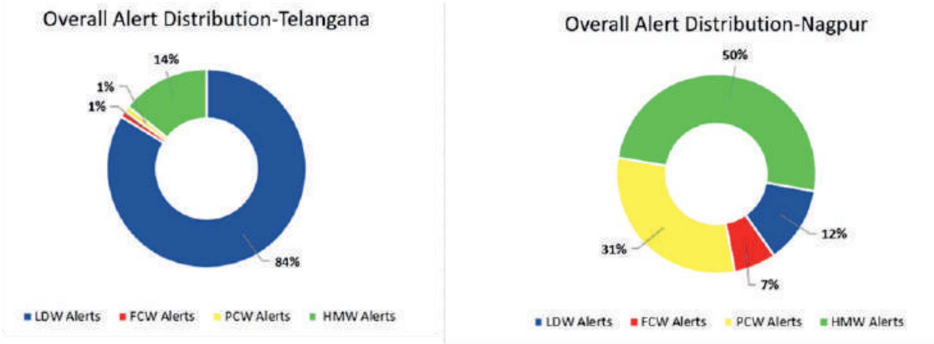


Figure 2.7 Comparison of ADAS alerts distribution on interurban highways (iRASTE-Telangana) and urban roads (iRASTE-Nagpur).

2.4.1.2 Risk score computation based on ADAS alerts.

Today road crash statistics of a fleet are the primary source of data for assessing risk level of a fleet. Unfortunately, this is a lagging indicator, i.e., it can be measured only after the road crash has happened. Hence interventions required to prevent road crashes become a reactive measure. This is particularly problematic for commercial fleets which see very high churn in drivers, with new drivers forming a large percentage of the employee base. Without a reliable leading indicator of fleet risk, training needs cannot be assessed.

Data from ADAS devices provide a means of reliably computing risk score of a fleet. **Risk score based on ADAS data is a leading indicator of road crash risk and can be used by fleet operators to design proactive interventions** such as driver training, personalized coaching, performance rewards etc. The following section explains how risk score of a fleet is computed in study corridor.

As mentioned earlier, ADAS device provides 4 types of audio/visual alerts to drivers in-cabin. These include Forward Collision Warning (FCW), Pedestrian Collision Warning (PCW), Lane Departure Warning (LDW) and Unsafe Headway Warning (HMW). Moreover, Speed Limit Indicator (SLI) is provided as a visual indicator / warning only on the ADAS display unit, wherever such road signs are encountered on the road network traversed. To compute risk score of the fleet, firstly risk score is computed for every individual driver. Driver risk score is computed as a sum of 4 alerts (FCW, PCW, LDW, HMW) generated by the driver, normalized by distance over which alerts were generated as presented in equation 2.1. SLI alert is not included in risk score computation as speed signs may not be reliably available for every road segment. Once driver risk score is computed, fleet risk score is computed as the median of all individual driver scores as presented in equation 2.2. The use of median prevents the influence of the outliers.

$$\text{Driver Risk Score} = \frac{\sum(FCW, PCW, LDW, HMW)}{\textit{Distance over which alerts are generated}} \quad \text{............Eq. 2.1.}$$

$$\text{Fleet Risk Score} = \textit{Median of individual driver risk scores} \quad \text{.....................Eq. 2.2.}$$

Risk score is computed for every period, including Control period and Observation periods. Lower the risk score, lower is the likelihood of road crashes. As explained in study methodology section, each period spans 1 month. This allows for sufficient randomness in route assignments such that risk score of a driver is not adversely impacted by route assignment. Normalization of alert count by distance ensures that risk score is comparable across drivers who drive different distances in a month. A distance filter of 320 km is also applied in every period, i.e., only a driver who has driven a minimum of 320 km in a month is considered for risk score assignment. This value of distance filter allows for sufficient randomness in routes, based on distance driven by a driver per day.

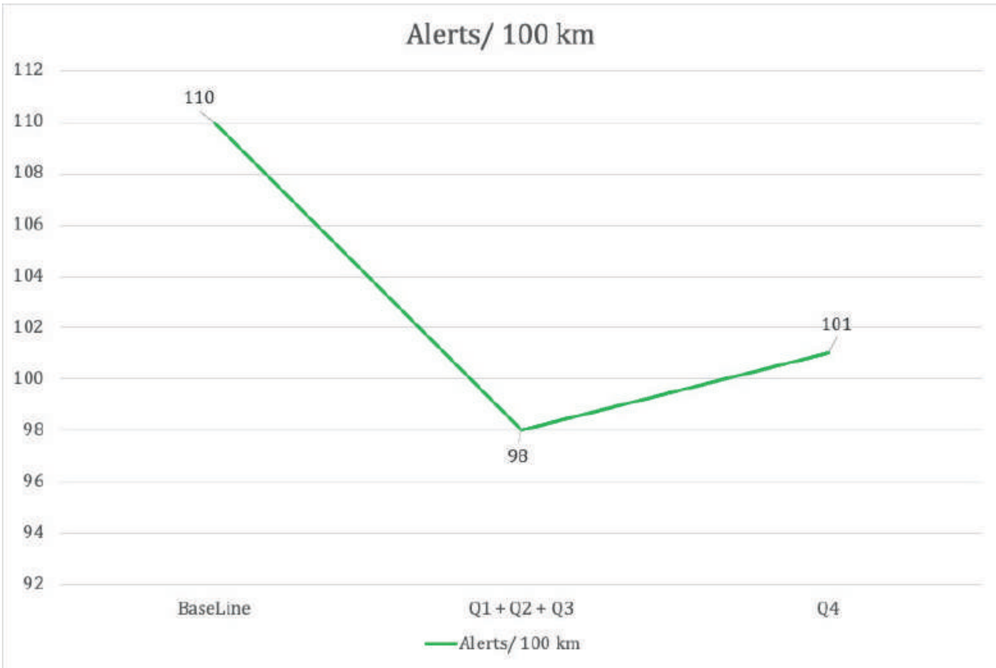


Figure 2.8 Driver Performance Avg. Alerts per 100 Kms

The above chart represents the Risk Score of the Driver Performance per 100 km. Initially, 110 alerts / 100 km have been considered as a baseline to evaluate further Data/ results. Baseline is considered by turning OFF the In-Cabin alerts for all the vehicles but the alerts have been pushed to the cloud regularly. In the Baseline period, Drivers weren't trained on the ADAS + DMS technology. After baseline alert count has been captured, all the Devices have been turned ON, wherein the Drivers were then able to see the alerts and hear an audio visual of the alerts.

In Q1 + Q2 + Q3, there was a major dip in the alerts as the team has done continuous Driver Training sessions. All the drivers were trained on the device structure, it's uses, functionalities and its importance.

Later in Q4, the Alerts had a minor jump/rise. After all the analysis, surveys, discussions etc, it was observed that, non-continuous driver training sessions impact a distraction of the project goals and milestones. Drivers are not in that continuous loop if they aren't trained directly or indirectly on a regular basis. Regular and frequent training can be a good motivation for all drivers to reduce their risk score.

Limitations

The risk score is not normalized to a standard scale, e.g., 1-100. Equal weightage is assigned to every alert type. The absolute value of risk score thus computed is dependent on alert characteristics of the fleet. Hence risk score in this study is used only within a fleet type to observe improvements and to set performance targets. Such a risk score can also be used to compare performance across fleets with similar operating characteristics such as shift timing, frequency, route features etc. However, it should not be used to compare performance across fleets that have different operating characteristics

2.4.1.3 Classroom training to Cabin training: A major upgrade in driver skilling

Traditionally, driver skill gaps have been addressed via classroom training, test tracks or other spot checks in the field. Driver performance improves post the intervention but drops soon after. In Project iRASTE, the team took the opportunity to move away from Classroom training to real-time Cabin training. Along with introduction of new vehicle safety technology, it is also important to redesign existing driver training workflows. With Cabin training, the objective was to combine existing classroom training with on-the-job training via driver risk scores. The coaching schedule for drivers was adapted as shown in Figure 2.9 and subsequent table depicts the comparison of classroom training versus cabin training and a brief overview of the three training programs.

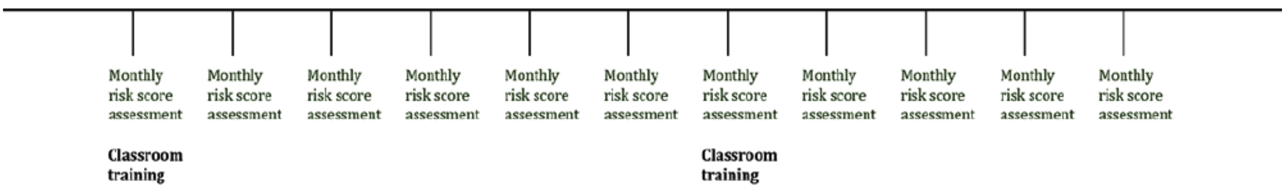


Figure 2.9 Coaching schedule for drivers in Cabin training approach.

Classroom Training Approach	CabinTraining Approach
Trainings are conducted in special settings only – classroom, test track etc. Training frequency varies across fleets	Classroom training is combined with on-the-job training in the vehicle cabin via driver risk scores
Training outcomes are not immediately measurable	Risk scores are available monthly as an objective measure of training outcome (e.g., objective driver scores used by services like Uber encourage improved driver performance
Training content is standard, is not customized to learning ability of the driver	Monthly risk scores and individual alert performance encourage personalized coaching
Special setting for training disrupts operator schedule	Training is primarily on-the-job

600+ TGSRTC drivers trained in Defensive driving with ADAS and DMS until Mar'24

120 Safety Champion Awards delivered

40+ Safety Wardens and Safety Driving Instructors were trained in Feb'24

Figure 2.10 Driver training and recognition programs are critical for program success.

2.4.1.4 Observations on drivers' adoption of ADAS

With Cabin training based on ADAS, the objective is to combine existing classroom training with on-the-job training via driver risk scores. It is important to continuously analyze individual driver scores to assess perceived ease of use and perceived usefulness of new technology and workflows.

iRASTE team has conducted a survey with minimal questions on the importance of ADAS to the drivers of TGSRTC. The overall sample size was 50 drivers and additionally the Depot Managers, Driving Instructors, Safety Wardens etc. were interviewed. There were 4 questions in the survey form:

1. How useful was the iRASTE training to you?
2. How useful were the 4 alerts from the ADAS unit?
3. Do you think ADAS device helped reduce road accidents?
4. Will it be useful/effective to deploy ADAS devices in all TGSRTC buses?

The Results proved that 90% of the Drivers had a positive opinion on adopting ADAS in all the remaining buses and also the effectiveness of ADAS training.

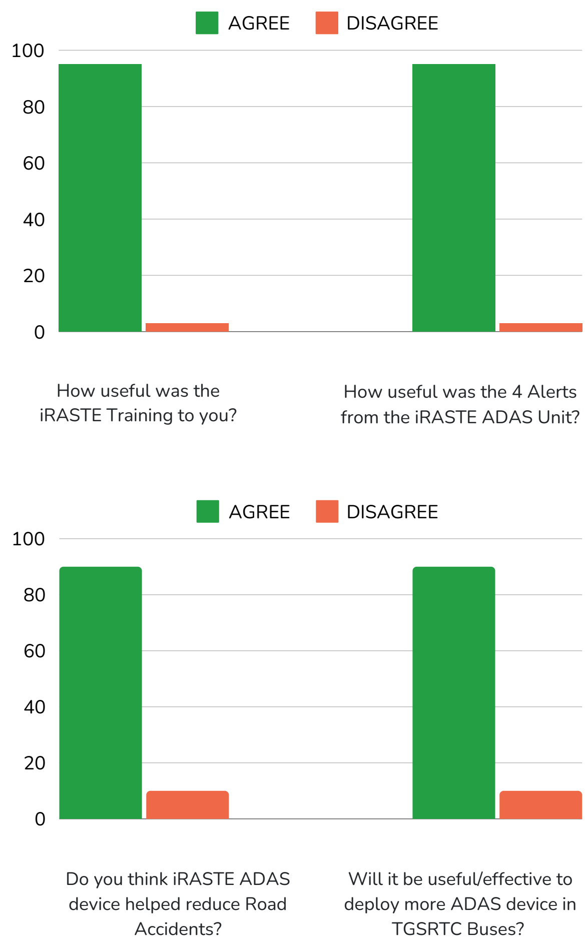


Figure 2.11 Results of survey on importance of ADAS

2.4.1.5 Observations on Road Crash statistics in ADAS vs non-ADAS buses

As drivers become more familiar with ADAS technology, relative accident rate of ADAS buses drops sharply. In 2024, an assessment was made of crash statistics in ADAS vs non-ADAS buses in TGSRTC service. ADAS was installed on 200 buses of TGSRTC that ply on highways. During the same period, TGSRTC also operated 200-250 non-ADAS buses, including electric buses. This allowed for comparison of road crash statistics of ADAS and non-ADAS buses during the same period.

Road Crash data was obtained from TGSRTC that happened during the period from January 2023 to March 2024. These included road crashes involving both ADAS and non-ADAS buses. This allowed for road crash rate comparison in the same period.

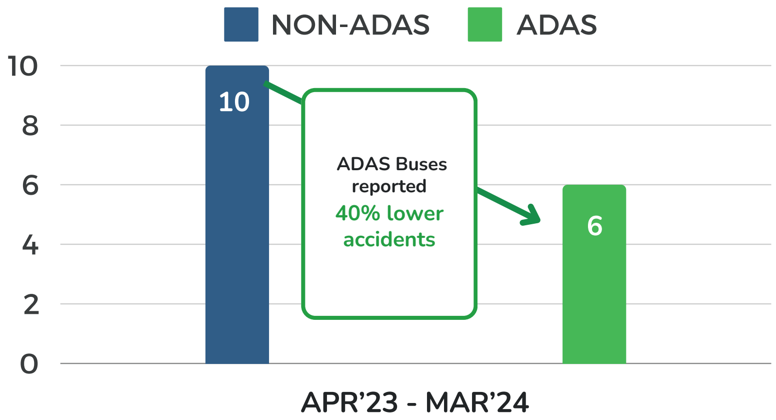


Figure 2.12 Road Crash of ADAS v/s NON ADAS Buses within the 5 Depots of TGSRTC

A total of 16 Fatal accidents were reported by 5 depots during Apr'23 – Mar'24. 6 accidents were reported in ADAS buses, and 10 accidents were reported in non-ADAS buses.

During the period of Feb'24 – April'24, iRASTE team initiated an innovative campaign with all ADAS-equipped TGSRTC bus drivers, Safety Wardens (SW) and Safety Driving Instructors (SDI) targeting a decrease in road crashes. Focused on one of the ADAS alerts i.e., Lane Departure Alerts (LDW), iRASTE initiated the 'Lane Discipline Challenge' campaign, which aimed to minimize lane departure warnings / alerts, and enhance the overall driving behaviour of bus drivers in the road network. The iRASTE team not only emphasized safety but also recognized exemplary driving behaviour by awarding top drivers with a 'Certificate of Appreciation' and Cash Rewards, reinforcing positive driving practices in the road network.

The 3 campaigns initiated by iRASTE-Telangana were:

1. **Lane Departure Warning Campaign:** Driving Instructors and the Safety Wardens were asked to train all the drivers and set a target for them on a daily basis to reduce Lane Departure Warnings in their Depots. The Depot which has reduced the Maximum % of alerts within the campaign period is rewarded.
2. **Zero Fatalities Campaign:** Safety Driver Instructors and Safety Wardens were asked to ensure that no fatal accidents occurred during the three-month campaign. Out of 17 Depots, 11 Depots were able to achieve the target by not even having a single Fatal accident for 3 months.
3. **Driver Performance Campaign:** We have categorized set limits for Driver Performance Matrix i.e., total alerts / 100 km. We have different the bunch of drivers into 4 categories. VERY GOOD, GOOD, AVERAGE, WEAK. The campaign emphasizes how many Drivers have been moved from the WEAK Category to AVERAGE, AVERAGE to GOOD and GOOD to VERY GOOD.

The event organized by TGSRTC & iRASTE-Telangana to incentivize exceptional driving performance was a significant initiative aimed to promote Road Safety and its measures.
The highlight of the event was recognizing and rewarding Safety Driving Instructors and Safety Wardens who made drivers achieve outstanding results in reducing Lane Departure warnings and maintaining impeccable driving records.

The primary goal of the campaign was to encourage drivers to minimize lane departure warnings and improve driver performance thereby enhancing Road Safety and reducing Road Accidents. TGSRTC and iRASTE together aim to foster a culture of safe driving practices among its depots by acknowledging and rewarding extraordinary drivers.

The event was graced by Shri. Kalmeshwar Shingenavar, IPS (Commissioner of Police – Crime), a notable figure in the field of law enforcement and Road Safety. His participation underscored the importance of the campaign and highlighted the commitment to TGSRTC's safety standards.

The winners of the campaign along with the Depot Manager and the Regional Managers were rewarded for their outstanding contribution to making iRASTE-Telangana a big success and joining hands with the project to reduce overall accidents.

Drivers who didn't have a single minor/major/fatal accident history for the past 20+ years were also rewarded by the IPS officer.

The event was not only to celebrate/reward the winners but also to showcase a powerful reminder on the Importance of Road Safety and how technology can play a crucial role in reducing accidents. By incentivizing such positive behaviors, TGSRTC aimed to inspire all other guests, Depot Managers, Regional Managers etc. to prioritize Road Safety and continuously improve their driving skills.

Figure 2.13 TGSRTC - iRASTE Campaign results event

Limitations

Data on total km recorded by non-ADAS buses was unavailable to the study team. This prevented normalization of road crash rates based on km driven. Hence road crash rate has been normalized based on number of buses.

2.4.1.6 (a) Road Crash Forensics

Offline analysis of ADAS alerts can provide some inputs to augment our understanding of crash reasons. Figure 2.14(a) is an illustration of alerts generated prior to a road crash at Trimurti Chowk. Though the illustration is not able to point the specific crash reason, it helps to confirm road crash time and location. In these cases, a road-facing dash-camera can provide invaluable evidence related to a crash.

Figure 2.14 (a) Illustration of ADAS alerts recorded prior to a crash

2.4.1.6 (b) Identification of Hotspots

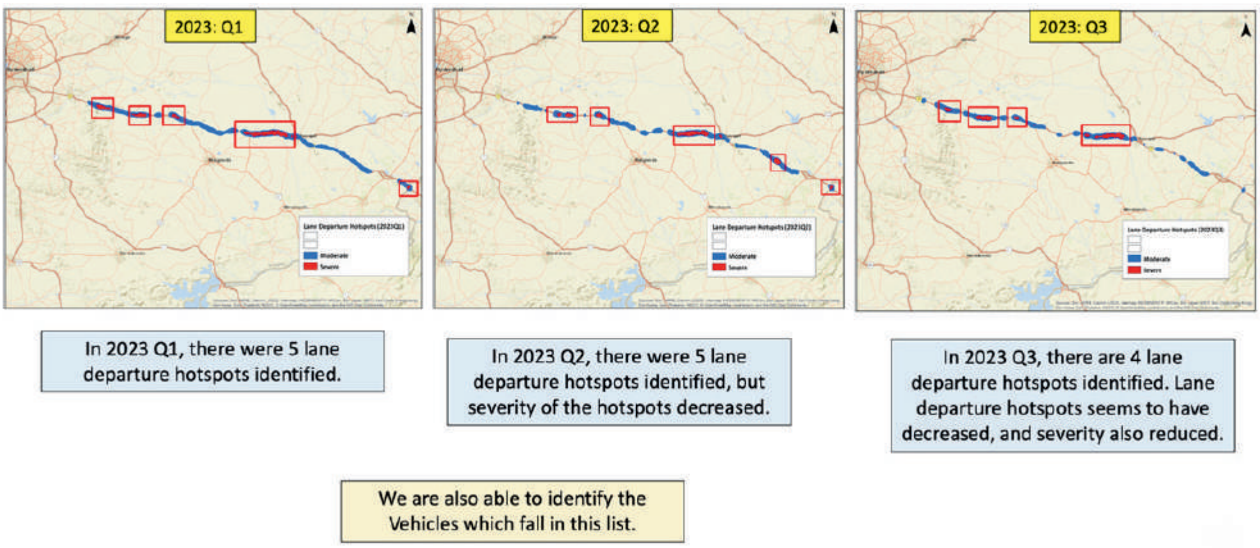


Figure 2.14 (b) Lane Departure warning Hotspot with severity

The above figure represents the Hotspots identified based on severity. The Lane Departure Warnings have been a major contributor to accidents. The Lane Departure Warning is the highest-ranking alert compared to other type of alerts. The Blue Highlighted zone indicates “Moderate”, and the Red indicates “Severe”. In 2023 Q1, there were 5 Lane Departure hotspots identified which were severe. Whereas in Q2, the number of Lane Departure hotspots remained the same, but severity has decreased. The impact of decrease in severity is the reflection of multiple training sessions and regular encouragement. In Q3, the Lane Departure hotspots have reduced to 4 along with the severity.

2.4.1.7 Study limitations

a. All drivers of ADAS buses didn’t have uniform experience with ADAS.

Driver inexperience with ADAS can adversely impact driver risk scores. ADAS was installed on 200 TGSRTC fleet that ply on fixed routes. Since drivers are assigned based on a dynamic schedule, a driver with relatively less experience with ADAS may be assigned to drive an ADAS-enabled bus. Real-world scheduling challenges prevent fleet managers from assigning the same set of drivers to ADAS buses. **Driver inexperience with ADAS can adversely impact driver risk scores.** This problem is further compounded by driver churn, i.e., new drivers entering the system or old drivers leaving. If a new driver doesn’t receive ADAS training upon joining, the driver may spend multiple periods before becoming familiar with the technology. However, this is an unavoidable phenomenon when dealing with large fleet operations. In this study, this was mitigated by having an efficient driver training program.

b. Route assignment may affect driver’s ability to improve risk score.

To minimize the effect of route on risk score of a driver, Control and Observation periods span a large window of 1 month. This allows for sufficient randomness in route assignments such that risk score of a driver is not adversely impacted by route assignment. However, the effect of route on driver performance should be taken up for future studies.

c. More frequent training and rewards cycle can improve driver performance.

During the study period, classroom training and reward cycles were undertaken once every 6 months. However, during new technology adoption phase, a more frequent training and rewards cycle should be adopted.

2.4.1.8 Dispelling Myths about lane indiscipline in India

The study of TGSRTC Fleet indicates that LDW is the 1st highest type of ADAS warning generated by bus drivers. It is observed that instances of lane indiscipline are higher on highways.

Adequate training on the importance of lane discipline and how to maintain it on the road is often missed. As part of iRASTE, consistent monitoring and feedback were provided to TGRSTC bus drivers on this key safety discipline. Lane departure trend shows that with active involvement of depot managers & Campaigns, it is possible to reduce instances of lane indiscipline. During this study, bus drivers responded very well to training and technology initiatives.

2.4.1.9 Outcomes

The results of this study demonstrate the effectiveness of AI-based ADAS devices in improving safety of large TGSRTC fleets. As a result of Driver Training & Safety Warden/Driving Instructor Training & the LDW/Zero Fatalities Campaigns, we observed a 40% reduction in crash rate compared to ADAS and non-ADAS equipped TGSRTC buses. Another important contribution of this study is the ADAS-based Cabin training approach. This represents a major upgrade in driver skilling with 7 out of 10 drivers reporting above-average scores after 5 observation periods. Improvements in defensive driving practices like safe driving distance and alertness to Vulnerable Road Users (VRUs) are noteworthy. Periodic reinforcement of safe driving behaviors among drivers via training and digital campaigns is absolutely essential to sustain this improvement. This requires fleet operators to periodically track and incentivize safety performance of drivers of ADAS-enabled fleet who exhibit better compliance with road safety.

2.5 Assessment of Driver Behaviour using DMS devices

2.5.1 Driver Monitoring System (DMS)

The Driver Monitoring System (DMS) stands at the forefront of cutting-edge automotive technology, with a primary mission to elevate road safety and optimize driver performance. In 6 the ever-evolving landscape of automotive innovation, DMS has emerged as an indispensable component, addressing the growing imperative for safer and more efficient transportation systems. Employing a sophisticated blend of sensors and cameras, this system diligently observes the driver's behavior, vigilance, and overall condition, averting accidents and fostering a more secure and enhanced driving experience as shown in Figure 2.15.

Figure 2.15 Driver Monitoring System

Objectives of DMS:

The implementation of a Driver Monitoring System is guided by a set of paramount objectives:

- **Elevating Road Safety:** Foremost among its aims, DMS seeks to curtail accidents attributed to driver distractions, drowsiness, or impairment. By ensuring that drivers remain attentive and focused, it actively works towards reducing road mishaps.

- **Enhancing Driver Performance:** DMS is tailored to identify and rectify issues related to driver performance, such as fatigue, inattention, or impaired driving. This, in turn, contributes to safer and more proficient driving.
- **Preventing Accidents:** Through the early detection and prompt alerting of drivers to potential hazards or risky behaviors, DMS plays a pivotal role in accident prevention, thereby diminishing injury and fatality rates on the roads.

Key Features of DMS:

The Driver Monitoring System incorporates a range of essential features to effectively meet its objectives:

- **Facial Recognition:** DMS harnesses the power of cameras to monitor the driver's facial expressions, tracking factors such as eye movements and head position. It can even discern signs of drowsiness and can identify the driver to personalize settings
- **Eye-Tracking:** Precise eye-tracking technology enables DMS to gauge the driver's gaze, distinguishing between focused attention on the road and distraction caused by smartphones, dashboards, or other diversions.
- **Alerting Mechanisms:** DMS provides real-time alerts to drivers when it detects potential dangers. These alerts encompass lane departure warnings, following distances that are too close, or veering off the road.
- **Data Logging:** The system can record and store data related to driver behavior, enabling later analysis and feedback for continuous improvement.

Implementation of DMS:

- **Hardware Installation:** Equipping the vehicle with the requisite cameras and sensors is the foundational step, necessitating optimal positioning to effectively monitor the driver's facial expressions and eye movements.
- **Software Integration:** The development or integration of DMS software into the vehicle's existing control systems is essential for seamless functionality.
- **Calibration:** Calibration is critical to ensuring precise recognition of the driver's facial features and eye movements while establishing alert thresholds.
- **Training and Education:** A comprehensive driver education program is imperative to acquaint drivers with the system's capabilities, benefits, and proper responses to alerts and feedback.
- **Data Analysis:** Continuous data analysis of DMS-collected information identifies trends and areas where drivers may require improvement, enabling proactive measures.
- **Maintenance and Updates:** Regular maintenance and updates to the DMS hardware and software is vital to sustain peak performance and align with evolving vehicle technologies.

In Summary, the Driver Monitoring System embodies a pivotal stride in automotive safety technology, aiming to cultivate safer roads, optimize driver performance, and ultimately preserve lives. Its widespread integration in vehicles reflects a collective commitment to shaping a safer and more responsible driving environment for all.

2.5.2 Study Area and Data Collection

2.5.2.1 Study Area

The bus equipped with Driver Monitoring Systems (DMS) traverses the NH-65 highway in Telangana, India. This study focuses on a 150-kilometer (Km) test corridor, specific to interurban regions, stretching from Malkapur Village to Kodad Town. The corridor features predominantly four-lane divided partial controlled access highway segments, with median openings spaced approximately every 2 to 3 km. In developed regions, there are additional lanes, often six or more, accommodating various road users, diverse land use establishments, and traffic features. The test corridor includes 91 three-arm intersections, 18 four-arm intersections, and 193 midblock regions (road segment between two consecutive intersections). Horizontal curve radius ranges from a minimum of 20.55 meters (m) to a maximum of 1040.17 m, while level / altitude differences range from a minimum of 0.5 m to a maximum of 10.3 m throughout the corridor. Additionally, the posted speed limit of this corridor is 80 kmph.

To evaluate driver inattention behavior at any location, the test corridor is divided into 500-meter segments using Geographic Information System (GIS) tools (QGIS.org). This segmentation aligns with the typical level of accuracy usually recorded in the police records i.e., First Information Reports (FIRs). Notably, this study does not rely on road crash records to assess driver inattention behavior, focusing solely on DMS-generated inattention alerts. Following corridor segmentation, it was found that the test corridor comprises 156 curved (high & low) and 150 straight road segments.

The test corridor is further categorized by traffic direction, recognizing that different sides exhibit distinct characteristics affecting driver inattention. Thus, the corridor is divided into two parts for better analysis: The Left-Hand Side (LHS) from Malkapur village to Kodad town (M-K) and the Right-Hand Side (RHS) from Kodad town to Malkapur village (K-M). While both sections have the same length, they differ in terms of road design, traffic flow patterns, environmental factors, and land use. Figure 2.16 provides a visual representation of the test corridor overlaid on a GIS map.

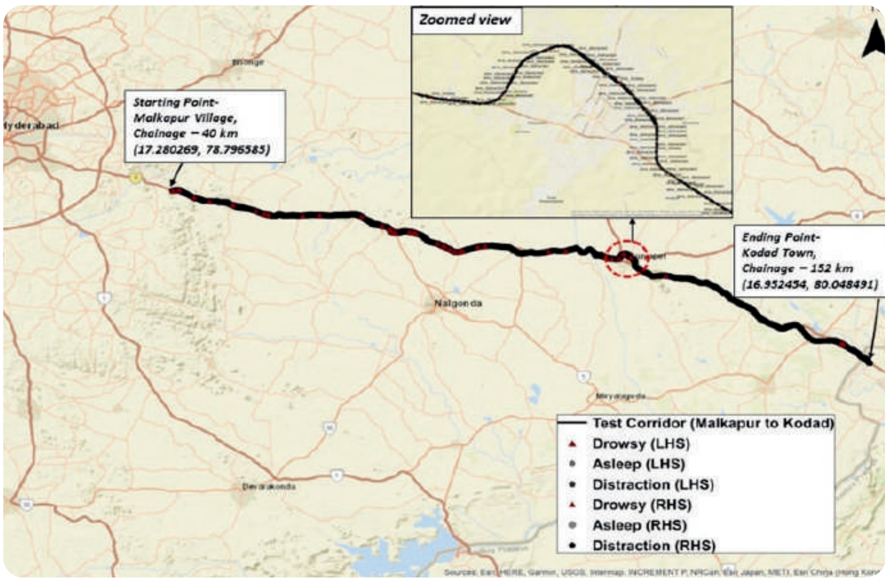


Figure 2.16 Test corridor with driver inattention events (with illustrations)

2.5.3 Data Collection

Data from November 2023 to January 2024 was extracted from the cloud server. For a detailed analysis of speed profiles, data from one Month was selected. It was determined that 22 out of 30 bus drivers effectively operated the DMS-equipped buses, successfully completing full round trips.

(a) (b)

Figure 2.17 (a) Device of Cipia FS10 (b) DMS device with a driver

- **Drowsiness Alert:** The DMS detects signs of drowsiness or fatigue in the driver.
- **On-Phone Alert:** The DMS detects that the driver is using a mobile phone while driving.
- **Distraction Alert:** The DMS detects that the driver's attention is diverted away from the road.
- **No Seat Belt Alert:** The DMS detects that the driver is not wearing a seat belt
- **Asleep Alert:** The DMS detects signs that the driver is falling asleep or has become unresponsive

The following table shows a sample data collected from one of the DMS Equipped Bus.

Table 2.3 Count of Different DMS Alerts by Time of Day

Time of day	dms_asleep	dms_distracted	dms_drowsy	dms_noseatbelt	dms_onphone	Grand Total
12am - 4am	101	409	101	83	5	699
4am - 8am	86	332	35	55	7	515
8am - 12pm	107	247	106	62	8	530
12pm - 4pm	140	293	122	81	10	646
4pm - 8pm	40	357	17	72	6	492
8pm - 12am	42	398	21	98	1	560

Characteristics of DMS Alerts

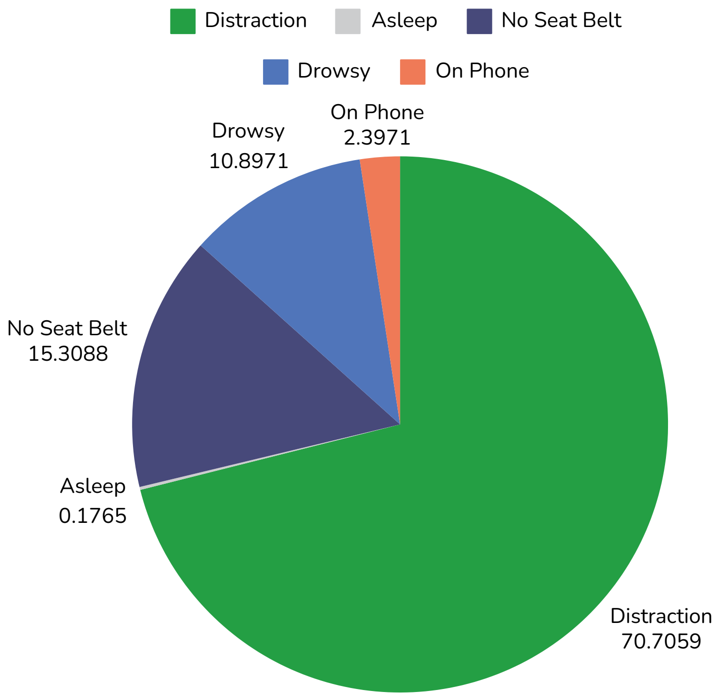


Figure 2.18 Ratio of DMS Alerts

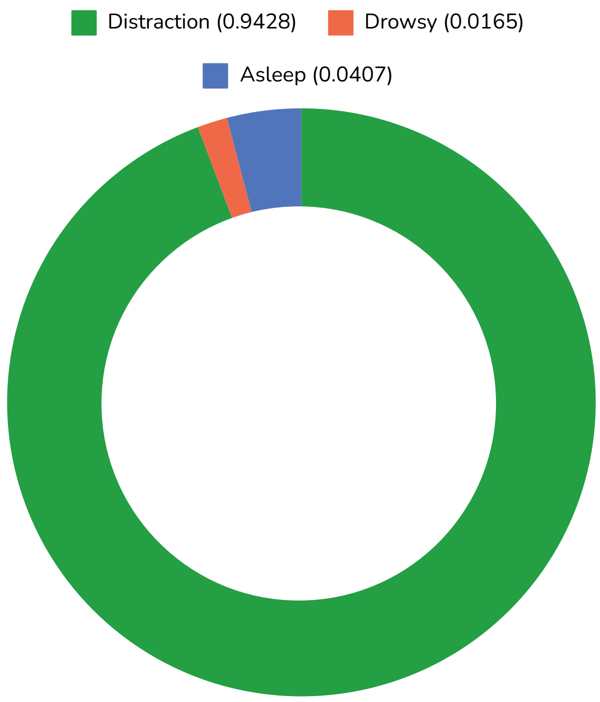


Figure 2.19 November 2023 to January 2024

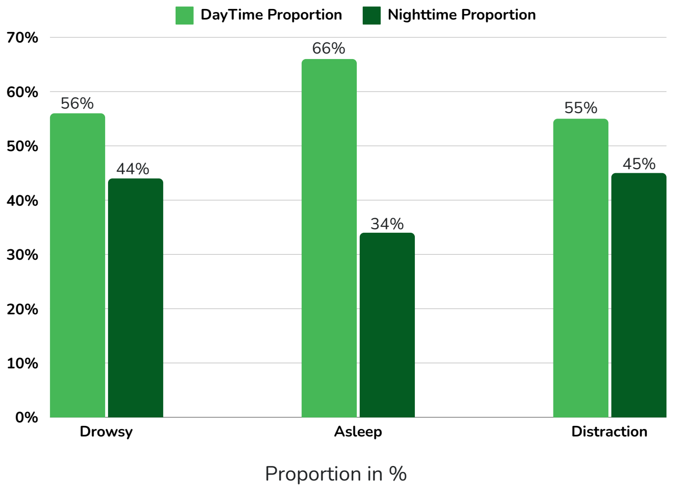
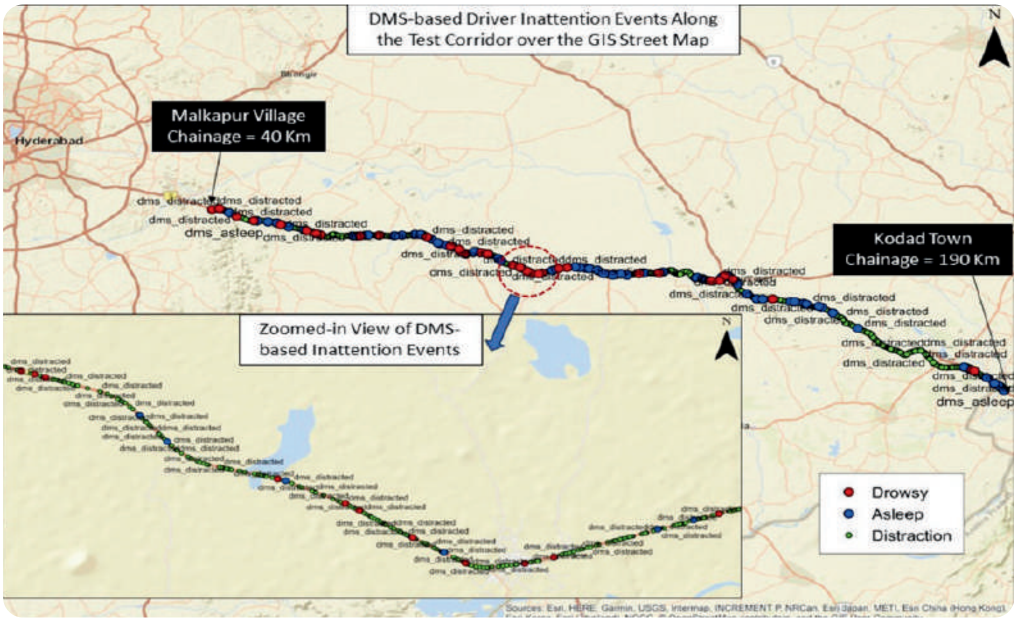


Figure 2.20 Day and Nighttime proportion of events (in %)

Driver Inattention Events - NH 65



2.5.4 Drivers' response from questionnaire form

A survey was conducted to collect feedback from the Bus drivers through a questionnaire as detailed below. 190 TGSRTC drivers participated in this survey.

1. Name	13. Speed Limit
2. Age	14. Use Of Cell Phone
3. Marital Status	15. Influence Of Smoking
4. Educational Level	16. Accidents Involved
5. Job Satisfaction	17. Accident Details
6. Sleep Medical Condition Affect Your Driving	18. Training Of DMS
7. Bus Driving Experience	19. Purpose Of DMS
8. Total Driving Experience (Years)	20. Meaning & action Of Alerts In DMS [Drowsiness]
9. Truck Experience (Years)	21. Meaning & action Of Alerts In DMS [Distraction]
10. How Often Do You Drive at Night	22. Monitored While Driving
11. Aggressive Driving Behaviors	23. Rate Use of DMS In Road Safety
12. Stress While driving	24. DMS Should Be Mandatory for All Buses

2.6 Effect of DMS on Driver Behavior

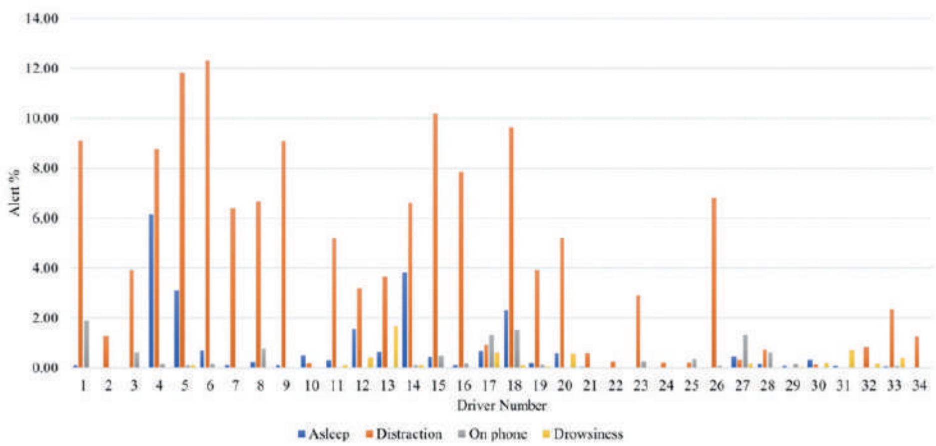


Figure 2.21 Relation b/w Alert % and Number of drivers

The graphical representation presented in the Figure 2.21 elucidates the connection between the number of drivers, explicitly portrayed along the x-axis, and the associated percentage of alerts graphically depicted along the y-axis. This visual representation serves to highlight and clarify the relationship between these two variables, providing a comprehensive insight into how changes in the number of drivers relates to fluctuations in the percentage of alerts.

Based on the aforementioned graphs, it is readily apparent that the distraction alert percentage, highlighted in orange, is notably higher compared to other alert types. Moreover, the data indicates that driver 6 experienced a higher frequency of alerts as depicted in Figure 2.21.

In delving into the distraction alert percentage across all alerts, the objective is to examine the intricate interplay between alert data and the diverse demographic factors associated with drivers. These encompass age, marital status, education level, job satisfaction, sleep patterns, medical conditions impacting driving, driving experience, aggressive driving behavior, stress while driving, and involvement in accidents. The aim is to discern the demographic variables that exert a more substantial influence, leveraging the parameters mentioned above. Subsequent analysis reveals a notable correlation: the distraction alert percentage demonstrates a heightened susceptibility to the driver's experience.

The correlation between distraction alert percentage and driver experience, as inferred from demographic data, exhibits a stronger relationship compared to other parameters. This connection is characterized by a negative exponential regression with an R-squared value of 0.88. The corresponding Figure 2.22 visually underscores a conspicuous and consistent linear decline in distraction alert percentage as driver experience progressively increases, providing a clear and compelling representation of the inverse relationship between these two variables.

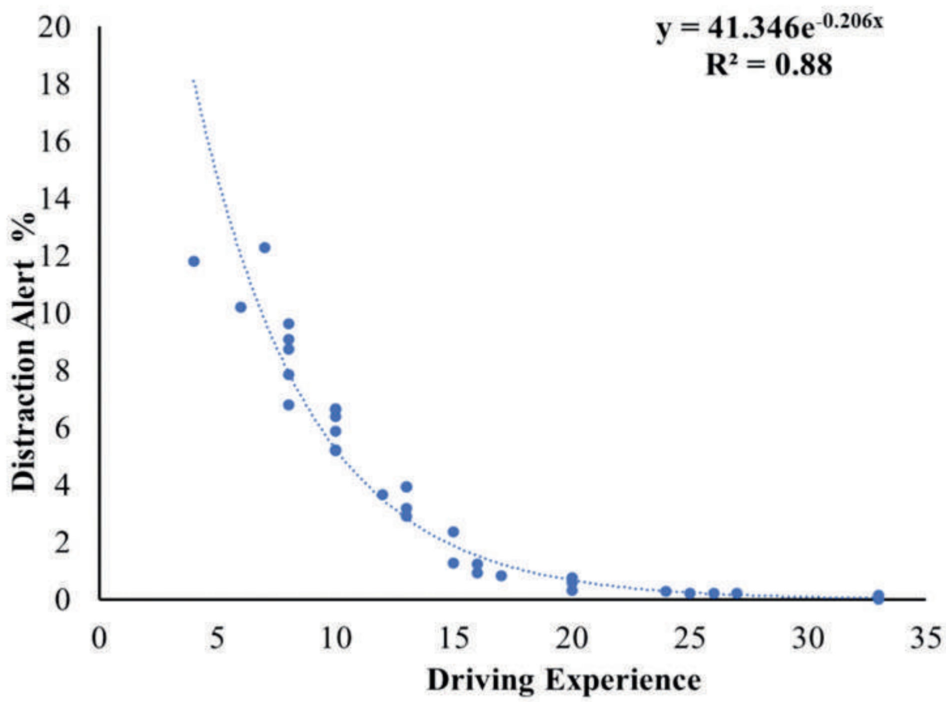


Figure 2.22 Relation b/w Distraction alert % and driver experience

2.7 Impact of ADAS and DMS on Road Safety

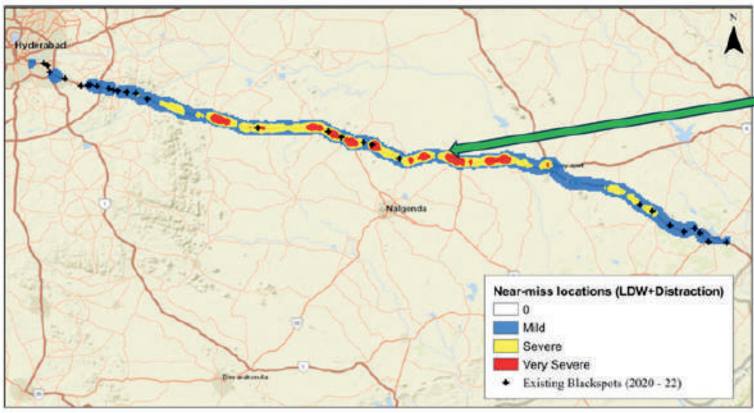
Advanced Driver Assistance Systems (ADAS) and Driver Monitoring Systems (DMS) are essential technologies that improve vehicle safety by sending real-time alerts and feedback to drivers. Understanding the number of alerts provided by these systems, the speed profile of drivers after receiving alerts, the duration of braking, and the total response time is critical for determining their effectiveness. Ensuring that drivers respond effectively to alerts can considerably lower the probability of an accident, therefore this is an essential area of research for improving safety

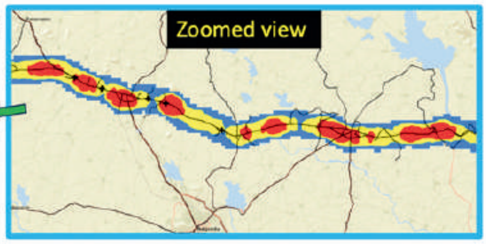
- One key finding is that drivers' speed profiles show a clear trend: while not all drivers reduce their speed immediately after receiving an alert, the majority do so irrespective of their previous speed. Interestingly, driver responses in questionnaires revealed that drivers often claim they reduce speed after receiving an alert, but various situational factors sometimes prevent them from doing so. The difference highlights the complexities of driver behavior and the impact of external factors on the effectiveness of DMS.
- The analysis of braking duration and total response time further underscores the variability in driver reactions to different alerts. Braking duration, which measures the time taken to reduce vehicle speed after an alert, varied widely, ranging from 40 to 60 seconds.
- Similarly, total response time, defined as the time from receiving an alert to the significant reduction in vehicle speed, also showed considerable variation, ranging from 45 to 57 seconds. These findings suggest that the nature of the alert and possibly the context in which it is received significantly impact how quickly and effectively drivers respond.

When determining whether drivers received alerts within a certain distance, numerous characteristics emerged as significant predictors. Factors such as driver age, experience, number of curves in that stretch, altitude differences, minimum radius of curves, and running speed played a crucial role. This finding demonstrates neural networks' improved capacity to handle the complicated and non-linear relationships among variables, making them a more effective tool for improving DMS performance.

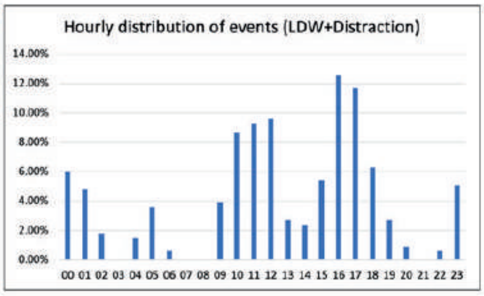
2.8 Near Miss Alerts

DMS + ADAS (Near Miss Locations)
(Using Combinations of Lane Departures + Driver Distraction)





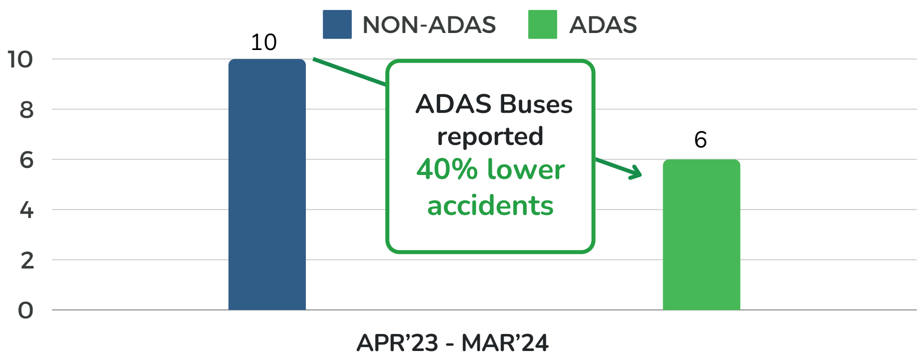
Combination of driver's distraction and lane departure warnings can provide valuable insight.



Based on the data generated from the devices, we observed that near-miss hotspots can be identified by using ADAS + DMS alerts. These are the spots where a driver switched lanes without using an indicator with a distraction event at high speed (60kmph +). A distraction alert is generated when the driver does not focus on the road (Head Facing towards Road). As a part of the Analysis, the insight has been categorized based on severity. This analysis helps the Depot Management to train the driver not to be distracted when driving especially at high speed.

2.9 Outcomes

- More than 500+ TGSRTC Drivers were trained on the importance of ADAS Technology & AI in preventing Road Accidents.
- 40+Driving Instructors & Safety Wardens from all regions of TGSRTC Depots were trained to ensure training continuity
- 40% Lower Fatal Accidents in ADAS buses compared to Non-ADAS.



Driver Training

- More than 500+ TGSRTC Drivers were trained on the importance of ADAS Technology & AI in preventing Road Accidents.
- Drivers improved their driving behavior by adopting to the latest technology.
- 40+Driving Instructors & Safety Wardens from all TGSRTC Depots were trained to ensure continuous training on Road Safety and the Use of AI in preventing Accidents and Fatalities.
- TGSRTC is the 1st Road Transport Corporation in India to appoint Safety Wardens (SW) & Driving Instructors (SDI) for each depot

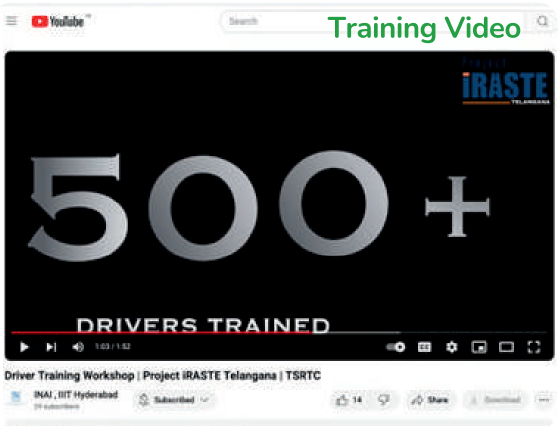


Figure 2.23 Driver Training Program & Safety Warden/Safety Driving Instructors Training of TGSRTC.

Campaign (Feb'24 – April '24)

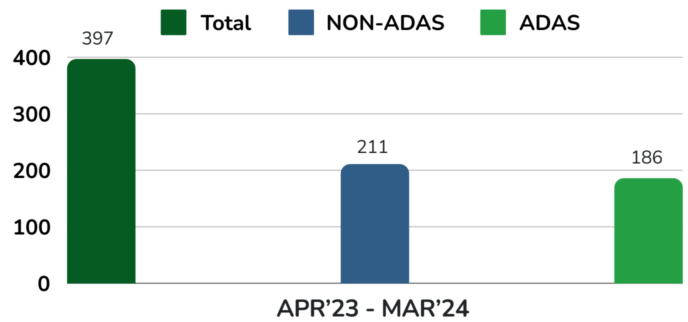
- Lane Departure Warning Campaign (Feb'24 – April'24)
- Zero Fatalities Campaign (Feb'24 – April'24)
- Driver Performance Campaign (Feb'24 – April'24)

Depot Name	Baseline	Result
MIYAPUR-1	0.68	0.72
BHEL	0.69	0.72
HYD-1	0.19	0.99
NIZAMABAD-1	0.12	0.10
NIZAMABAD-2	0.17	0.16

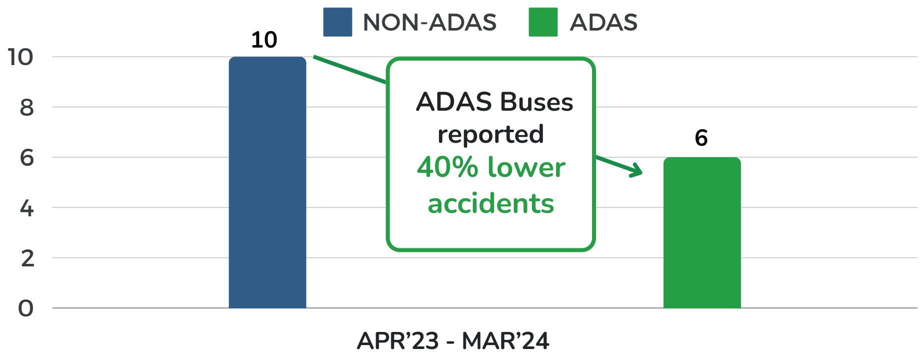
Accidents

Vehicle Count

Average Counts taken from 5 Depots
(MYP-1, BHEL, HYD-1, NZB-1 & NZB-2)

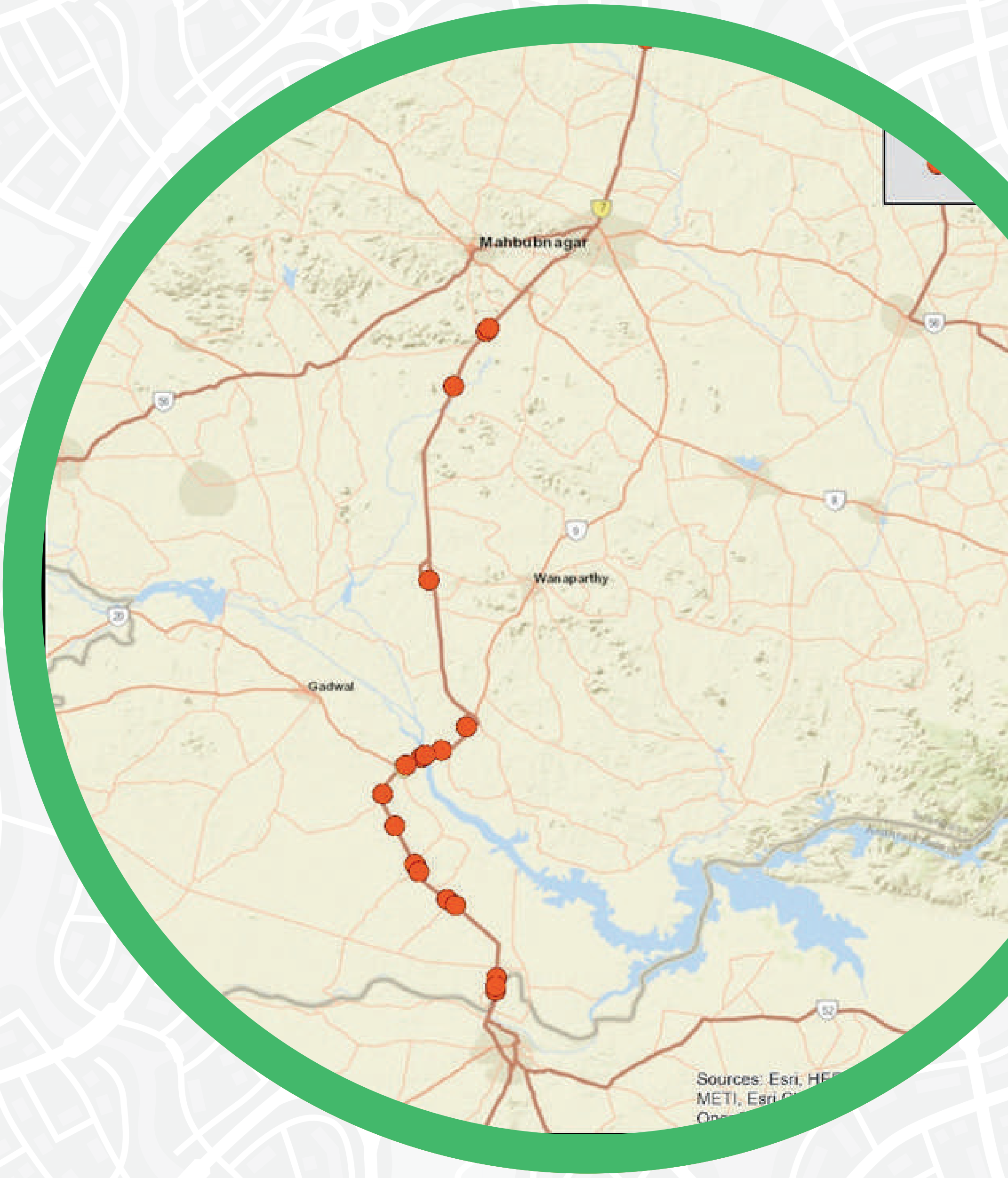


Fatal Accident Data for 5 Depots
(BHEL, MYP-1, HYD-1, NZB-1 & NZB-2)



3

MOBILITY SAFETY



3 Mobility Safety Analysis

In this study vector, alert information from the ADAS devices was utilized to proactively identify the crash prone areas, we define such as "Greyspots". Collision alerts were generated by ADAS-equipped buses that operated on interurban routes along three National Highways (NHs) in India, the Hyderabad to Kodad (towards Vijayawada) (NH-65), Hyderabad to Pullur (towards Bangalore) (NH-44), and Hyderabad to Adilabad (NH-44) routes.

- The ADAS system on these buses generated a significant number of alerts as the buses were driven along these highways. Traditionally, identifying unsafe locations, known as Blackspots, relied on past information recorded as First Information Reports (FIRs) by the Police about accidents. However, this approach has limitations as it only identifies locations after crash or accidents have occurred.
- By adopting a proactive approach with the information from AI based devices, potential Blackspots can be identified before they appear, and we label such potential spots as 'Greyspots'. These Greyspots are identified based on ADAS alert data and also severity levels at the locations. Early detection of Greyspots (i.e., potential Blackspots) allows road authorities to take proactive measures to prevent crashes and reduce injuries and fatalities.
- This analysis utilized ADAS data and also incorporated static data such as the road network's geometric parameters because the geometry can contribute to the road crashes. Figure 3.1 outlines the overall methodology employed for Greyspot identification.

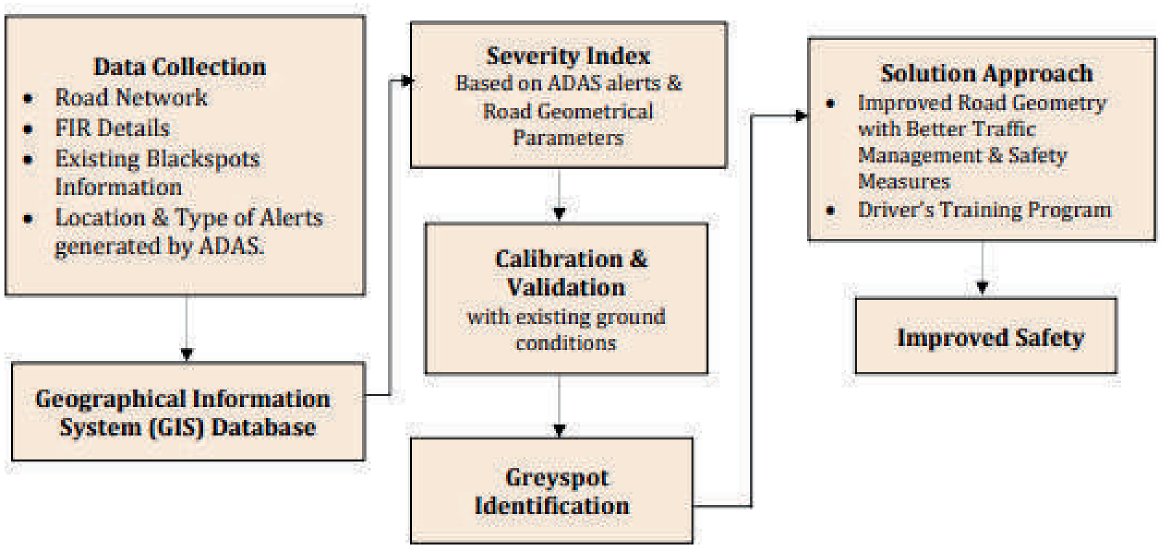


Figure 3.1 Suggested methodology for the identification of Greyspots.

As presented in Figure 3.1, data have been collected from three major sources:

a) The road networks for all three corridors were gathered from both local and national road authorities and was updated based on Google Earth (Google Earth Pro, n.d.) and primary field visits. The length of the considered interurban NH corridors is approximately 150 Kilometers (km), 180 Kms, and 300 Kms for the first, second, and third corridors respectively, totaling 691 km. This encompasses highways and connecting roads but excludes the urban areas of Hyderabad city. First Information Reports (FIRs) related to road crashes were gathered from the particular road-owning agencies of these individual interurban NH corridors. The location data of these FIRs were transformed into geo-spatial information such as latitude and longitude, to ensure the compatibility of these FIR points with Geographic Information Systems (GIS). These FIRs describe road crashes with their resulting fatalities & injuries. We collected FIRs of three years from 2020 to 2022, from the concerned authorities. A total of 1326, 2776, and 1504 FIR records were collected for the three corridors, respectively, and utilized for further analyses. Additionally, the existing blackspot information of these three corridors were gathered from publicly available inventory of Telangana Traffic Police (TTP) which showed that 1st corridor had 44 blackspots, 2nd corridor had 39 blackspots and 3rd corridor had 71 blackspots during the year 2018 to 2020 (Telangana police department, n.d.).

b) Lastly, we collected the ADAS alerts in a quarter-wise format from the beginning of the project i.e., September 2022. These alerts are generated in real-time along with their timestamp information (Date & Time), geopositioned information (Latitude & Longitude), and speed information (in Kmph).

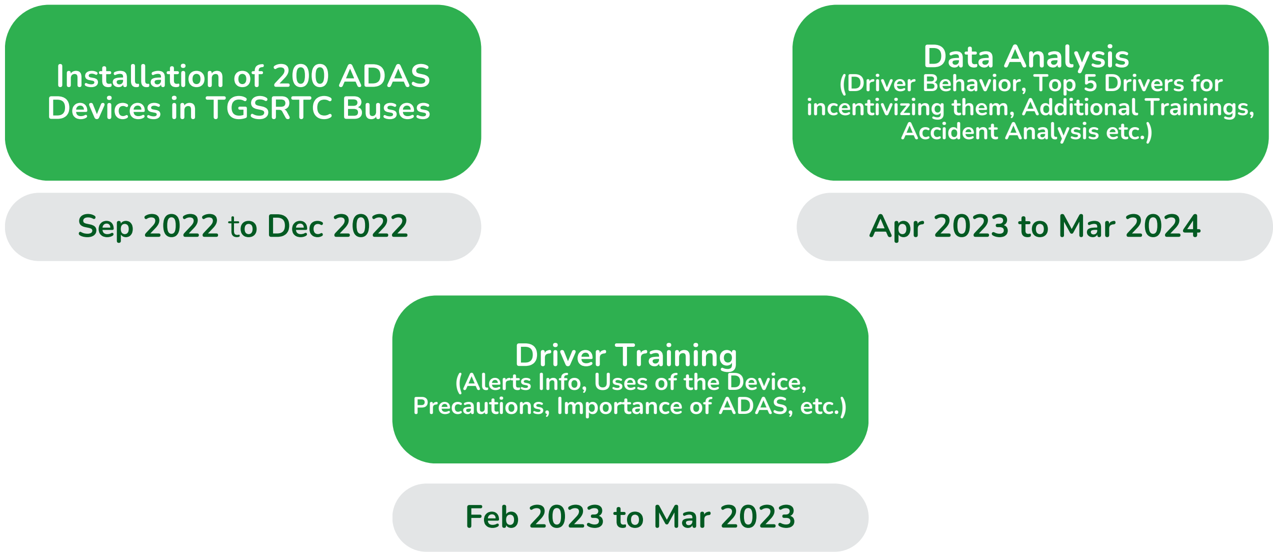


Table 3.1 Description of ADAS alerts

Alerts	Details
Forward Collision Warning (FCW)	This alert generated when the SV approaches the Lead Vehicle (LV) closely or experiences sudden braking at high speeds near the LV.
Headway Monitoring Warning (HMW)	ADAS warns the driver when the SV doesn't maintain a 2.5 second headway with the LV. If the headway drops to 0.6 seconds or less, the HMW alert triggers.
Lane Departure Warning (LDW)	It generates when the SV, traveling at 55 kmph or more, and changes lane suddenly or strays onto lane lines without signalling.
Pedestrian & Cyclist Collision Warning (PCW)	PCW alerts the driver when pedestrians / cyclists are in the vicinity of SV. This alert generates when the speed of SV falls between 7 to 50 kmph.

3.1 Concept Behind Greyspot Identification

For Greyspot identification, a Severity Index (SI) was developed to measure the level of severity at various locations along the interurban National Highway (NH) corridors. To do this, the study corridors were divided into 500-meter square cells. This cell size was chosen based on the typical accuracy of police crash records (First Information Reports, FIRs) and the assumption that ADAS alerts at any location are influenced by a 500-meter surrounding area. This approach focuses on the proactive identification of potential future blackspots.

The development of the SI in this study utilizes multiple types of data from these interurban NH corridors, including FIR records (road crash data from year 2020 to 2022), road geometry information (considered static data, requiring a one-time extraction for the road network), and various ADAS alerts (dynamic data collected from ADAS devices). The combined data was prepared using the GIS, specifically QGIS, and statistical analysis was performed using SPSS-22.

The SI value primarily depends on calculating the number of road crashes among various road users (including vehicles and pedestrians), which is influenced by factors such as road geometry type, traffic management options (e.g., unsignalized intersections, free-left turnings, 3/4/5-arm intersections with signals), and more. This information was collected for all three interurban NH corridors and compared with the number of ADAS alerts in each corridor segment using Multinomial Logit (MNL) Regression analysis.

To validate the analysis, the top 20 severe locations (excluding existing blackspots) were identified and compared with the existing blackspots identified by the Telangana government and newly identified blackspots by iRASTE-Telangana (refer to the Infrastructure Safety section). After achieving good accuracy, these top 20 locations were further audited on the ground for validation.

3.2 Road Network on GIS Platform

A road network Shapefile (compatible with GIS) was initially created manually, and it was subsequently updated to correct missing links and edit certain existing links through several field visits. Figure 3.2 illustrates the road network of three interurban NH corridors.

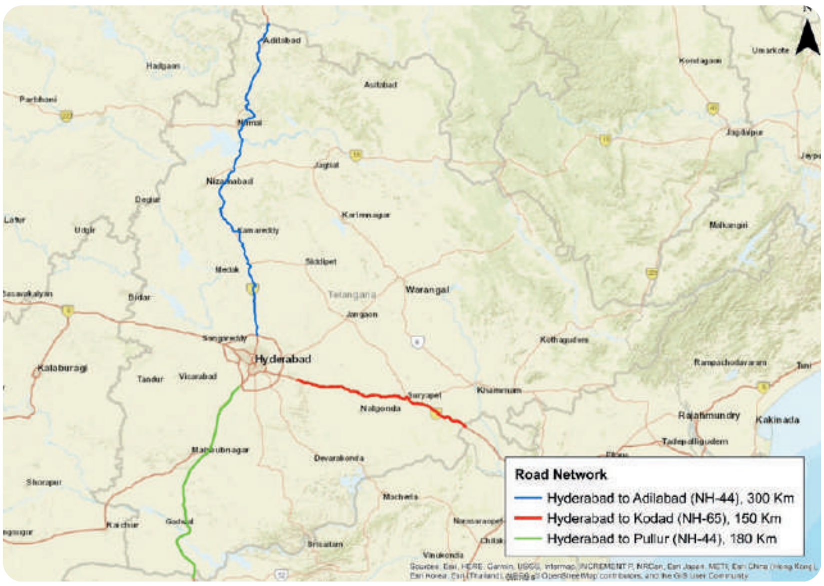


Figure 3.2 Road Network of Three Interurban NH corridors on GIS Platform

3.3 Grid formation over the road network

To assess the severity at specific locations and integrate both static data (like road width, road length, 3 arm intersection, 4 arms intersection) and dynamic data (counts of ADAS alerts: FCW, HMW, LDW, PCW) within the study area (comprising three corridors), prepared square cells (grids) with sides measuring 500 meters (m) over the three corridors. This grid size was chosen based on the typical accuracy level recorded in police reports (such as First Information Reports). Additionally, we assume that any changes in driver behavior are a factor of influence in a 500-meter radius on a road network. Figure 3.3 shows an overall view of grid formation over the road network.

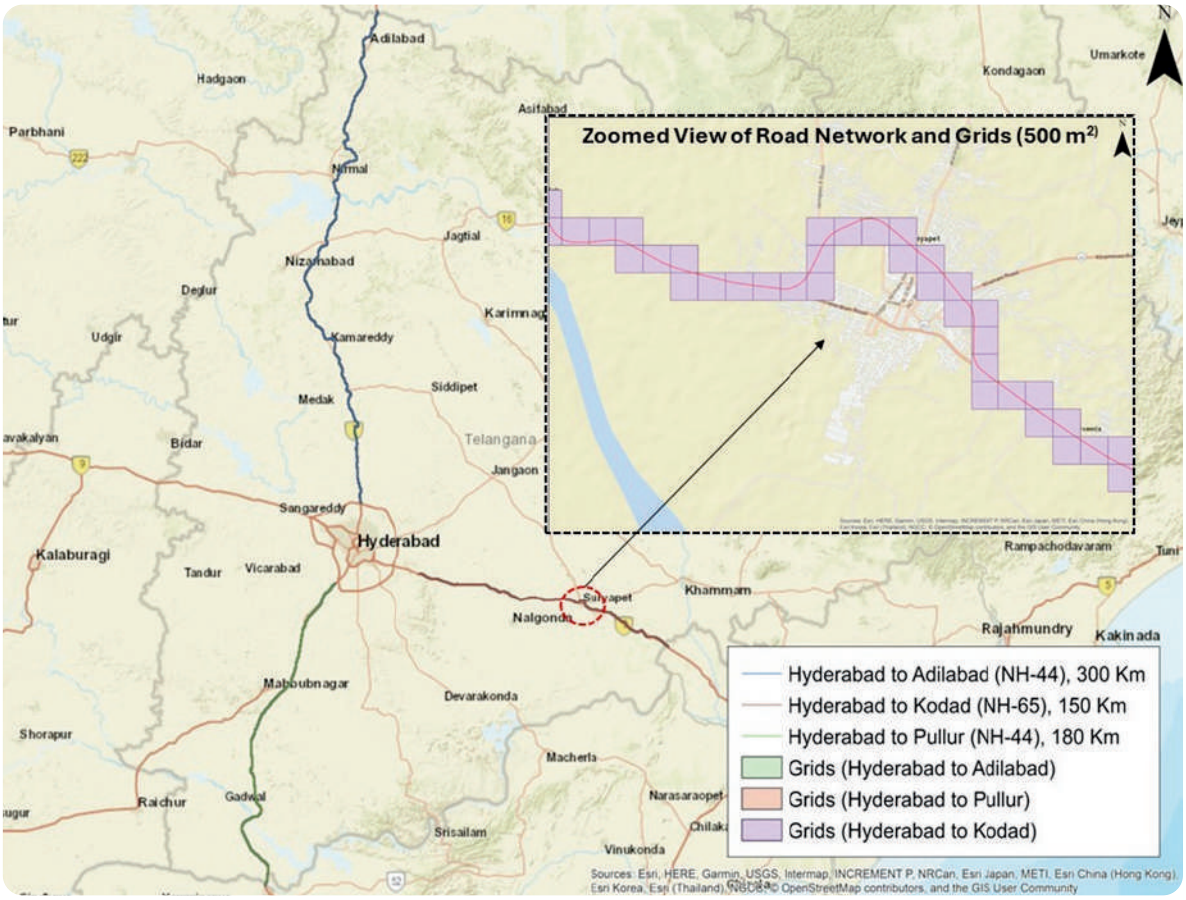


Figure 3.3 Grid Formation Over the Three Interurban Corridors on GIS Platform

Based on the above prepared road network and grid network, the extracted various road geometry parameters for all three interurban NH corridors such as 3-arm intersection, sum of roads, altitude level difference of corridor, minimum radius of horizontal curvature, and number of horizontal curves are shown in Figure 3.4. These attributes were calculated / identified using GIS tools of QGIS and further updated during the primary field visits.

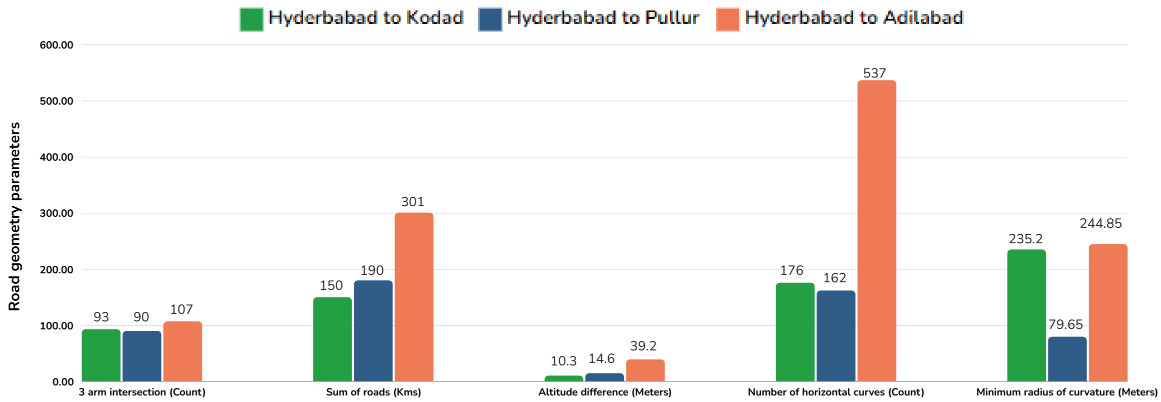


Figure 3.4 Various Road Geometry Parameters of All Three Interurban NH Corridors

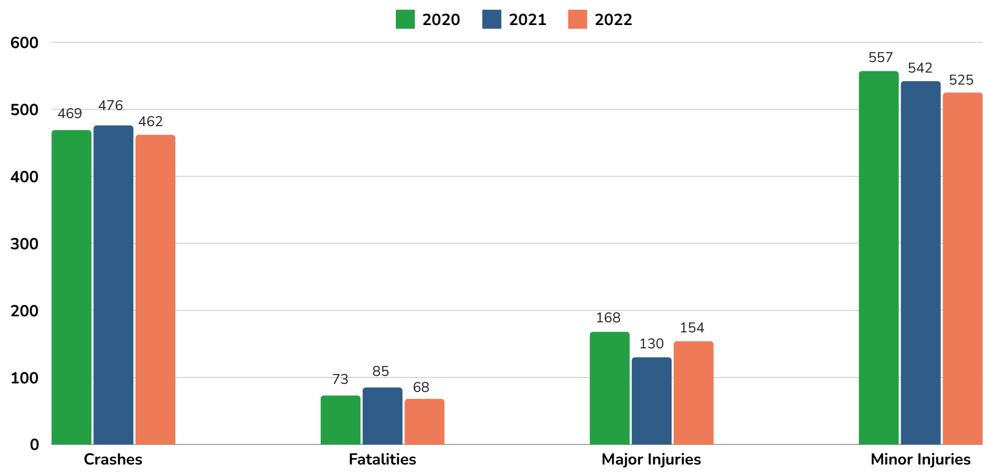
Figure 3.4 compares road geometry parameters of three corridors: Hyderabad to Kodad, Hyderabad to Pullur, and Hyderabad to Adilabad. It shows that Hyderabad to Adilabad has the highest number of 3-arm intersections (107), the longest length (301 km), and the most horizontal curves (537), indicating a more complex and winding route. In contrast, Hyderabad to Pullur, with 180 km of roads, has the sharpest curves, reflected in the smallest minimum radius of curvature (79.65 meters). The altitude difference is greatest for Hyderabad to Adilabad corridor at 39.2 meters, while Hyderabad to Kodad and Hyderabad to Pullur have similar, lower altitude differences of 10.3 meters and 14.6 meters, respectively. Overall, the Hyderabad to Adilabad route is the most extensive and winding, while Hyderabad to Pullur features the sharpest turns. The Hyderabad to Kodad route generally falls between these extremes, making it comparatively less challenging in terms of intersections and curves.

3.4 Road Crashes and Blackspots over the Three Interurban NH Corridors

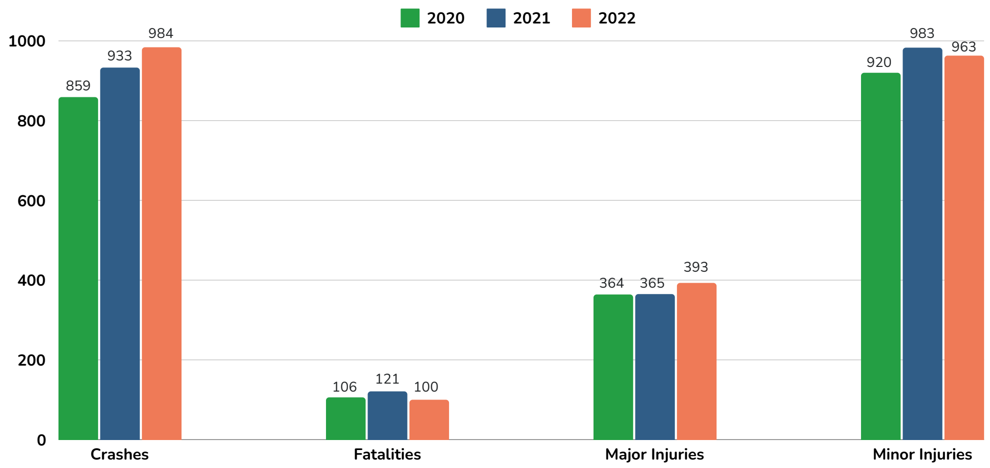
We approached the concerned road-owning authorities of these corridors regarding the road crashes data in terms of First Information Reports (FIRs) and gathered last three years of road crashes data of all three interurban NH corridors of years from 2020 to 2022. These data were properly formatted in the MS-Excel including the location details (in terms of Chainage), date & time, number of fatalities & injuries, weather conditions, road type, and so on. Using these data, we further converted these road crash locations which were in chainage format originally into the geographic coordinates such as Latitude and Longitude using the tools of GIS. and is shown in Figure 3.5.

Figure 3.5 FIR locations and Related Information on GIS platform

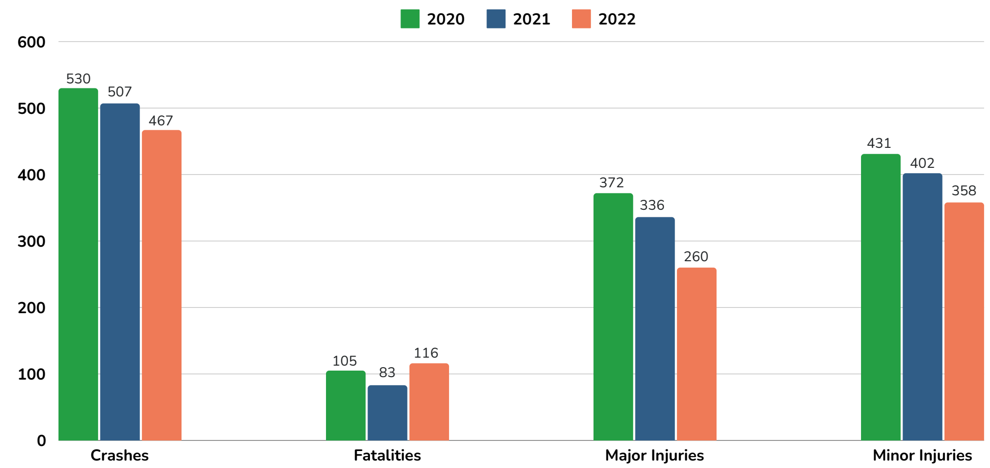
Further, to understand the trend of road crashes in all three interurban NH corridors separately, detailed analysis was done on the recorded road crashes for the year 2020, 2021, and 2022 as presented in Figure 3.6 (a), (b), and (c).



a. Hyderabad to Kodad (NH-65),



b. Hyderabad to Pullur (NH-44)



c. Hyderabad to Adilabad (NH-44).

Figure 3.6 Statistics of Road Crashes of all Three Interurban NH Corridors; (a) Corridor-1 – Hyderabad to Kodad, (b) Corridor-2 – Hyderabad to Pullur, and (c) Corridor-3 – Hyderabad to Adilabad.

Figure 3.6 (a) presents road crash statistics for the Hyderabad to Kodad corridor from year 2020 to 2022. Crashes showed a slight increase from 469 in 2020 to 476 in 2021, before slightly decreasing to 462 in 2022. Fatalities rose from 73 in 2020 to 85 in 2021, then dropped to 68 in 2022. Major injuries significantly decreased from 168 in 2020 to 130 in 2021, followed by a rise to 154 in 2022. Minor injuries consistently decreased from 557 in 2020 to 542 in 2021, and further to 515 in 2022. Figure 3.6 (b) presents road crash statistics for the Hyderabad to Pullur corridor in the same years, where crashes increased steadily from 839 in 2020 to 933 in 2021 and 984 in 2022. Fatalities rose from 106 in 2020 to 121 in 2021, then decreased to 100 in 2022. Major injuries also increased, from 354 in 2020 to 365 in 2021, and further to 393 in 2022. Minor injuries arose from 920 in 2020 to 983 in 2021, then slightly decreased to 963 in 2022. Similarly, Figure 3.6 (c) presents the road crash statistics of Hyderabad to Adilabad corridor for same years. In year 2020, the highest number of crashes occurred, totaling 530, followed by a decrease in 2021 to 507 and a further drop in 2022 to 467. Fatalities also saw a decrease from 105 in 2020 to 83 in 2021 but then rose to 116 in 2022. Major injuries showed a similar pattern, with the highest count of 372 in 2020, decreasing to 336 in 2021 and significantly falling to 260 in 2022. Minor injuries were the most frequent outcome each year, with a reduction from 431 in 2020 to 402 in 2021 and then to 358 in 2022.

So, from the road crash data analysis, it was inferred that the second corridor has the highest road crash risk, followed by third corridor and then first corridor. Apart from the counts of crashes, it was noted that frequency of fatalities due to road crashes were consistently same during those three years (2020 – 22). Additionally, it is worth noting that the number of minor injuries and non- injuries is greater in the first corridor compared to the third corridor. Interestingly, despite being nearly twice as long, the third corridor maintains a lower injury count. This discrepancy could be attributed to the differing speed limits: 80 Kmph for the first corridor and 80 Km for the third corridor. Based on all these road crash data analysis, it was inferred that all these three interurban NH corridors are posing high risk of road crashes and require immediate, advanced, and multifaceted road safety solutions to improve the road safety status of these corridors.

Based on the road crash records and their level of severity, Blackspots have been identified for all three corridors, conforming to the Indian Road Congress (IRC) guidelines, particularly IRC 131 (2022) manual and the same has been brought to GIS platform as shown in Figure 3.6. Also, for detailed blackspot identification analysis, refer to Chapter 4 of this report.

Figure 3.7 Blackspots on the GIS Platform

Figure 3.7 describes the identified blackspots of all the considered corridors, where 19 most severe Blackspots were identified for corridor-1, and 23 most severe Blackspots for corridor-2, and 23 most severe Blackspots for corridor-3, which are comprehensively described in Infrastructure Safety chapter of this report (refer to Chapter 4).

3.5 ADAS Alerts

ADAS alerts are collision alerts which include Forward Collision Warning (FCW), Headway Monitoring and Warning (HMW), Lane Departure Warning (LDW), and Pedestrian & Cyclist Collision Warning (PCW), generated by the bus fleet and stored in the cloud server. For the analysis, these ADAS alerts were extracted from the cloud server and utilized in the study for the identification of “Greyspots”. After some data processing and cleaning, these alerts were arranged in a quarter-wise time-period such as Jul’23 to Sept’23 (2023: Q3) and Oct’23 to Dec’23 (2023: Q4) of the year 2023. After that, these were imported into the Geographic Information System (GIS) platform for better visualization and analysis as presented in Figure 3.8.

Figure 3.8 Generation of ADAS alerts over the concerned study state, city, and corridors

Figure 3.8 shows the ADAS alerts over the road network of the concerned state, city, and study corridors. The statistics of alerts generated for the considered duration of 2023: Q3 and 2023: Q4 of year 2023 are presented quarterwise in Table 3.2. This table details ADAS alerts across three corridors (Hyderabad to Kodad, Pullur, and Adilabad) for 2023: Q3 and 2023: Q4 period. Each type of alert such as FCW, HMW, LDW, and PCW are listed. Across all corridors, there is a consistent decrease in total alerts from 2023: Q3 to 2023: Q4. The Hyderabad to Kodad corridor has the highest alert counts, particularly for LDW, while PCW alerts are the least frequent overall.

Table 3.2 ADAS Alert Data Statistics

Quarters	Corridor name	FCW	HMW	LDW	PCW	Total ADAS Alerts
2023:Q3	Hyderabad to Kodad	4251	93117	859124	1082	957574
2023:Q4		3908	87448	830312	993	922661
2023:Q3	Hyderabad to Pullur	1045	26162	180170	97	207474
2023:Q4		748	23374	180750	97	204969
2023:Q3	Hyderabad to Adilabad	2116	34932	369346	481	406875
2023:Q4		1426	23933	223069	239	248667

Figure 3.9 visually displays the quarterly statistics (2023: Q3) for ADAS alerts generated on different corridors over the GIS street map, which were considered for further analysis.

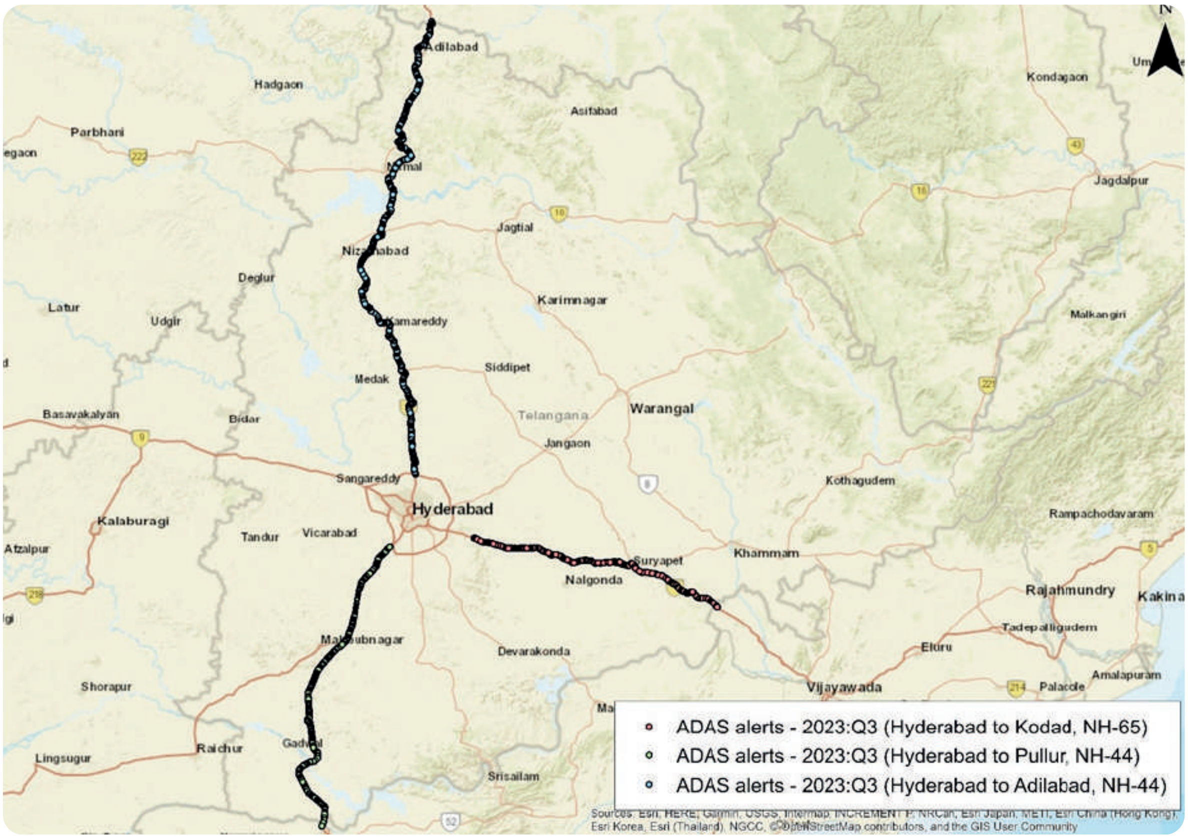


Figure 3.9 ADAS Alerts Generated over the Three Interurban NH Corridors

Moreover, the number of buses operated during these two-quarter time periods on all three corridors are presented in Table 3.3. It presents the variation of number of buses travelling over these corridors which ultimately affects the count of ADAS alert generation.

Table 3.3 quarter wise Total no. of Bus operated on corridors

Quarters	Corridor name	Total no. of buses operated
2023:Q3	Hyderabad to Kodad	82
2023:Q4		71
2023:Q3	Hyderabad to Pullur	46
2023:Q4		35
2023:Q3	Hyderabad to Adilabad	27
2023:Q4		16

As there were variations in number of buses travelling in each corridor, these alerts were normalized concerning number of buses to make a fair comparison among the alerts over different corridors. Figure 3.10 presents the normalized ADAS alerts count per bus for three considered interurban NH corridors in 2023: Q3 and 2023: Q4. From Hyderabad to Kodad, alerts increased from 11678 to 12995, from Hyderabad to Pullur, alerts rose from 4510 to 58561, and from Hyderabad to Adilabad, alerts slightly increased from 15070 to 15542. This indicates a rise in driving issues or safety warnings across all three corridors. The Hyderabad to Adilabad route consistently had the highest alerts, suggesting it was the most hazardous. The Hyderabad to Pullur route experienced the most significant increase, pointing to potential emerging issues. These trends highlight the need for closer examination of road conditions, driver behavior, or traffic patterns to improve safety and reduce alerts.

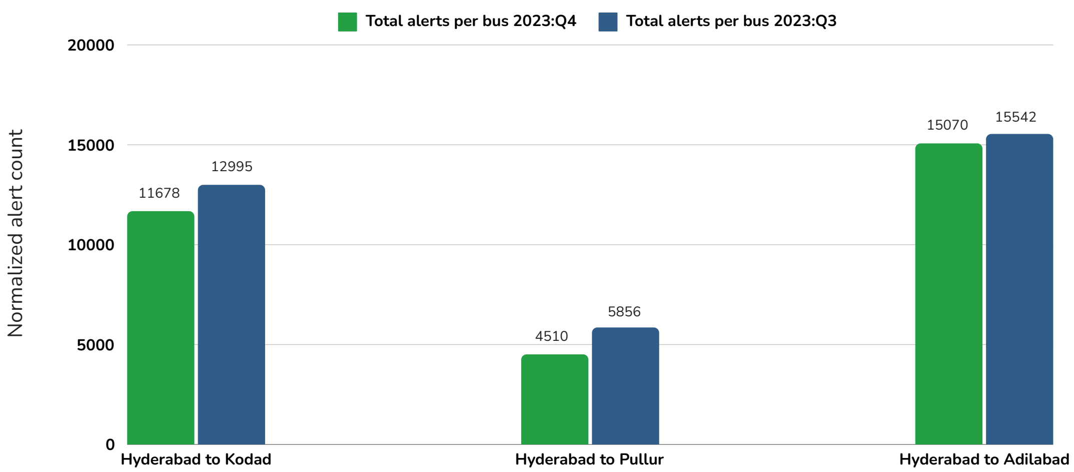


Figure 3.10 Corridor-wise generation of ADAS alerts per number of buses.

Further examined the detailed characteristics of ADAS alerts generated over these corridors as presented in Figure 3.11, 3.12, and 3.13 represents corridor-wise comparison of all ADAS alerts such as FCW, HMW, LDW, and PCW generated during 2023: Q3 and 2023: Q4.

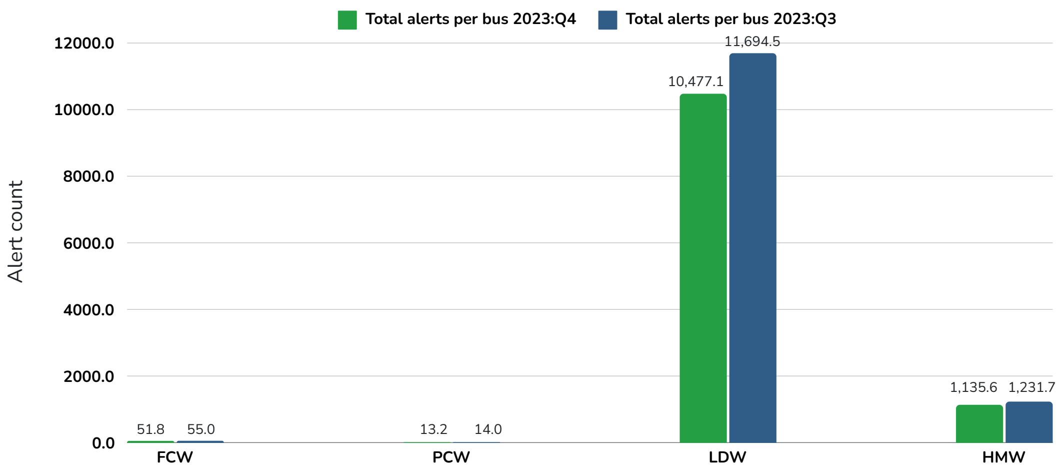


Figure 3.11 Quarter wise alert distribution per each bus for 1st corridor

According to Figure 3.11, Hyderabad to Kodad corridor shows an increase in ADAS alerts from 2023: Q3 to 2023: Q4 across all categories. FCW rose slightly from 51.8 to 55.0, and PCW increased from 13.2 to 14.0. LDW, the most frequent alert type, jumped significantly from 10,477.1 to 11,694.5. HMW also saw a rise from 1,135.6 to 1,231.7. These trends suggest escalating safety issues, particularly with lane discipline, necessitating enhanced safety measures on this route.

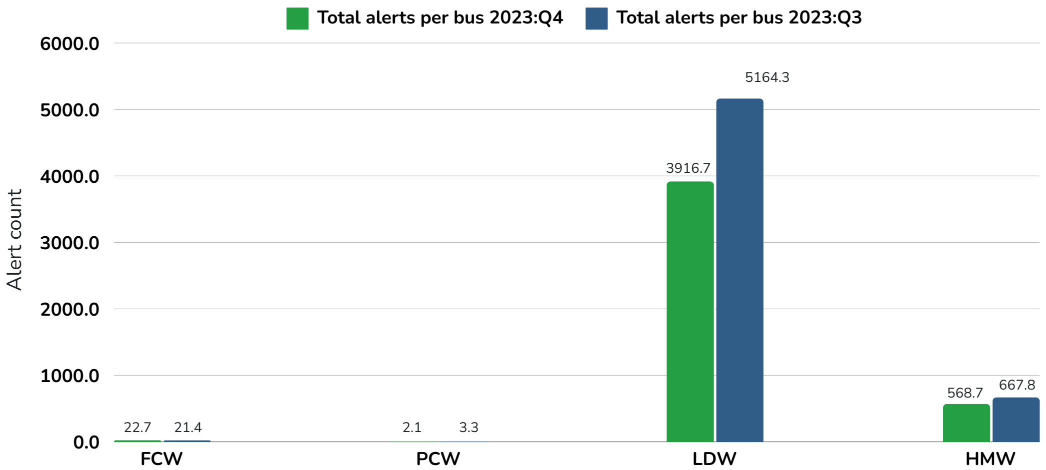


Figure 3.12 Quarter wise alert distribution per each bus for 2nd corridor

According to Figure 3.12, Hyderabad to Pullur corridor shows ADAS alert counts for 2023: Q3 and 2023: Q4, categorized by alert type. FCW decreased slightly from 22.7 to 21.4. PCW increased from 2.1 to 3.3. LDW saw a significant rise from 3916.7 to 5164.3, the highest among all alerts. HMW also increased from 568.7 to 667.8.

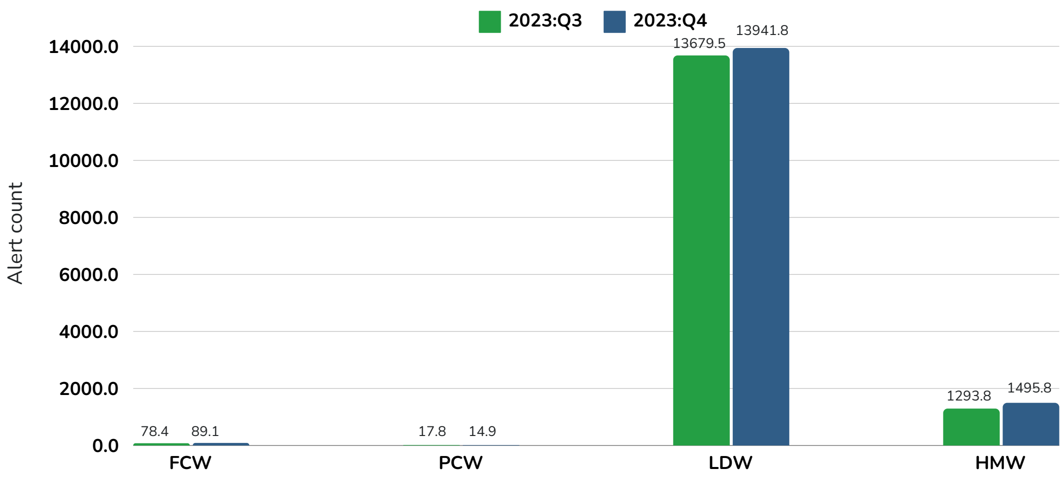


Figure 3.13 Quarter wise alert distribution per each bus for 3rd corridor

As per Figure 3.13, Hyderabad to Adilabad corridor presents the ADAS alert counts for 2023: Q3 and 2023: Q4. FCW increased from 78.4 to 89.1, indicating a rise in collision risks. PCW decreased from 17.8 to 14.9. LDW saw a slight increase from 13,679.5 to 13,941.8, maintaining the highest count among all alerts. HMW rose from 1,293.8 to 1,495.8.

So, all these trends suggest heightened safety concerns, particularly with lane discipline and headway monitoring, necessitating enhanced safety measures on all the corridors.

These ADAS devices also can detect the speed of vehicle (in Kmph) at the time of alert generation while driving, making speed information crucial for this mobility safety study. Therefore, this study incorporated the speed data from these alerts to identify Greyspots and further calculated the 85th percentile speed for each alert during the 2023: Q3 and 2023: Q4 time-periods. This approach helps understand driver's speeding behavior and determines which alerts are triggered at specific speed ranges, thereby identifying unsafe locations. Figure 3.14 illustrates the detailed distribution of all ADAS alerts across various speed ranges from 0 to 90 km/h.

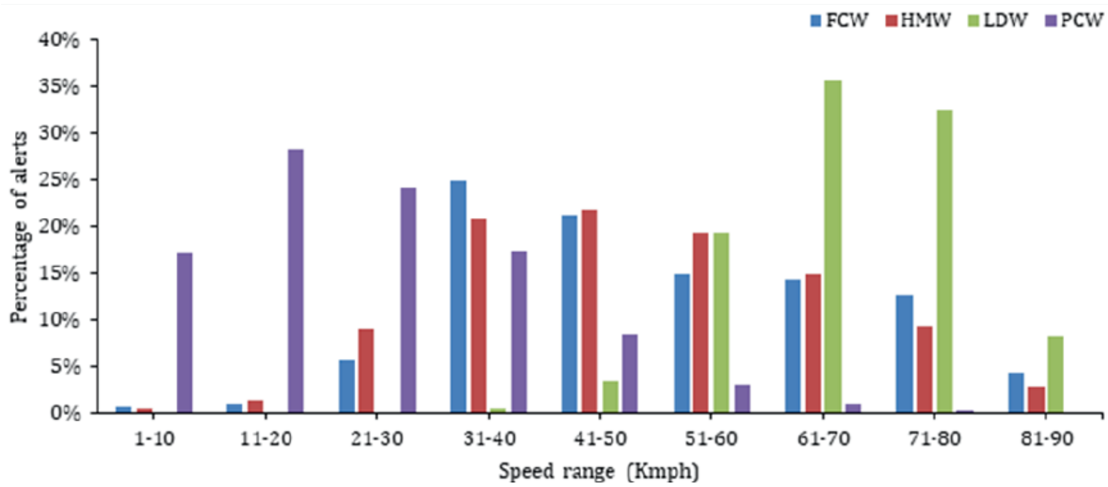


Figure 3.14 Distribution of ADAS alerts based on their speed.

Figure 3.14 presents the percentage distribution of all four types of ADAS alerts (FCW, HMW, LDW, and PCW) across different speed ranges. At lower speeds (1-10 km/h), PCW alerts are predominant at 17.16 %, with minimal FCW, HMW, and LDW alerts. As speed increases to 11-20 km/h, PCW alerts rise significantly to 28.32 %, while FCW and HMW alerts also increase slightly. In the 21-30 km/h range, HMW alerts dominate at 8.99 %, and PCW remains high at 24.23 %. Between 31-40 km/h, FCW and HMW alerts peak at 24.86 % and 20.88 %, respectively, with a moderate 17.32 % for PCW. At higher speeds (41-50 km/h), HMW remains steady at 21.70 %, and LDW alerts rise to 3.48 %. In the 51- 60 km/h range, LDW alerts spike to 19.38 %, overtaking HMW and FCW. Between 61-70 km/h, LDW alerts peak at 35.60 %, while HMW and FCW decrease. At 71-80 km/h, LDW stays high at 32.53 %, but all alerts decrease at 81-90 km/h, with LDW at 8.32 % and minimal PCW at 0.07 %. This distribution indicates that different types of alerts are more prevalent at specific speed ranges, reflecting varying driving risks.

3.6 Measuring the Level of Severity – Severity Index (SI)

To identify the most unsafe locations (**"Greyspots"**), study areas which are three interurban NH corridors such as Hyderabad to Kodad, Hyderabad to Pullur, and Hyderabad to Adilabad were divided into cells (or grids) of size 500m × 500m in the GIS platform. Further for each of these cells of all three corridors, integrated both static & dynamic parameters and road crash attributes in the same GIS platform and prepared a GIS dataset for all corridors separately. **Static Parameters** includes the road geometry features such as number of intersecting arms (3 / 4 arms), length of roads within the cell, number of horizontal curves (if any), radius of the curvature of shortest horizontal curve (if any), difference in altitude level within that grid cell. **Dynamic Parameters** includes the count of all ADAS-based collision alerts such as FCW, HMW, LDW, and PCW which are dynamic in nature because it depends on the driver's driving behaviour and situations occurring on the road network while driving. Other than that, the **Road Crash** information for each of these corridors were incorporated into this GIS dataset separately that includes the total number of road crashes occurred on each grid with their resulted fatalities and injuries. Finally, the data is complete with all this information for calculating Severity Index (SI) values.

After that, for the analysis, one statistical regression method has utilized i.e., Multinomial Logistic Regression where Dependent Variable (DV) is considered as the **Combined Weighted Severity Value (CWSV)** which aggregates the Crash Severity Value (CSV) based on the road crashes had occurred on each grids of the particular corridor's road network and Weightages according to the road crashes which are as follows:

a. . For calculating the CSVs, utilized the guidelines of IRC 131 (2022) which has the method to calculate severity of particular road segment based on various kinds of road crashes such as fatal crashes, major injury crashes, minor injury crashes, and no injury crashes, which is presented in Equation 1 (IRC 131, 2022):

Crash Severity Value (CSV) *= 10*(Fatal Crash) + 5*(Major Injury Crash) + 2*(Minor Injury Crash) + 1*(Non-injury Crash)*.......................... ***Eq. 01***.

b. Secondly, provided the weightage to road crashes based on their count in the particular grid by underscoring the significance of road crashes in the development of road crash prone areas, which are as presented in Table 3.4

Table 3.4 Weights to road crashes

Road Crashes	Weightage
0 to 1	10
2 to 4	20
>= 5	30

Based on the above two calculations, the calculated values such as CWSV were considered as DV for MNL regression model development. As considered regression model is MNL which requires DV in multiple variables such as 1, 2, 3......, the calculated CWSVs were further divided into three groups based on their severity as presented in Table 3.5.

Table 3.5 Final categorization of CWSVs

Weighted SI	Category	Numeric category for regression
10 to 15	MILD	1
16 to 45	MODERATE	2
> 45	SEVERE	3

Moreover, there are various Independent Variables have been considered such as road geometrical parameters which include the number of intersecting arms (3 / 4 arms), length of roads within the cell, number of horizontal curves (if any), radius of the curvature of shortest horizontal curve (if any), difference in altitude level (all these are in static data), and the count of ADAS alerts (dynamic data).

Note: *During the data pre-processing and characteristics analysis, it was found that in all three interurban NH corridors, there are high amount of disparity in altitude level of the road network; where altitude level of Corridor 1 (Hyderabad to Kodad: NH-65) varies from 0 to 10.3 meters, Corridor 2 (Hyderabad to Pullur: NH-44) varies from 0 to 14.6 m, and Corridor 3 (Hyderabad to Adilabad: NH-44) varies from 0 to 39.2 m. So, this information suggests that altitude level is a significant parameter for the model development because in all these corridors there's a huge difference in altitude level of roads which significantly impacts the accuracy of Greyspot identification model.*

According to the above fact, developed a MNL regression model for Corridor 1 and subsequently tested for the other two corridors, Corridor 2 and Corridor 3. To initiate the model development, firstly all DV and IVs were normalized into a 0 to 1 scale to make all the data all the same level for regression analysis using the universal formula of Normalization as presented in Eq. 02 which facilitated to develop robust MNL regression model.

$$x_n = \frac{x_i - x_{min}}{x_{max} - x_{min}} \dots\dots\dots\dots\dots \textbf{Eq. 02}$$

where,

x_n = *The normalized value in the dataset*

x_i = *The* i^{th} *value in the dataset*

x_{min} = *The minimum value in the dataset*

x_{max} = *The maximum value in the dataset*

After all these data pre-processing works, the combined dataset was imported into the regression analysis platform such as in (International Business Machines Corp., n.d.) i.e., IBM – SPSS software, where the MNL regression analysis has been performed and model has been developed for corridor-1 to calculate the Greyspots. After that, utilizing the model parameter coefficients calculated the utility function for each grid of the corridors and further calculated the probabilities of each grid of the corridor that one grid has how much probability of becoming a future road crash-prone area and based on that assign various categories to the grids such as Mild, Moderate, and Severe. At the last, to validate the model and its results, the grids which have the same category between predicted category (based on the calculated probabilities) and actual category (categorized based on Combined Weighted Severity Values) are to be compared and counted, to calculate the final accuracy of the model. After that, same MNL model was applied to other two subsequent corridors to identify the Greyspots.

3.6.1 MNL Regression Model for 1st Corridor

The first corridor presented on NH-65 highway spans 150 km and features a four-lane divided carriageway, connecting Hyderabad city to Kodad town. The average altitude difference per 100 kilometers is 6.866 meters. The posted speed limit on this corridor is 80 Kmph. During the period from year 2020 to 2022, a total of 1407 FIRs were filed in connection with road crashes along this corridor with 226 fatalities and 2066 injuries. This corridor has various road geometry parameters such as minimum radius of horizontal curvature, horizontal curves, altitude difference, sum of road length, number of 3-arms intersections (as static data, requires one-time extraction from the road network). Also, various ADAS alerts such as FCW, LDW, and PCW alerts with the combined 85th percentile speed value of all these three considered for the analysis (as dynamic data, which will change in every quarter time-period or any).

After that, we performed a regression analysis i.e., MNL regression in the IBM-SPSS platform considering categorized weighted SI such as Mild (i.e., 1), Moderate (i.e., 2), and Severe (i.e., 3) as DV and other road geometry and ADAS alerts (FCW, LDW, and PCW) as independent variables (IVs) and developed a MNL regression model. This model provided the coefficients for each independent variable to calculate the utility values for each category (Mild, Moderate, and Severe) as presented in Equations 3, 4, and 5.

a. U1(Mild) = 3.891 + 0.377*(nMinRadius) + 0.768*(nHorizontalCurves) + 0.176*(nAltitudeDifference) – 2.820*(nLength) + 0.898*(n3arms) + .586*(n85th%ileSpeed) – 8.798*(nPCW) – 8.853(nLDW) – 0.493*(nFCW)..**Eq. 03**

b. U2(Moderate) = 2.508 + 1.187*(nMinRadius) – 1.138*(nHorizontalCurves) + 0.088*(nAltitudeDifference) + 0.084*(nLength) + 0.901*(n3arms) + 0.174*(n85th%ileSpeed) + 1.405*(nPCW) – 3.453*(nLDW) – 3.480*(nFCW)..................................**Eq. 04**

c. U3(Severe)= 0(Considered) ....**Eq. 05**

The above equations (Eq. 3 to 5) shows the parameter estimates of the MNL regression for 1st corridor and the goodness of fit of the model is calculated based on the Pseudo R-Square (particularly McFadden), and Chi-Square test. From this check, it can be inferred that, goodness of fit of this MNL model is good with McFadden value is 0.220 which is nearer to 0.2, and the significance value of the Chi-Square test is 0.051 which shows the highly significant results and relation among the independent variable with dependent variable. Further, the accuracy of this model is calculated based on the confusion matrix or classification matrix among the observed severity of grids and predicted severity of grids as presented in Table 3.6, where it describes the classification matrix details with the accuracy of predictions for three categories: Mild, Moderate, and Severe. Each row represents the actual observed category, while each column shows the predicted category. The diagonal values indicate correct predictions. For Mild, there are 67 correct predictions out of 104 (64.40 %). For Moderate, 111 out of 147 predictions are accurate (67.30 %). Severe has 50 correct predictions out of 101 (49.50 %). The overall prediction accuracy is 61.60 %. The distribution of predictions is 28.60% for Mild, 50.80 % for Moderate, and 20.50 % for Severe, reflecting the model's performance across different categories.

Table 3.6 Classification matrix among the observed and predicted results: Corridor-1.

Observed	Predicted			
	Mild	Moderate	Severe	Percentage Correct
Mild	67	31	6	64.40 %
Moderate	34	111	2	67.30 %
Severe	5	46	50	49.50 %
Overall Percentage	28.60 %	50.80 %	20.50 %	61.60 %

After calculating the utility values for all grids of road network of Corridor-1, further as a part of MNL regression method, calculated the probability values for each grid using the standard equation of probability calculation under the MNL regression model as presented in Equation 6.

$$P = \frac{e^{U_1}}{e^{U_1} + e^{U_2} + e^{U_3}} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots . \dots \dots \dots \dots \boldsymbol{Eq. 06}$$

Using the above Eq. 6, calculated the probabilities for each grid of the road network for each category of severity (Mild – p1, Moderate – p2, and Severe – p3). After that, based on these three kinds of probability values for the grids of the road network calculated the category of the grid in terms of Mild, Moderate, and Severe, where Mild predicted category has been denoted based on their higher probability value among the other two probability values (p2 and p3), Moderate predicted category has been denoted based on their higher probability value among the other two probability values (p1 and p3), and the Severe predicted category has been denoted based on their higher probability value among the other two probability values (p1 and p2).

3.6.2 Application of this MNL on other two subsequent corridors

The MNL model developed for Greyspot identification was further applied to two subsequent study corridors: Hyderabad to Pullur (NH-44) and Hyderabad to Adilabad (NH-44) to evaluate its performance.

The results showed that the developed model performed well on both corridors. For Corridor-2, the overall accuracy was 63.60 %, with category-wise accuracies of 66.20 % for Mild to Mild, 34.30 % for Moderate to Moderate, and 81.80 % for Severe to Severe. For Corridor-3, the overall accuracy was 52.60 %, with category-wise accuracies of 78.50 % for Mild to Mild, 40.10 % for Moderate to Moderate, and 3.30 % for Severe to Severe.

From this testing, it can be inferred that Corridor-2 demonstrated strong performance, especially in identifying mild and severe Greyspots with good accuracies. Corridor-3 showed excellent accuracy in identifying mild Greyspots, including its robustness in detecting less severe locations. Overall, the developed MNL model effectively identified Greyspots across different severity levels, proving to be a valuable tool for proactive road safety measures on multiple corridors.

3.7 Validation of the results

After having good accuracy between predicted categories (based on the calculated probabilities that depends on the road geometry and ADAS alerts) and actual category (categorized based on Weighted SI that depends on road crashes / fatalities / injuries) of the road segments, further the results were validated in two ways:

a. First, by comparing the identified severe locations with the existing blackspots of the particular corridors.

b. Secondly, validate the identified severe locations / road segments with actual ground conditions by doing field visits in all the study corridors.

To perform this validation, study team selected top 20 Greyspots of all the corridors of 2023Q4 period and to identify these top locations for each corridor all the predicted / calculated grids have been sorted in descending order and carved out the top 20 severe locations thar have high crash probabilities. After that, the above validation checks performed on these selected locations which are as follows:

A. Comparison of identified severe locations with existing blackspots

Under this, to compare the identified top 20 severe locations of each study corridor, gathered blackspot location information for the same corridors from two sources such as first from Telangana state traffic police department and second list of blackspots which was calculated utilizing the latest road crash data (gathered from National Highway Authority of India, NHAI) by using the latest blackspot calculation methodologies such as Annual Average Total Crashes (AATC) method of IRC 131 (2022) manual under Infrastructure safety section (refer to Chapter 4). After gathering of all the above information, further imported all this information into the GIS platform for better visualization and comparison. For the comparison, exact severe road segments and also the adjacent segments were compared with the blackspots whose results are as detailed in Table 3.7.

Table 3.7 presents a comparison of the top 20 identified severe locations with existing blackspots along three corridors for the 2023Q4 time-period whose key highlights are-

- For the Hyderabad to Kodad corridor, the TS traffic blackspots are matching with 65.90 % of top severe identified locations, whereas the AATC blackspots are matching with 60 % of the identified top severe locations.

- Similarly, for the Hyderabad to Pullur corridor, the TS traffic blackspots are matching with 59 % of top severe identified locations, whereas the AATC blackspots are matching with 40 % of the identified top severe locations.

- Lastly, for the third corridor i.e., Hyderabad to Adilabad, the TS traffic blackspots are matching with 56.8 % of top severe identified locations, whereas the AATC blackspots are matching with 46.15 % of the identified top severe locations.

Table 3.7 Comparison of top 20 identified severe locations with existing blackspots

Time-period	2023Q4 (October 2023 to December 2023)		
Corridor	Hyderabad to Kodad	Hyderabad to Pullur	Hyderabad to Adilabad
TS Traffic Blackspots (identified by Telangana state traffic department)	65.90%	59%	56.80 %
AATC Blackspots (calculated as per IRC 131: 2022)	60%	40%	46.15 %

So, based on the above validation check, it can be inferred that the severe locations identified by the developed regression model significantly match the existing blackspots. This validates the identified locations as highly crash prone, aligning perfectly with existing blackspots. Locations that do not match existing blackspots are still severe but do not fall into the blackspot category and these unmatched locations will not receive any specific road safety attention, which may lead to them becoming blackspots in the future.

B. Field validation of identified severe locations

To strengthen the analysis, the top 20 identified severe locations were further validated through multiple field visits along the study corridors. During these visits, detailed investigations were conducted to understand the real ground conditions and situations contributing to the high crash severity at these locations. This hands-on approach allowed for a comprehensive assessment of the factors causing crashes, there confirming the accuracy and relevance of the identified severe locations.

The results of the detailed validation process revealed significant insights into the top 20 identified severe locations along the study corridors which are detailed in section 3.8. Some key highlights are as follows:

a. For the Hyderabad to Kodad corridor, the identified severe locations matched substantially with the existing blackspots and the primary reasons for high crash severity in this corridor included inadequate signage, high traffic volume and over-speeding particularly during peak hours, blind curves, lack of pedestrian walking and crossing facilities, and so on.

b. On the Hyderabad to Pullur corridor, there was a noticeable alignment between the severe locations identified by the regression model and the blackspots and the high crash severity in this corridor was attributed to curves and blind spots, high pedestrian activity without proper crossing facilities, lack of speed regulation leading to high-speed driving, and so on.

c. For the Hyderabad to Adilabad corridor, the high crash severity of the identified locations was due to inadequate lighting, sharp curves, high altitude difference, frequent animal crossings, roadside encroachments reducing the effective road width, and so on.

These field visits confirmed that the severe locations identified by the developed regression model are indeed highly crash-prone and correspond well with existing blackspots. The investigation into ground conditions highlighted specific factors contributing to high crash severity, emphasizing the need for targeted road safety interventions. This validation process not only confirmed the accuracy of the regression model but also identified areas requiring immediate attention to prevent future crashes and enhance road safety.

3.8 Identification of Greyspots

Based on the developed Greyspot identification regression models, a comprehensive list of Greyspots, including intersections and midblock regions traversed by the ADAS-equipped TGSRTC fleet of buses, was prepared. The process involved calculating the severity (in terms of probability) for all grids of road segments and sorting them in descending order. Locations with probability greater than 0.75 (on a scale of 0 to 1) excluding existing blackspots, were identified and designated as **"Greyspots".**

Quantitatively, this approach filtered out locations with high crash severity probabilities, focusing on those surpassing the 0.75 probability threshold. This rigorous sorting process ensured that only the most critical areas, which are not already recognized as blackspots, were classified as Greyspots. The identified Greyspot locations for all the study corridors are detailed in the succeeding sections, providing a targeted list of high-risk areas that require attention for improving road safety.

A. Hyderabad to Kodad Corridor

Figure 3.15 and Table 3.8 below present the GIS representation and the list of Greyspots identified during the 2023: Q3. These visual and tabular data illustrate the specific locations and severity of the Greyspots identified through the regression models.

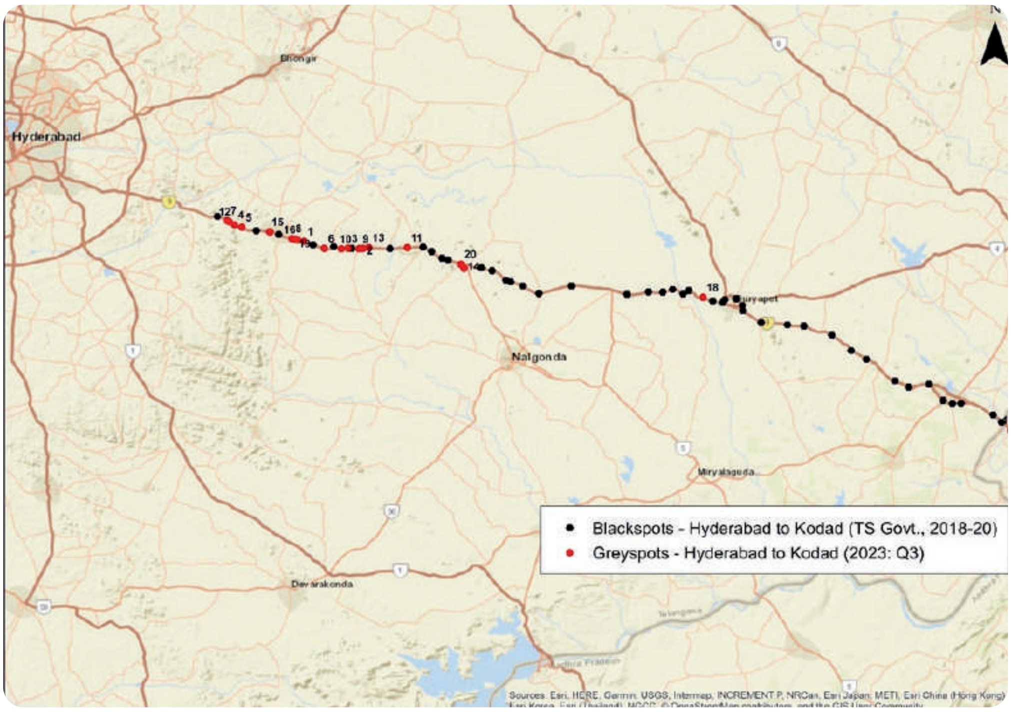


Figure 3.15 Identified Greyspots of 2023: Q3 Period.

Table 3.8 Detailed list of top 20 Greyspot Locations of 2023: Q3.

Rank	Grid ID	Location name	Geo-location		Road section type
			Latitude	Longitude	
1	251	Mallikarjuna PBRI T-Intersection to Divis Farm, Choutuppal	17.24111	78.93736	Midblock
2	230	Shivam Gardens, Veliminedu	17.22992	79.03081	Midblock
3	267	Kaithapur T-Intersection	17.26761	78.82691	Intersection
4	279	Yellagiri Crossroad	17.2634	78.83869	Intersection
5	221	Gundlabavi T-Intersection	17.23001	78.96965	Intersection
6	272	Near burralagudem Bus Stop, Gudem	17.27419	78.8151	Midblock
7	255	Bangarigadda	17.24576	78.91819	Midblock
8	298	Flyover Ending, UP Bihar Family Dhaba, Veliminedu	17.22948	79.02462	Midblock
9	225	Gundrampally	17.22936	78.99674	Intersection
10	243	Near Durga Bhavani Tiffin Center, Chityala	17.23117	79.10163	Intersection
11	269	Borralagudem Bus Stop to Ratna Poultrys	17.27233	78.81852	Midblock
12	232	Indian Oil Petrol Bunk to Jinukala Farmhouse, Pittampally	17.23131	79.04034	Midblock
13	354	Narketpalle Bypass Curve	17.1985	79.1912	Midblock
14	289	Lakkaram	17.2562	78.88321	Intersection
15	295	Lingojigude Flyover	17.24404	78.92678	Midblock
16	128	Rayanagudem Curve (Sansai Hyundai Car Showroom)	17.15253	79.57069	Midblock
17	256	Bharat Petroleum Petrol Pump, Kondal	17.24492	78.92313	Midblock
18	359	Shabari Gardens, Narketpalle Bypass Curve	17.20507	79.18617	Midblock
19	231	Before Indian Oil Veliminedu, Pittampally	17.23065	79.03528	Midblock
20	257	Sri Gayatri Wines	17.24263	78.93187	Midblock

Likewise, Figure 3.16 and Table 3.9 provide the corresponding GIS representation and list of Greyspots for the 2023: Q4.

Figure 3.16 Identified Greyspot of 2023: Q4 Period.

Table 3.9 Detailed list of top 20 Greyspot Locations of 2023: Q4

Rank	Grid Label	Location name	Geo-location		Road section type
			Latitude	Longitude	
1	251	Mallikarjuna PBRI T-Intersection to Divis Farm, Choutuppal	17.24111	78.93736	Midblock
2	233	Kuteeram South Indian, Pittampally	17.2313	79.04522	Midblock
3	230	Shivam Gardens, Veliminedu	17.22992	79.03081	Midblock
4	267	Kaithapur T-Intersection	17.26761	78.82691	Intersection
5	279	Yellagiri Crossroad	17.2634	78.83869	Intersection
6	220	After Panthangi Toll plaza	17.23173	78.96411	Intersection
7	221	Gundlabavi T-Intersection	17.23001	78.96965	Intersection
8	272	Near Burralagudem Bus Stop, Gudem	17.27419	78.8151	Midblock
9	255	Bangarigadda	17.24576	78.91819	Midblock
10	298	Flyover Ending, UP Bihar Family Dhaba, Veliminedu	17.22948	79.02462	Midblock
11	225	Gundrampally	17.22936	78.99674	Intersection
12	243	Near Durga Bhavani Tiffin Center, Chityala	17.23117	79.10163	Intersection
13	269	Borralagudem Bus Stop to Ratna Poultrys	17.27233	78.81852	Midblock
14	232	Indian Oil Petrol Bunk to Jinukala Farmhouse, Pittampally	17.23131	79.04034	Midblock
15	354	Narketpalle Bypass Curve	17.1985	79.1912	Midblock
16	289	Lakkaram	17.2562	78.88321	Intersection
17	295	Lingojigudem Flyover	17.24404	78.92678	Midblock
18	128	Rayanagudem Curve (Sansai Hyundai Car Showroom)	17.15253	79.57069	Midblock
19	256	Bharat Petroleum Petrol Pump, Kondal	17.24492	78.92313	Midblock
20	359	Shabari Gardens, Narketpalle Bypass Curve	17.20507	79.18617	Midblock

B. Hyderabad to Pullur Corridor

Figure 3.17 and Table 3.10 below display the GIS representation and list of Greyspots identified during the 2023: Q3. Similarly, Figure 3.18 and Table 3.11 provide the GIS representation and list of Greyspots for the 2023: Q4. These visual and tabular data offer a comprehensive view of the Greyspot locations and their severity for each respective quarter.

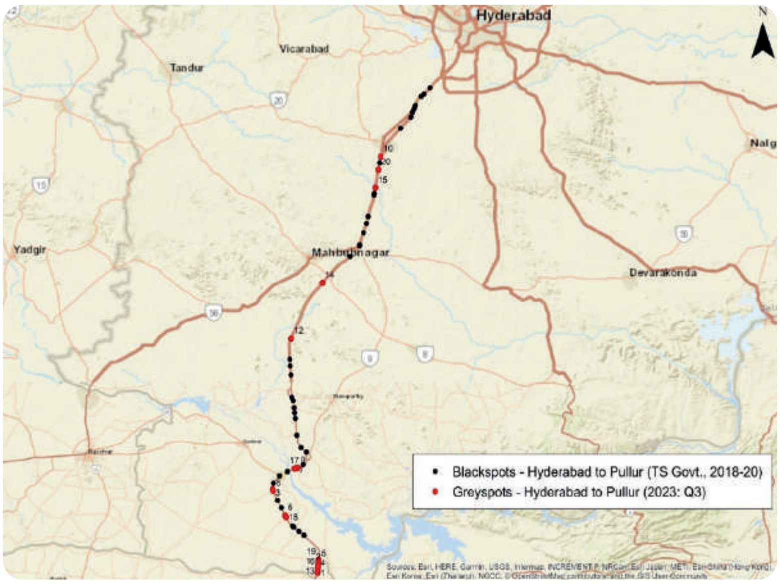


Figure 3.17 Identified Greyspot during Quarter 3 of year 2023.

Table 3.10 Detailed list of top 20 Greyspot Locations of Quarter 3 of year 2023

Rank	Grid Label	Location name	Geo-location		Road section type
			Latitude	Longitude	
1	11	Near Doon Punjabi Dhaba, Pullur	15.892913	78.017337	Midblock
2	13	Global Rainbow Pool, Pullur	15.901638	78.017972	Midblock
3	89	Putandoddi	16.110187	77.886647	Midblock
4	236	Near NBR hotel, Sakalamaddi, Moosapet	16.58894	77.968589	Midblock
5	9	Suraj Family Dhaba (Near IOCL Petrol Bunk)	15.883737	78.016746	Midblock
6	16	Gurunanak Dhaba, Pullur	15.911511	78.018728	Intersection
7	65	Shivnath Group Land, Itikyala	16.03819	77.92272	Midblock
8	116	Pebburu	16.168012	77.954473	Midblock
9	88	Putandoddi Curve	16.104246	77.888133	Midblock
10	259	Near Sithara Family Hotel, Annasagar	16.652048	78.005588	Intersection
11	117	Rangapur	16.168748	77.958721	Midblock
12	384	MSN Unit 5, Solipur	17.027819	78.198506	Midblock
13	8	Gateway of Rayalseema (Kurnool)	15.879317	78.016436	Midblock
14	216	HP Petrol Pump, Addakal	16.524432	77.93917	Midblock
15	270	Pothulamadugu	16.679342	78.030044	Intersection
16	361	Dundhubi River Bridge	16.941384	78.182968	Midblock
17	12	Pullur	15.896998	78.017621	Midblock
18	115	Bharat Petrol Pump, Pebburu	16.16727	77.950074	Midblock
19	64	Vallur Crossroad	16.032202	77.925905	Intersection
20	17	Alampur X Road to Vyasnavi Junior College	15.915592	78.018979	Midblock

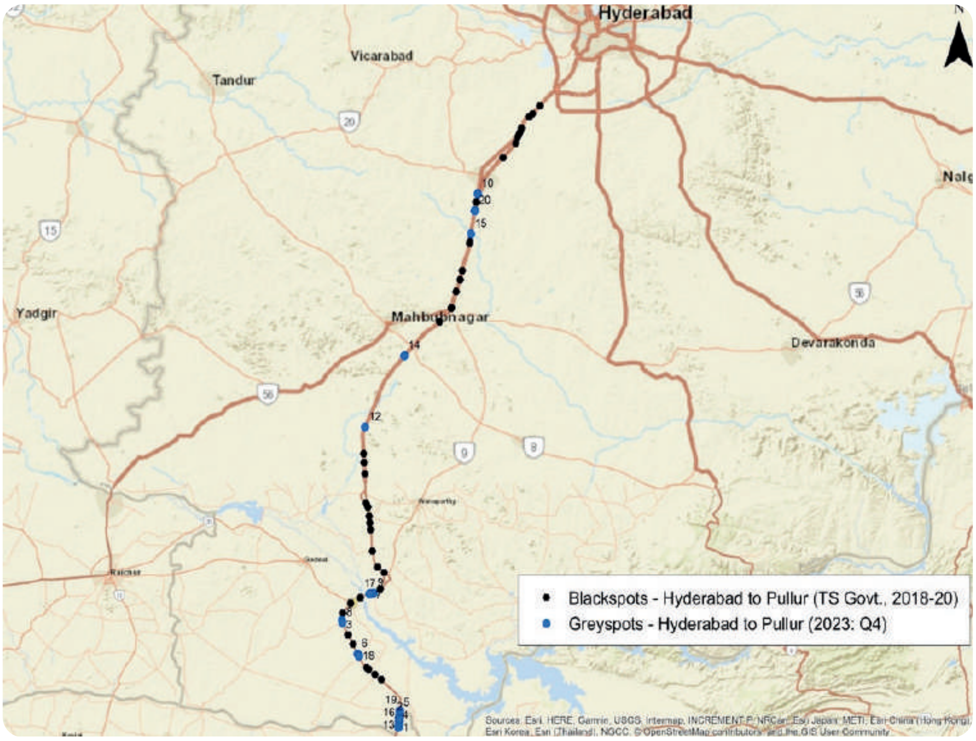


Figure 3.18 Identified Greyspots of Quarter 4 of year 2023

Table 3.11 Detailed list of top 20 Greyspot Locations of Quarter 4 of year 2023

Rank	Grid Label	Location name	Geo-location		Road section type
			Latitude	Longitude	
1	11	Near Doon Punjabi Dhaba, Pullur	15.892913	78.017337	Midblock
2	13	Global Rainbow Pool, Pullur	15.901638	78.017972	Midblock
3	89	Putandoddi	16.110187	77.886647	Midblock
4	9	Suraj Family Dhaba (Near IOCL Petrol Bunk)	15.883737	78.016746	Midblock
5	16	Gurunanak Dhaba, Pullur	15.911511	78.018728	Intersection
6	65	Shivnath Group Land, Itikyala	16.03819	77.92272	Midblock
7	116	Pebburu	16.168012	77.954473	Midblock
8	88	Putandoddi Curve	16.104246	77.888133	Midblock
9	117	Rangapur	16.168748	77.958721	Midblock
10	384	MSN Unit 5, Solipur	17.027819	78.198506	Midblock
11	8	Gateway of Rayalseema (Kurnool)	15.879317	78.016436	Midblock
12	216	HP Petrol Pump, Addakal	16.524432	77.93917	Midblock
13	12	Pullur	15.896998	78.017621	Midblock
14	115	Bharat Petrol Pump, Pebburu	16.16727	77.950074	Midblock
15	64	Vallur Crossroad	16.032202	77.925905	Intersection
16	17	Alampur X Road to Vyasnavi Junior College	15.915592	78.018979	Midblock
17	374	Raikal	16.989756	78.191393	Midblock
18	127	Sri Krishna delicacy Udupi Veg family restaurant, Pebbair	16.19115	77.984758	Midblock
19	256	BeforeNear Sithara Family Hotel, Annasagar	16.647215	78.00215	Midblock
20	15	Near Gurunanak family hotel Pullur	15.908	78.018489	Intersection

C. Hyderabad to Adilabad Corridor

Figure 3.19 and Table 3.12 below present the GIS representation and the list of Greyspots identified during the 2023: Q3. Likewise, Figure 3.20 and Table 3.13 display the GIS representation and list of Greyspots for the 2023: Q4. These visual and tabular data provide a detailed overview of the Greyspot locations and their severity for each respective quarter.

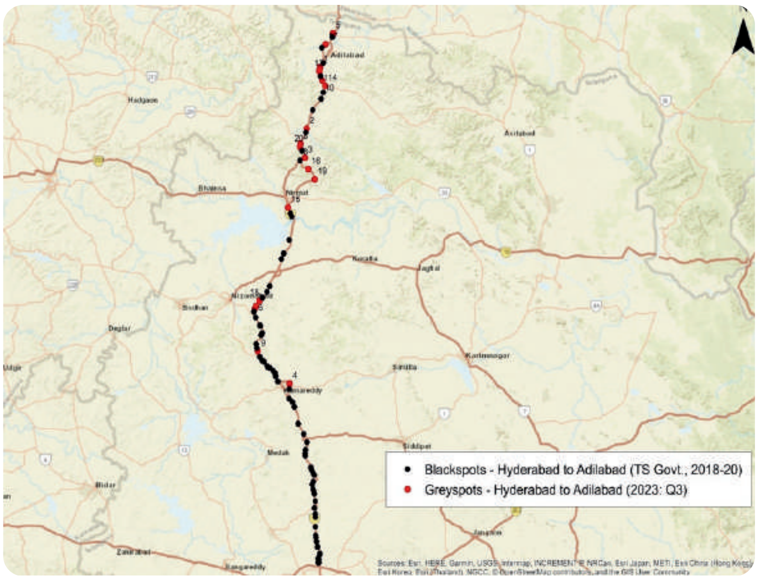


Figure 3.19 Identified Greyspot during Quarter 3 of year 2023

Table 3.12 Detailed list of top 20 Greyspot Locations of Quarter 3 of year 2023

Rank	Grid Label	Location name	Geo-location		Road section type
			Latitude	Longitude	
1	682	Devapur Forest Checkpost Curve	19.612477	78.492852	Midblock
2	603	Ghandari Curve	19.365009	78.434312	Midblock
3	565	Kistapur Curve	19.24719	78.426843	Midblock
4	224	Rameshwarpalle Curve, Shabdipur	18.337789	78.360211	Midblock
5	730	Poosai Curve Starting	19.748247	78.548357	Midblock
6	339	Amruthapur	18.640695	78.210733	Midblock
7	342	Mentrajpalle	18.649916	78.214335	Midblock
8	583	Neradigonda 2	19.301048	78.406417	Midblock
9	284	Dhaggi	18.46935	78.222085	Midblock
10	665	Gudihathnur Curve	19.559009	78.501271	Midblock
11	679	Pangadpipri	19.602609	78.489638	Midblock
12	677	NHAI Public Toilet to Chand Mewat Dhaba	19.595328	78.489107	Midblock
13	584	Laxmi Function Hall, Neradigonda 2	19.305366	78.407213	Midblock
14	659	Gudihathnur T-Intersection	19.536533	78.513781	Intersection
15	476	Kadthal	19.04707	78.353938	Intersection
16	541	Boragaon	19.201948	78.441495	Midblock
17	711	Mallapur (Near Bridge)	19.703823	78.515826	Midblock
18	350	Poppalpalle	18.671471	78.229989	Midblock
19	527	Rasimatla Curve	19.160294	78.469223	Midblock
20	580	Substation, Neradigonda 2	19.291551	78.40467	Midblock

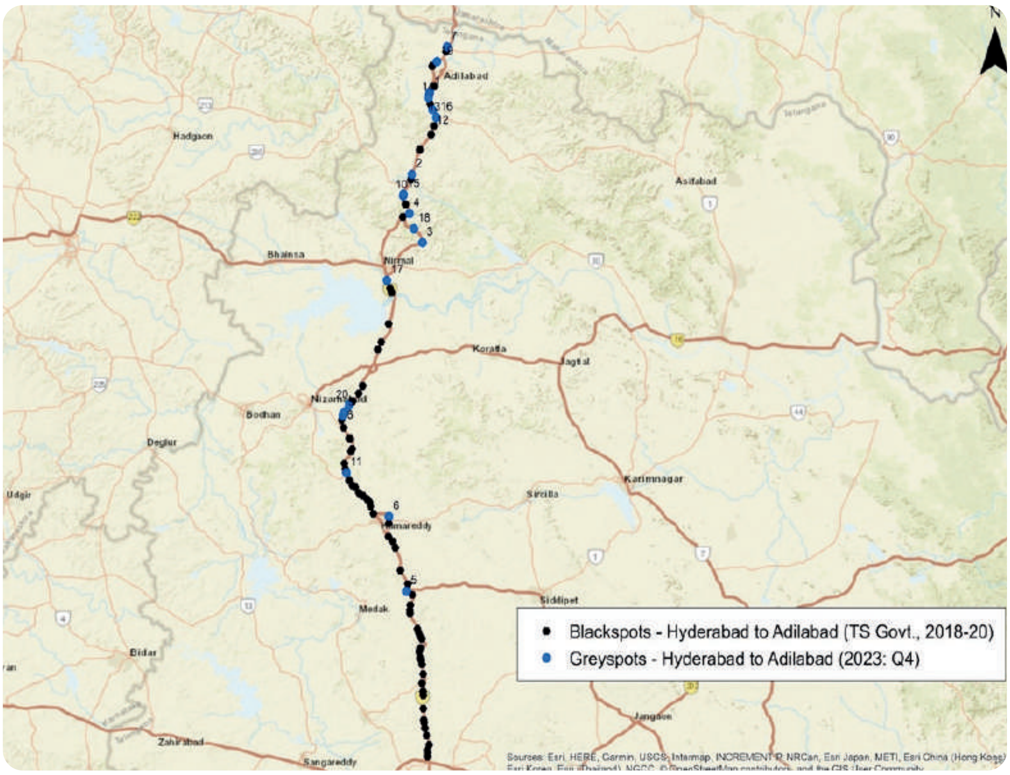


Figure 3.20 Identified Greyspot during Quarter 4 of year 2023

Table 3.13 Detailed list of top 20 Greyspot Locations of Quarter 4 of year 2023.

Rank	Road Segment ID	Location name	Geo-location		Road section type
			Latitude	Longitude	
1	682	Devapur Forest Checkpost Curve	19.612477	78.492852	Midblock
2	603	Ghandari Curve	19.365009	78.434312	Midblock
3	527	Rasimatla Curve	19.160294	78.469223	Midblock
4	565	Kistapur Curve	19.24719	78.426843	Midblock
5	153	Ramayampet Curve Intersection	18.113766	78.417540	Intersection
6	224	Rameshwarpalle Curve, Shabdipur	18.337789	78.360211	Midblock
7	730	Poosai Curve Starting	19.748247	78.548357	Midblock
8	339	Amruthapur	18.640695	78.210733	Midblock
9	342	Mentrajpalle	18.649916	78.214335	Midblock
10	583	Neradigonda 2	19.301048	78.406417	Midblock
11	284	Dhaggi	18.46935	78.222085	Midblock
12	665	Gudihathnu Curve	19.559009	78.501271	Midblock
13	679	Pangadpipri	19.602609	78.489638	Midblock
14	677	NHAI Public Toilet to Chand Mewat Dhaba	19.595328	78.489107	Midblock
15	584	Laxmi Function Hall, Neradigonda 2	19.305366	78.407213	Midblock
16	659	Gudihathnur T-Intersection	19.53653273	78.513781	Intersection
17	476	Kadthal	19.04707	78.353938	Intersection
18	541	Boragaon	19.201948	78.441495	Midblock
19	711	Mallapur (Near Bridge)	19.703823	78.515826	Midblock
20	350	Poppalpalle	18.671471	78.229989	Midblock

3.8.1 Consistency analysis between predicted Greyspot

This section examines the overlap and uniqueness of identified Greyspots across three corridors: Hyderabad to Kodad, Hyderabad to Pullur, and Hyderabad to Adilabad. Table 3.14 provides a count of Greyspots identified during two time periods, third quarter (2023Q3) and fourth quarter (2023Q4) of year 2023, for each corridor. In 2023:Q3 and 2023:Q4, all three corridors consistently had 20 Greyspots identified. Table 3.14 also shows the percentage of common Greyspots across these corridors:

a. For Hyderabad to Kodad, there was an 81% similarity in Greyspots between 2023:Q3 and 2023:Q4.
b. For Hyderabad to Pullur, there was a higher similarity of 94% in Greyspots between 2023:Q3 and 2023:Q4.
c. For Hyderabad to Adilabad, there was the highest similarity of 96% in Greyspots between 2023:Q3 and 2023:Q4.

These statistics indicate a significant majority of Greyspots identified in one quarter (2023Q3) were also identified in the subsequent quarter (2023Q4), reflecting consistency in high-risk areas over time within each corridor. The high percentages of common Greyspots suggest that these locations consistently exhibit factors contributing to high crash severity, warranting continuous monitoring and targeted safety interventions. Such analysis helps in understanding the stability and dynamics of Greyspots over time, guiding effective road safety strategies and interventions tailored to specific corridors and their unique challenges.

Table 3.14 Count of Greyspots and matching percentage

Time period	Greyspots		
	Hyderabad to Kodad	Hyderabad to Pullur	Hyderabad to Adilabad
2023Q3	20	20	20
2023Q4	20	20	20
Common	**81%**	**94%**	**96%**

3.8.2 Final Greyspots

Based on the aforementioned analysis and the identification of significant commonalities in the Greyspots observed during the third and fourth quarters of year 2023, the study team proceeded to conduct a more comprehensive evaluation. They aimed to pinpoint the Greyspot locations across all three National Highway (NH) corridors by leveraging the most recent Advanced Driver Assistance Systems (ADAS) alerts data from the first quarter of year 2024. This approach allowed for a more precise and current understanding of Greyspot dynamics, ensuring that the latest trends and potential hazard zones were accurately identified and mapped.

As a result of the detailed analysis, Table 3.15 presents the attributes of the newly identified 20 Greyspots along the Hyderabad to Kodad corridor. This table includes a comprehensive list with each Greyspot's rank, specific location name, and precise geo-positional information, such as latitude and longitude coordinates.

Table 3.15 Greyspots of Hyderabad to Kodad Corridor: 2024Q1

Rank	Road Segment ID	Location name	Latitude	Longitude
1	280	Sri Durga Bhavani Automobiles, Koyyalagudem	17.26188	78.841493
2	359	Narketpalle Bypass Curve 1	17.205067	79.186172
3	279	Yellagiri Junction Bus Stop	17.263404	78.838687
4	264	Tangedu Forest, Near Lakkaram	17.257365	78.874679
5	257	Sri Gayatri Wines, Lingoji Guda	17.242631	78.931867
6	272	Near Borralagudem Bus Stop	17.274187	78.815098
7	245	Chityala 1 (1.25 Kms ahead from 7 Midway Plaza Restaurant)	17.23201	79.110687
8	354	Narketpalle Bypass Curve 2	17.198496	79.191197
9	225	JB Nature Valley, Gundrampally	17.229356	78.996738
10	289	MRR Garden and Function Hall, Lakkaram	17.256199	78.883212
11	269	Borralagudem (at the exit of truck lay bye)	17.272329	78.818516
12	267	Kaithapur T Junction	17.267607	78.826911
13	221	Choutuppal Median Opening (Near Anil Hotel)	17.230014	78.969653
14	128	Sansai Hyundai Car Showroom, Suryapet	17.15253	79.570686

Rank	Road Segment ID	Location name	Latitude	longitude
15	204	Narketpalle Bypass Curve 3 (Near Kakatiya Towers)	17.19829	79.205474
16	256	BPCL Petrol Pump, Bangarigadda	17.244921	78.923125
17	255	Teatime Hotel, Bangarigadda	17.245756	78.91819
18	298	Near UP Bihar Family Dhaba, Veliminedu	17.229475	79.024621
19	232	IOCL Petrol Pump, Pittampally	17.23131	79.04034
20	244	Chityala 2	17.231228	79.106274

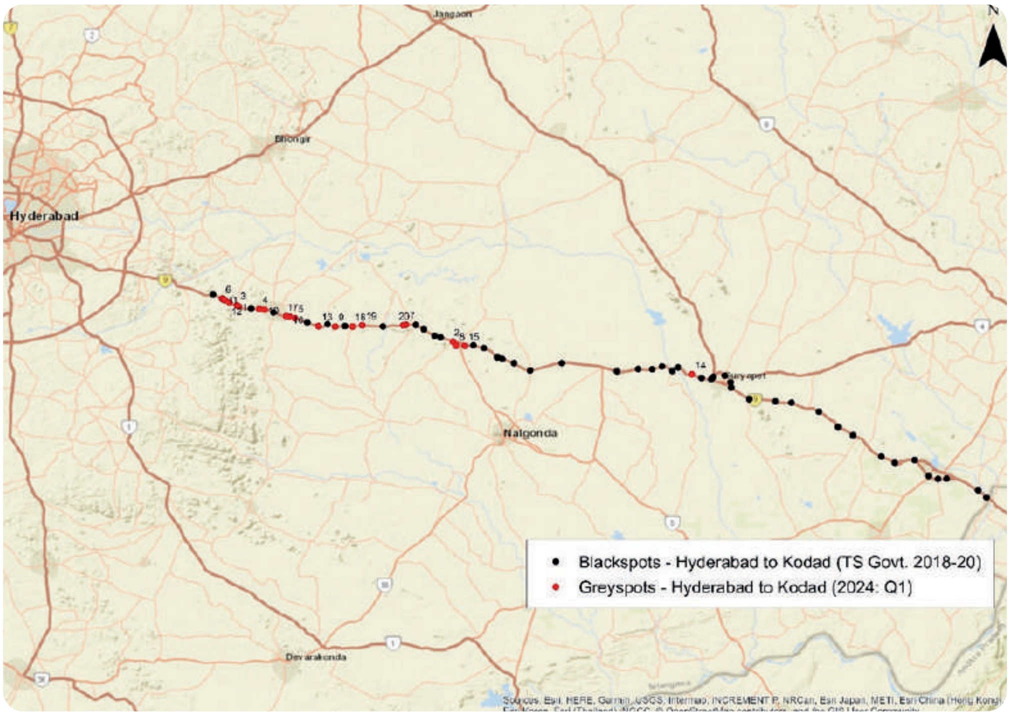


Figure 3.21 Greyspots of Hyderabad to Kodad Corridor (2024Q1) on the GIS Platform

In addition, Figure 3.21 visually represents the top 20 Greyspots calculated for the Hyderabad to Kodad corridor for the first quarter of 2024. This figure not only highlights these Greyspots but also includes the blackspots within the same corridor, providing a clear and detailed overview of the areas with the highest concentration of potential hazards.

Similarly, Table 3.16 presents the attributes of the newly identified 20 Greyspots along the Hyderabad to Pullur corridor. This table includes a comprehensive list with each Greyspot's rank, specific location name, and precise geopositioned information, such as latitude and longitude coordinates

Table 3.16 Greyspots of Hyderabad to Pullur Corridor: 2024Q1

Rank	Road Segment ID	Location name	Latitude	Longitude
1	385	Solipur T Junction	17.03294	78.20047
2	399	Rasoi Multicusine Restaurant, Farooqnagar	17.07285	78.22391
3	185	Near Mehmood Dhaba, Nirven	16.39458	77.94096
4	366	Between HPCL and IOCL Petrol Bunk, Balanagar	16.9584	78.18594
5	23	Chinnamudyala Junction	15.94303	78.02099
6	127	Bunyadpur Curve	16.19115	77.98476
7	401	Near Maruti Suzuki Showroom, Farooqnagar	17.07732	78.22789
8	180	Near Kothakotta Bypass Curve	16.38089	77.93079
9	351	Kethireddipalle Midblock	16.90081	78.17528
10	397	Farooqnagar Midblock	17.06683	78.21882
11	89	Putandoddi Culvert	16.11019	77.88665
12	353	Near Uttara HPCL Petrol Bunk, Kethireddipalle	16.90926	78.17758
13	33	BPCL Petrol Bunk, Peddapthulapadu	15.96522	77.99712
14	361	Sri Ayyappa Swamy Devalayam, Balanagar	16.94138	78.18297
15	143	Shakhapur, Towards Thomalapalle	16.2409	77.95963
16	365	Near JK Fuel Terminus, Balanagar	16.95462	78.1852
17	352	Chai Club, Kethireddipalle	16.90497	78.17665
18	374	Raikal 1 (Towards Balanagar)	16.98976	78.19139
19	373	Raikal 2 (Towards Balanagar)	16.98553	78.19064
20	367	Near Bhavani Hotel, Burgul	16.96362	78.18689

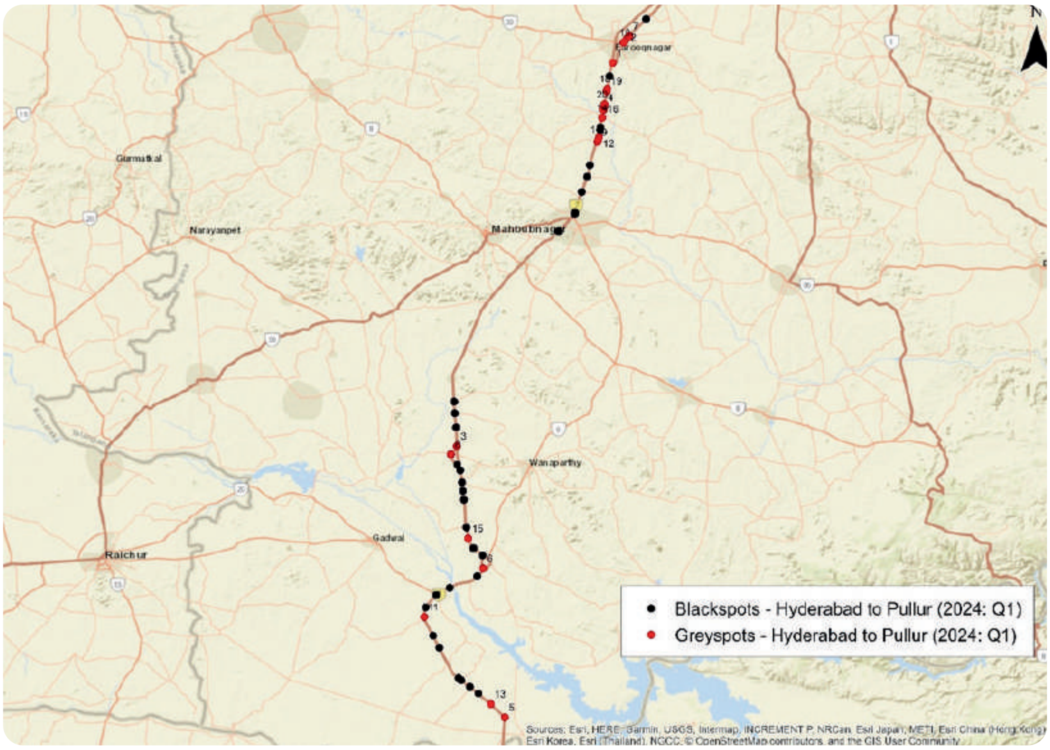


Figure 3.22 Greyspots of Hyderabad to Pullur Corridor (2024Q1) on the GIS Platform

Figure 3.22 visually represents the top 20 Greyspots calculated for the Hyderabad to Pullur corridor for the first quarter of 2024. This figure not only highlights these Greyspots but also includes the blackspots within the same corridor, providing a clear and detailed overview of the areas with the highest concentration of potential hazards.

Lastly, Table 3.17 presents the attributes of the newly identified 20 Greyspots along the Hyderabad to Adilabad 35 corridor. This table includes a comprehensive list with each Greyspot's rank, specific location name, and precise geopositioned information, such as latitude and longitude coordinates.

Table 3.17 Greyspots of Hyderabad to Adilabad Corridor: 2024Q1

Rank	Road Segment ID	Location name	Latitude	Longitude
1	224	Rameshwarpalle to Adloor (Curve Region)	18.33805	78.3601
2	565	Kistapur Curve	19.24704	78.42653
3	603	Ghandari T Intersection, Near Sailani Baba Dargah	19.36483	78.43424
4	231	Kamareddy Curve Region	18.34279	78.35631
5	153	Ramayampet Junction	18.11279	78.4178
6	682	Devapur Forest Check Post	19.61291	78.49324
7	521	Near Bhimanna Temple, Burugupalle	19.1519	78.4505
8	753	Penganga Bridge (Maharashtra Border)	19.81591	78.57838
9	539	Boragaon Curve	19.19088	78.45465
10	536	Tandra Curve	19.18723	78.45919
11	493	Ellapelly T Junction	19.09321	78.37886
12	528	Rasimatla Curve	19.16472	78.47106
13	547	Boragaon Curve 2	19.20733	78.43727
14	491	Near Full Gospel Church, Kondapur	19.08831	78.37539
15	506	Vinayaka Temple, Kishanraopet	19.12991	78.402
16	519	Burugupalle	19.15098	78.44132
17	490	Kondapur Highway Bridge Junction	19.08351	78.37533
18	551	Dhonnara T Junction	19.21431	78.41355
19	484	Venkatapur Rural	19.0655	78.36492
20	535	Boragaon Curve 3	19.18978	78.45695

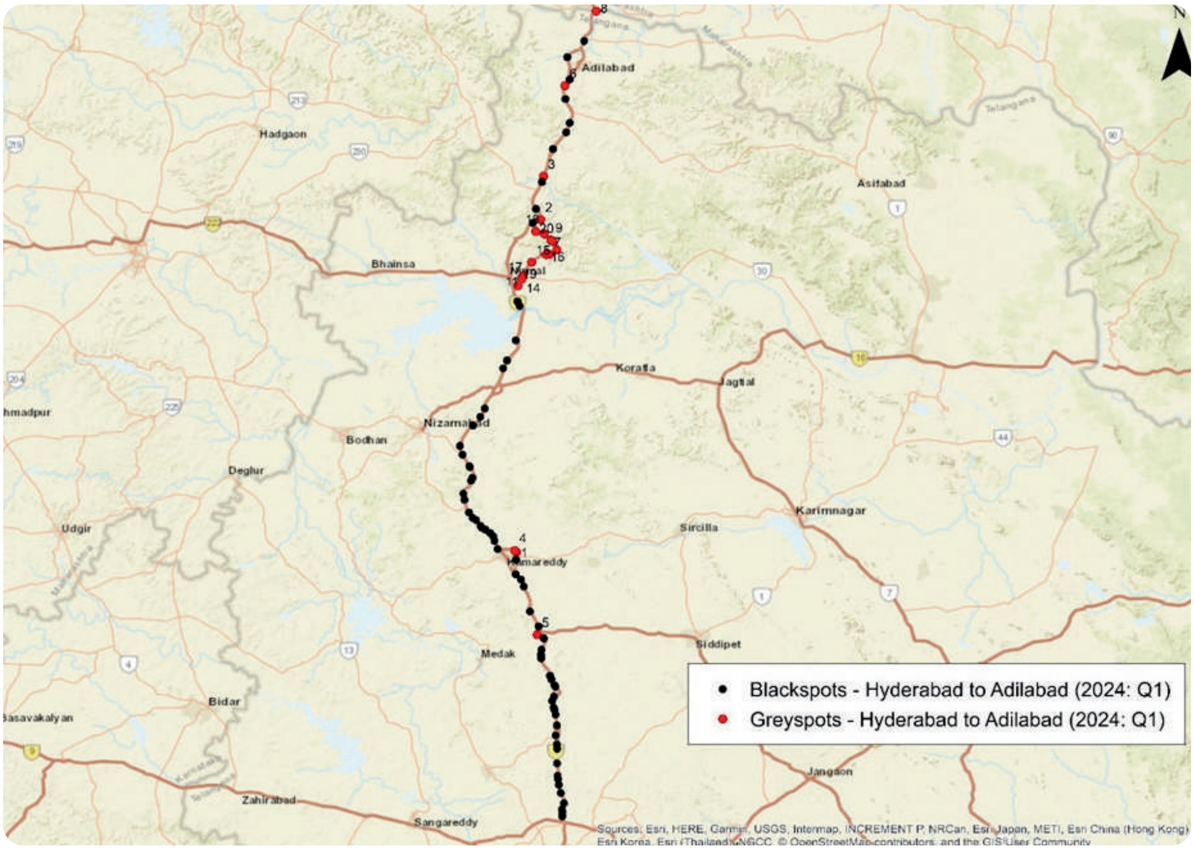


Figure 3.23 Greyspots of Hyderabad to Adilabad Corridor (2024Q1) on the GIS Platform

Figure 3.23 visually represents the top 20 Greyspots calculated for the Hyderabad to Adilabad corridor for the first quarter of 2024. This figure not only highlights these Greyspots but also includes the blackspots within the same corridor, providing a clear and detailed overview of the areas with the highest concentration of potential hazards.

These identified Greyspots, which are areas with a higher incidence of safety-related incidents or potential hazards such as generation of high amount of ADAS alerts, provide critical data that can guide the implementation of safety measures. By pinpointing and considering these locations, agencies can prioritize their efforts, such as enhancing signage, improving road conditions, implementing speed controls, and increasing monitoring. This targeted approach not only helps in reducing crashes but also ensures that resources are allocated efficiently, leading to safer and more reliable roadways for all users.

3.9 Ground Observations of Top Severe Greyspots

From March 18-21, year 2024, a team comprising engineers from CSIR - CRRI and INAI, IIIT Hyderabad conducted visits in all identified top 20 Greyspot locations of year 2024 in all the three interurban NH corridors, assessing significant severity values. There the team has observed issues and proposed remedial measures for the newly identified Greyspots, emphasizing proactive measures under the principle of "Prevention is better than cure" to prevent these locations from evolving into blackspots.

Based on the reconnaissance visits, several common contributory factors were identified for these locations appearing on the Greyspot list:

a. **Speed Violation:** Absence of effective traffic calming measures, such as Transverse Bar Markings up to 15 mm thickness at midblock locations, contributed to speed violations.

b. Road Infrastructure Damage: Poorly maintained road infrastructure and inadequate traffic management measures exacerbated safety risks.

c. Pedestrian Safety: Insufficient pedestrian facilities led to pedestrians walking on the carriageway, highlighting the need for designated zebra crossings at key points.

d. Over-speeding: Many vehicles were observed exceeding safe speed limits, posing hazards to both drivers and pedestrians.

e. Effectiveness of Transverse Bar Markings: While some Transverse Bar Markings (TBMs) were present, they did not sufficiently reduce vehicle speeds, necessitating further enhancements.

f. Crash Barriers: Critical areas with steep slopes lacked crash barriers beyond the carriageway shoulder, underscoring the importance of installing crash barriers to prevent accidents.

These findings underscore the urgent need for targeted interventions to improve road safety at these Greyspot locations and unsafe corridors. Addressing these factors comprehensively can mitigate risks and enhance safety for all road users, aligning with proactive measures to prevent these areas from becoming blackspots in the future.

Below section details the safety concerns and suggested solutions for top 5 Greyspots among the top 20 of all three corridors for Quarter 1 of the year 2024 (2024:Q1).

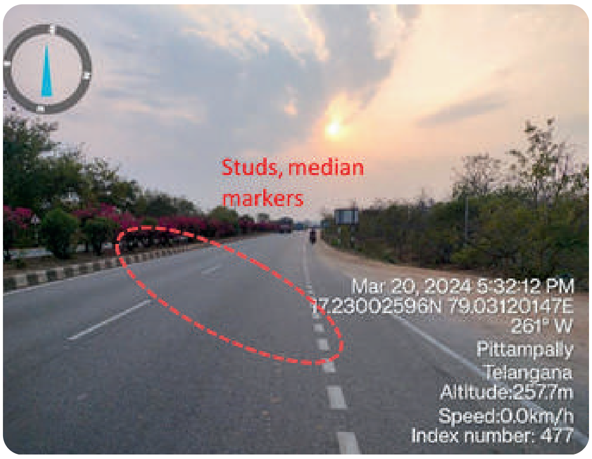
A. Hyderabad to Kodad (1st corridor)

Kaithapur T junction (Ch. 47.00 KM)		
Issues	**Problems**	**Suggested Solutions**
	• Here its starts with downward and then upward slope with 4 sets of TBM are provided still over- speeding continues. • The speed limit sign board is not there. Road studs, Crash barrier retro reflector poles are absent.	• Provide proper road markings, road signs, and all other road furniture. • Install the crash barrier and also provide the Rumble Strip or take speed control measures. At median connect the crash barrier to avoid hazard.

2. Yellagiri Crossroad (Ch. 47.00KM)		
Issues	**Problems**	**Suggested Solutions**
	• Here full S curve is there with one minor road connecting but without median cut. 4 sets of TBM are provided still over-speeding continues. • Downward gradient meets upward gradient of flyover. The speed limit sign board is not as per code and too much of information towards downward gradient. • Also, the visibility issue is there. Road studs, Crash barrier retro reflector poles are absent.	• Provide proper road markings, road signs, and all other road furniture. • Install the crash barrier and also provide the Rumble Strip or take speed control measures. At medianconnect the crash barrier to avoid hazard. • Provide deacceleration lane before the minor road connection.

03. Mallikarjuna PBRIT-junction to Divisfarm, Choutuppal (Ch. 58 KM)		
Issues	**Problems**	**Suggested Solutions**
	• There is a straight but slightly upward gradient from LHS. There is a median opening and an intersection before coming to this location. • There is a convergence of 2 lane from 3 lane. There are 5 sets of TBM to control the speed but ineffective at RHS. Crash barrier should be installed on both sides. • There is an over information feeding in the form of road sign. Only zebra crossing facility is available for pedestrian at crossing.	• Provide crash barrier and road marking and other road furniture as per code provision. • Take over speeding control measures

04. ShivamGardens, Veliminedu (Ch. 68.7KM)		
Issues	**Problems**	**Suggested Solutions**
	• It is straight region with intersection at RHS side. • Here the Gore area at the merging of slip road should be developed • Here there is no crash barrier on either side. There is no speed control measure and no street light. • There is no retro reflector poles or flexible median reflector and studs as well	• Provide proper road markings, road signs, and all other road furniture. • Speed calming measures / Rumble strips on LHS. • Install the crash barrier. Also provide street light and gore area treatment.



5. Near Jinukala Farmhouse, pittampally (Ch. 70 KM)		
Issues	**Problems**	**Suggested Solutions**
	• There is a C curve with Downward gradient and upward gradient then once again downward gradient. In between the path there is a restaurant. • No speed calming measures, no crash barrier on either side. Very high speed and no over-speeding measures have taken. No studs.	• Provide crash barrier and road marking and other road furniture as per code provision. • Take over speeding control measures and measures for the open drainage. • Also rectify the median cut to avoid wrong side driving.

B. Hyderabad to Pullur

1. Putandoddi (Ch. 170.640 KM)		
Issues	**Problems**	**Suggested Solutions**
	• The region starting with curve and near to the blackspot. • There is no end treatment of crash barrier and transverse pipe at culvert. • At RHS side TBM is there but still over-speeding issue is not resolved. • No sign board of speed limit.	• Provide proper treatment at culvert region also provide retro reflector poles at starting of curve. • Provide proper road markings, road signs, and all other road furniture.

02 Gurunanak Dhaba Pullur(Ch. 198.200 KM)		
Issues	**Problems**	**Suggested Solutions**
	• There is a downward gradient with no proper marking and no TBM. So, the over speeding is a serious issue. • There is no proper installation of crash barrier on either side. • The slope of minor road which merges with highway has an issue. • There no proper marking, no studs no sign board. • On both sides unpaved road is merging.	• Take speed control measure as soon as possible. Also install TBM. • Provide proper road markings, road signs, and all other road furniture. • Provide proper lightings road studs, crash barrier, etc.

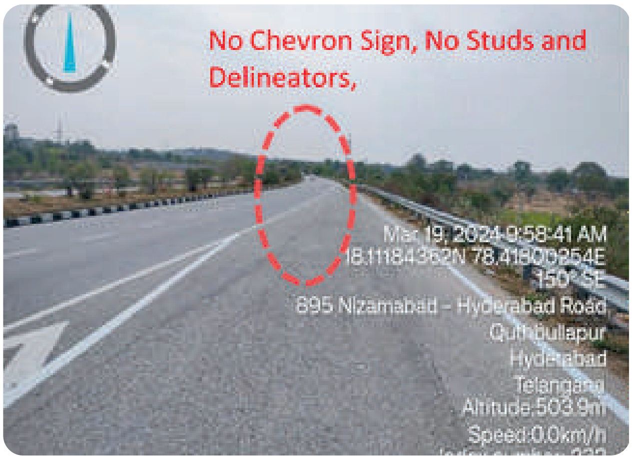
3. Global Rainbow Swimming Pool (Ch. 198.200 KM)		
Issues	**Problems**	**Suggested Solutions**
	• It is straight region with slope issue, high edge drop and soft shoulder. • On RHS highway there is service road to go into global rainbow pool. • There is no proper sign board and road marking. Lane width extended at one location with no OHM & lane exterior. • The Jio petrol pump is not properly joined with major road. There is also wrong side driving.	• Provide crash barrier and road marking and other road furniture as per code provision. • Take speed control measure.

4. Near DoonPunjabi Dhaba (Ch. 198.780 KM)		
Issues	Problems	Suggested Solutions
	• It is completely straight region with highly over speeding and overtaking region • On LHS the lane width has variation. • There is no crash barrier on either side. Also, wrong side driving is there.	• Provide crash barrier androad marking and other road furniture as per code provision.

5. Suraj FamilyDhaba (near IOCLpump) (Ch. 201.100 KM)		
Issues	**Problems**	**Suggested Solutions**
	• It is straight region and there is no sign board of truck lay bye. • On RHS marking is present but divider is broken on eitherside. • Slope issue on LHS as well as no sign board of speed control is installed.	• Provide proper road markings, road signs, and all other road furniture. • Provide studs as well as crash barrier and also reconstruct the divider on either side.

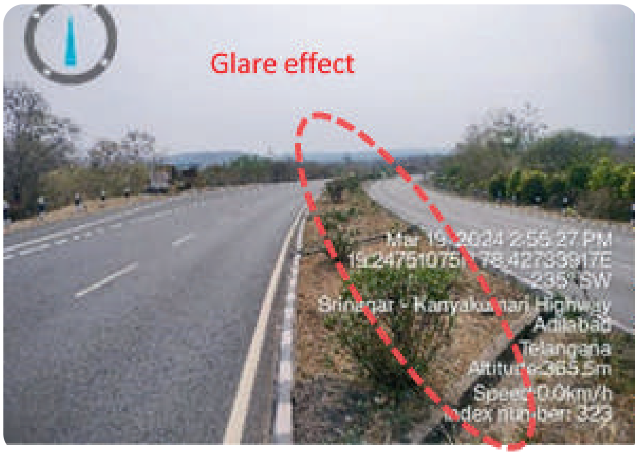
C. Hyderabad to Adilabad

1. Ramayampet CurveIntersection (Ch. 409.4KM)		
Issues	Problems	Suggested Solutions
	• Here it is C – curve with downward gradient and upward gradient and service road connecting to it both side. • Here the OHM is placed wrong and Chevron sign board at curve is also not there no both side. • Here it is issue in installing the crash barrier. There is no speed control measure and no street light. • There is no retro reflector poles or flexible median reflector and studs as well.	• Provide proper road markings, road signs, and all other road furniture. • Speed calming measures / Rumble strips on LHS. • Rectify the alignment of crash barrier. Also provide street light and gore area treatment.



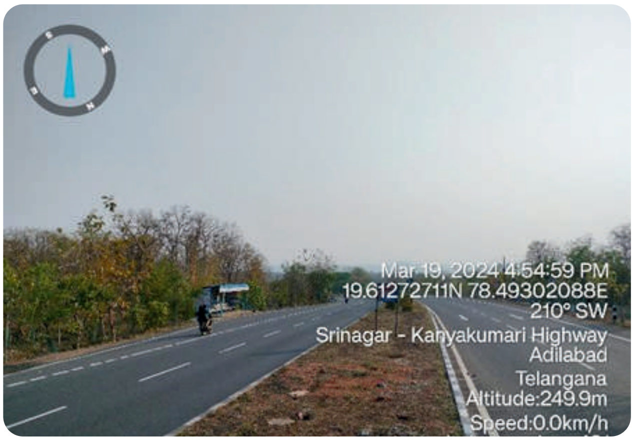
2. Rasimatla Curve(Ch. 264.2 KM)		
Issues	**Problems**	**Suggested Solutions**
	• It starts with downward gradient continues with curve and then still downward gradient. • On LHS the bus stop is on the curve which has median cut also • There is no crash barrier on either side, which is essential. • Due to gradient and no speed control measures the over speeding is happening. There are 5 sets of TBM but not that much effective. • As more than one service road and minor road meets here, this junction is sensitive.	• Provide proper crash barrier, studs and speed control measures. • Provide proper road markings, road signs, and all other road furniture.

3. Kistapur Curve(Ch. 248.1 KM)		
Issues	Problems	Suggested Solutions
	• There a fully C curve with upward gradient, minor road intersection on LHS and with less visibility a median cut is there. • No proper marking, no proper speed control measures have taken which makes this location risky. • No studs no delineators no lighting is there as well as no proper crash barrier.	• Provide proper road markings, road signs, and all other road furniture. • Provide crash barrier, lightings, speed control measures, studs, proper sign board are required.



4. Ghandhari Curve(Ch. 233.8 KM)		
Issues	**Problems**	**Suggested Solutions**
	• There is a downward gradient with marking and TBM. But still, the over speeding is a serious issue. • There is no proper installation of crash barrier on either side. • No studs, OHM markings are wrong and as there are 2 minor road connecting and median cut is provided so wrong side driving is an issue.	• Take speed control measure as soon as possible. Also install more TBM. • Provide proper road markings, road signs, and all other road furniture. • Provide proper lightings road studs, crash barrier, etc.

5. Devapur CheckPost (Ch. 203.15KM)		
Issues	Problems	Suggested Solutions
	• This location is situated on C curve with upward cure from RHS and the minor road is connecting on the curve area. • On LHS the vehicle movement is very high in terms of speed. • OHM sign is not there on both sides. The studs in the middle lane of both sides are missing. • Crash barrier is missing after the bus stop. The median island of minor road has an issue.	• Provide proper road markings, road signs, and all other road furniture. • IProvide studs as well as crash barrier



3.10 Data Dashboard

Our iRASTE-Telangana team developed a web-based dashboard to show the identified Greyspot locations. Figure 3.24 shows a snapshot of the locations present in Table 3.17 on a dashboard map. In addition, a map of these Greyspots with the existing blackspots is also available on the dashboard, for reference. This map is shown in Figure 3.25.

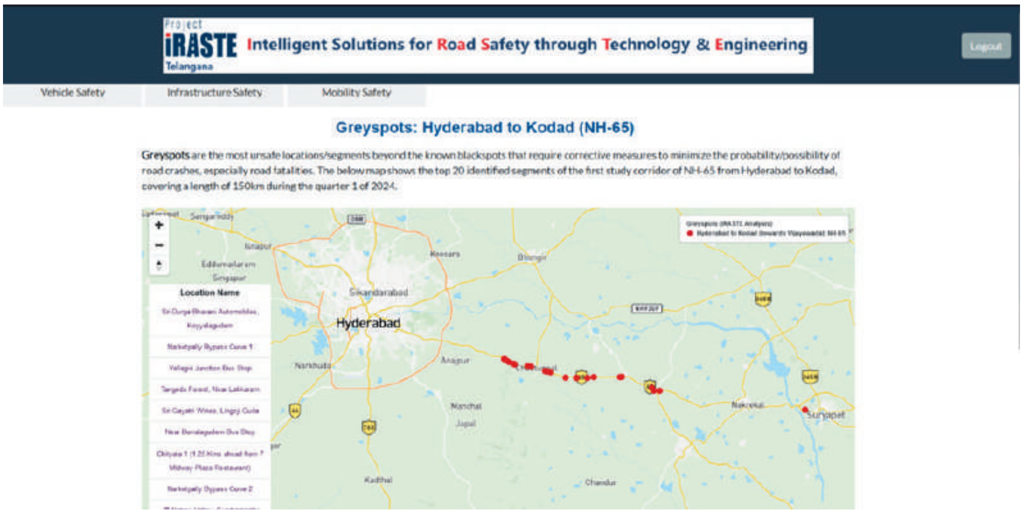


Figure 3.24 Identified Greyspots in the three interurban NH corridors, Telangana state

https://inaix.iiit.ac.in/telangana-iraste/greyspots_dashboard2

Figure 3.25 Blackspots identified in three interurban NH corridors, Telangana state.

https://inaix.iiit.ac.in/telangana-iraste/Blackspots.

3.11 Outcomes

We have integrated several sources of data in a GIS database including multiple types of ADAS alerts, road network, with geometrical attributes, FIR data, blackspot information, etc. based on primary and secondary data, various models have been developed to identify unsafe locations apart from known blackspots which are called as Greyspots i.e., Intersections, Midblock and Unsafe Corridors. We have identified 60 Greyspots (potential to become future blackspots) in each corridor of this project, A web-based dashboard has been created for easy access to the information This realtime dashboard with maps and locations can be accessed at https://inaix.iiit.ac.in/telangana-iraste/

Mobility Analysis

- Upgraded the Greyspot prediction algorithm to reflect Highway behavior.
- Generated top 20 Greyspots for each corridor and ranked them by severity.
- Submitted the Greyspot List to NHAI/GMR for their corrective actions.

Greyspots Hyderabad to Pullur (NH-44)

The below map shows the top 20 identified segments of the second study corridor of NH-44 from Hyderabad to Pullur, covering a length of 180km during the quarter 4 of 2023.

Greyspots Hyderabad to Adilabad (NH-44)

The below map shows the top 20 identified segments of the third study corridor of NH-44 from Hyderabad to Adilabad, covering a length of 300km during the quarter 4 of 2023.

Greyspots Hyderabad to Kodad (NH-44)

Greyspots are the most unsafe locations/segments beyond the known blackspots that require corrective measures to minimize the probability/possibility of road crashes, especially road fatalities. The below map shows the top 20 identified segments of the first study corridor of NH-65 from Hyderabad to Kodad, covering a length of 150km during the quarter 4 of 2023.

INFRASTRUCTURE SAFETY

4

4. Infrastructure Safety

The accomplishment of the tasks related to Infrastructure Safety vector was initiated with a reconnaissance visit to all the study corridors made by the CSIR - CRRI team along with INAI engineer consisting of **Dr. S. Velmurugan (Head & Chief Scientist, TES Division, CSIR – CRRI), Dr. Ch. Ravisekhar (Head & Chief Scientist, TPE Division, CSIR – CRRI), and Mr. Dev Singh Thakur (Research Engineer, INAI, IIIT Hyderabad)** during the period from 19th to 20th April, 2023 and from 21st to 22nd October 2023. During the above visits, the team held detailed discussions with the various concessionaires of National Highway Authority of India (NHAI) and representatives of Road Safety Committee of Telangana state (refer to Figure 4.1 and 4.2) namely, Mr. Shrikant (Project Manager, GMR), Mr. Nageswara Rao, Project Director, NH-44 to understand the broad characteristics of traffic, issues related to traffic management and enforcement faced on the project corridor in general and the identified blackspots in particular.

Figure 4.1: Meeting with Project Director (PD) of NH-44 by the iRASTE: TS team

Figure 4.2: Meeting with Concessionaires of NH-65 & NH-44 NHAI, Telangana by the iRASTE: TS team

The blackspots have been identified on the above three corridors based on the analysis of the First Information Report (FIRs) related to road crashes were obtained from the NHAI officials. The FIRs encompassing the road crash and fatality data from 01/01/2020 to 31/12/2022 were analyzed to deduce the blackspots conforming to IRC: 131 (2022). Accordingly, a total of 1407, 2776, and 1504 FIR records collected for three study corridors i.e., Hyderabad to Kodad (NH-65), Hyderabad to Pullur (NH-44) and Hyderabad to Adilabad (NH-44), respectively, were utilized in this analysis.

Further, based on the location details given in the FIR, it was geo-coded (by incorporating the latitude / longitude) to make it compatible for depiction on GIS platform. Based on the analysis of the FIR data, 19, 23 and 23 blackspots were identified on each of the above interurban corridors i.e., Hyderabad to Kodad (NH-65), Hyderabad to Pullur (NH-44) and Hyderabad to Adilabad (NH-44) respectively, conforming to IRC: 131 (2022). It may be noted that IRC has proposed an unique blackspot identification method i.e., Annual Average Total Crashes (AATC) method which is based on the concept of assessment of average crash values covering the road categories of the respective states / Union Territory (UT), by considering the various factors like traffic patterns, road geometry, land use and road users on road types like National Highways (NH), State Highways (SH), and Other Roads (OR). Subsequent to the above identification, blackspot rectification strategies in the form of feasible and cost-effective engineering treatment have been conceived for the top 5 identified blackspots in this study (refer to Figure 4.3).

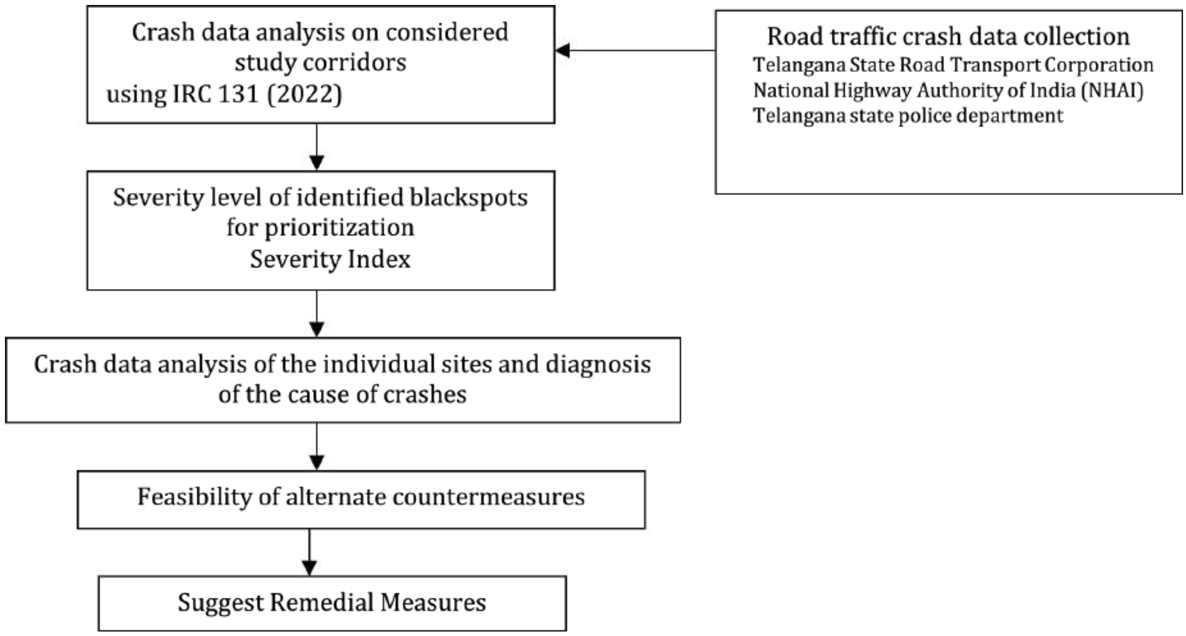


Figure 4.3: Methodology for the Blackspot Identification and Treatment

4.1 Crash Data Analysis

In this section, the collision profile of the three study corridors i.e., Hyderabad to Kodad (NH-65), Hyderabad to Pullur (NH-44) and Hyderabad to Adilabad (NH-44) are presented by providing a comprehensive analysis of various aspects related to road crashes. Understanding these factors is crucial for identifying the prevalent risks and challenges and thus developing targeted road safety interventions.

4.1.1 Hyderabad to Kodad Corridor (NH-65)

ROAD CRASHES

Road crash statistics of Hyderabad to Kodad (NH-65) reveal (refer to Figure 4.4) a concerning trend, with a significant number of road crashes during the reported period between 01/01/2020 to 31/12/2022.

- In 2020, the number of road crashes registered minor increase reaching 545 from the reported figure of 522 in the year 2019. However, the number of fatalities decreased to 76, while there were 200 grievous injuries and 661 minor injuries.
- The year 2021 saw a slight rise in crashes to 547, with 98 fatalities, 145 grievous injuries, and 627 minor injuries.
- In 2022, the number of crashes decreased slightly to 528, resulting in 85 fatalities, 166 grievous injuries and 578 minor injuries.

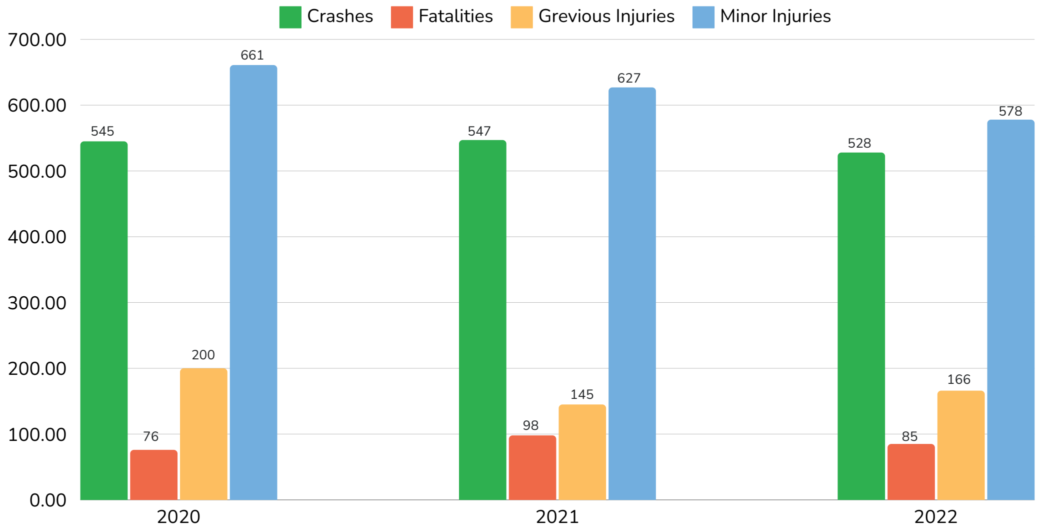


Figure 4.4: Overall Crash data characteristics for Hyderabad to Kodad Corridor

ROAD USERS

The dynamics of road users and their involvement in road crashes occurring on NH-65 exhibit a diverse range of vehicle types, including cars, trucks, motorcycles, buses and pedestrians. Understanding this mix is crucial for developing targeted interventions and safety measures to mitigate the risks associated with different vehicle types and other road users (like pedestrians and cyclists) on the study corridor.

Figure 4.5 compares the involvement of various vehicle types and road users in crashes along the Hyderabad to Kodad corridor over three years (2020, 2021, and 2022). It shows the number of crashes and the involvement of different vehicle types such as trucks, cars, buses, two-wheelers, and road users like pedestrians.

- In 2020, there were 545 crashes, with cars being the most commonly involved vehicles, followed by two-wheelers and trucks.

- In 2021, the total number of crashes increased slightly to 547, and here too, the share of cars involvement was the highest involvement, followed by two-wheelers and trucks.
- In 2022, the number of crashes decreased to 528, but despite that the share of cars involvement in road crashes remained virtually the same which is followed by two-wheelers and trucks.

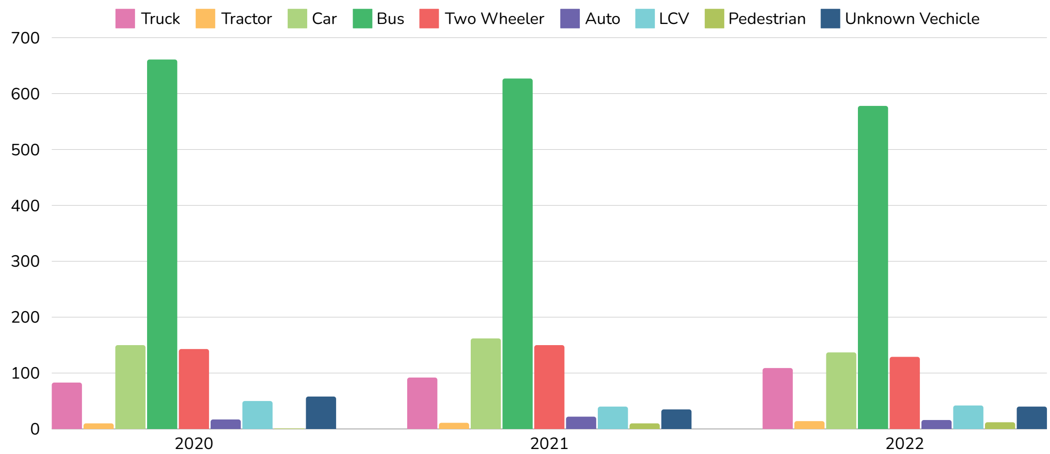


Figure 4.5: Comparison of Various vehicle Types involved in Road Crashes on NH-65

Overall, the data provides insights into the types of vehicles and road users frequently involved in crashes on the Hyderabad to Kodad corridor of NH-65 over three years.

COLLISION TYPE

Table 4.6 explains the categories of collision between vehicle to vehicle and/or road infrastructure. It shows the frequency of different collision types at NH-65 in 2020, 2021 and 2022. The collision types and their respective counts are as follows

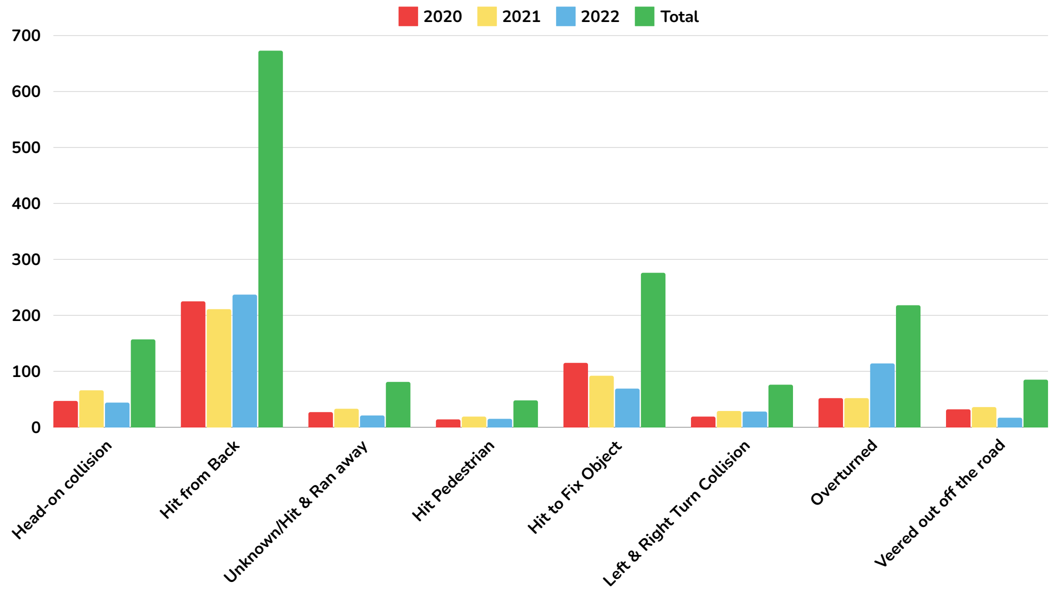


Figure 4.6: Head-on Collision Categories

Figure 4.7 visually represents the distribution of collision type occurred during the road crashes

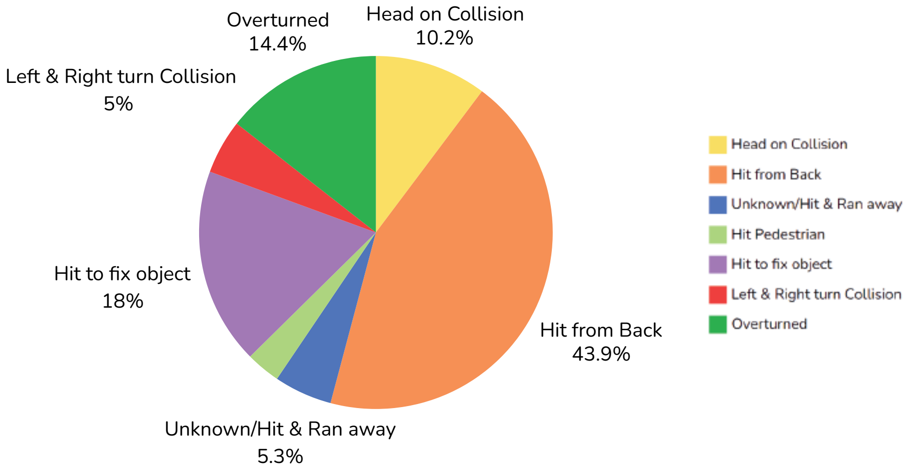


Figure 4.7: Collision Types on NH-65

4.1.2 CAUSATIVE FACTORS

Several factors contribute to casualties on NH-65, like speeding, reckless driving, road design deficiencies, and poor adherence to the traffic regulations. Addressing these factors is essential to reduce casualties and enhance overall road safety on the highway.

Figure 4.8 provides data on the causative factors contributing to road crashes on the study corridor in the years 2020, 2021, and 2022 with a summary of the causative factors:

- **Overspeeding:** In 2020, there were 301 road crashes caused by over speeding, which increased to 307 in 2021 and further increased to 341 in 2022, resulting in a total of 949 accidents.
- **Drunken Driver:** There were 53 road crashes caused by drunken driving in 2020, 60 in 2021, and 50 in 2022, totaling 163 road crashes.
- **Driven on wrong side/Fault of Driver:** In 2020, there were 62 road crashes caused due to driving on the wrong side or driver's fault, which decreased to 45 in 2021 and slightly increased to 48 in 2022and thus totaling 155 road crashes.
- **Drowsiness:** There were 62 accidents attributed to driver drowsiness in 2020, 46 in 2021, and 50 in 2022, making a total of 158 accidents.
- **Mechanical Problem/Vehicle out of Control:** In 2020, there were 93 accidents resulting from mechanical problems or vehicles going out of control. This number increased to 136 in 2021 and slightly decreased to 131 in 2022, resulting in a total of 360 accidents.

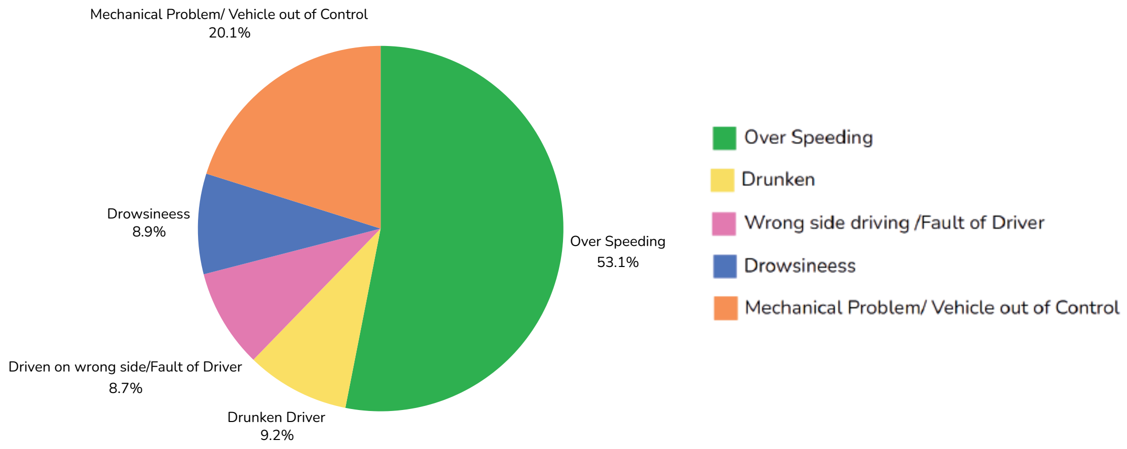


Figure 4.8: Crashes with the Causative Factor on NH-65

These figures provide insights into the major causative factors which contribute to the road crashes wherein speeding appears to be the dominant factor, followed by mechanical problems/vehicle control issues, and driver-related factors such as drunken driving, driving on the wrong side, and drowsiness.

ROAD CONDITION

Figure 4.8 presents data on the number of crashes categorized by road condition along the Hyderabad to Kodad corridor in the years 2020, 2021 and 2022, with a total count.

- **Straight Road:** In 2020, there were 433 crashes reported on straight roads, which increased slightly to 436 in 2021 and decreased to 426 in 2022. The total number of crashes on straight roads over the three-year period is 1295.
- **Sharp Curve/Hump/Dip:** There were 21 crashes reported on roads with sharp curves, humps, or dips in 2020, 20 in 2021, and 22 in 2022. The total count of crashes on such roads is 63.
- **Slight Curve:** In 2020, there were 76 crashes reported on roads with slight curves, which increased to 83 in 2021 and decreased to 70 in 2022. The total number of crashes on roads with slight curves over the three-year period is 229.

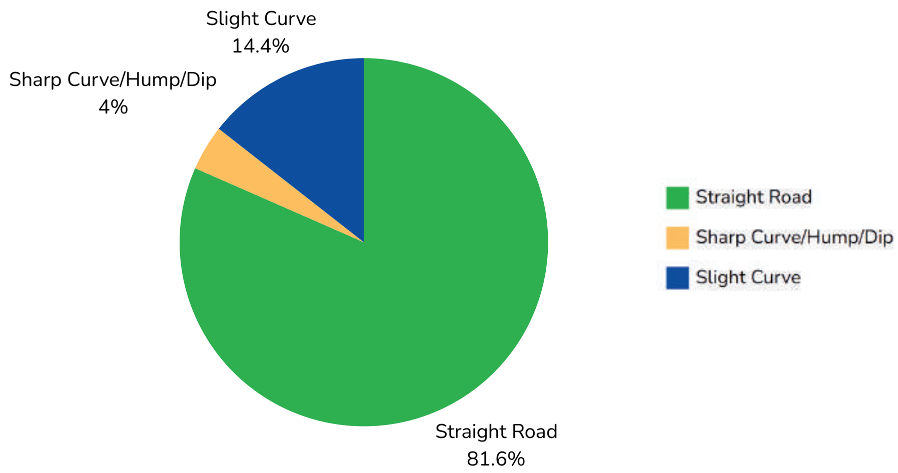


Figure 4.9: Typology of the Road related with Road Crashes on NH-65

These figures provide insights into the distribution of crashes based on different road typologies NH-65. Straight roads have the highest number of crashes, followed by roads with slight curves and those with sharp curves, humps, or dips.

4.1.3 Hyderabad to Pullur Corridor (NH-44)

In this section, the collision profile of the Hyderabad to Pullur corridor (NH-44) is discussed providing an overview of the various aspects related to road crashes. Understanding these factors is crucial for identifying the prevalent risks and challenges on NH-44 and developing targeted road safety interventions.

ROAD CRASHES

Road crash statistics on NH-44 reveal a concerning trend, with a significant number of road crashes occurring each year. Figure 4.10 presents crash data characteristics for the Hyderabad to Pullur corridor over a span of three years, from 2020 to 2022.

- In 2020, there were 896 crashes reported, resulting in 112 fatalities, 385 grievous injuries and 935 minor injuries.
- In 2021, the number of crashes increased to 1004, with 127 fatalities, 420 grievous injuries, and 1027 minor injuries.
- In 2022, the number of crashes decreased to 1059, resulting in 107 fatalities, 425 grievous injuries, and 1025 minor injuries.

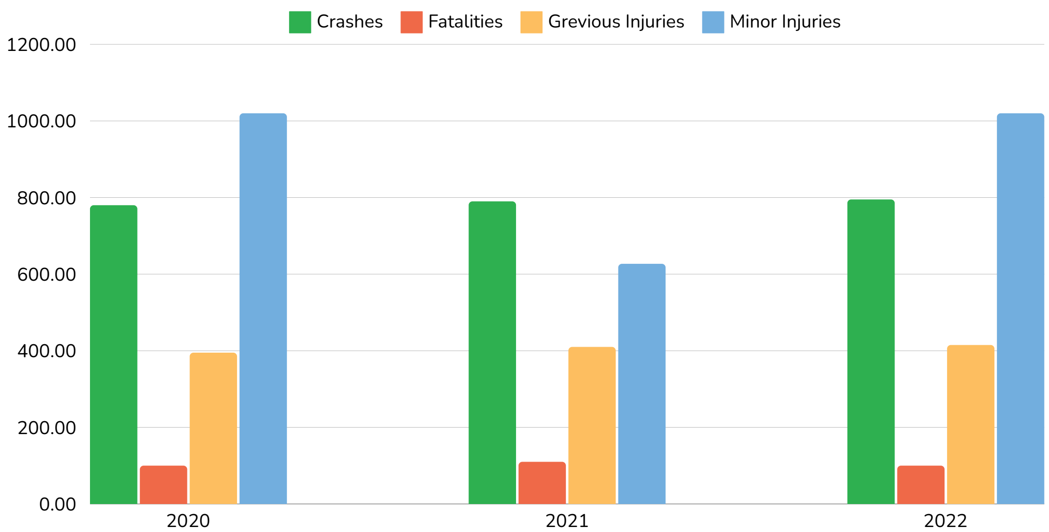


Figure 4.10: Overall Crash data characteristics of Hyderabad – Pullur Section of NH-44

ROAD USERS

The dynamics of road users and their involvement in road crashes occurring on NH-44 exhibited a diverse range of vehicle types, including cars, trucks, motorcycles, buses and pedestrians. Understanding this mix is crucial for developing targeted interventions and safety measures to mitigate the risks associated with different vehicle types and other road users (like pedestrians and cyclists) on the study corridor. Figure 4.11 compares the involvement of various vehicle types and road users in crashes along the Hyderabad to Pullur corridor over a three-year period (2020, 2021, and 2022). It shows the number of crashes and the involvement of different vehicle types such as trucks, cars, buses, two-wheelers, and road users like pedestrians.

- In 2020, there were 896 crashes, with cars being the most commonly involved vehicles, followed by two-wheelers and trucks.
- In 2021, the total number of crashes increased slightly to 1004, and cars had the highest involvement, followed by two-wheelers and trucks.
- In 2022, the number of crashes increased to 1059, and cars remained the most commonly involved, followed by two-wheelers and trucks.

COLLISION TYPE

Figure 4.11 explains the categories of collision between vehicle to vehicle and/or road infrastructure. It shows the frequency of different collision types on NH-44 in 2020, 2021 and 2022. The collision types and their respective counts are as follows:

- Head-on Collision: 88 in 2020, 68 in 2021, 47 in 2022 (Grand total: 203).
- Hit from Back: 188 in 2020, 206 in 2021, 153 in 2022 (Grand total: 547).
- Unknown/Hit & Ran Away: 10 in 2020, 0 in 2021, 9 in 2022 (Grand total: 19).
- Hit Pedestrian: 102 in 2020, 152 in 2021, 200 in 2022 (Grand total: 454).
- Hit to Fix Object: 70 in 2020, 95 in 2021, 147 in 2022 (Grand total: 312).
- Left & Right Turn Collision: 89 in 2020, 48 in 2021, 42 in 2022 (Grand total: 179).
- Overturned: 70 in 2020, 78 in 2021, 61 in 2022 (Grand total: 209).
- Veered out off the Road: 1 in 2020, 1 in 2021, 3 in 2022 (Grand total: 5).

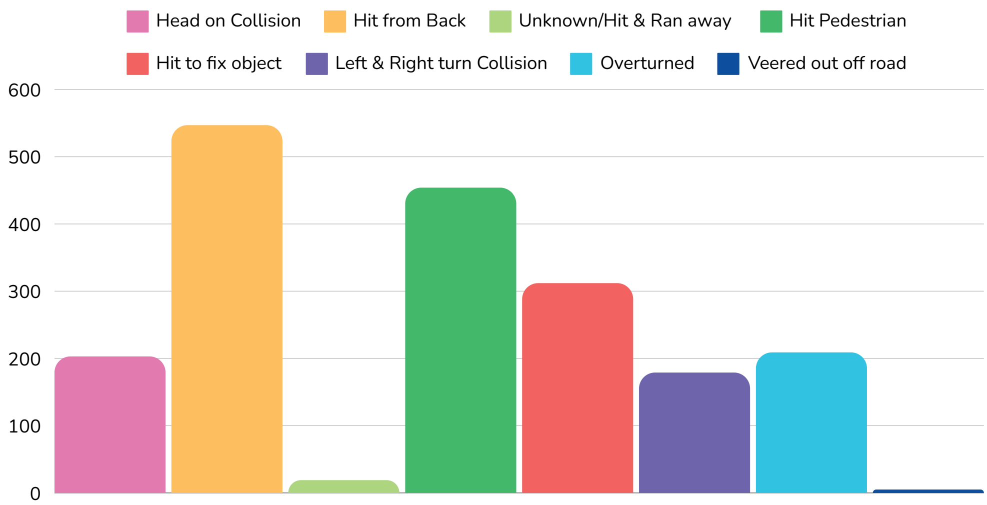


Figure 4.11: Profile of the Collision Types on Hyderabad – Pullur Section of NH-44

CAUSATIVE FACTORS

Several factors contribute to casualties on NH44, including speeding, reckless driving behaviors, inadequate infrastructure, road design deficiencies, and poor enforcement of traffic regulations. Addressing these factors is essential to reduce casualties and enhance overall road safety on the highway. Figure 4.12 provides data on the causative factors contributing to road crashes in the Hyderabad to Pullur corridor in the years 2020, 2021, and 2022, with the total count. Here's a summary of the causative factors:

- **Overspeeding:** In 2020, there were 229 road crashes caused by overspeeding, which increased to 269 in 2021 and further increased to 390 in 2022, resulting in a total of 888 road crashes.
- **Drunken Driver:** There were 103 road crashes caused by drunken driving in 2020, 61 in 2021, and 96 in 2022, resulting in a total of 260 crashes.
- **Driven on wrong side/Fault of Driver**: In 2020, there were 172 accidents caused by driving on the wrong side or driver's fault, which decreased to 147 in 2021 and slightly decreased to 130 in 2022, with a total of 449 accidents.
- **Drowsiness:** There were 51 accidents attributed to driver drowsiness in 2020, 33 in 2021, and 71 in 2022, making a total of 155 accidents.
- **Mechanical Problem/Vehicle out of Control**: In 2020, there were 339 accidents resulting from mechanical problems or vehicles going out of control. This number increased to 491 in 2021 and slightly decreased to 362 in 2022, resulting in a total of 1192 accidents.

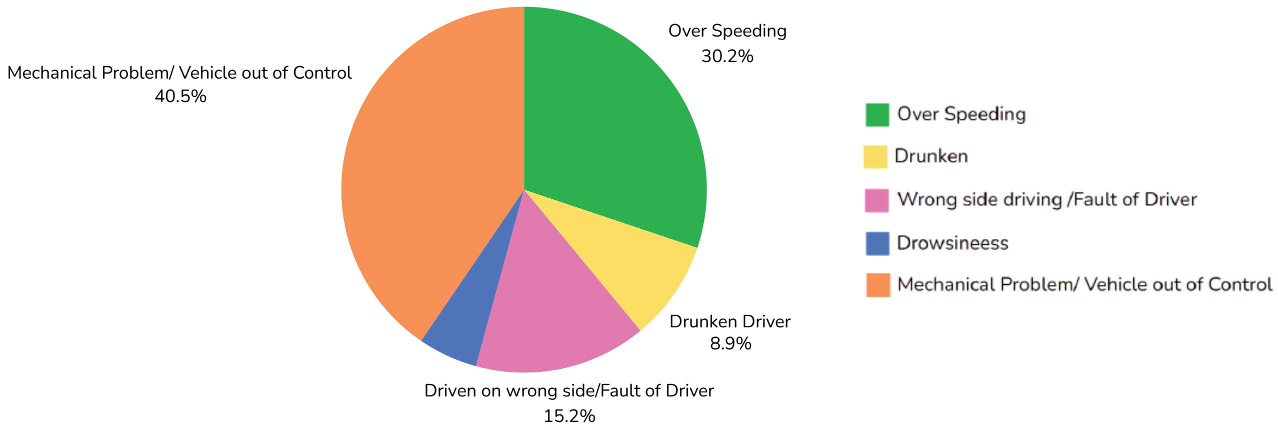


Figure 4.12: Crashes with the Causative Factors on Hyderabad- Pullur Section of NH-44

These figures provide insights into the major causative factors contributing to accidents along the Hyderabad to Pullur corridor over three years. Mechanical problems/vehicle control issues appear to be the most prevalent factor, followed by overspeeding, and driver-related factors such as drunken driving, driving on the wrong side, and drowsiness.

ROAD CONDITION

Figure 4.13 presents data on the number of crashes categorized by road condition along the Hyderabad to Pullur corridor in the years 2020, 2021 and 2022, with a total count.

- **Straight Road:** In 2020, there were 531 crashes reported on straight roads, which increased slightly to 567 in 2021 and increased to 607 in 2022. The total number of crashes on straight roads over the three-year period is 1705.
- **Sharp Curve/Hump/Dip:** There were 262 crashes reported on roads with sharp curves, humps, or dips in 2020, 315 in 2021, and 282 in 2022. The total count of crashes on such roads is 859.

- **Slight Curve:** In 2020, there were 103 crashes reported on roads with slight curves, which increased to 121 in 2021 and also increased to 170 in 2022. The total number of crashes on roads with slight curves over the three-year period is 394.

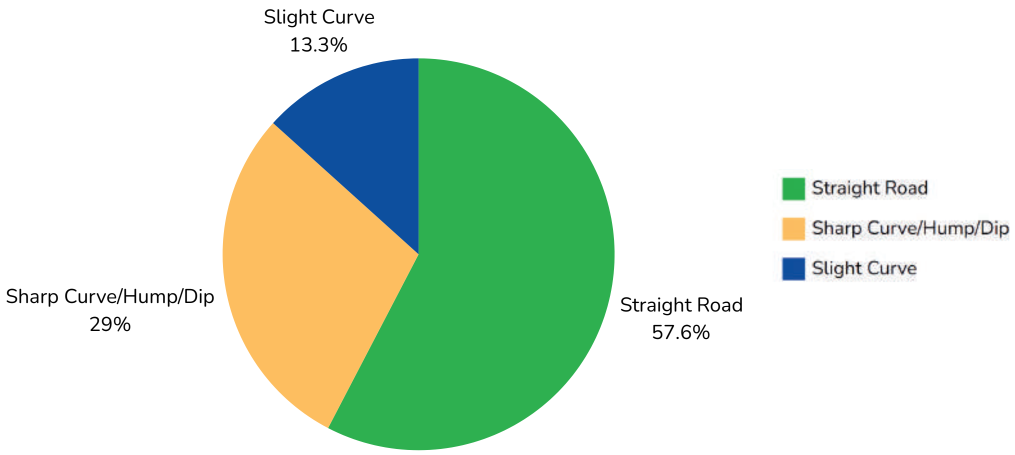


Figure 4.13: Crashes with the Road Condition on the Hyderabad – Pullur Section of NH-44

These figures provide insights into the distribution of crashes based on different road conditions along the Hyderabad to Pullur corridor. Straight roads account for the highest number of crashes, followed by roads with sharp curves, humps, or dips and those with slight curves which is in line with the national crash reporting trends on the high-speed corridors.

4.1.4 Hyderabad to Adilabad Corridor NH-44

In this section, the collision profile of the Hyderabad to Adilabad corridor NH-44 is discussed and it provides a comprehensive analysis of various aspects related to road crashes. Understanding these factors is crucial for identifying the prevalent risks and challenges on NH-44 and developing targeted road safety interventions.

ROAD CRASHES

Figure 4.14 presents crash data characteristics for the Hyderabad to Adilabad section of NH-44 over a span of three years, from 2020 to 2022.

- In 2020, there were 896 crashes reported, resulting in 112 fatalities, 385 grievous injuries and 935 minor injuries.
- In 2021, the number of crashes increased to 1004, with 127 fatalities, 420 grievous injuries, and 1027 minor injuries.
- In 2022, the number of crashes decreased to 1059, resulting in 107 fatalities, 425 grievous injuries, and 1025 minor injuries.

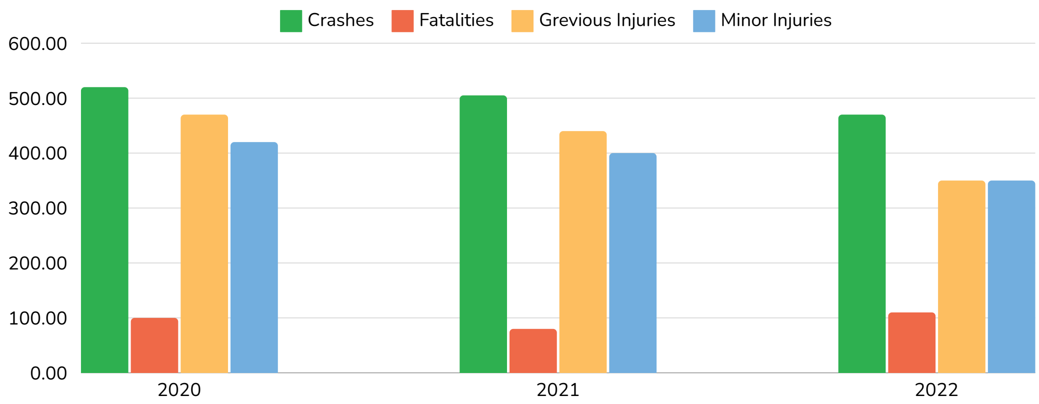


Figure 4.14: Overall Crash data characteristics for Hyderabad to Adilabad Section of NH-44

ROAD USERS

The dynamics of road users on NH-44 exhibit a diverse range of vehicle types, including cars, trucks, motorcycles, buses and pedestrians. Understanding this mix of vehicles is crucial for developing targeted interventions and safety measures to mitigate the risks associated with different vehicle interactions on the highway. Table 4.1 offers a comprehensive overview of crashes involving different vehicle and road user categories. The most common type, accounting for 114 incidents, involved cars and two-wheelers. The second, occurring 78 times, involved two-wheelers and trucks, followed by the third, totaling 51 incidents, involved cars and trucks. Concerns were highlighted for crashes involving unidentified vehicles hitting two-wheelers and pedestrians as well as with roadside objects. VRUs that included cycles, two-wheelers, auto-rickshaws and pedestrians, accounted for 35.4 % of crashes which were caused by goods vehicles accounting for 23.9 % of crashes and passenger vehicles accounting for 14.54%. These findings emphasize the pressing need for a system to mitigate such incidents, particularly addressing the needs of the VRUs.

Table 4.1: Comparison of Vehicles / Road Users Involved on the Hyderabad - Adilabad section of NH-44

VEHICLE / VEHICLE	CAR	BUS	TWO-WHEELER	CYCLE	AUTO RICKSHAW	PEDESTRIAN	TRUCK	TIPPER	LIGHT COMMERCIAL VEHICLE	TRACTOR	UNKNOWN VEHICLE	WITH OBJECT
CAR	1	2	114	7	5	7	51	23	4	4	19	0
BUS	2	-	15	2	1	2	10	2	2	2	2	3
TWO-WHEELER	114	15	28	5	12	11	78	29	13	11	80	110
CYCLE	7	2	4	-	4	1	6	5	1	2	10	4
AUTO RICKSHAW	8	1	12	4	-	1	8	6	0	0	6	9
PEDESTRIAN	7	2	11	1	1	-	8	0	1	0	45	1
TRUCK	51	10	78	6	8	8	14	16	10	13	9	89
TIPPER	20	2	29	5	6	0	16	-	1	1	4	20
TRACTOR	4	2	11	2	0	0	13	1	1	-	2	1
LIGHT COMMERCIAL VEHICLE	4	2	13	1	0	1	10	1	-	1	4	4
UNKNOWN VEHICLE	19	2	80	10	6	45	9	4	4	2	-	23
WITH OBJECT	0	3	110	4	9	1	89	20	4	1	23	-

COLLISION TYPES

The following table explains the categories of collision between vehicle to vehicle and/or road infrastructure. Figure 4.15 shows the frequency of different collision types along the Hyderabad to Pullur corridor in 2020, 2021, and 2022. It presents a comprehensive overview of various types of vehicle collisions from 2020 to 2022, highlighting significant trends and totals. Head-on collisions increased each year, from 19 in 2020 to 34 in 2022, totaling 76. Collisions where vehicles were hit from the back remained relatively stable, with a slight increase from 106 in 2020 to 113 in 2022, resulting in 323 total incidents. Pedestrian-related collisions were the highest, peaking at 184 in 2021, with a total of 529 over the three years.

Collisions involving vehicles hitting fixed objects were consistently low, summing to 35 incidents. Left turn collisions saw a notable peak in 2021 with 48 incidents, but decreased to 23 in 2022, totaling 110. Overturned vehicle incidents decreased from 132 in 2020 to 93 in 2022, amounting to 335. Right turn collisions were infrequent, with a total of 13. Hit and run incidents declined from 24 in 2020 to 17 in 2022, totaling 59. Lastly, incidents where vehicles veered off the road significantly dropped from 15 in 2020 to 3 in both 2021 and 2022, resulting in a total of 21. Overall, the data indicates that pedestrian collisions and overturned vehicles were the most frequent, while right turn collisions and hitting fixed objects were the least frequent. Trends show a mix of increases and decreases across different collision types over the three years.

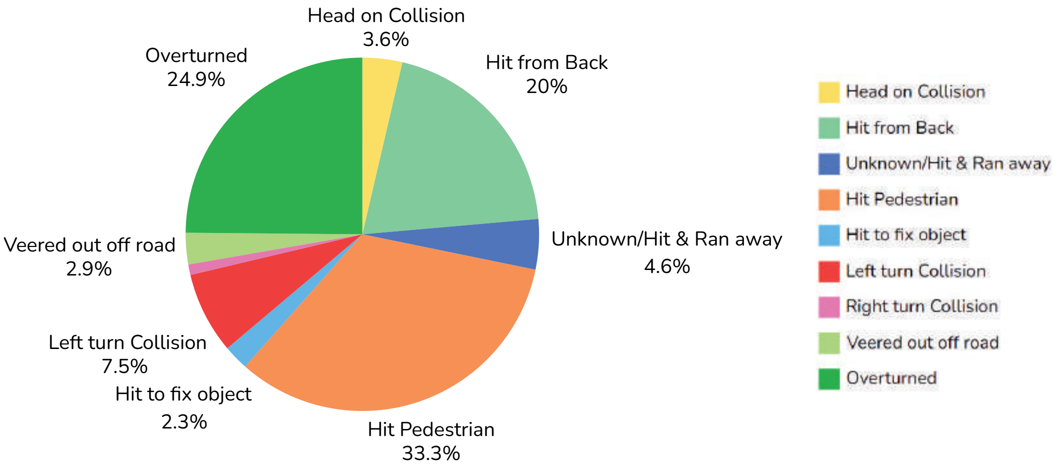


Figure 4.15: Collision Types on Hyderabad - Adilabad section of NH-44

CAUSATIVE FACTORS

Several factors contribute to casualties on NH-44, including speeding, reckless driving behaviors, inadequate infrastructure, road design deficiencies, and poor enforcement of traffic regulations. Addressing these factors is essential to reduce casualties and enhance overall road safety on the highway. Table 4.16 details the number of road accidents from 2020 to 2022 caused by various factors, along with their totals over the three years. Here's a breakdown of the data:

- **Drowsiness:** The number of accidents caused by drowsiness was very low, with 1 incident each in 2020 and 2021, and a sharp increase to 9 in 2022, totaling 11 incidents over the three years.
- **Drunken Driving:** Accidents due to drunken driving saw a significant decrease from 46 in 2020 to 21 in 2021, with a slight increase to 25 in 2022, resulting in a total of 92 incidents.
- **Overspeeding:** Overspeeding was the leading cause of accidents, peaking at 284 in 2021. It started with 269 incidents in 2020 and decreased to 213 in 2022, accumulating a total of 766 incidents over the period.
- **Mechanical Problems / Vehicle Out of Control:** Accidents due to mechanical problems or loss of vehicle control was considerable, with 103 incidents in 2020, decreasing to 85 in 2021, and then rising to 125 in 2022, totaling 313 incidents.
- **Wrong Side Driving / Fault of Driver:** Accidents caused by driving on the wrong side or driver faults remained relatively stable, with 111 incidents in 2020, increasing slightly to 116 in 2021, and then decreasing to 93 in 2022, resulting in a total of 320 incidents.

Overall, the figure highlights that overspeeding is the most frequent causative factor for accidents, while drowsiness is the least frequent. The data shows fluctuations in accident numbers across different causative factors over the three years, indicating areas where road safety measures may need to be intensified.

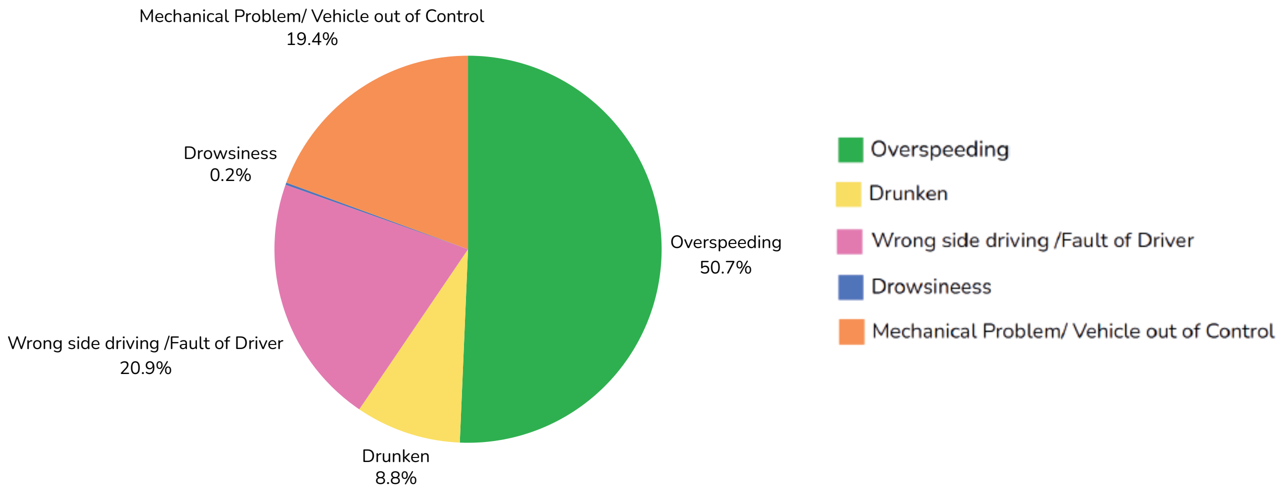


Figure 4.16: Crashes with the Causative Factors on Hyderabad - Adilabad section of NH-44

Accidents occurring on different road types are explained in the section below with a chart of statistics. Figure 4.17 provides data on the number of road crashes from 2020 to 2022 based on different road conditions, along with their totals over the three years. Here's a detailed breakdown:

- **Straight Road**: The majority of accidents occurred on straight roads, with 517 incidents in 2020, 484 in 2021, and 402 in 2022. This resulted in a total of 1,403 accidents over the three years. The trend shows a gradual decrease in the number of accidents each year.
- **Slight Curve:** Accidents on roads with a slight curve were considerably fewer compared to straight roads. There were 11 incidents in 2020, which increased to 22 in 2021 and further to 48 in 2022. The total number of accidents on slight curves is 81, indicating an upward trend over the years.
- **Sharp Curve / Dip / Hump:** The least number of accidents occurred on roads with sharp curves, dips, or humps. There were no incidents reported in 2020, only 1 in 2021, and an increase to 17 in 2022. The total number of accidents in this category is 18, showing a significant rise in 2022.

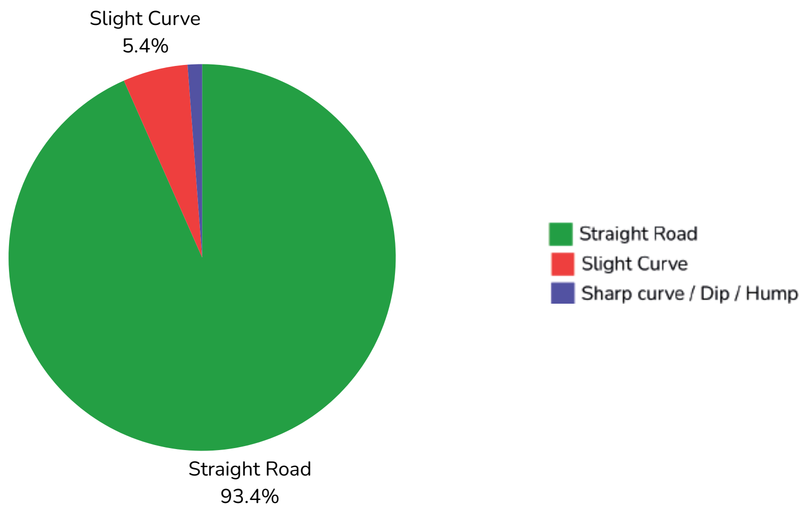


Figure 4.17:Crashes with the Road Condition on the Hyderabad - Adilabad section of NH-44

Overall, the figure indicates that most crashes happen on straight roads, although there has been a declining trend over the years. Conversely, road crashes on slight curves and sharp curves, dips, or humps show an increasing trend, with sharp curves, dips, and humps experiencing a notable rise in 2022. This data suggests the need for targeted road safety measures on curves and uneven road sections to prevent accidents.

4.2 Identification of Blackspots on Interurban Highway Corridors

After analyzing the characteristics of data, focus shifted to the identification of the blackspots by segmenting the corridor and employing Annual Average Total Crashes (AATC) method coupled with Setting Reaction Level (SRL) approach. The salient characteristics of this method and their findings are discussed in the succeeding sections.

4.2.1 Segmentation of the Test Corridor

For blackspot identification process, first, all the three study corridors were divided into multiple segments to assess crash severity on a segment basis wherein under AATC method, the study corridors are divided into 500-meter segments in accordance with IRC 131 (2022) and all the segments were considered for the analysis.

4.2.2 Creation of GIS Database

In QGIS, a GIS-based superimposed database was created by integrating the information on the various segments of the study corridor and the associated crash data. The goal is to evaluate segment severity using diverse blackspot identification methods.

4.2.3 Application of Annual Average Total Crashes (AATC) method with Setting Reaction Level (SRL) Approach

This methodology is based on the concept of assessment of average crash values covering the road categories of the respective states / Union Territory (UTs), by considering the various factors like traffic patterns, road geometry, land use and road users on road types like National Highways (NH), State Highways (SH), and Other Roads (OR). These factors contribute to the rational consideration of crash frequencies and fatality rates across varying road types. Transport Research Wing Report (2021) of MoRT&H highlights at pan India level NHs constituting only 2.1 % of the road network, contributing to 31.2 % of crashes, 36.4 % of fatalities, and 30.6 % of injuries whereas SHs constituting 2.8 % of the network account for 23.4 % of crashes, 24.7 % of fatalities and 24.1 % of injuries At the same time, Other Roads (which includes the MDR, ODR, VR and Urban Roads as well) comprising 95.1 % of the network accounts for the remaining share of crashes, fatalities and injuries.

As such, AATC method addressed these variations by proposing different AATC values based on the reported crash data in the respective state / UT and road category. In the defined process, a blackspot is characterized as a 500-meter road segment where the number of road crashes surpasses the AATC value over the past three calendar years. The procedure for computing AATC values involved collecting fatal crash data for the various types of road types (NH, SH, OR) from specific states, if road network traverses the candidate state. Additionally, the length of roads for each road category within the state is obtained, and the state-wise AATC value is calculated for each road category by dividing crash count by the number of years and road length, resulting in AATC/Km value. Further, the division of the AATC/Km value by 500 meters (m) yielded the AATC/500m value.

Eventually, blackspot identification hinges on state / UT specific AATC/500m values corresponding to road categories. These values are instrumental in assessing crash data against AATC/500m values within each road category in each state. Thereafter, Setting Reaction Level (SRL) approach is applied to classify blackspots into four distinct classes based on reaction values multiplied by AATC/500m values. These classes are defined as follows:

a. First-order: Crashes that exceed AATC/500m by 15 times.
b. Second order: Crashes occurring between 10 to 15 times AATC/500m.
c. Third order: Crashes happening between 5 to 10 times AATC/500m.
d. Fourth order: Crashes occurring between 3 to 5 times AATC/500m.

Further, IRC 131 (2022) provides ready reckoner / calculated AATC/500m values for all Indian states / UT road categories vide Annexure B of IRC 131 (2022) which serves as a reference / useful tool for blackspot identification. Consequently, this study adopted a segmented road network GIS database for further analysis. Accordingly, Telangana state specific AATC values given in the above annexure applicable for NH roads in the state (detailed in Table 4.2), helped to compare road crashes across segments and identify blackspots exhibiting varying severity levels.

Table 4.2: Standard AATC Values for Different Road Categories of Telangana State (Source: IRC 131: 2022)

Road category	NH	SH	OR
AATC/Km	1.82	1.5	0.56
3AATC/500m	2.73	2.25	0.83
5AATC/500m	4.55	3.76	1.39
10AATC/500m	9.1	7.51	2.78
15AATC/500m	13.65	11.27	4.16

Table 4.3 provides an analysis of the Average Annual Total Crashes (AATC) statistics for the three interurban corridors considered in this study namely, Hyderabad to Kodad (NH-65), Hyderabad to Pullur (NH-44) and Hyderabad to Adilabad (NH-44) and the corridor lengths are 150 Km, 180 Km, and 301 Km, respectively. Recorded road crashes are 1620 for Hyderabad to Kodad, 2959 for Hyderabad to Pullur, and 1504 for Hyderabad to Adilabad during the period from 1.1.2020 to 31.12.2022. Out of the three corridors, Hyderabad to Pullur corridor recorded the highest AATC per Kilometer at 14.72 indicating a higher crash frequency whereas AATC value of 9.10 was recorded for both Hyderabad – Kodad and Hyderabad – Adilabad corridors. The setting reaction level (SRL), a threshold for initiating safety measures, is 15 for Hyderabad to Pullur and 10 for the other two corridors.

Table 4.3: Average Annual Total Crashes (AATC) Statistics Reported on Interurban Corridors Around Hyderabad

Parameters	Hyderabad to Kodad	Hyderabad to Pullur	Hyderabad to Adilabad
Type of Road	National Highway (NH65)	National Highway (NH44)	National Highway (NH44)
Length of the Corridor	150	180	301
Total Number of Road Crashes	1620	2959	1504
AATC/Km	8.53	14.72	12.993
AATC/500m	4.26	7.36	6.496
Setting Reaction Level	10	15	10
AATC value (Study corridor)	9.1	13.64	9.1

Applying the above outlined method and AATC values, a comparative analysis was performed by comparing / matching the road crashes with various AATC/Km values for all corridors. Further isolating the segments exceeding these AATC values in terms of crash occurrences yielded a list of 'AATC Blackspots', which is categorized to be falling under first, second, third and fourth order and the same is discussed in the succeeding sections for each of the study corridors.

4.2.4 Blackspots: Hyderabad to Kodad

Table 4.4 lists the identified blackspots on the Hyderabad - Kodad, section of NH-65 as 19 blackspots (encompassing 3 Intersections and 16 Midblocks). with the relevant attributes whereas Figure 4.18 depicts the blackspots on the GIS Street Map of the study corridor.

Table 4.4: List of Blackspots Identified on Hyderabad to Kodad Section of NH-65 as per IRC: 131 (2022)

Road ID	Location Name	Concerned authority	Chainage	Road section type	Length (m)	Crashes	Deaths	Injuries	Latitude	Longitude
157	Near reliance petrol pump, Chityala	NHAI	80.6	MB	500	23	0	40	17.222631	79.143277
342	Kodad bypass, flyover ending	NHAI	174.56	MB	500	16	4	46	16.987566	79.954484
178	AP lingotam	NHAI	91.65	MB	500	13	3	14	17.194011	79.238354
174	Flyover ending, AP Lingotam	NHAI	89.6	MB	500	12	2	11	17.19926	79.219079
312	Munagala	NHAI	163.8	MB (Curve)	500	12	0	27	17.053054	79.83509
322	Mukunda Puram	NHAI	163.6	MB	500	11	1	22	17.022464	79.872431
306	Eklashkhanpet	NHAI	160.45	MB (Curve)	500	10	2	22	17.066726	79.808878
163	Gopalayalapalli	NHAI	83.95	IS	500	10	1	14	17.210903	79.170486
329	Akupamula turning	NHAI	167.25	MB (Curve)	500	10	4	22	17.008774	79.903706
334	Talwar Honda, Kodad bypass	NHAI	169.9	MB (Curve)	500	11	1	25	17.015915	79.926976
329	Akupamula turning	NHAI	167.25	MB (Curve)	500	10	4	22	17.008774	79.903706
337	Near SRM heaven's school	NHAI	171.6	IS	500	10	1	19	17.005726	79.937612
191	Muthyalamma Gudem	NHAI	98.8	MB	500	10	1	10	17.164546	79.294824
126	Gundrampally	NHAI	64.2	MB	500	10	0	13	17.2306	78.991801
139	Pittampally	NHAI	71.1	MB	500	9	2	14	17.23083	79.056271
144	Peddakaparthy	NHAI	73.8	MB	500	7	2	11	17.229839	79.081156
119	Near Panthangi toll plaza	NHAI	60.5	MB	500	4	5	4	17.233254	78.959204
279	Undrugonda	NHAI	146	MB	500	7	3	13	17.112404	79.688433
170	Narketpalle Junction	NHAI	87.4	IS	500	9	3	9	17.195985	79.198186

Figure 4.18: Illustration of Blackspots on Hyderabad - Kodad Section of NH-65 on the GIS Platform.

4.2.5 Blackspots: Hyderabad to Pullur

Similarly, Table 4.5 lists the identified list of 23 blackspots (encompassing 4 Intersections and 19 Midblocks) on the Hyderabad to Pullur section of NH-44. Figure 4.19 depicts the blackspots on the GIS Street Map of the study corridor.

Table 4.5: List of Blackspots Identified on Hyderabad to Pullur Section of NH-44 as per IRC: 131 (2022)

Road ID	Location name	Road section type	Length (m)	Crashes	Deaths	Injuries	AATC	Latitude	Longitude
315	Saraswati temple, Beechupalli	MB	500	41	8	45	22.52	16.15992	77.93145
118	Raikal 1	MB	500	34	1	56	18.68	17.00186	78.19377
319	Near kanaka Durga temple, Beechupalli	MB	500	25	1	34	13.73	16.1509	77.91363
381	Pullur road 1	MB	500	23	3	27	12.63	15.90454	78.01822
384	Bit break, Pullur	MB	500	23	0	28	12.63	15.88959	78.01712
113	Solipur village	IS	500	22	4	36	12.08	17.02687	78.19832
201	Tadikonda	IS	500	22	4	48	12.08	16.65286	78.00623
115	HP petrol pump, Chilkamari	MB	500	21	2	43	11.53	17.01661	78.19643
301	Maddilety Dhaba, Pebbair	MB	500	21	0	25	11.53	16.19524	77.98335
357	Raimakulakunta	MB	500	21	2	26	11.53	15.99502	77.96089
383	Pullur road 2	MB	500	21	0	29	11.53	15.89458	78.01745
117	Near shadnagar toll plaza bus stop	MB	500	20	0	26	10.98	17.00677	78.19467
216	Sakalamaddi	MB	500	20	4	73	10.98	16.5894	77.96877
310	Rangapur, Beechupalli	MB	500	20	2	26	10.98	16.16805	77.9547
328	Putandoddi	IS	500	20	0	27	10.98	16.11744	77.88644
336	Srishanth hotel	MB	500	20	0	27	10.98	16.08045	77.90069
120	Raikal 2	MB	500	19	2	28	10.43	16.99207	78.19181
314	Beechupalli bridge	MB	500	17	1	30	9.34	16.16243	77.93577
264	Kothakota	MB	500	14	2	108	7.692	16.36506	77.93999
360	Sri Venkateshwara hotel	IS	500	17	1	29	9.34	15.98814	77.97069
200	Annasagar	MB	500	15	2	70	8.241	16.65709	78.0096
346	Near Vallur intersection	MB	500	17	1	22	9.34	16.03616	77.92381
348	Chandapur	MB	500	12	1	33	6.59	16.02733	77.92848

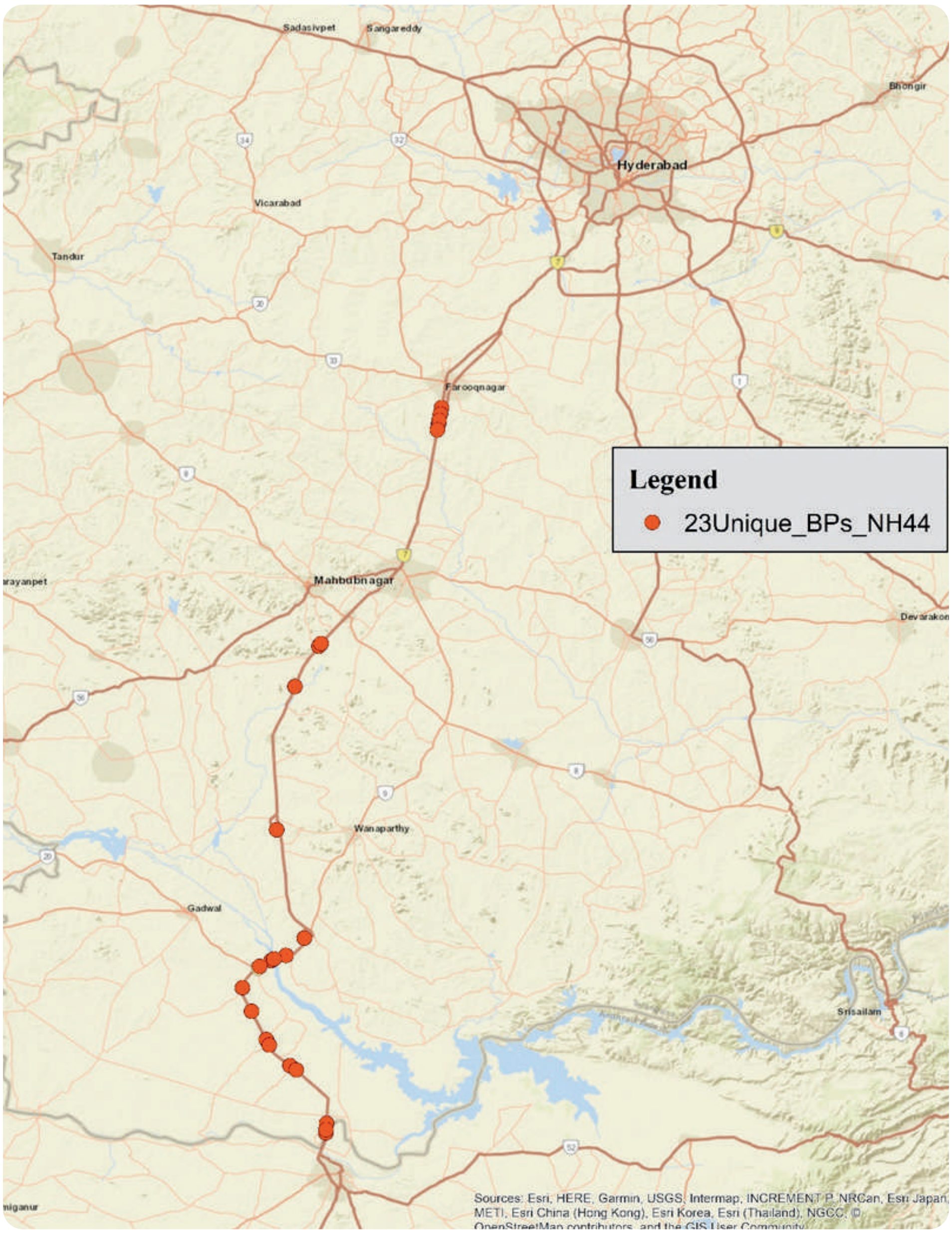


Figure 4.19: Illustration of Blackspots on Hyderabad - Pullur Section of NH-44 on the GIS Platform.

4.2.6 Blackspots: Hyderabad to Adilabad

Table 4.6 lists the identified blackspots on the Hyderabad - Adilabad section of NH-44 wherein 22 blackspots (encompassing 10 Intersections and 12 Midblocks) with the relevant attributes whereas Figure 4.20 depicts the blackspots on the GIS Street Map of the study corridor.

Table 4.6: List of Blackspots Identified on Hyderabad - Adilabad Section of NH-44 as per IRC: 131 (2022)

S. No.	Location name	Area	Chainage	Road section type	Latitude	Longitude	Crashes	Fatalities	Injuries	AATC values
1	Sadashivnagar Intersection (Padmaji wadi X road check post)	Sadashivnagar	364.5	Intersection	18.4313	78.2417	7	3	8	0.7692
2	Daggi to Vijjepalle	Daggi	357.5	Midblock	18.480847	78.218902	9	2	9	0.989
3	Chandrayanpally forest curve	Chandrayanpally	355.8	Midblock	18.497834	78.215897	9		14	0.989
4	Devitanda median opening	Devitanda	353.5	Midblock	18.513156	78.2281023	12	2	11	1.3186
5	HP petrol pump, Devitanda	Devitanda	352 - 352.5	Midblock	18.51934	78.233277	11	1	12	1.2087
6	Gannaram 1	Gannaram	351.5	Intersection	18.52555	78.2331784	10	1	13	1.0989
7	Gannaram 2	Gannaram	351	Intersection	18.533701	78.237427	11	1	14	1.2087
8	Anjaneya swami MPTS, Indalwai	Indalwai junction area (349.5 to 351)	350.8	Intersection	18.539999	78.240325	20	1	29	2.1978
9	Indalwai flyover starting		349.5	Midblock	18.541003	78.240807	10		12	1.098
10	MRO office Indalwai (only NH area)		349	Midblock	18.548244	78.243128	21	1	26	2.3076
11	Indalwai 2	Indalwai	348.2	Midblock	18.55027659	78.24320431	11	2	15	1.2087
12	Thirmanpally median opening	Thirmanpally	346	Midblock	18.570397	78.233976	11	3	11	1.2087
13	Anmol Dhaba area, Thirmanpally	Thirmanpally	345.5	Midblock	18.573587	78.23169	12		13	1.3186
14	Near HP petrol pump area	Thirmanpally	344.5	Intersection	18.582617	78.226072	14	2	13	1.538
15	Amruthapur T point / Nadepalle T point / Sudapally T junction	Sudapally	338.9	Intersection	18.627663	78.2058914	9	4	10	0.989
16	Mentrajpalle	Mentrajpalle	334.5 to 335.5	Intersection	18.6552992	78.2179186	12		13	1.318
17				Intersection	18.6572297	78.2192453	10	1	13	1.098
18	Bandham Raigarh Junction		251.2	Intersection	19.2380539	78.4052711	10		11	1.098
19	Neradigonda curve		242 - 242.5	Midblock	19.2897782	78.4044969	8	3	8	0.879
20	Kupti village	Kupti	235	Midblock	19.3515385	78.4324045	8	3	8	0.879
21	Gudihathnur	Gudihathnur	213.55	Midblock	19.5270089	78.5124077	11	1	9	1.208
22	Seetagondi	Seetagondi	207.45	Intersection	19.576028	78.4947511	16	1	17	1.758
23	Devapur forest area plus Pangadpipri curve area	Pangadpipri curve region	203.4 to 205.4	Midblock	19.5960747	78.4887706	11		13	1.208
24	Pangadpipri curve stretch			Midblock (Curve)	19.6126168	78.4928638	14	2	16	1.538

Figure 4.20: Illustration of Blackspots on Hyderabad - Adilabad Section of NH-44 on the GIS Platform.

4.3 Assessment of Speed Profile at the Selected Blackspots

It was felt pertinent to understand the speed profile at some of the selected blackspots in Midblock locations. Accordingly, spot speed studies were carried out at seven locations (refer to Table 4.7) which consisted of six midblock locations as well as in the vicinity of one major intersection (about 200 m away from the intersection). These studies were conducted using Laser Speed Guns covering both directions of travel. Direction wise sample data of spot speeds of different vehicles were collected to arrive at the various speed characteristics namely, minimum speed, maximum speed, mean speed, and different percentile speeds such as 15th, 50th, 85th and 95th in order to evolve appropriate speed control and safety measures. Table 4.8 presents the profile of the observed speed profile at the above-mentioned locations:

Table 4.7: Geo-position information of the Selected Locations for the Conduct of Speed Surveys

S. No.	Blackspot name	Latitude	Longitude	Road Section Type	Spot speed
1	Eklashkhanpet	21.1487	79.12154	Intersection	
2	AP Lingotam of NH-65	21.18391	79.11693	Intersection	
3	Hyderabad to Vijayawada	21.14944	79.16056	Midblock	
4	Vijayawada to Hyderabad	21.15139	79.14889	Midblock	
5	Kodad Bypass: NH:65	21.11083	79.07011	Midblock	
6	Kupti	20.98047	79.02711	Midblock	
7	Markal	21.10365	78.99068	Midblock	

Table 4.8: An Illustration of the Reported Pattern of Crashes in Selected Blackspots of NH-65 and NH-44

S. No.	Name of the Black Spot & Corridor Details	Latitude	Longitude	Crashes (2022-22)	Fatalities	Major Injuries	Minor Injuries	No Injuries
1	Eklashkhanpet, NH-65	17.06669	79.80905	10	2	2	11	0
2	AP Lingotam, NH-65	17.19452	79.23703	13	3	3	10	1
3	Vijayawada, NH-65	17.22997	79.08264	6	2	1	5	0
4	Kodad Bypass, Flyover Ending, NH65	16.98691	79.9558	16	4	5	19	22
5	Kupti, Hyderabad-Adilabad, NH-44	19.35154	78.4324	8	3	5	3	0
6	Markal, Hyderabad - Pullur NH-44	18.39257	78.28605	3	1	2	1	0

4.4 Geometric Design Plans (GDPs) for the Top 5 Blackspots on each Study Corridor

At the above-identified blackspots, the base / existing plans for the top 5 black pots for each of the interurban corridors namely, Hyderabad - Kodad (NH-65), Hyderabad - Pullur (NH-44) and Hyderabad - Adilabad (NH-44) has been conceived by the iRASTE-Telangana team in the absence of readily available physical survey drawings. Accordingly, for all the identified black spots, the base plans have been generated using the Google Earth tools covering up to a maximum of 500 meters (m) on either side of blackspot in the case of midblock whereas in the case of intersections up to 250 m on each of the approach arms of the intersections. These base plans were further updated during the audit field visits. The above prepared top 5 base plans of each study corridors were used by CSIR - CRRI study team for preparing the Detailed Geometric Design Plans (GDP) in the form of Detailed Project Report (DPR) and submitted to National Highways Authority of India, (NHAI) with a copy to the Concessionaire. It is borne in mind that in the absence of Total Station Survey data, the prepared DGP will be largely provisional as the accuracy level will be + or - 5 m only. While preparing the GDP for the top 5 blackspots in each of the above study corridors, the recorded data on speed profile (refer to Table 4.9) was taken on board so that appropriate speed restraining measures can be conceived as part of the DGP for the relevant midblock / intersection as the case may be.

4.4.1 Corridor 1: HYDERABAD TO KODAD (NH-65)

Hyderabad - Kodad section of NH 65 is a crucial stretch that connects major industrial centers in Telangana as well as serves as the arterial road connecting the capital city of Hyderabad of Telangana and Vijayawada including Amaravati, the upcoming capital of Andhra Pradesh. NH-65 falling under the Telangana region is approximately 150 Km long and has been upgraded to six lane divided highway with paved shoulders enhancing connectivity and economic activity in the region. It can be noted that the observed mean speeds of cars are well more than Speed Limit 80 Kmph at some of the black spots like Eklanshkhanpet (reporting 105 Kmph), Flyover under LAP Lingotam (reporting 105 Kmph) and Kodad Bypass (reporting 100 Kmph). Due to such over speeding, geometric design measures coupled with soft traffic calming measures in the form of 3 sets of Transverse Bar Marking (TBMs) measuring between 10 mm to 15 mm are proposed at appropriate locations in the top five blackspots identified on NH-65.

Table 4.9: Profile of the Spot Speeds at Selected Blackspots on NH-65, NH-44

S. No.	Name of the Location and Highway	Vehicle Type	Min Speed	Max Speed	Mean Speed	15 %ile Speed	50 %ile Speed	85 %ile Speed	95 %ile Speed
1	Eklashkhanpet, NH-65	Car	56	126	89.4	73	89	105	111
		2W	24	98	51.7	38	51	65	77
		HCV	31	73	48.9	41	49	56	60
		LCV	32	97	62.4	52	63	75	78
		Bus	35	87	61.5	49	60	75	83
2	Near AP Lingotam, NH-65	Car	64	132	93	81	93	105	111
		2W	29	103	51.9	37	48	71	83
		HCV	22	68	38.6	30	37	48	54
		LCV	29	74	53.4	43	53	68	74
		Bus	45	83	61.7	54	60	72	80
3	Hyderabad to Vijayawada, NH-65	Car	73	147	102.6	88	102	114	127
		2W	22	103	62.2	45	62	79	89
		LCV	21	86	67	58	67	78	83
		HCV	40	79	61	54	61	68	74
		Bus	55	89	73.9	65	75	82	85
4	Vijayawada to Hyderabad, NH-65	Car	34	114	76.3	64	76	88	99
		2W	23	98	51.9	38	50	68	77
		HCV	21	68	43.1	35	43	53	59
		Bus	20	81	54.6	47	55	65	71
5	Kodad Bypass, NH-65	Car	36	132	81.1	64	82	100	108
		2W	23	93	49.9	38	47	65	79
		LCV	22	80	50.1	38	47	64	71
		HCV	24	74	42.4	34	41	50	59
		Bus	32	75	49.3	34.25	48	63	71
6	Kupti, Hyderabad - Adilabad Section of NH-44	Car	37	114	68.8	55	69	83	91
		2W	29	77	49.3	39.6	50	58	63
		LCV	44	74	58.2	51.25	57	68	70
		HCV	24	77	58.7	47.2	59	71	74
		MAV	37	78	61.7	52.6	64	70	75
		Bus	30	72	60.4	54	64	68	71
7	Markal, Hyderabad - Pullur, NH-44	Car	52	130	79.5	67	79	92	100
		2W	30	92	50.9	36.7	46	68	80
		LCV	38	81	61.5	51	63	77	79
		HCV	40	77	60.9	55.5	61	67	71
		MAV	48	76	63.3	58.9	63	69	73
		Bus	56	81	69	60	69	76	79

A. EKLANSHKHANPET

Figure 4.21 showcases the existing conditions on the Eklashkhanpet section. It highlights the current road alignment, surrounding land use and infrastructure.

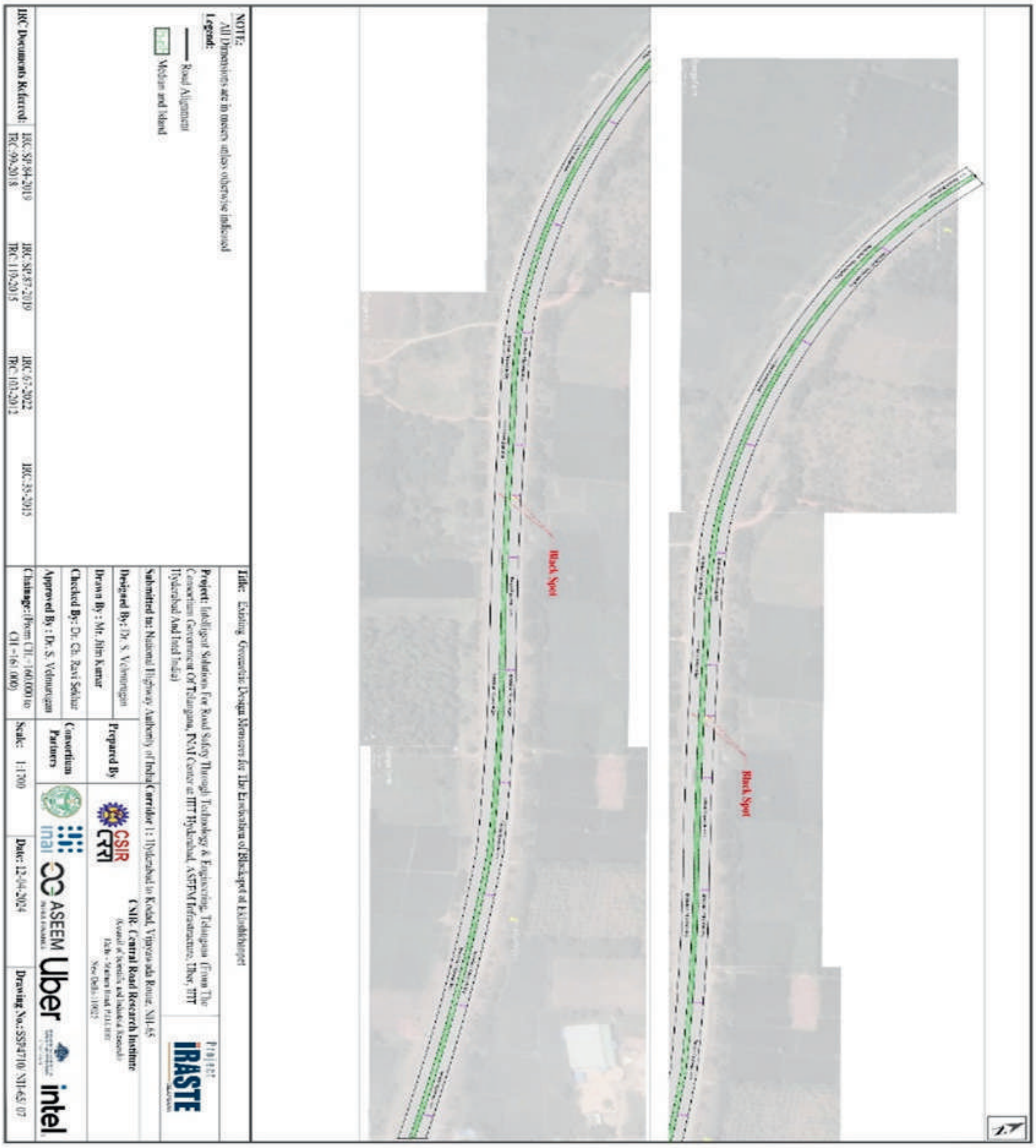


Figure 4.21: Existing Physical Survey Plan of Eklashkhanpet Section of NH-65

Figure 4.22 presents the proposed enhancements to improve safety and traffic management in the vicinity of Eklashkhanpet section of NH-65 (falling between Ch 160.800 to 161.000). This included the proposed geometric design improvements including the erection of 3 sets of TBMs, road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility.

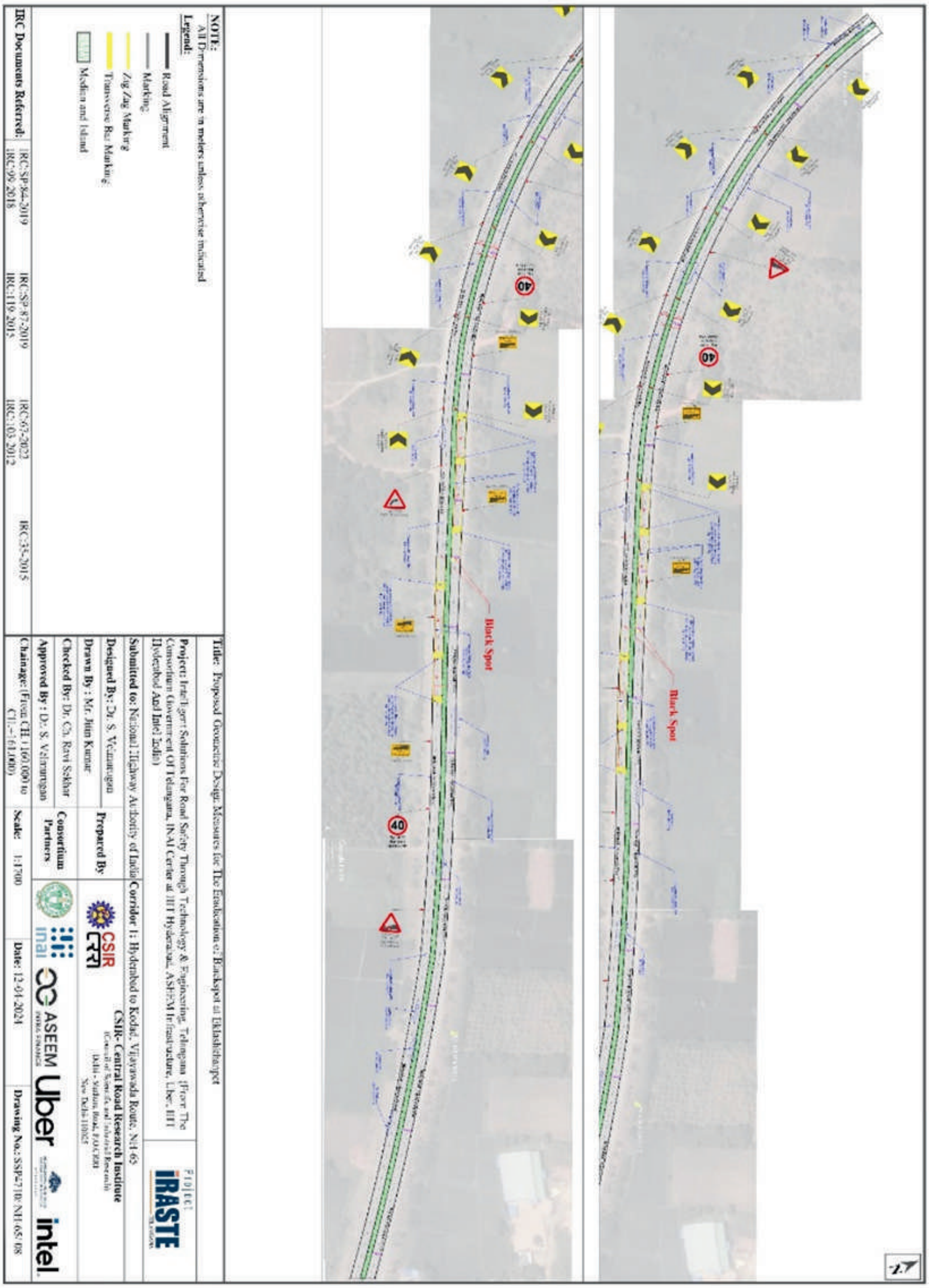


Figure 4.22: Detailed Geometric Design Plan (GDP) for the Eklashkhanpet Section of NH-65

B. FLYOVER ENDING AT AP LINGOTAM

Figure 4.23 indicates the existing plan of Flyover ending at AP Lingotam after Wings Restaurant spanning 24.5 m wide and merging into the main highway section of NH-65 in the vicinity of Narketpalle Power Substation. Figure 4.24 presents the proposed enhancements to improve safety and traffic management in the vicinity of AP Lingotam section of NH-65 (falling between Ch 90.800 to 92.300). This included the construction of a 48.5 m stretch with the proposed geometric design improvements including the erection of 3 sets of TBMs, road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility.

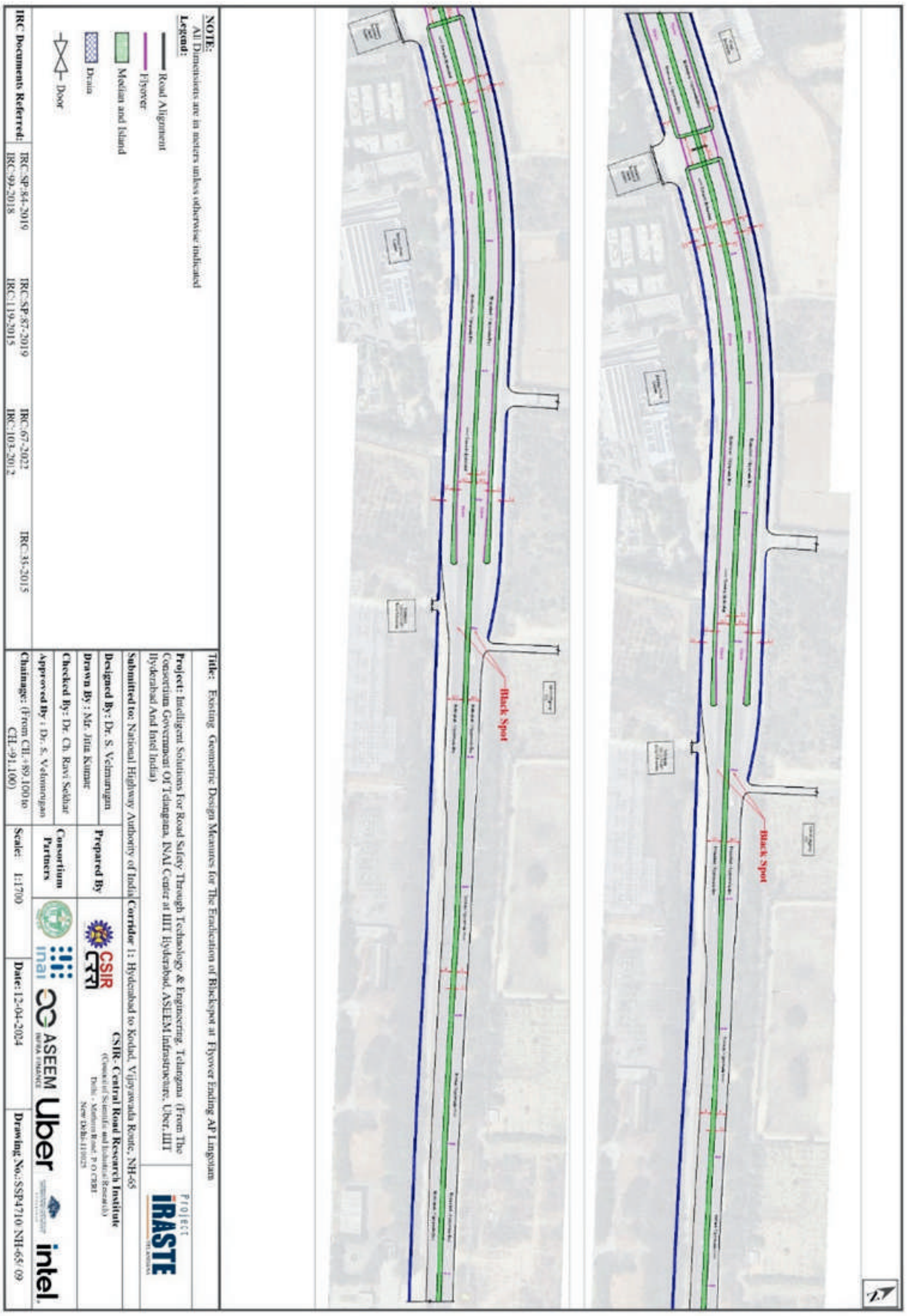


Figure 4.23: Existing Physical Survey Plan of AP LINGOTAM on NH-65

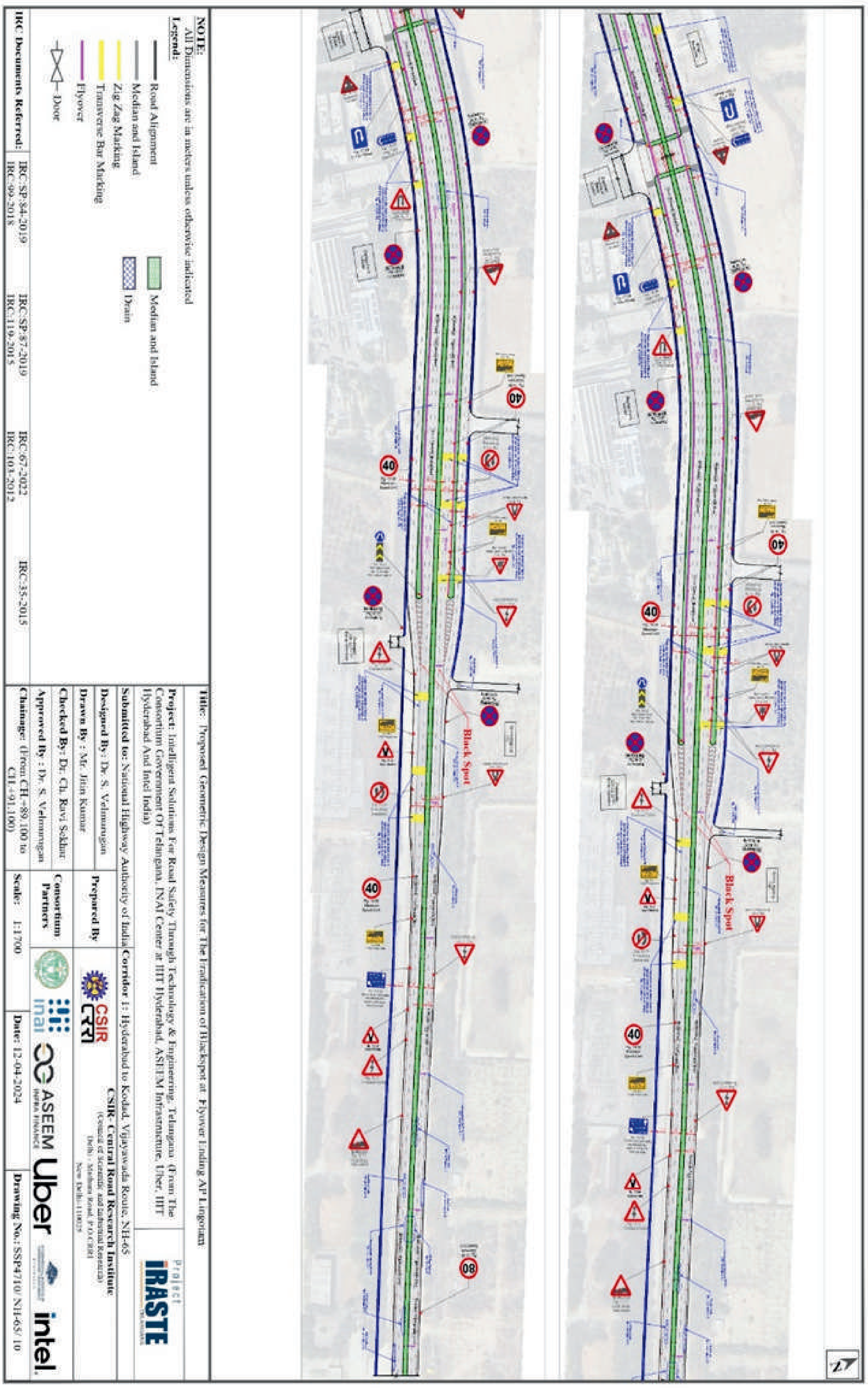


Figure 4.24: Detailed GDP of AP LINGOTAM (FLYOVER ENDING) at NH-65

C. KODAD BYPASS FLYOVER ENDING

Figure 4.25 shows the existing plan of Kodad Bypass Flyover near Aruna Multi specialty Hospital and the road section ends near Dhanalakshmi Family Dhaba Restaurant. Figure 4.26 presents the proposed enhancements to improve safety and traffic management in the vicinity of Kodad Bypass (falling between Ch 174.100 to 175.000). This included the proposed geometric design improvements including the erection of 3 sets of TBMs, road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility.

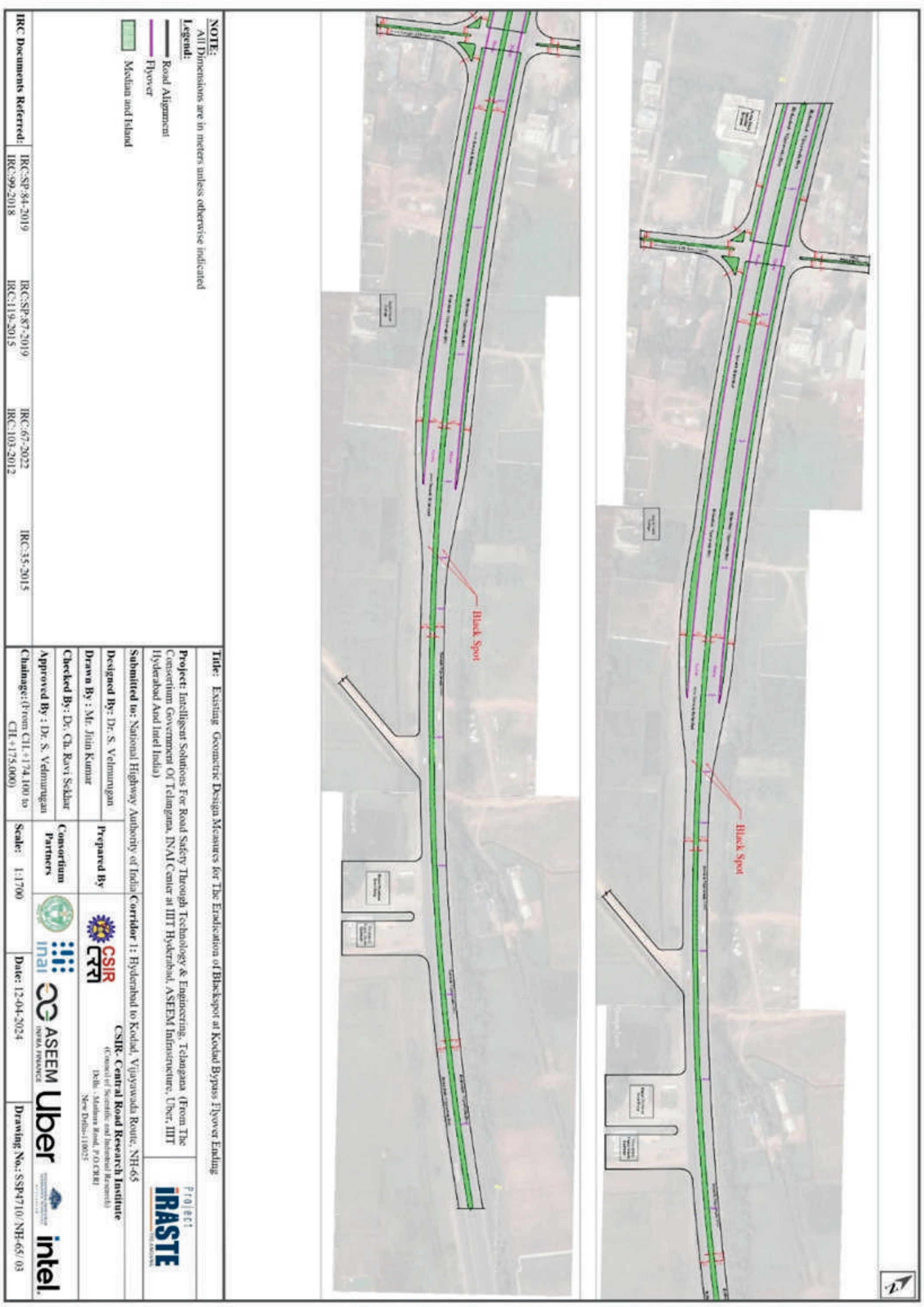


Figure 4.25: Existing Physical Survey Plan of Ending at Kodad Bypass Flyover on NH-65

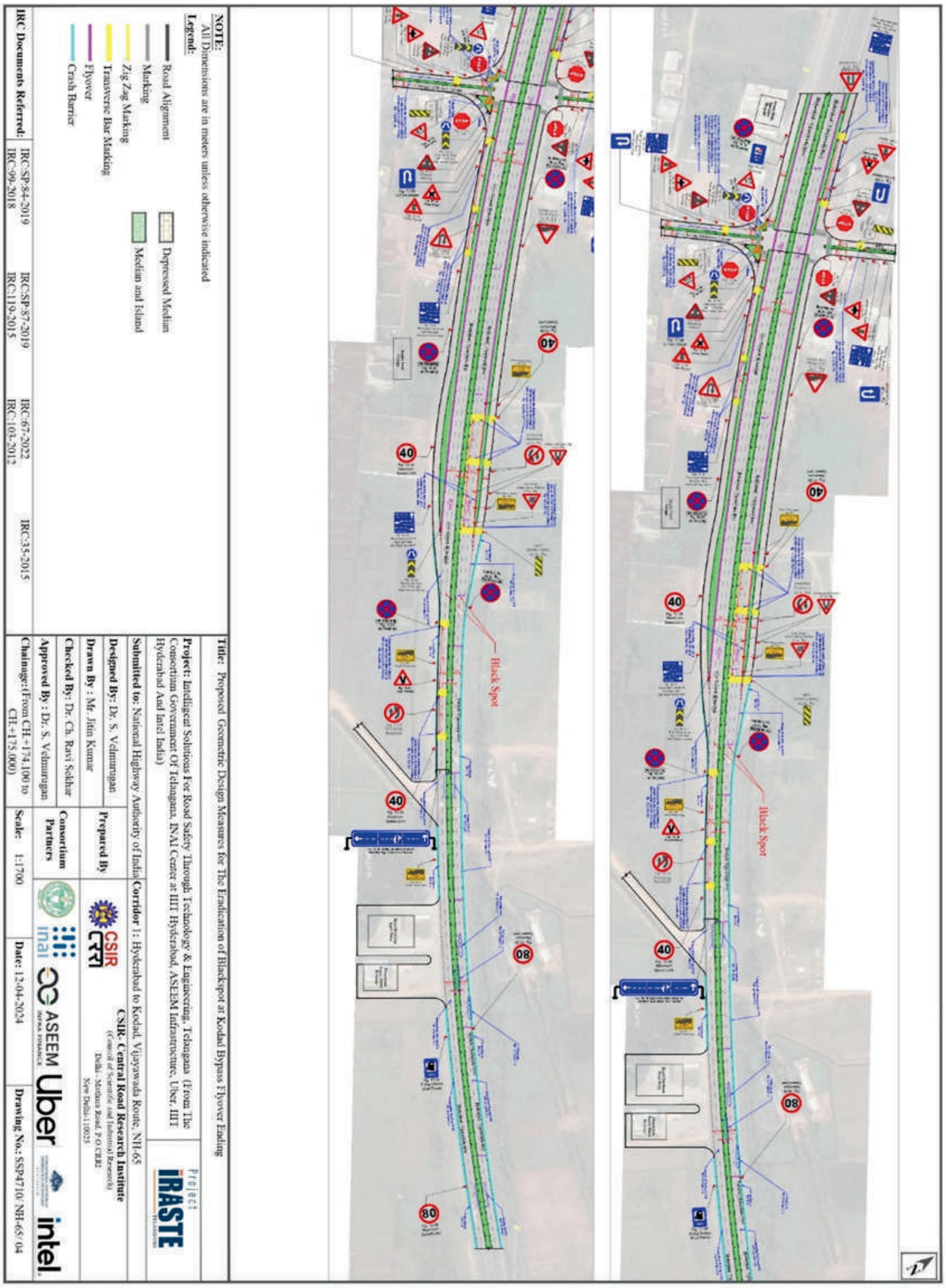


Figure 4.26: Detailed GDP of Kodad Bypass (FLYOVER ENDING) on NH-65

D. NEAR RELIANCE PETROL PUMP CHITYALA

Figure 4.27 shows the existing plan of Near Reliance Petrol Pump Chityala which is starting at the T intersection near Indian Oil Fuel Station and ends near Doon Khalsa Dhaba. Figure 4.28 presents the proposed enhancements to improve safety and traffic management in the vicinity of Reliance Petrol Pump, Chityala (spanning between Ch 79.400 to 81.000). This included the proposed geometric design improvements including the erection of 3 sets of TBMs, road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility.

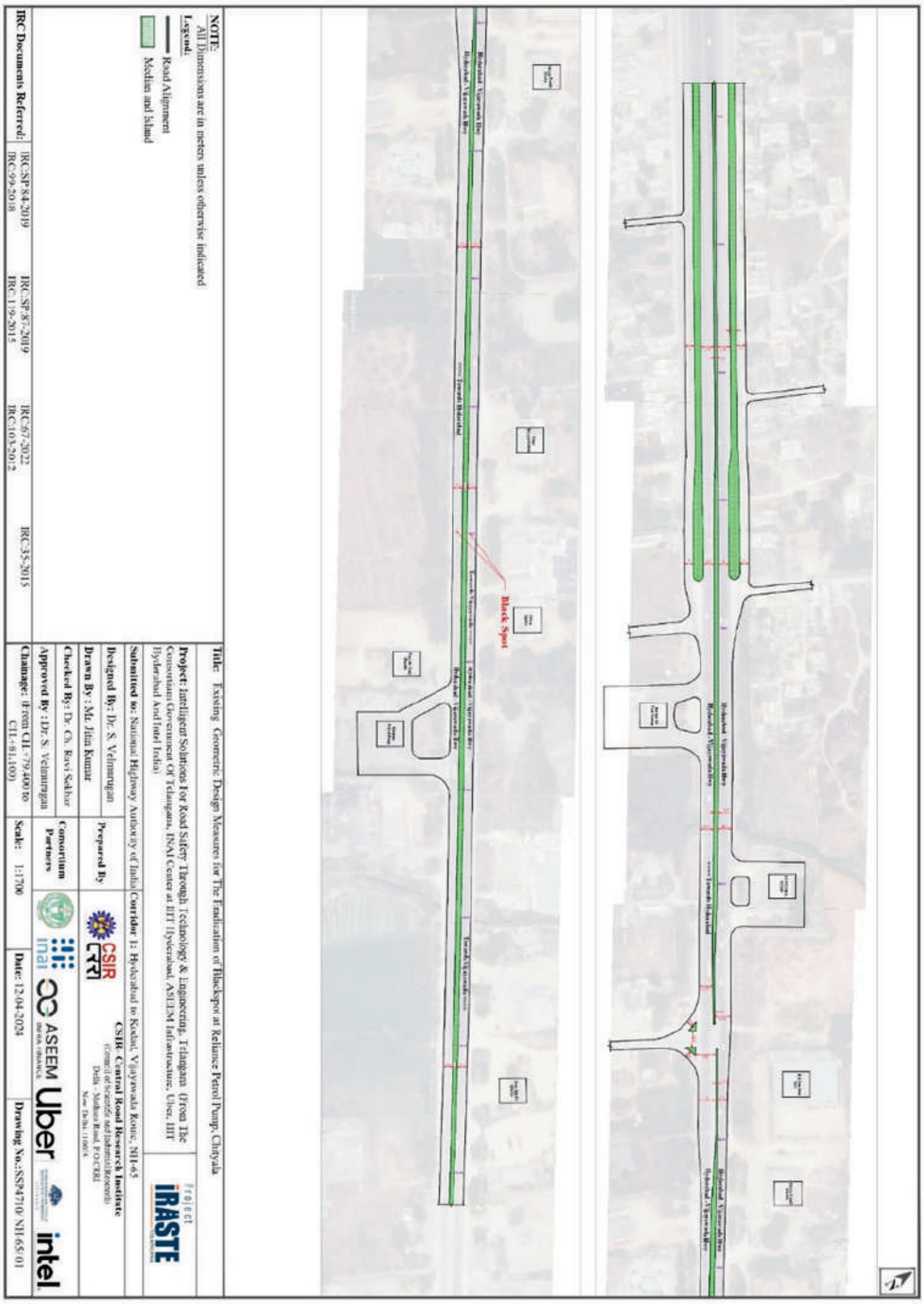


Figure 4.27: Existing Physical Survey Plan of near Reliance Petrol Pump, Chityala on NH-65

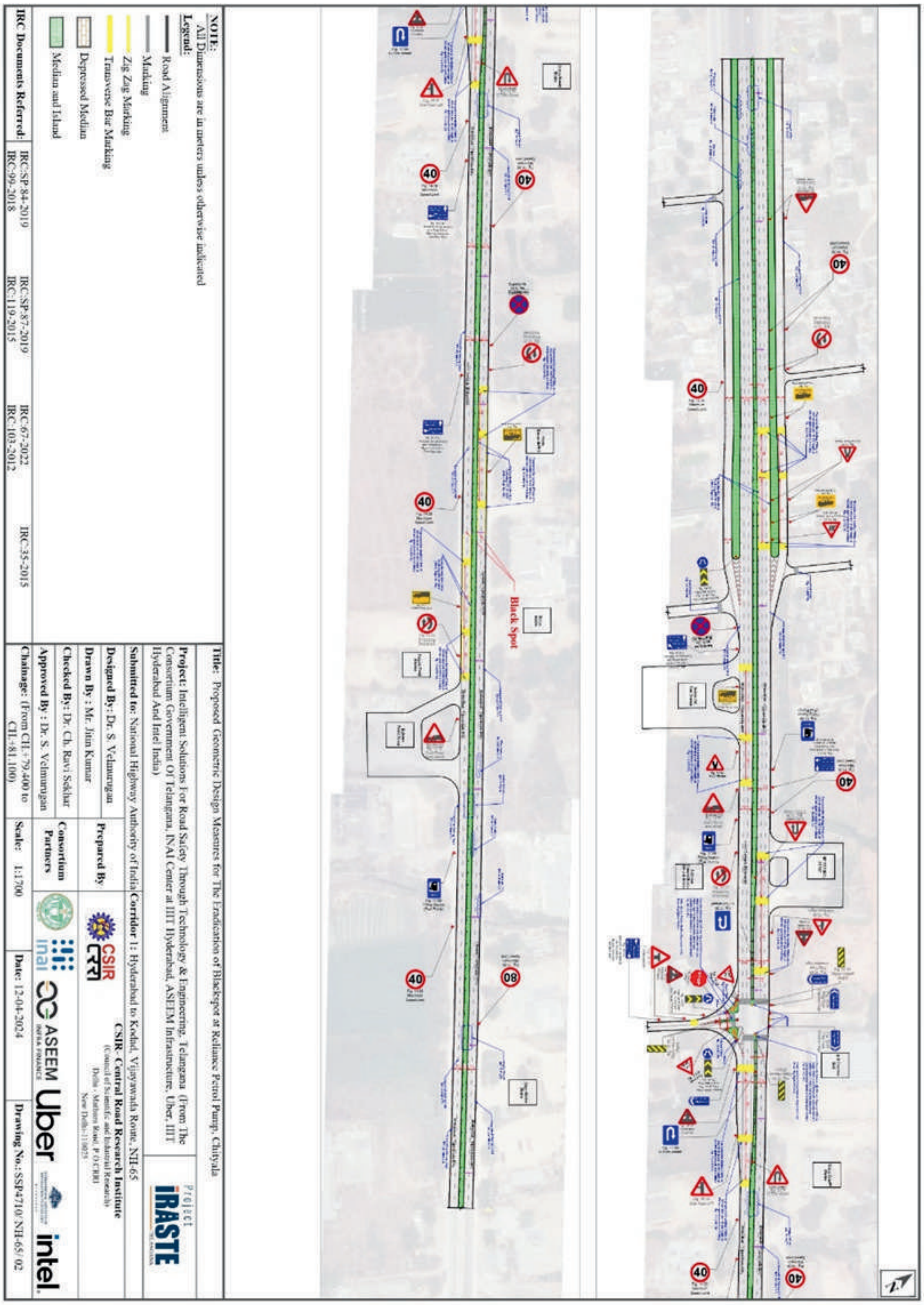


Figure 4.28: Detailed GDP Near Reliance Petrol Pump, Chityala on NH-65

E. AP LINGOTAM

Figure 4.29 shows the existing plan at A.P. starting at the narrow lane and expanding over 18.5 m, the road section ends near the highway lane merger location. Figure 4.30 presents the proposed enhancements to improve safety and traffic management in the vicinity of A.P. Lingotam (spanning between Ch 90.800 to 92.300). This included the proposed geometric design improvements including the erection of 3 sets of TBMs, road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility.

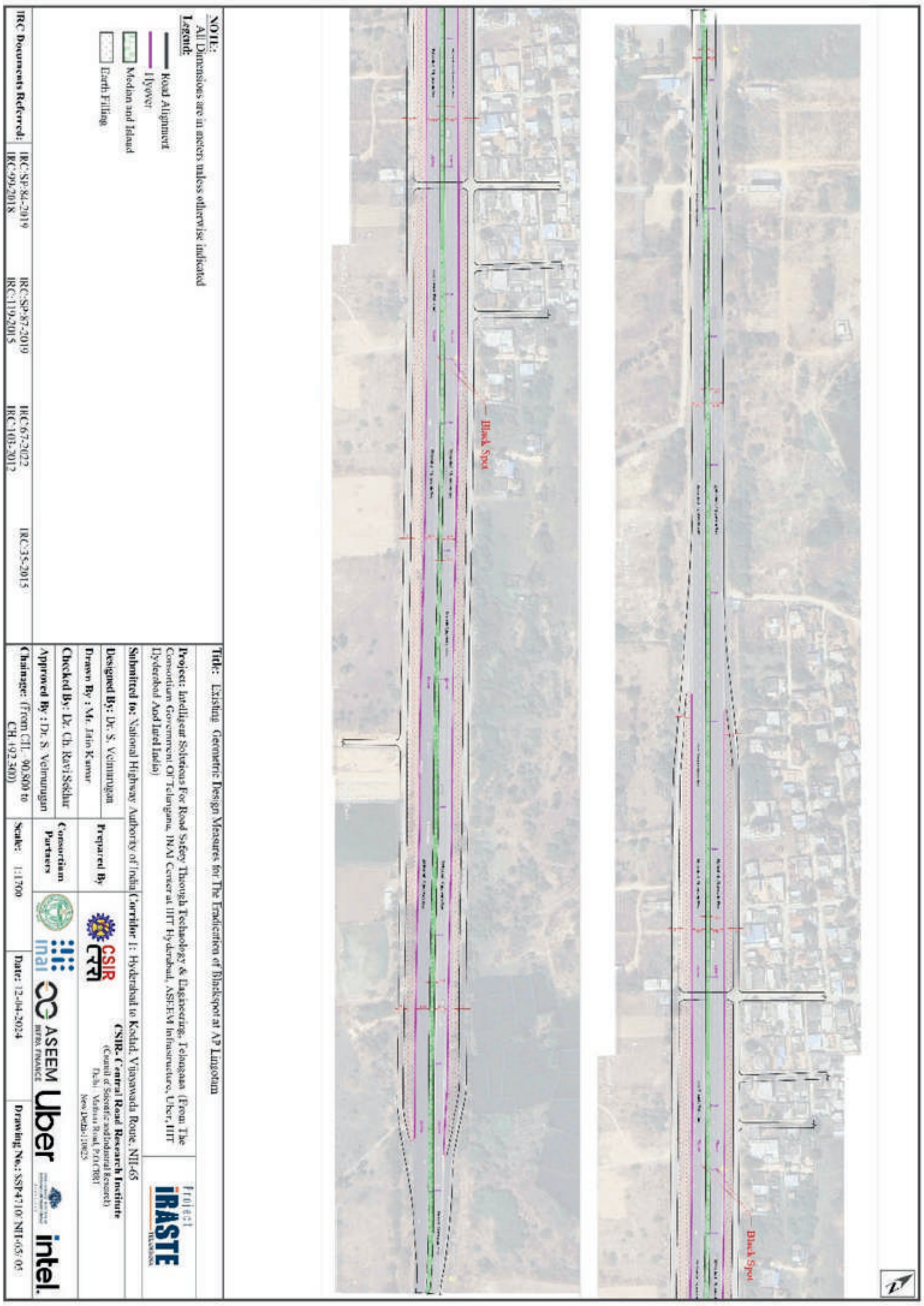


Figure 4.29: Existing Physical Survey Plan of AP LINGOTAM on NH-65

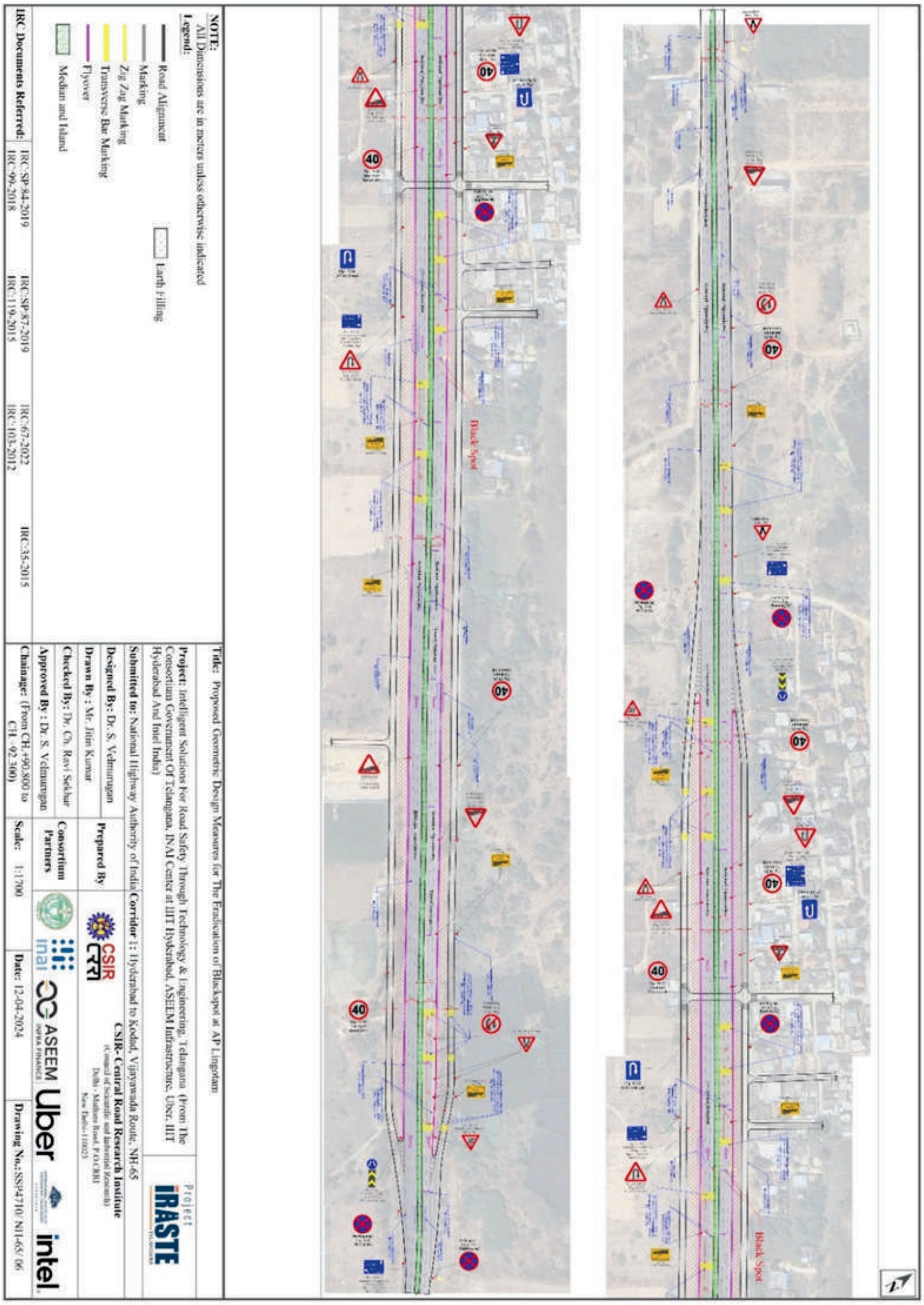


Figure 4.30: Detailed GDP of AP LINGOTAM on NH-65

4.4.2 CORRIDOR 2: HYDERABAD TO PULLUR (NH-44)

Hyderabad - Pullur section of NH 44 is a crucial stretch that connects the capital city of Hyderabad, Telangana and Bengaluru, the capital of Karnataka. As such, NH-44 falls under the Telangana region extends up to Pullur and is approximately 200 Km long and four lane divided section with paved shoulders enhancing connectivity and economic activity in the region. Here too, it was noted that the observed mean speeds of Cars are also well more than Speed Limit 80 Kmph at some of the black spots as noted in Markal (refer to Table 4.9).

Due to such overspeeding, geometric design measures coupled with soft traffic calming measures in the form of 3 sets of Transverse Bar Marking (TBMs) measuring between 10 mm to 15 mm are proposed at appropriate locations in the top five blackspots identified on NH-44.

A. SRI ANJANEYA SWAMI TEMPLE BEECHUPALLI

Figure 4.31 shows the existing plan of Beechuppalli around Km 163.100 to 164.600 having U-Turn Provision with Minor Intersection near Shri Anjaneya Temple. Figure 4.32 presents the proposed enhancements to improve safety and traffic management in the vicinity of Beechupalli. This is accomplished by providing geometric design improvements starting at the two lanes near Jogulamba Steel area and the erection of 3 sets of TBMs (leading to the U-Turn location) road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility.

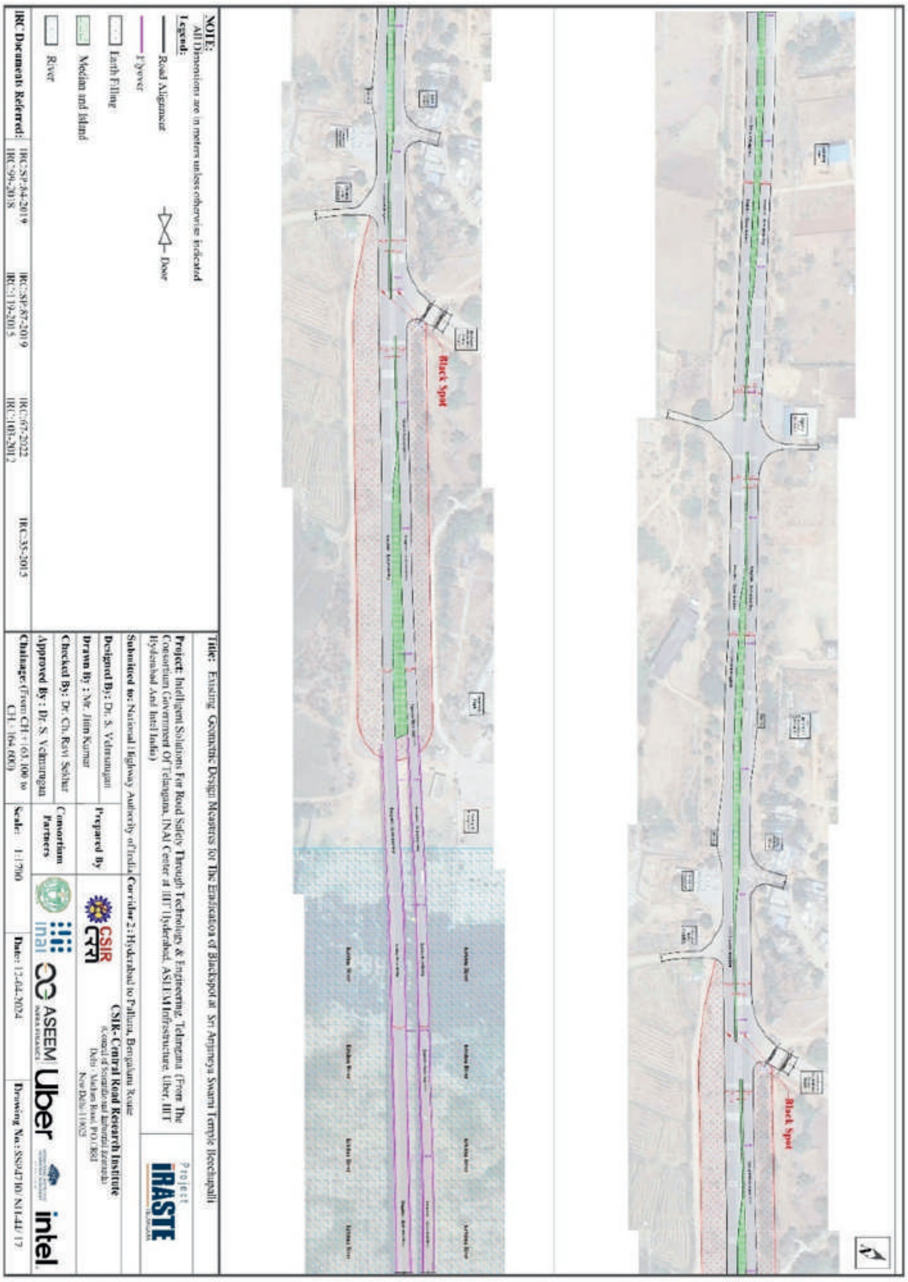


Figure 4.31: Existing Physical Survey Plan of Beechupalli Area on NH-44

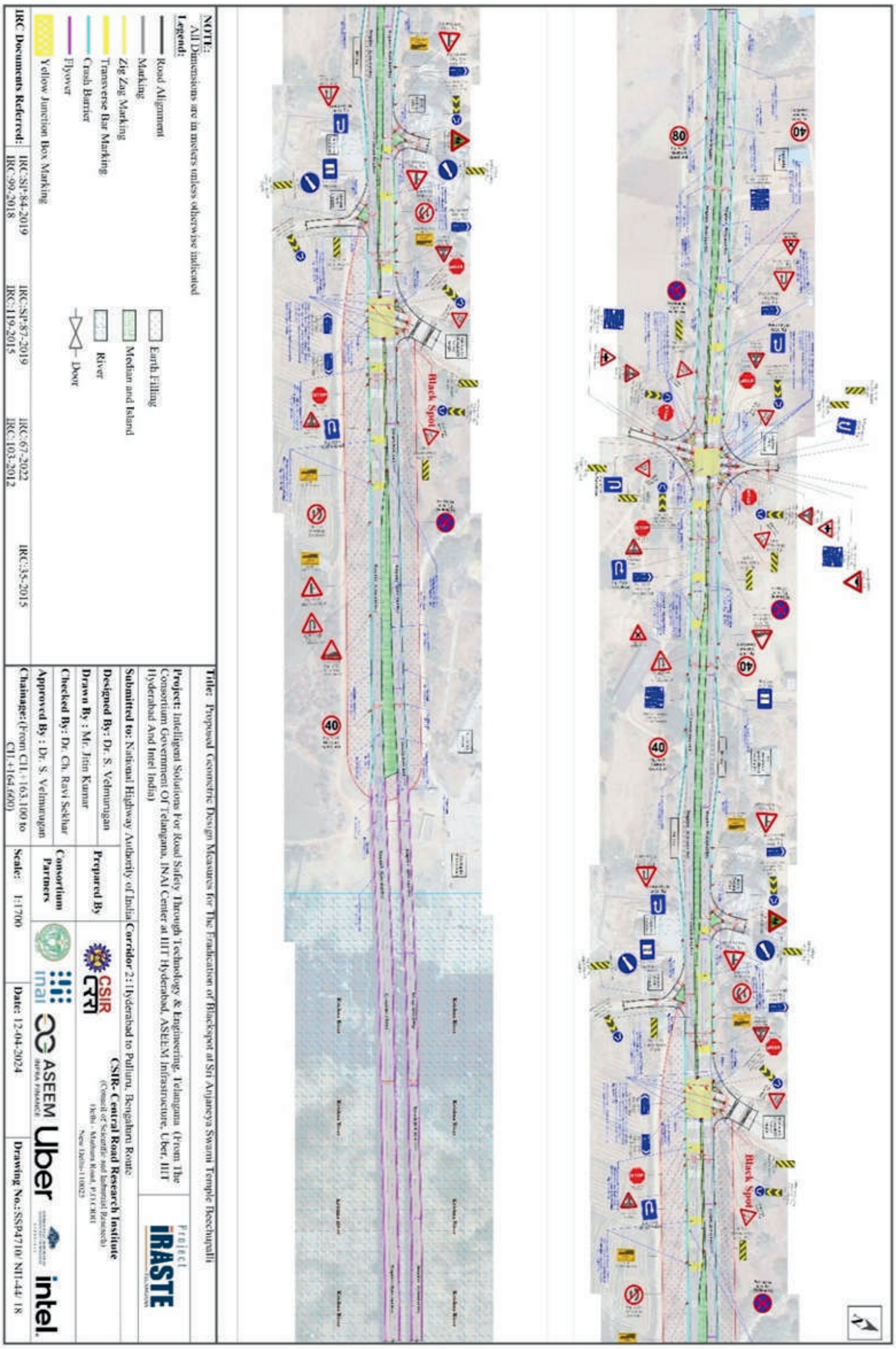


Figure 4.32: Detailed GDP of Beechupalli Area on NH-44

B. RAIMAKULAKUNTA

Figure 4.33 shows the existing plan of Raimakulakunta around Km 185.500 to 186.500 which has a midblock straight section having a minor intersection at around Km 186.300. Figure 4.34 presents the proposed enhancements to improve safety and traffic management in the vicinity of Raimakulakunta. This is accomplished by providing geometric design improvements and the erection of 3 sets of TBMs (leading to the U-Turn location) road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility.

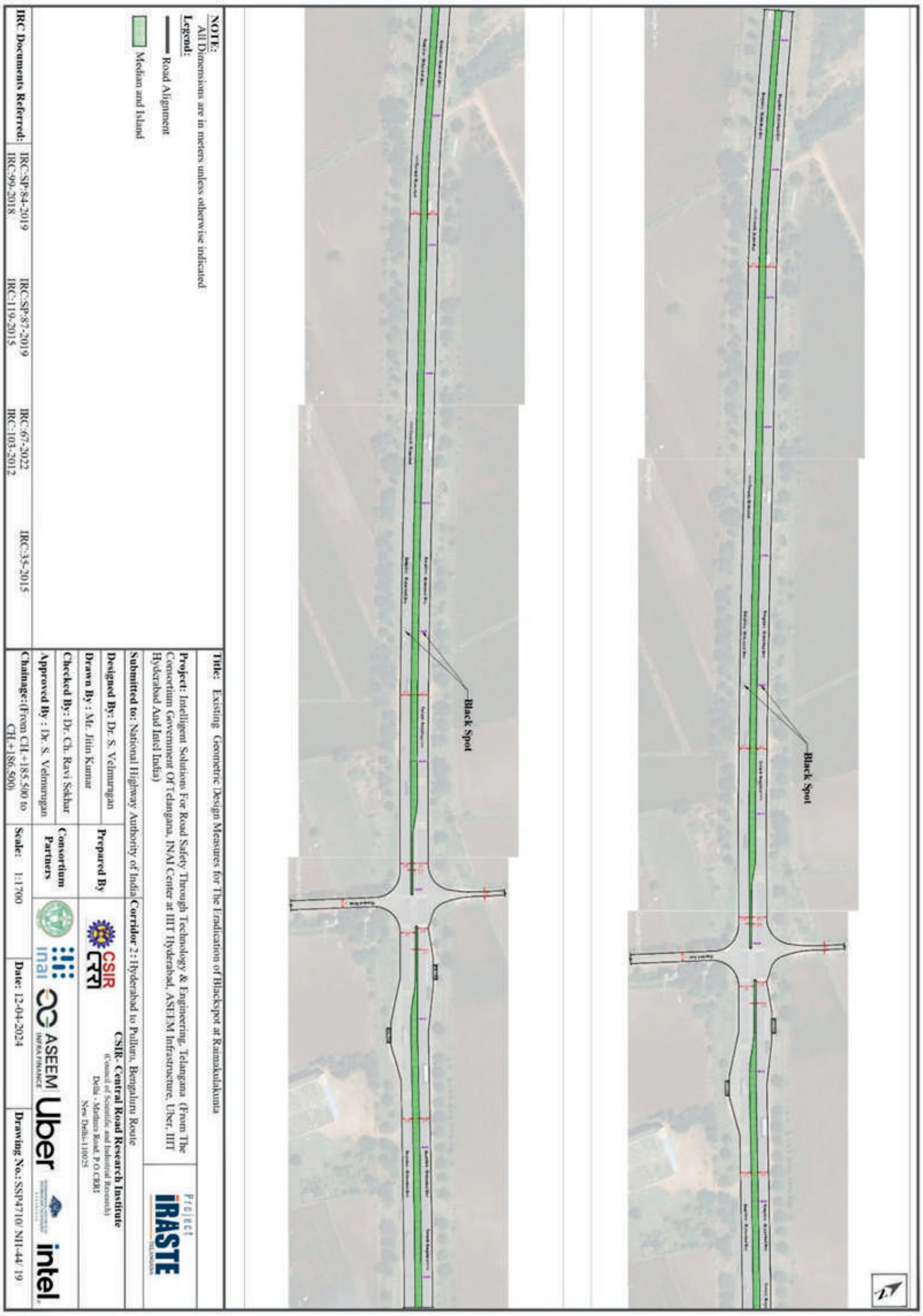


Figure 4.33: Existing Physical Survey Plan of Raimakulakunta Area on NH-44

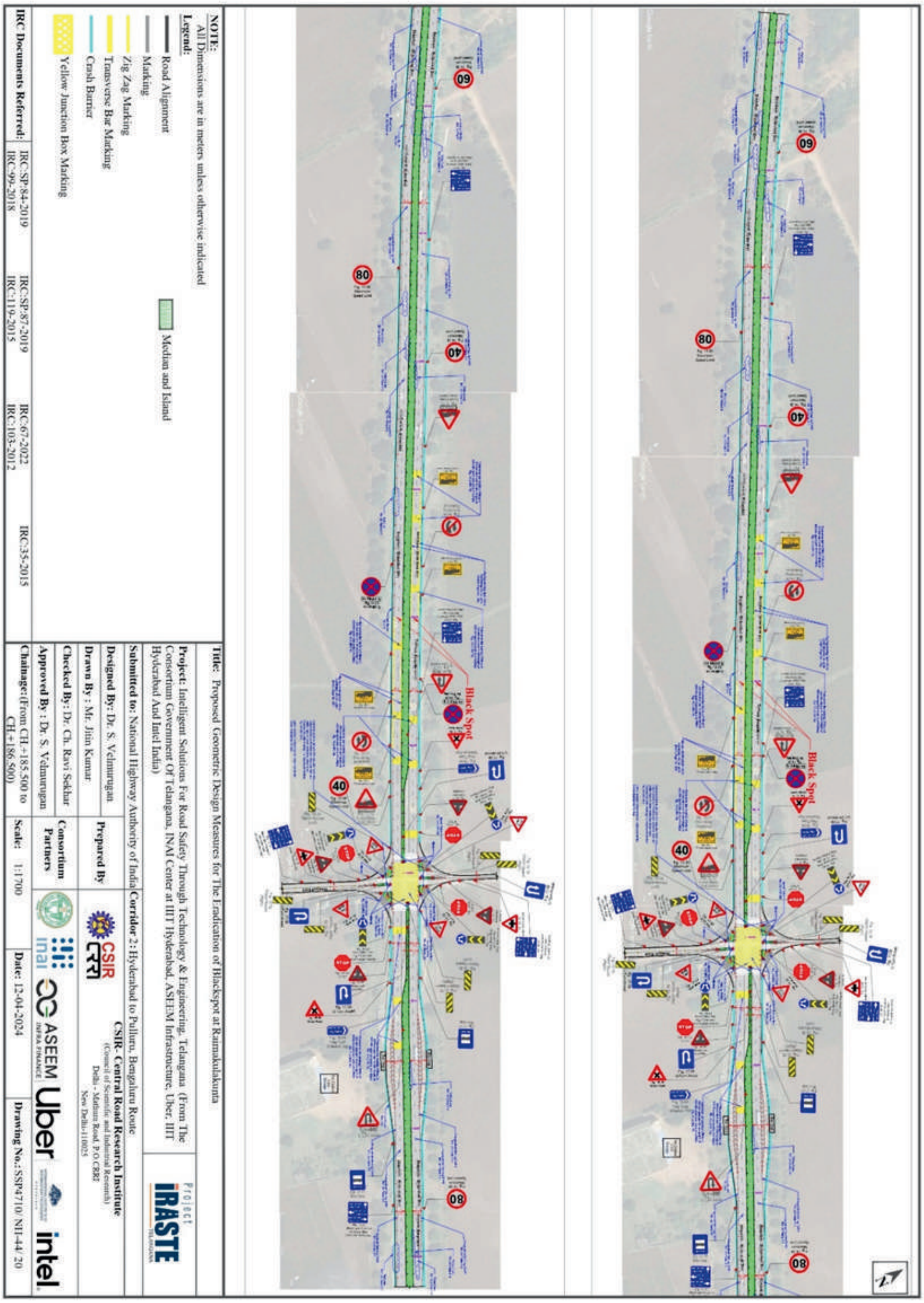


Figure 4.34: Detailed GDP of Raimakulakunta Area on NH-44

C. NEAR KANAKA DURGA TEMPLE

Figure 4.35 shows the existing plan near Kanaka Durga Temple around Km 164.500 to 166.100 which is having a midblock straight section having a minor intersection at around Km 165.200 and the black spots stretch extend up to Hindustan Petroleum Corporation Limited Petrol Pump area. Figure 4.36 presents the proposed enhancements to improve safety and traffic management in the vicinity of Kanaga Dura Temple area. This is accomplished by providing geometric design improvements and the erection of 3 sets of TBMs, road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility.

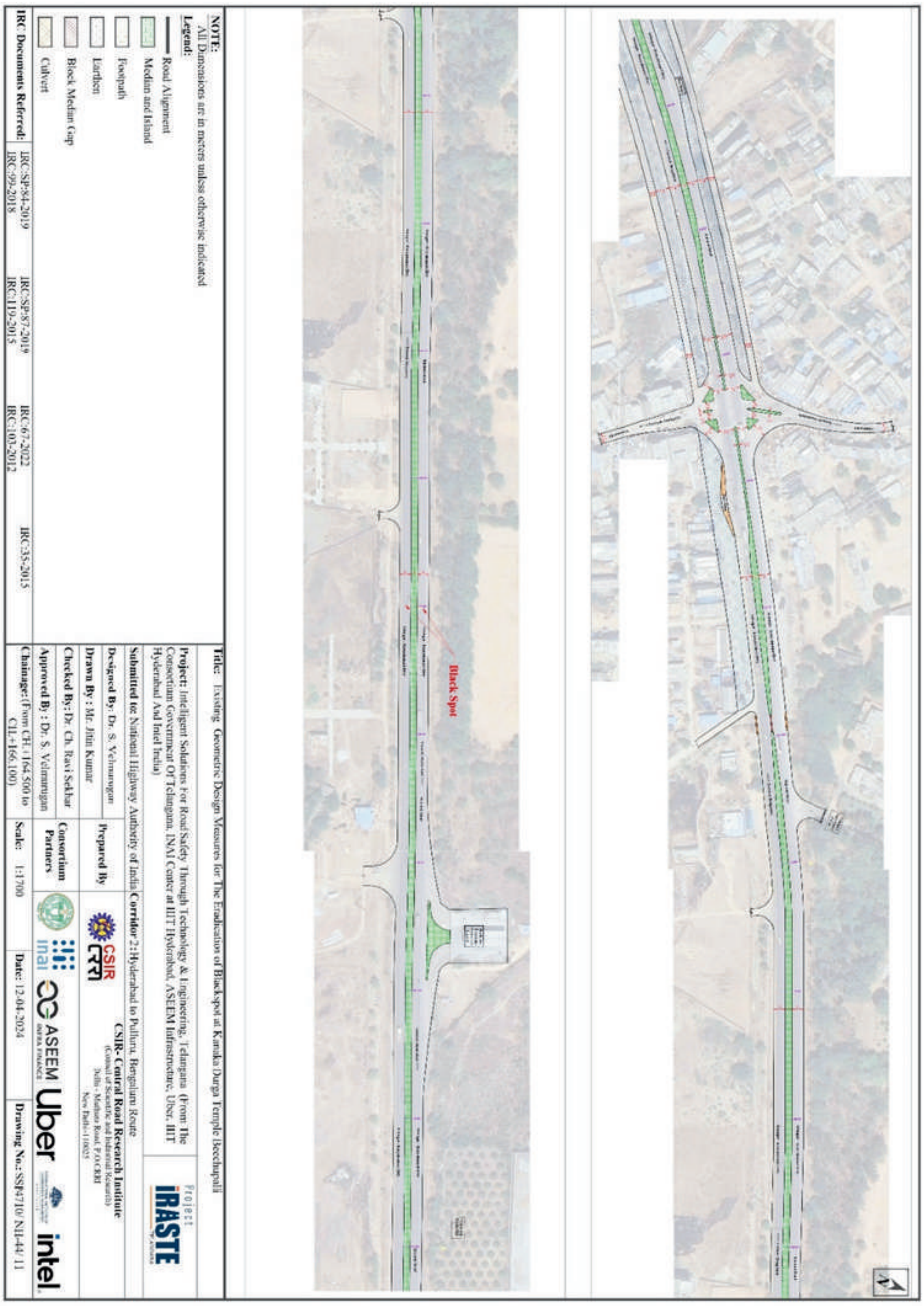


Figure 4.35: Existing Physical Survey Plan near Kanaka Durga Temple Area on NH-44

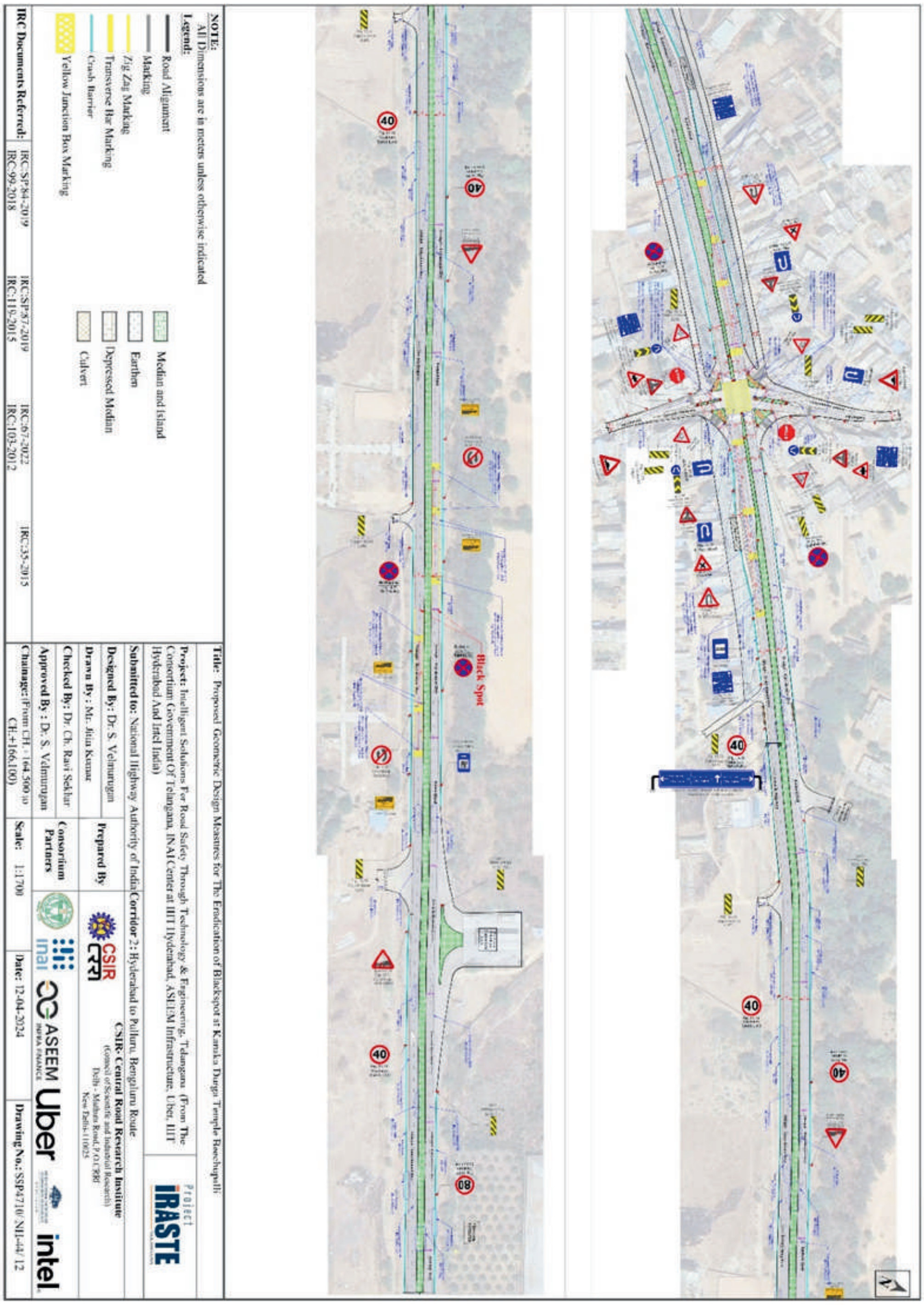


Figure 4.36: Detailed GDP of Raimakulakunta Area on NH-44

D. RAIKAL - 1

Figure 4.37 shows the existing plan around Raikal 1 area which starts at the T intersection near Bharat Petroleum Fuel Station and Indian Oil Fuel Station and the black spots extend up to about 300 m before Shadnagar Toll Plaza (Km 54.200 to 55.500). Figure 4.38 presents the proposed enhancements to improve safety and traffic management in the vicinity of Raikal I area. This is accomplished by providing geometric design improvements and the erection of 3 sets of TBMs on the midblock location coupled with the appropriate road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility.

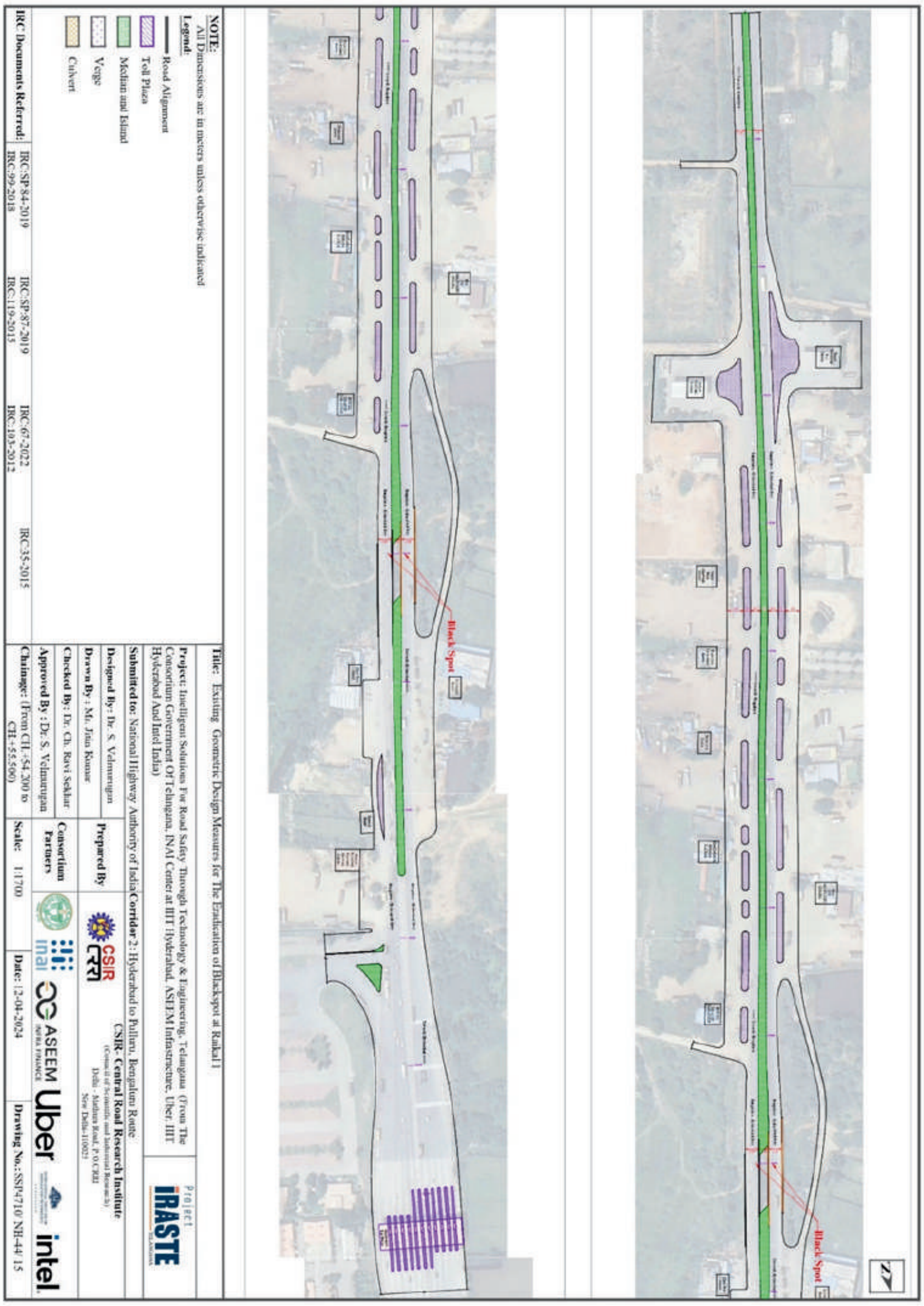


Figure 4.37: Existing Physical Survey Plan near Raikal 1 Area on NH-44

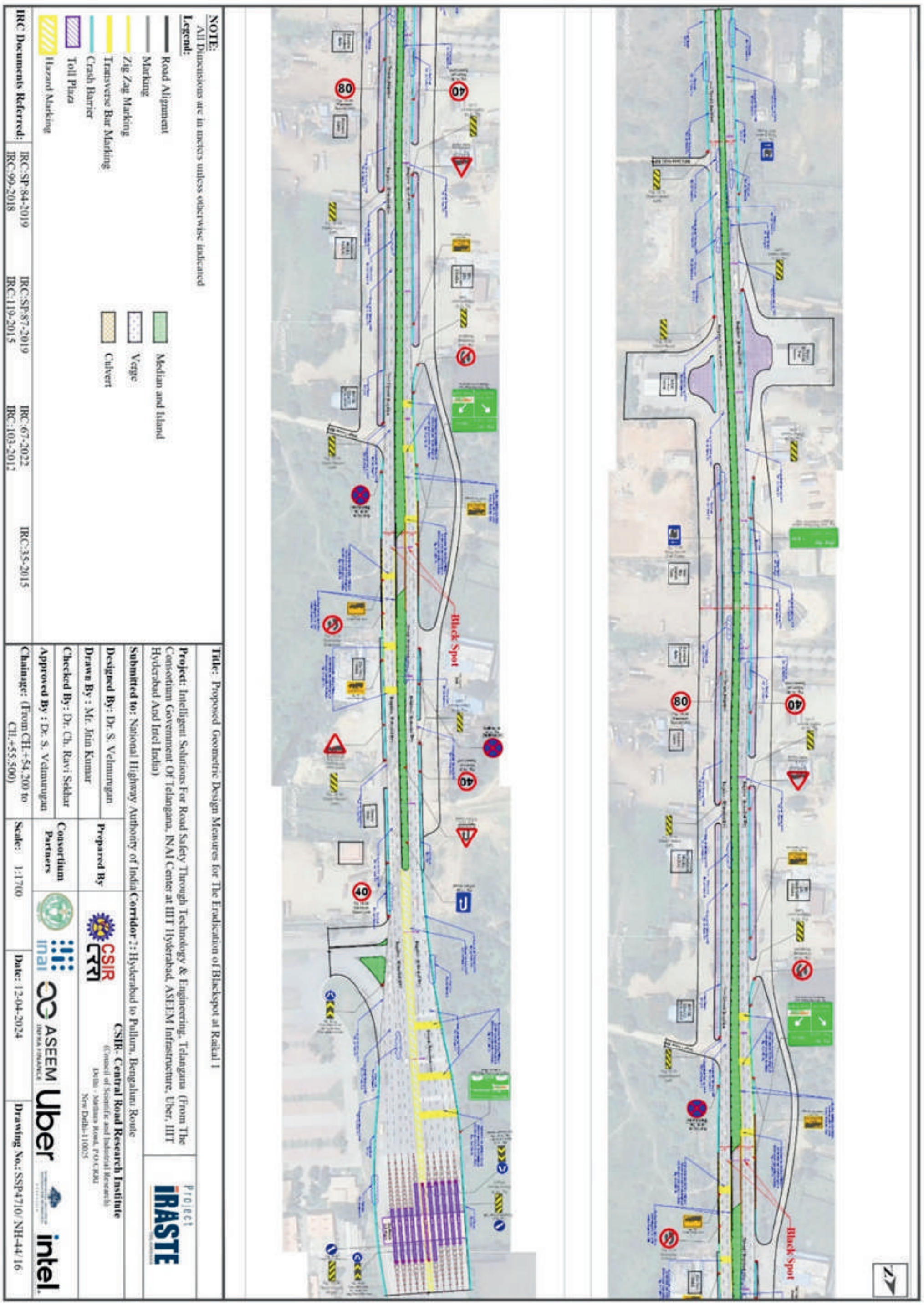


Figure 4.38: Detailed GDP of Raikal -1 Area

E. PULLUR ROAD - 1

Figure 4.39 shows the existing plan of Pullar Road 1 area at around Km 198.200 to 199.200 area. This is improved by providing geometric design improvements and the erection of 3 sets of TBMs on the midblock location coupled with the appropriate road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility (refer to Figure 4.40).

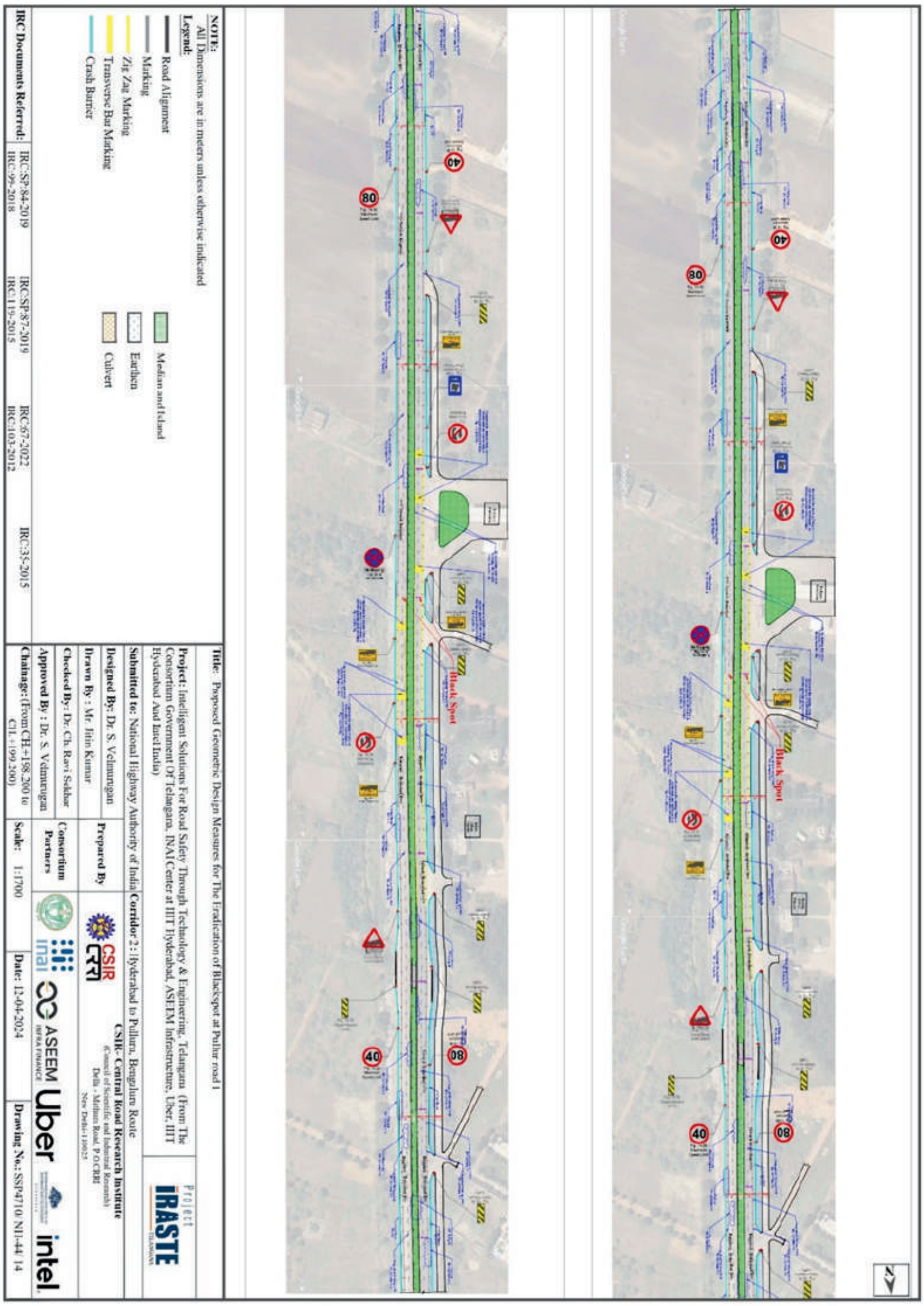


Figure 4.39: Existing Physical Survey Plan near Pullur Road 1 Area on NH-44

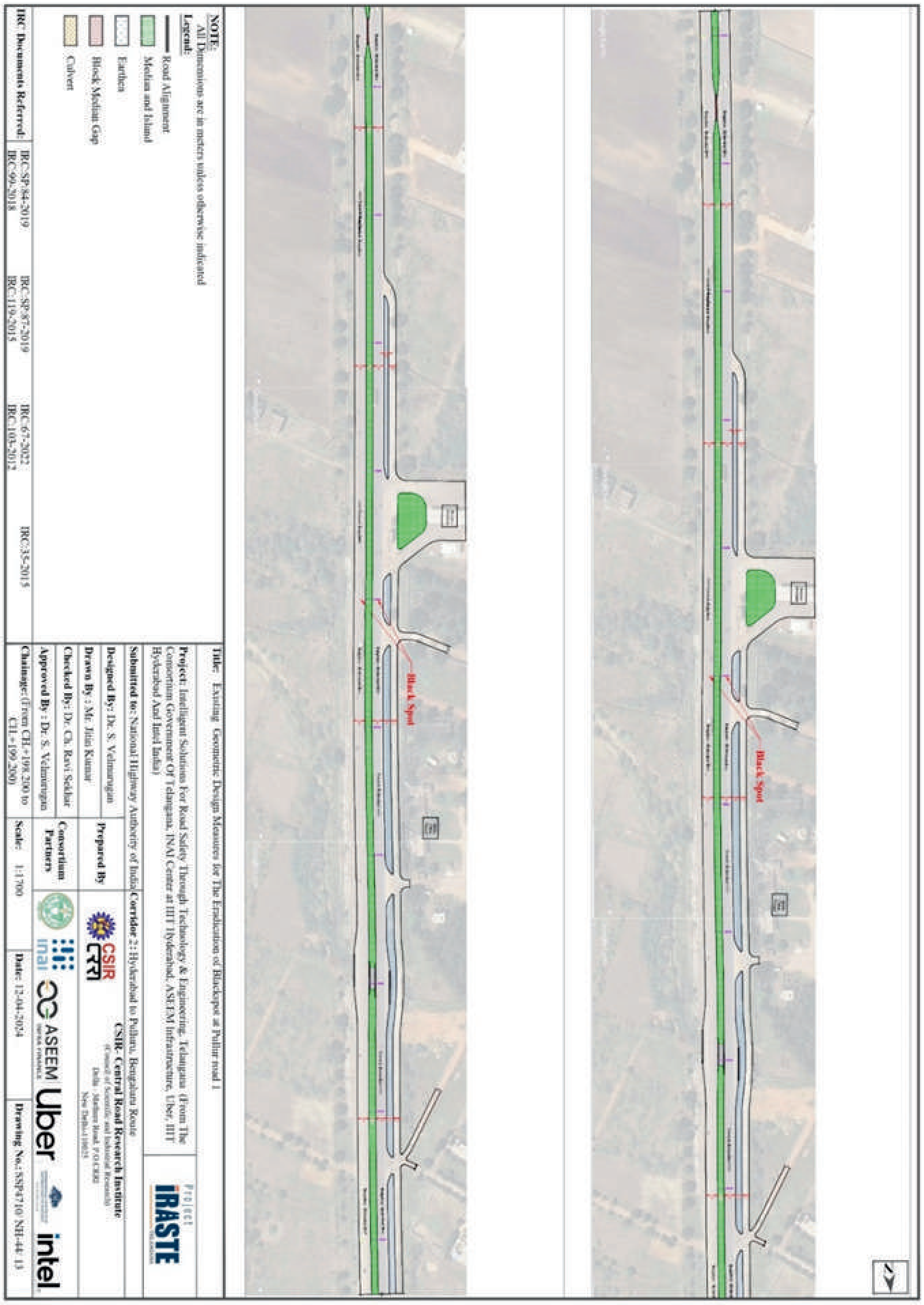


Figure 4.40: Detailed GDP of Pullur Road 1 Area on NH-44

4.4.3 CORRIDOR-3: HYDERABAD - ADILABAD (NH-44)

Hyderabad - Adilabad section of NH-44 is an important stretch that connects the capital city of Hyderabad, Telangana and Nagpur, are the winter capital of Maharashtra and various major industrial towns in Maharashtra as well as providing connectivity to Tamilnadu. As such, NH-44 falling under the Telangana region extends up to Adilabad and is approximately 303 Km long and four lanes divided section with paved shoulders enhancing connectivity and economic activity in the region. Here too, it was noted that the observed mean speeds of Cars are about 83 Kmph which is slightly higher as noted in Kupti (refer to Table 4.9).

This is despite the fact that the road stretch has rolling terrain after Km 150 up to 2Km 250. Due to overspeeding, geometric design measures coupled with soft traffic calming measures in the form of 3 sets of Transverse Bar Marking (TBMs) measuring between 10 mm to 15 mm are proposed at appropriate locations in the top five blackspots identified on NH-44.

A. AMRUTHAPUR

Figure 4.41 shows the existing plan of Amruthapur starting @ Km 338.600 to 339.500 near Bharat Benz Service Center and the black spot area ends near Sri Sai Family Restaurant. This is improved by providing geometric design improvements and the erection of 3 sets of TBMs on the Minor Intersection area coupled with the road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility (refer to Figure 4.42).

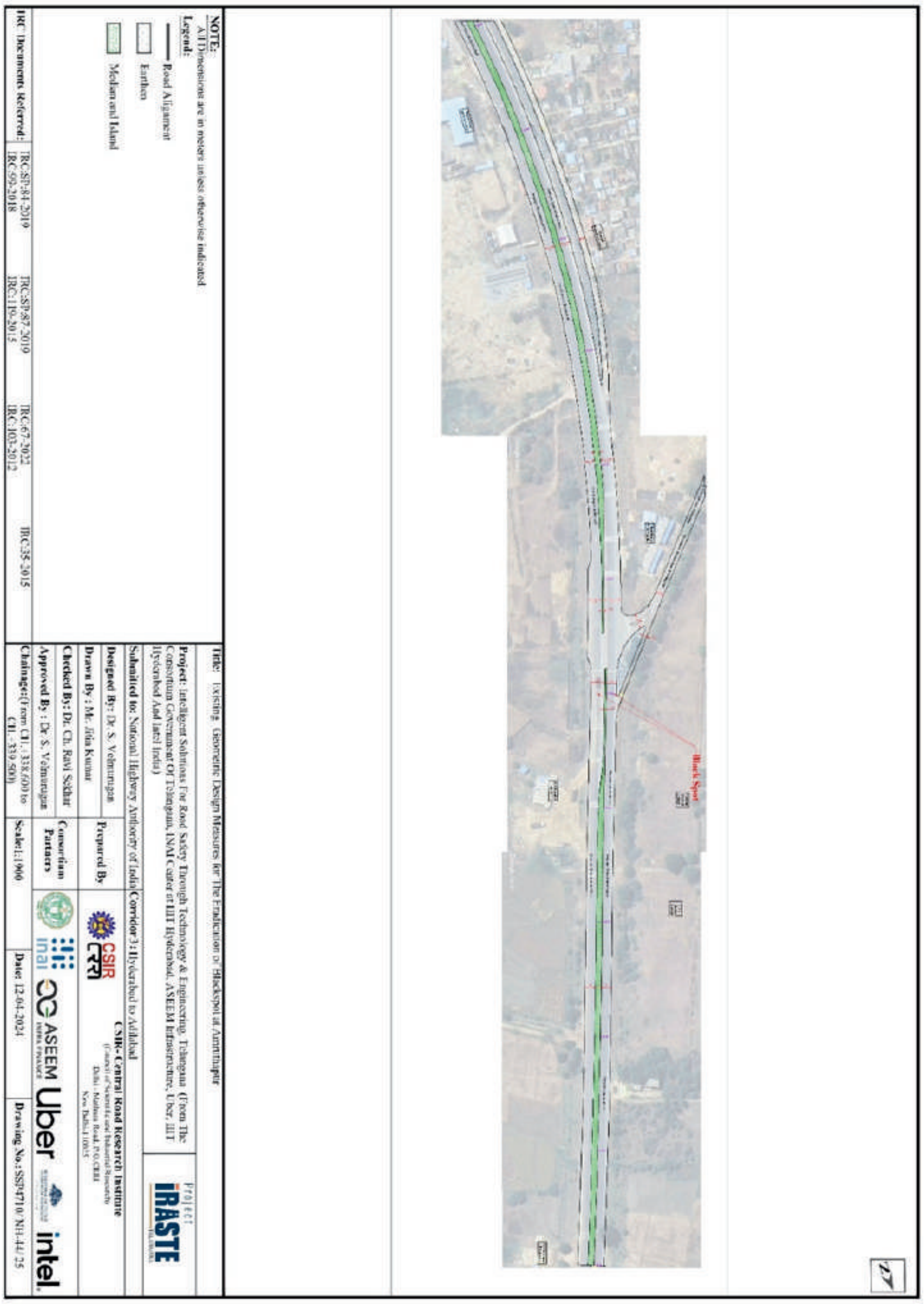


Figure 4.41: Existing Physical Survey Plan of Amruthapur Area on NH-44

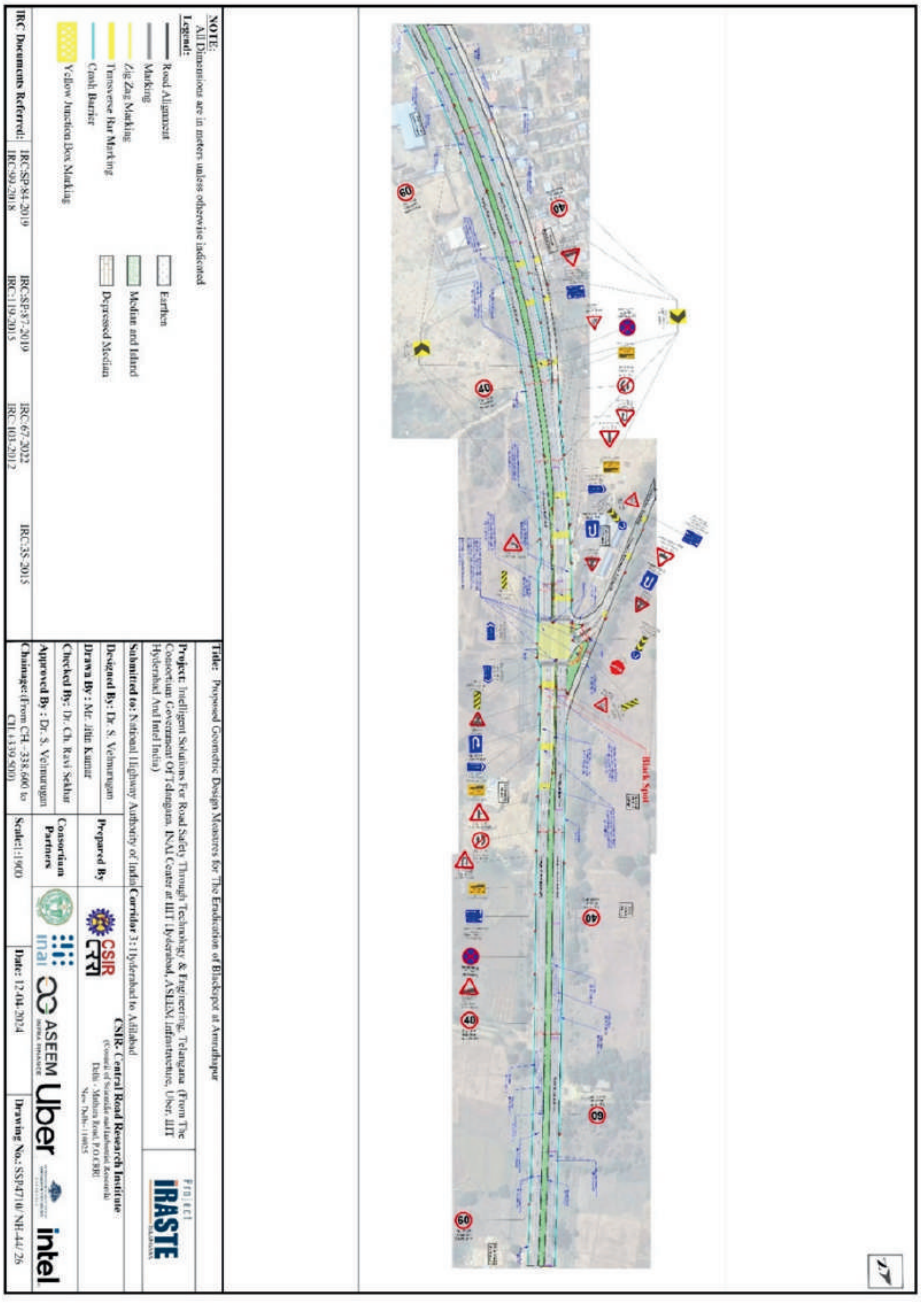


Figure 4.42: Detailed GDP of Amruthapur Area on NH-44

B. CHANDRAYANPALLY

Figure 4.43 shows the existing plan of Chandrayanpally starting at Km 355.300 to Km 356.300. This is improved by providing geometric design improvements and the erection of 3 sets of TBMs on the Midblock section of the road section at relevant places coupled with the appropriate road signs and enhancement of relevant road markings for delineation coupled with enhancing pedestrian accessibility (refer to Figure 4.44).

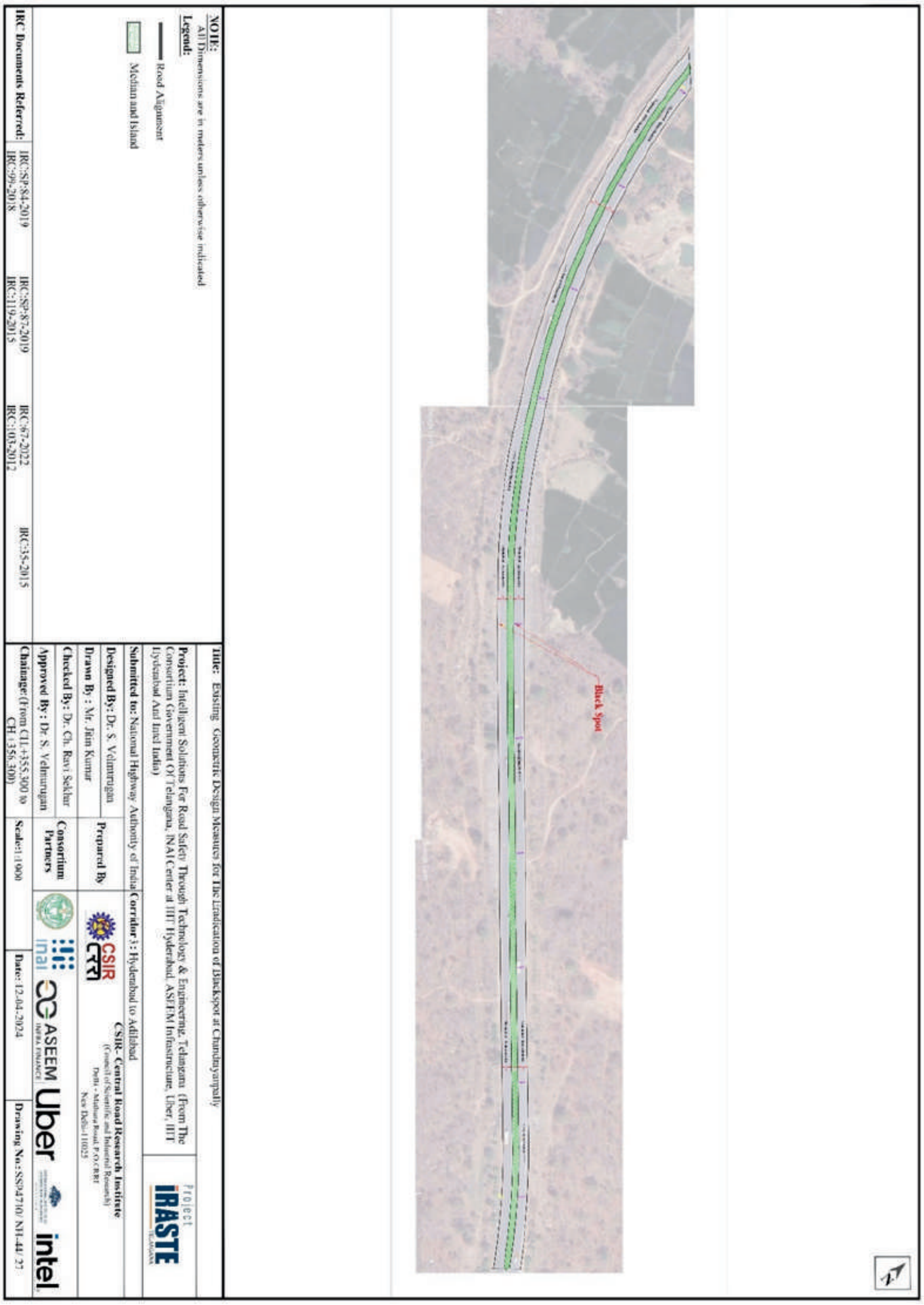


Figure 4.43: Existing Physical Survey Plan of Chandrayanpally Area on NH-44

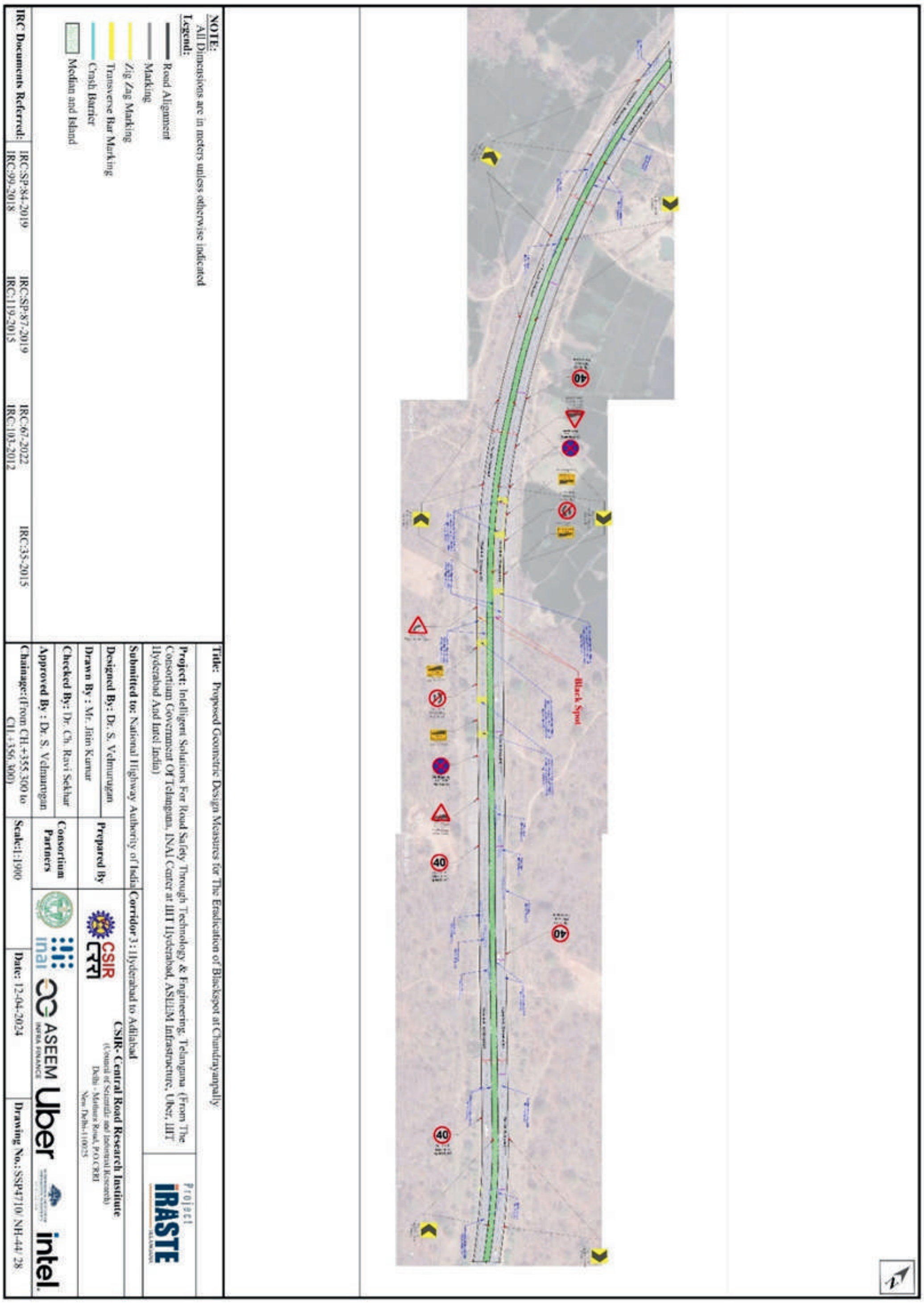


Figure 4.44: Detailed GDP of Chandrayanpally Area on NH-44

C. SEETAGONDI

Figure 4.45 shows the existing plan of Seetagondi area starting at Km 206.900 to 208.00. This blackspot is improved by providing geometric design improvements and the erection of 3 sets of TBMs on the Midblock section of the road section at relevant places including before the U-Turning location coupled with the road signs and enhancement of relevant road markings for delineation and enhanced pedestrian accessibility (refer to Figure 4.46).

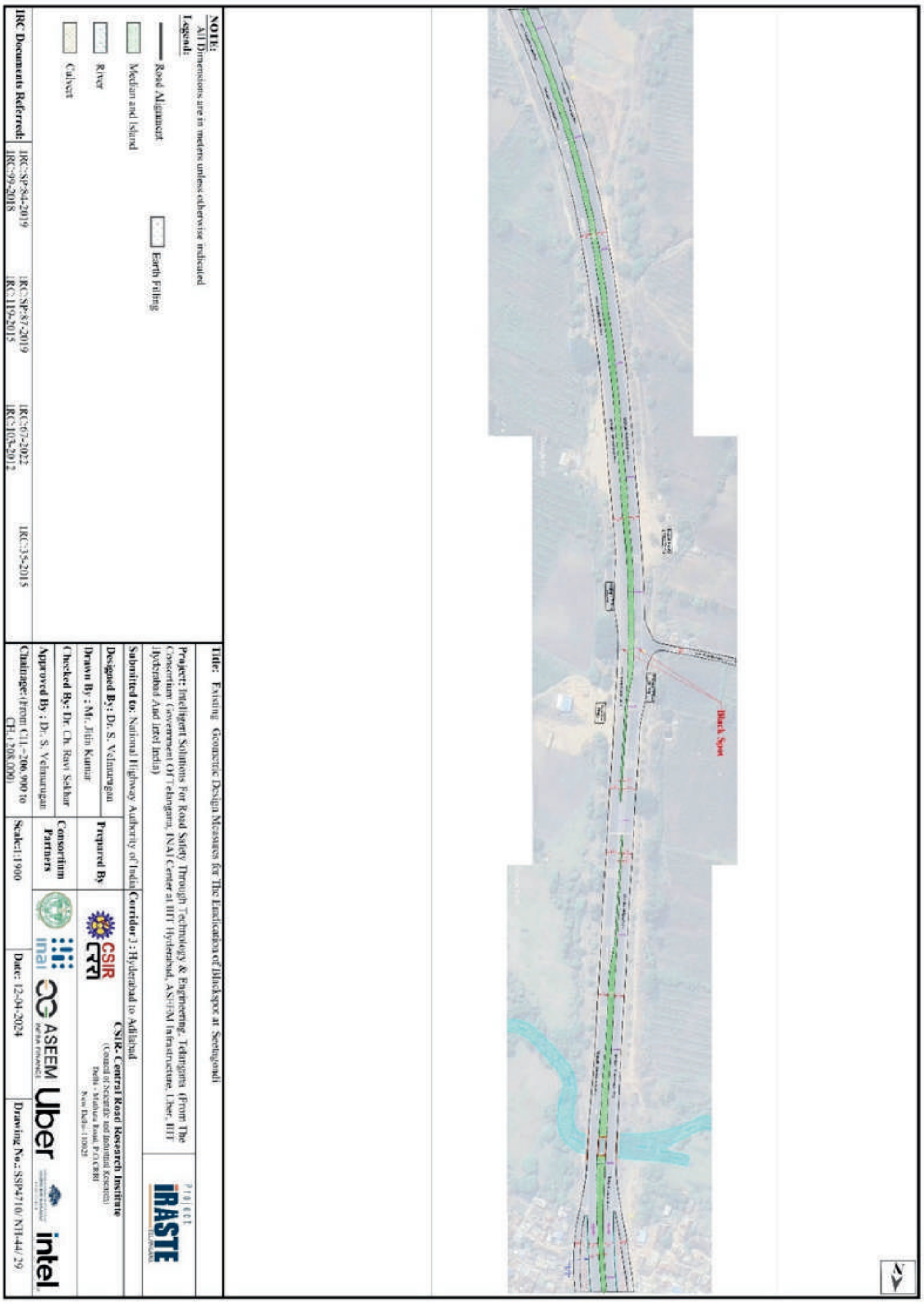


Figure 4.45: Existing Physical Survey Plan of Seetagondi Area on NH-44

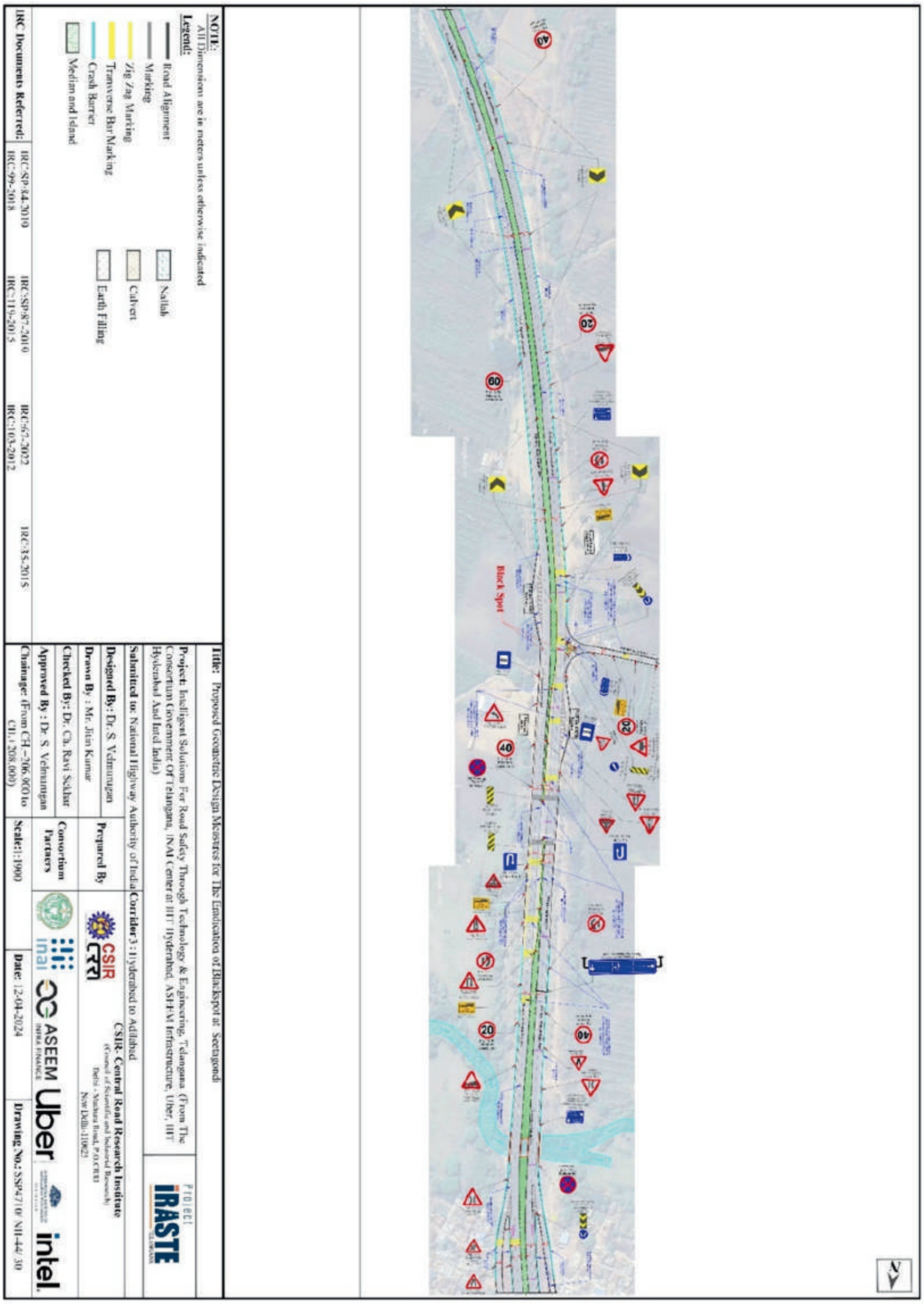


Figure 4.46: Detailed GDP of Seetagondi Area on NH-44

D. STRETCH 1A: Indalwai to Gannaram Stretch: Km 348.500 to 352.600

Figure 4.47 shows the existing plan of Stretch 1 extending from Indalwai to Gannaram stretch identified a Blackspot which starts at the T intersection Gannaram and ends near Chai Bunk @ Indalwai. This blackspot is improved by providing geometric design improvements at T - Intersection and the erection of 3 sets of TBMs on the Midblock section of the road section at relevant places coupled with the road signs and enhancement of relevant road markings for delineation and enhanced pedestrian accessibility (refer to Figure 4.48).

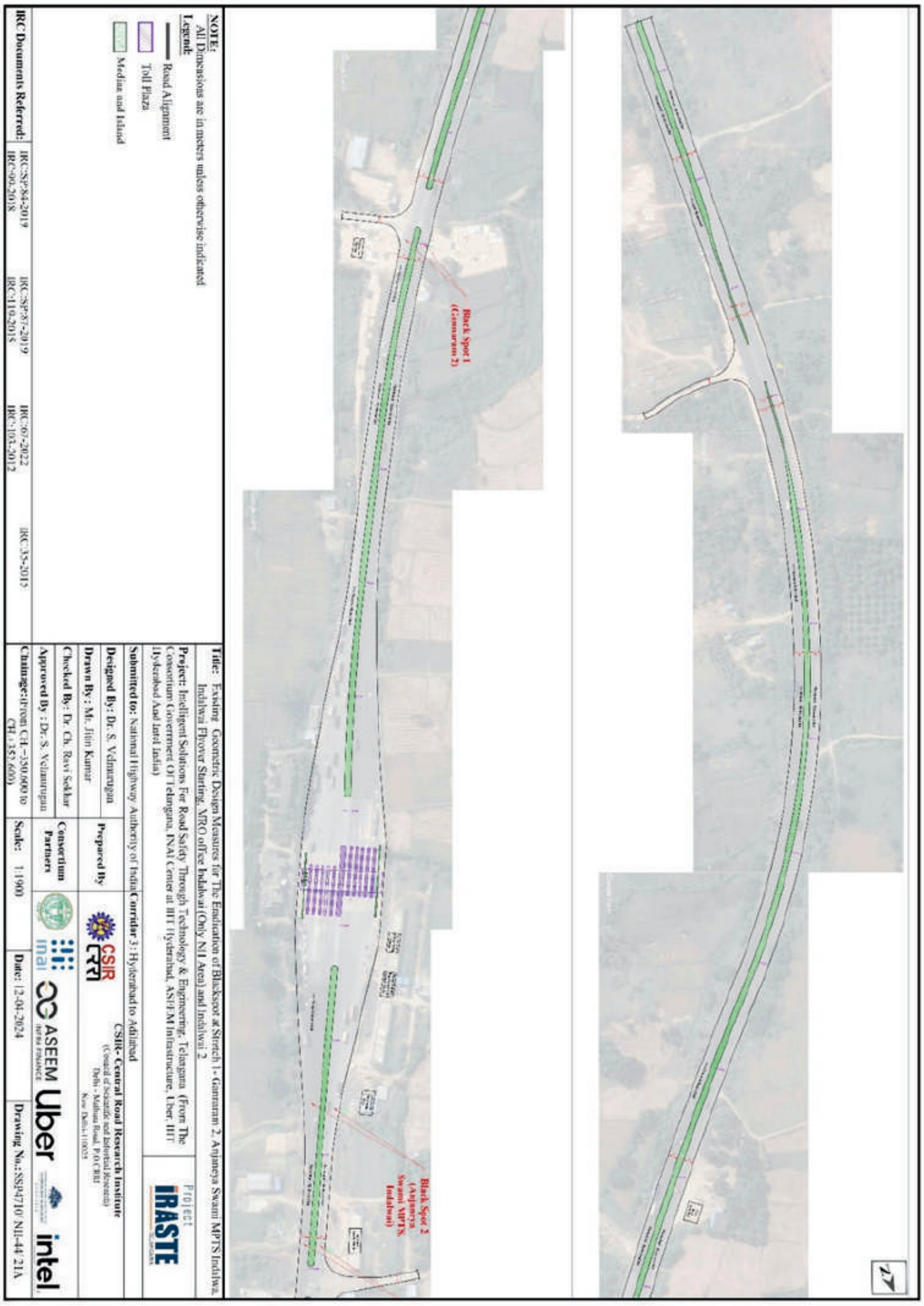


Figure 4.47: Existing Physical Survey Plan of Stretch 1A: Indalwai to Gannaram on NH-44

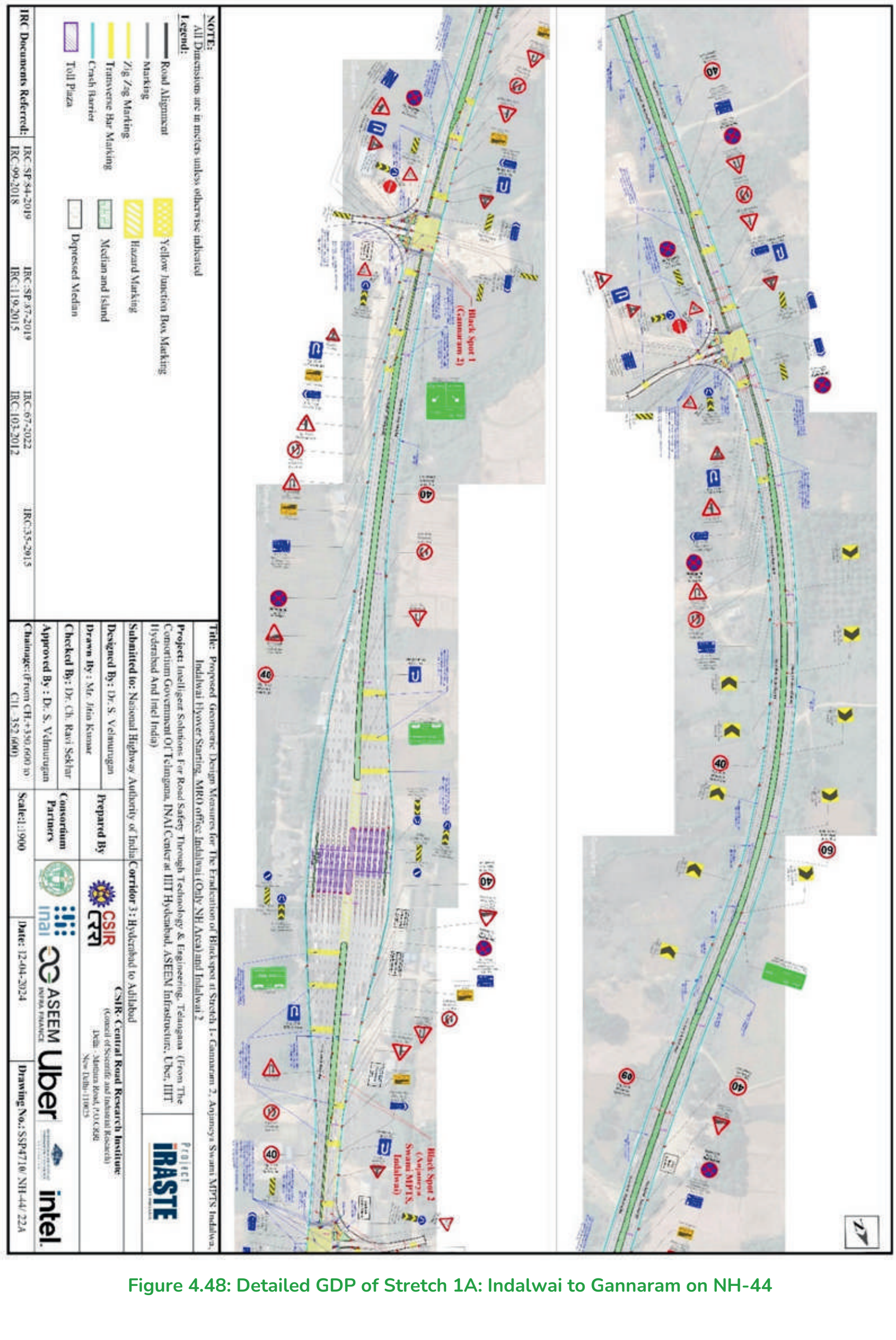


Figure 4.48: Detailed GDP of Stretch 1A: Indalwai to Gannaram on NH-44

E. STRETCH 1B: Devapur Forest Area plus Pangapipri Curve Area

Figure 4.49 shows the existing plan of Stretch 1B which starts at the Sri Laxmi Narasimha Mess the road section ends near Police Station Indalwai. This blackspot is improved by providing geometric design improvements at T – Intersection and the erection of 3 sets of TBMs on the Curved sections of the road section at relevant places coupled with the road signs and enhancement of relevant road markings for delineation and enhanced pedestrian accessibility (refer to Figure 4.50).

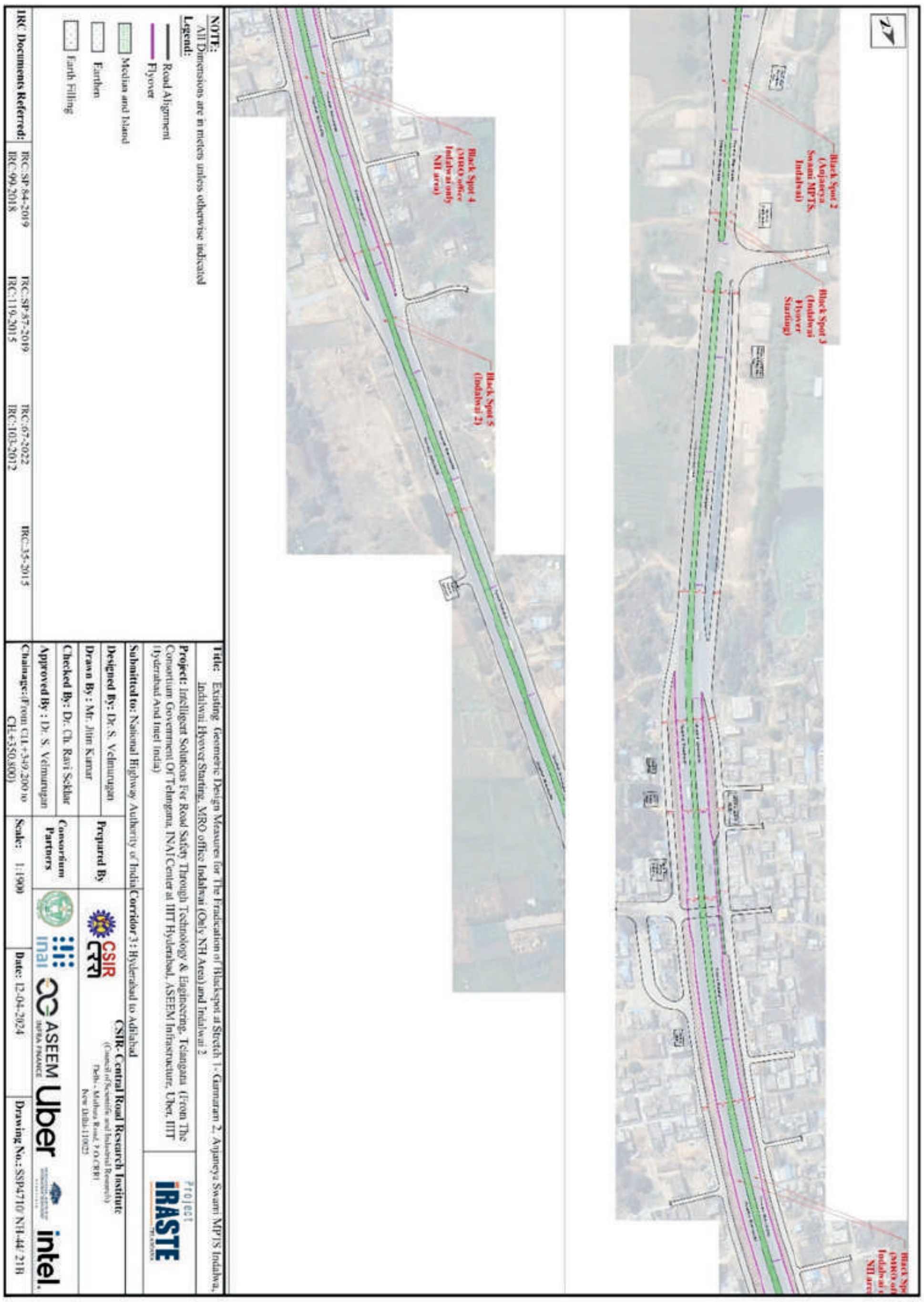


Figure 4.49: Existing Physical Survey Plan of Stretch 1B: Devapur Forest Area plus Pangadpipri Curved Sections on NH-44

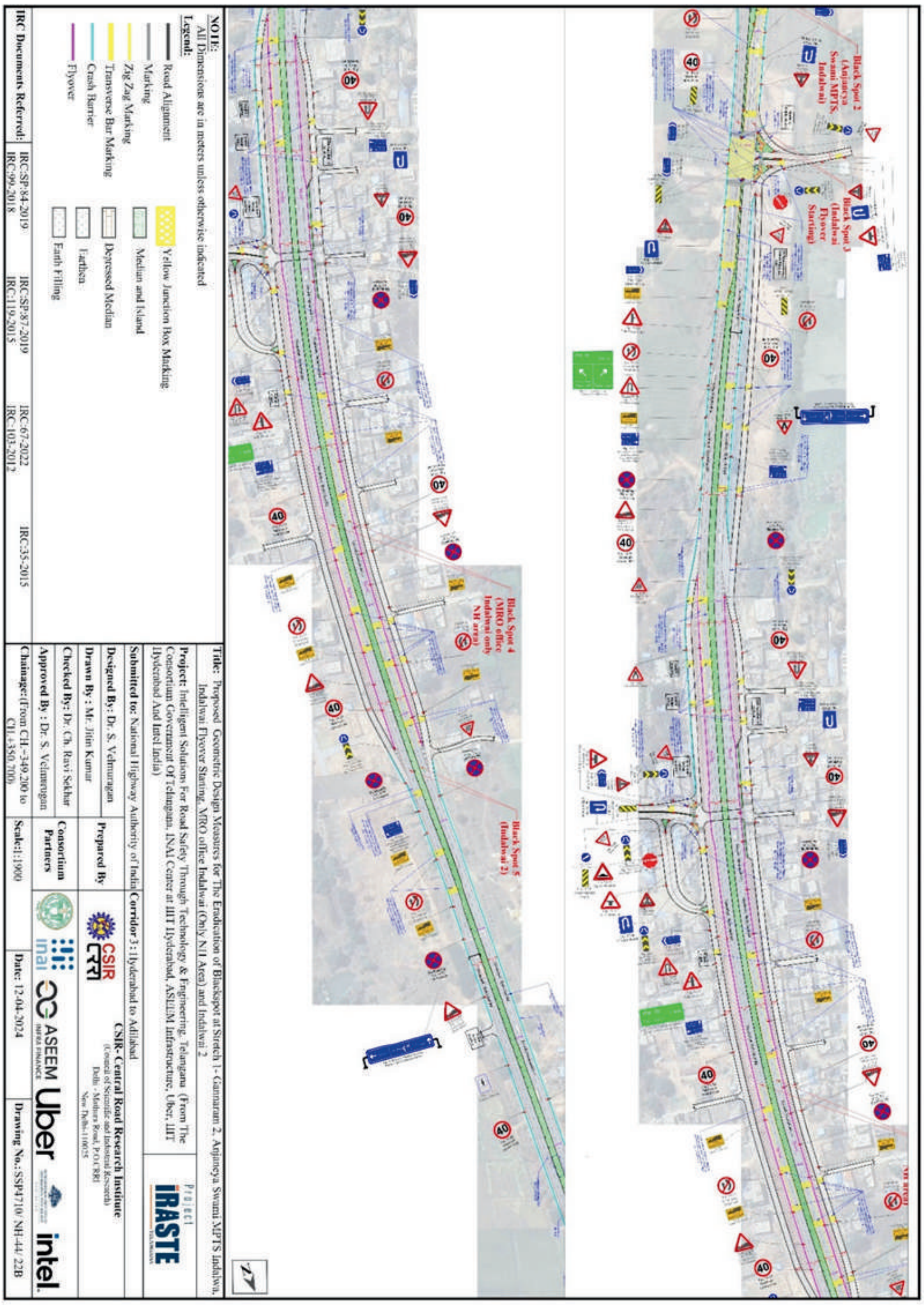


Figure 4.50: Detailed GDP of Stretch 1B: Devapur Forest Area plus Pangadpipri Curved Sections on NH-44

F. STRETCH 1C: Indalwai to Gannaram Midblock Location

Figure 4.51 shows the existing plan of Stretch 1C which starts at the Mission Bhagiratha - Nizamabad 40MLD Water Treatment Plant Indalwai on the way. This blackspot which is primarily a midblock is improved by providing geometric design improvements and the erection of 3 sets of TBMs on the Curved sections of the road section at relevant places coupled with the road signs and enhancement of relevant road markings for delineation and enhanced pedestrian accessibility (refer to Figure 4.52).

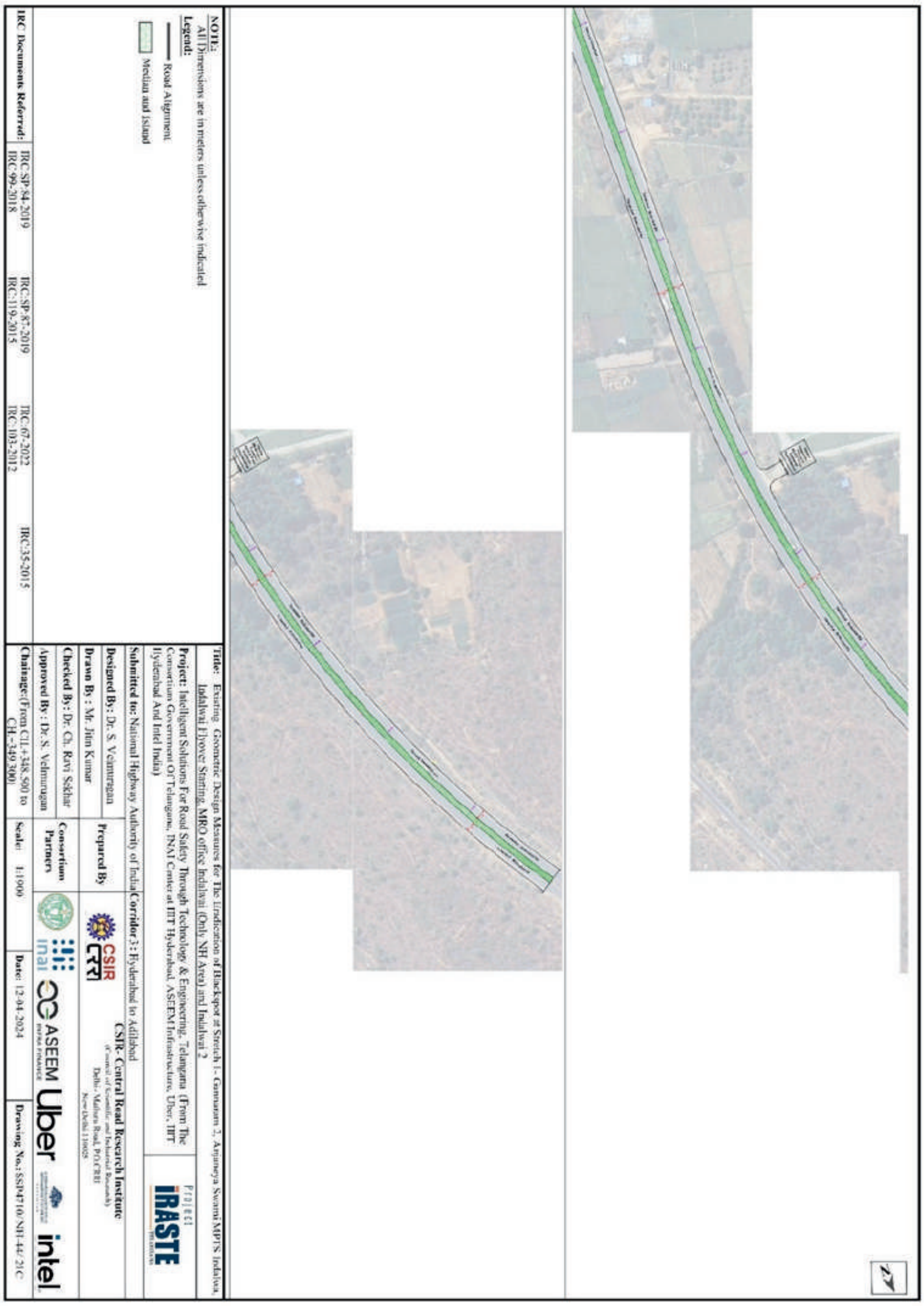


Figure 4.51: Physical Survey Plan of Stretch 1C: Indalwai to Gannaram Midblock Location on NH-44

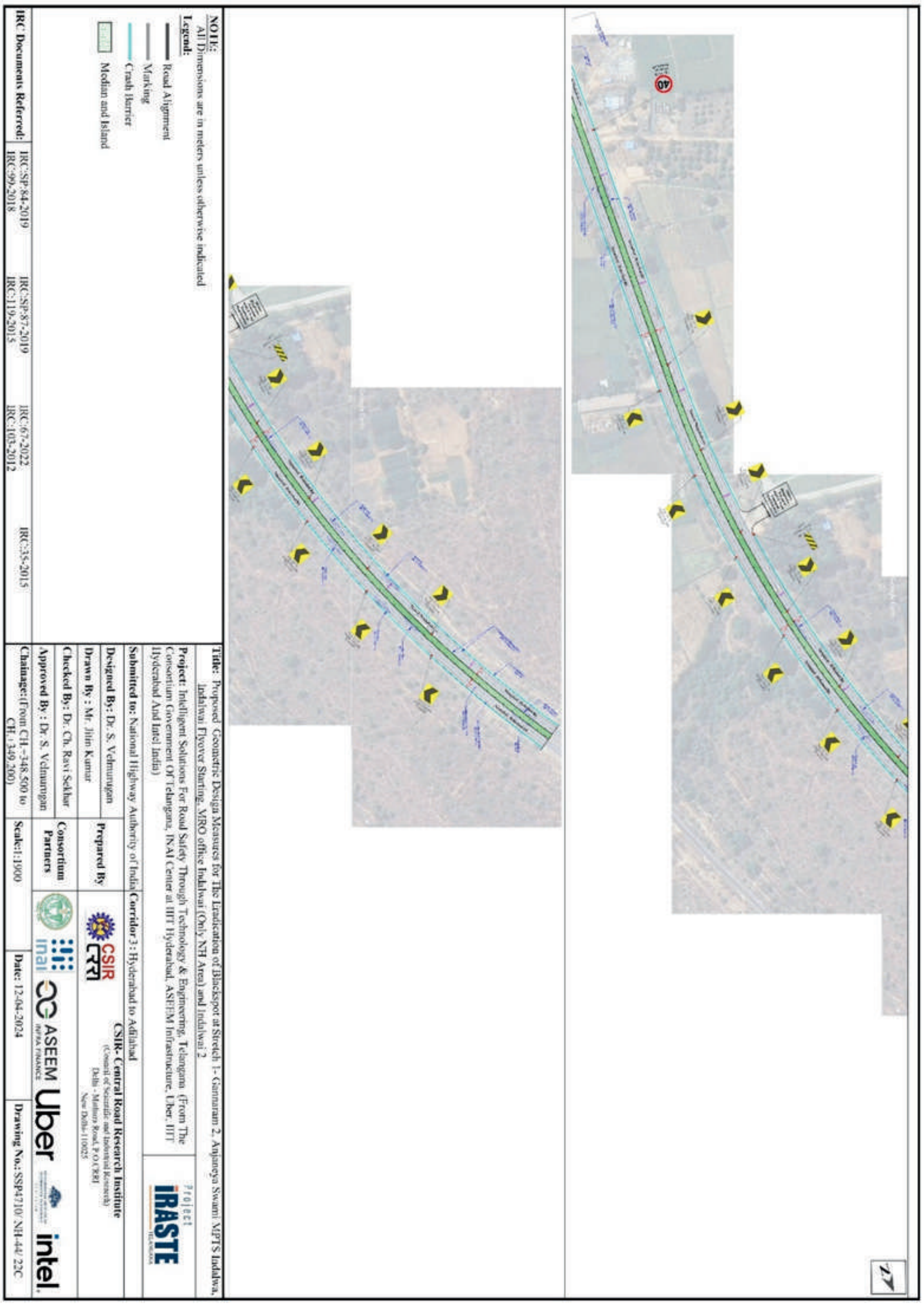


Figure 4.52: Detailed GDP of Stretch 1C: Indalwai to Gannaram Midblock Location on NH-44

G. STRETCH 2A: Devapur Forest to Pangadpipri: Km 203.300 to 205.700

Figure 4.53 shows the existing plan of Stretch 2A starting from Devapur Forest to Pangadpipri ends near bus stop and a minor junction. This blackspot which is blend of midblock with curves and ending with the minor junction is improved by providing geometric design improvements and the erection of 3 sets of TBMs on the Curved sections / Minor Junction of the road section at relevant places coupled with the road signs and enhancement of relevant road markings for delineation and enhanced pedestrian accessibility (refer to Figure 4.54).

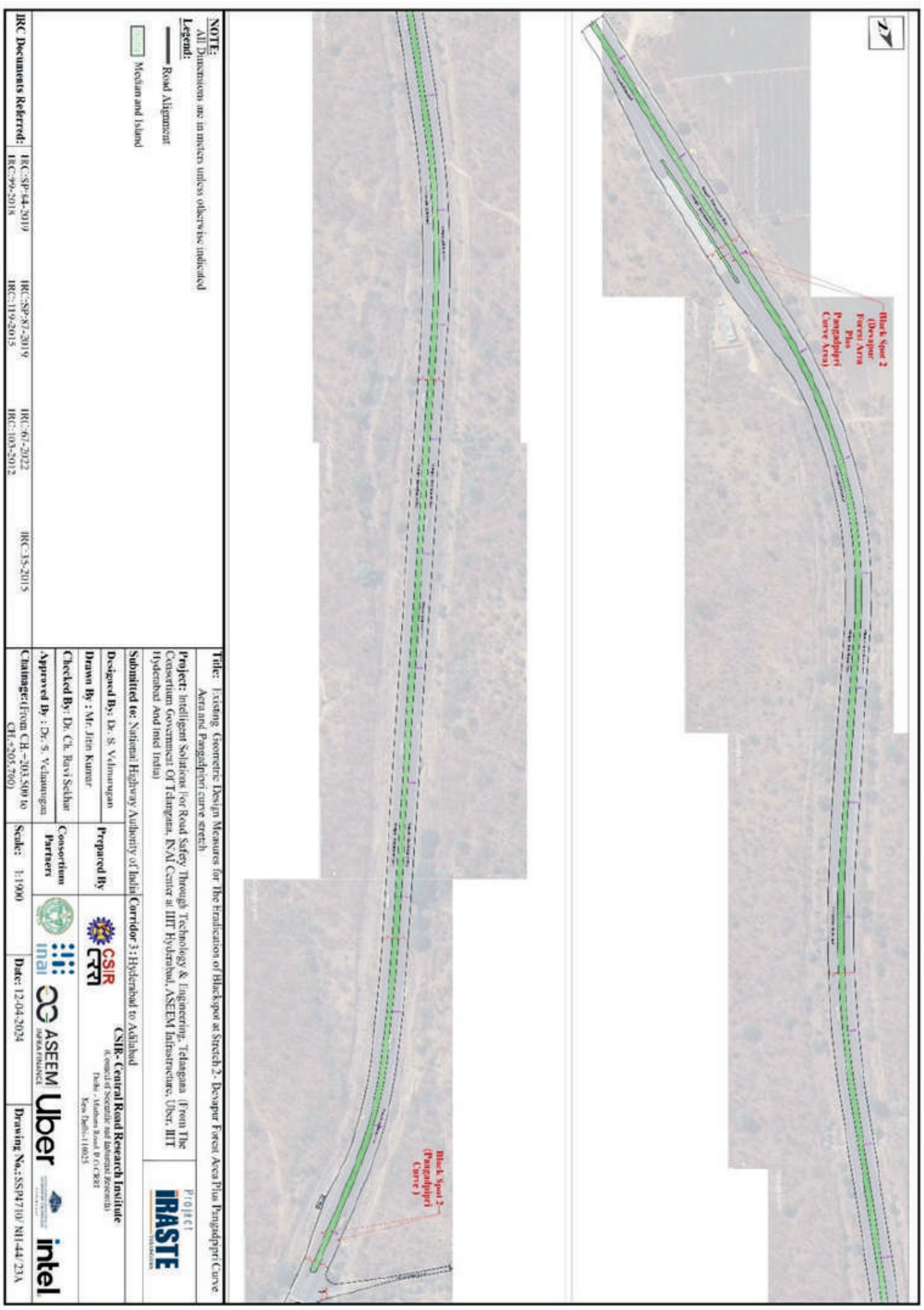


Figure 4.53: Physical Survey Plan of Stretch 2A: Devapur Forest to Pangadpipri on NH-44

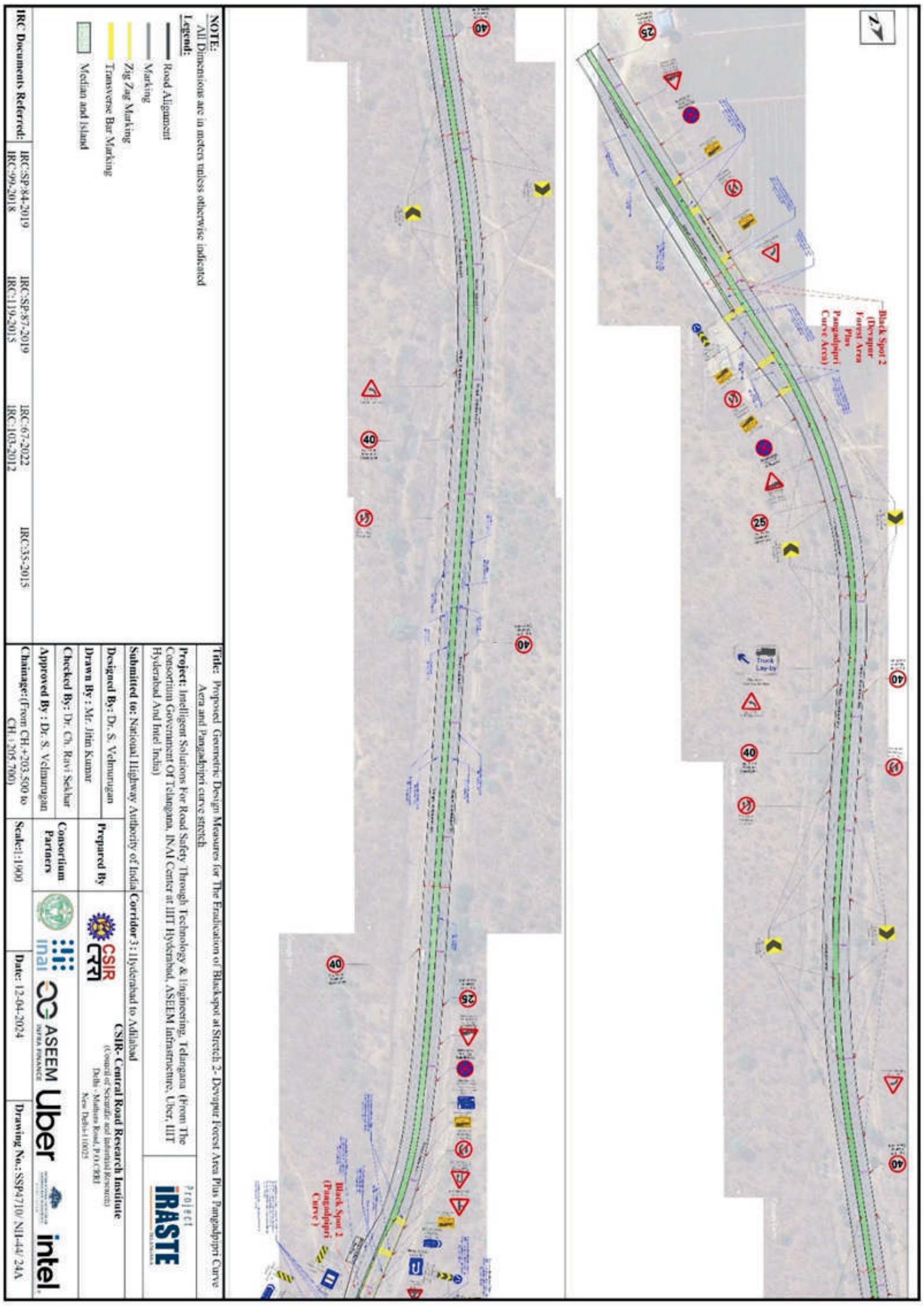


Figure 4.54: Detailed GDP of Stretch 2A: Devapur Forest to Pangadpipri on NH-44

H. STRETCH 2B Devapur Forest to Pangadpipri: Km 203.300 to 205.700

Figure 4.55 shows the existing plan of Stretch 2B Devapur Forest Area to Pangadpipri Curve location. This blackspot which is blend of midblock with curves and ending with a minor junction is improved by providing geometric design improvements and the erection of 3 sets of TBMs on the Curved sections / Minor Junctions of the road section at relevant places coupled with the road signs and enhancement of relevant road markings for delineation and enhanced pedestrian accessibility (refer to Figure 4.56).

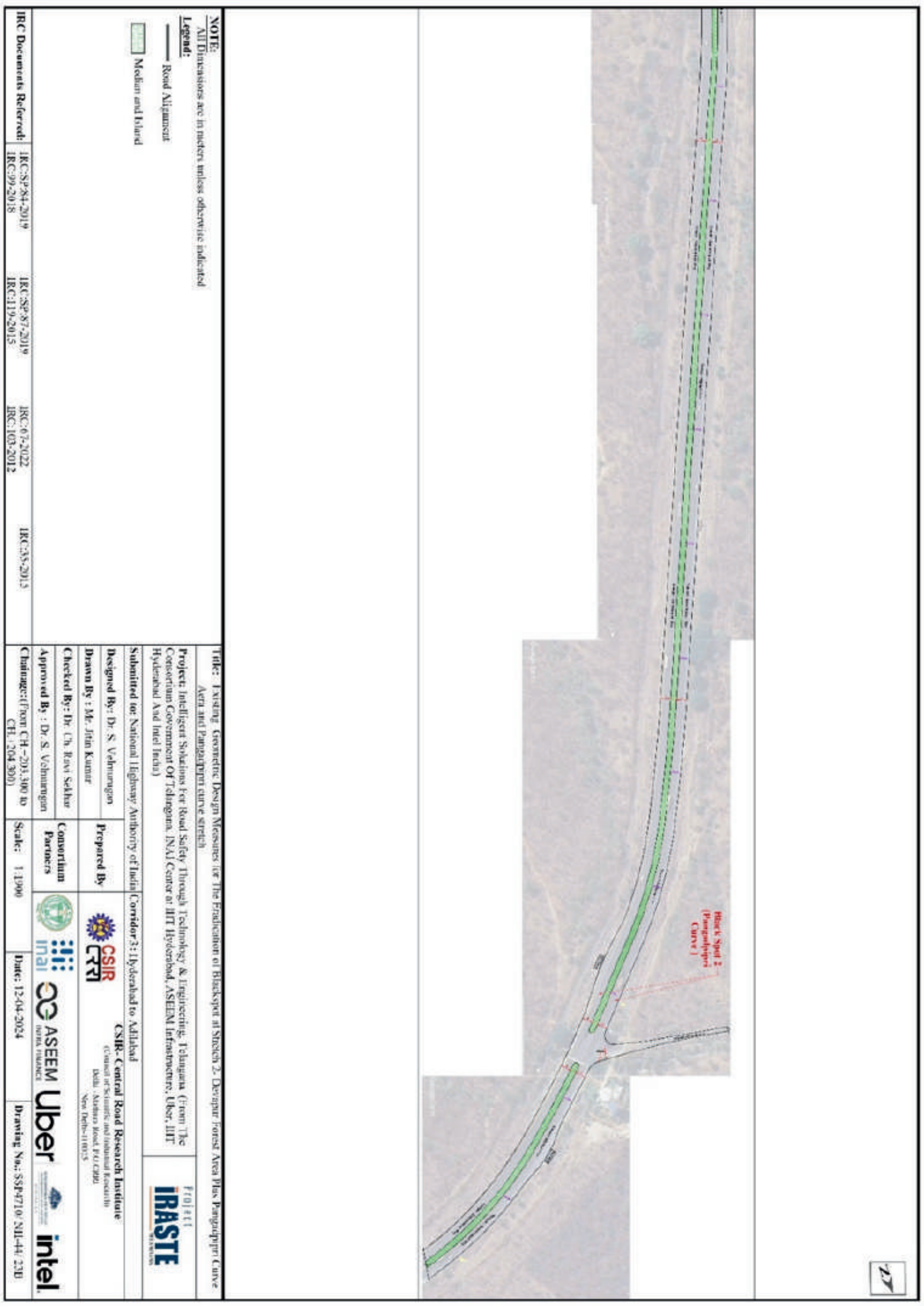


Figure 4.55: Physical Survey Plan of Stretch 2B from Devapur Forest to Pangadpipri) Curve Location on NH-44

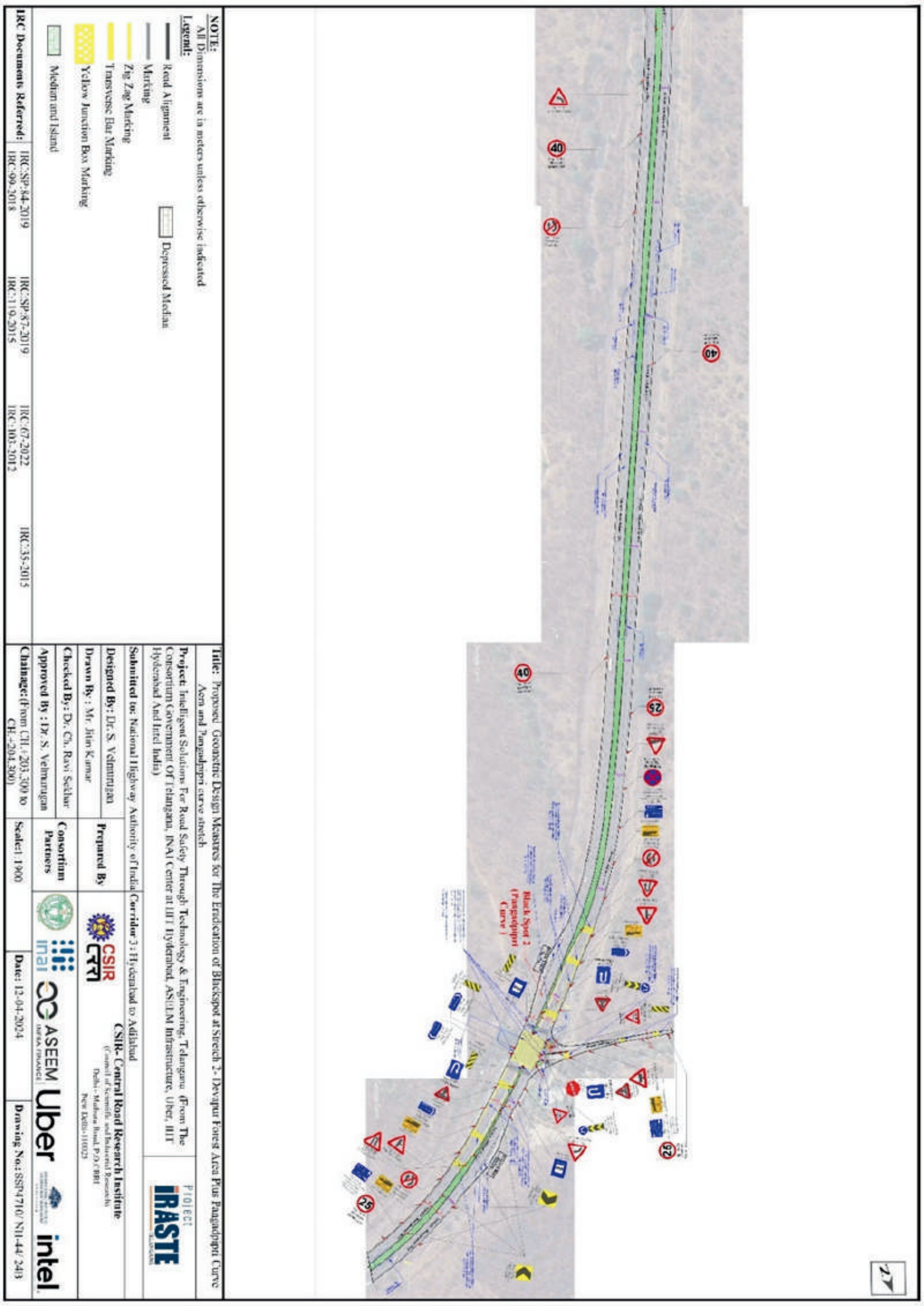


Figure 4.56: Detailed GDP of Stretch 2B from Devapur Forest to Pangadpipri) Curve Location on NH-44

I. THIRAMPALLY

Figure 4.57 shows the existing plan of Thirampally and ends at crossover starting at Km 206.900 to 208.00. This blackspot is improved by providing geometric design improvements and the erection of 3 sets of TBMs on the Midblock section of the road section at relevant places coupled with the road signs and enhancement of relevant road markings for delineation and enhanced pedestrian accessibility (refer to Figure 4.58).

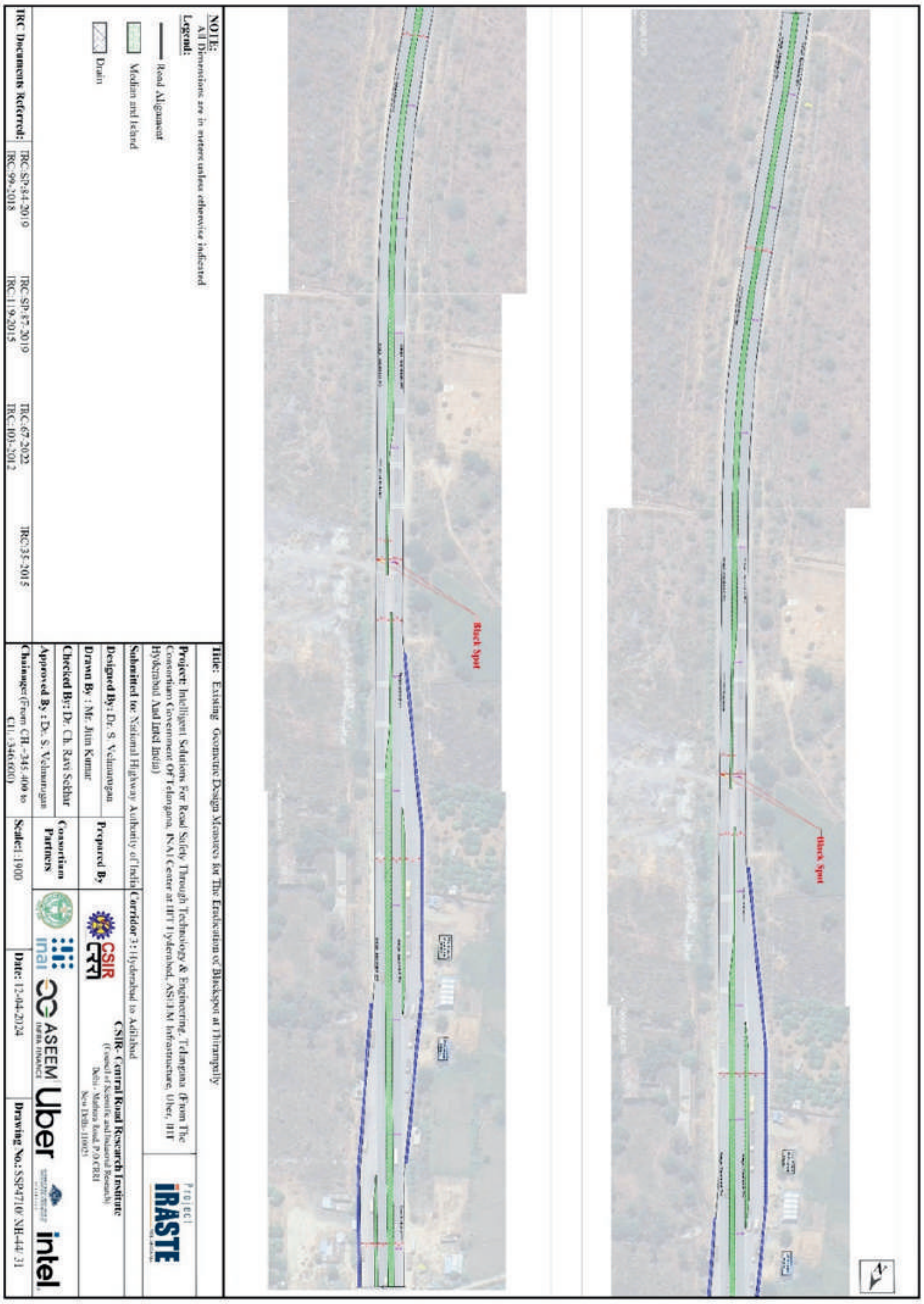


Figure 4.57: Physical Survey Plan of THIRAMPALLY - Existing

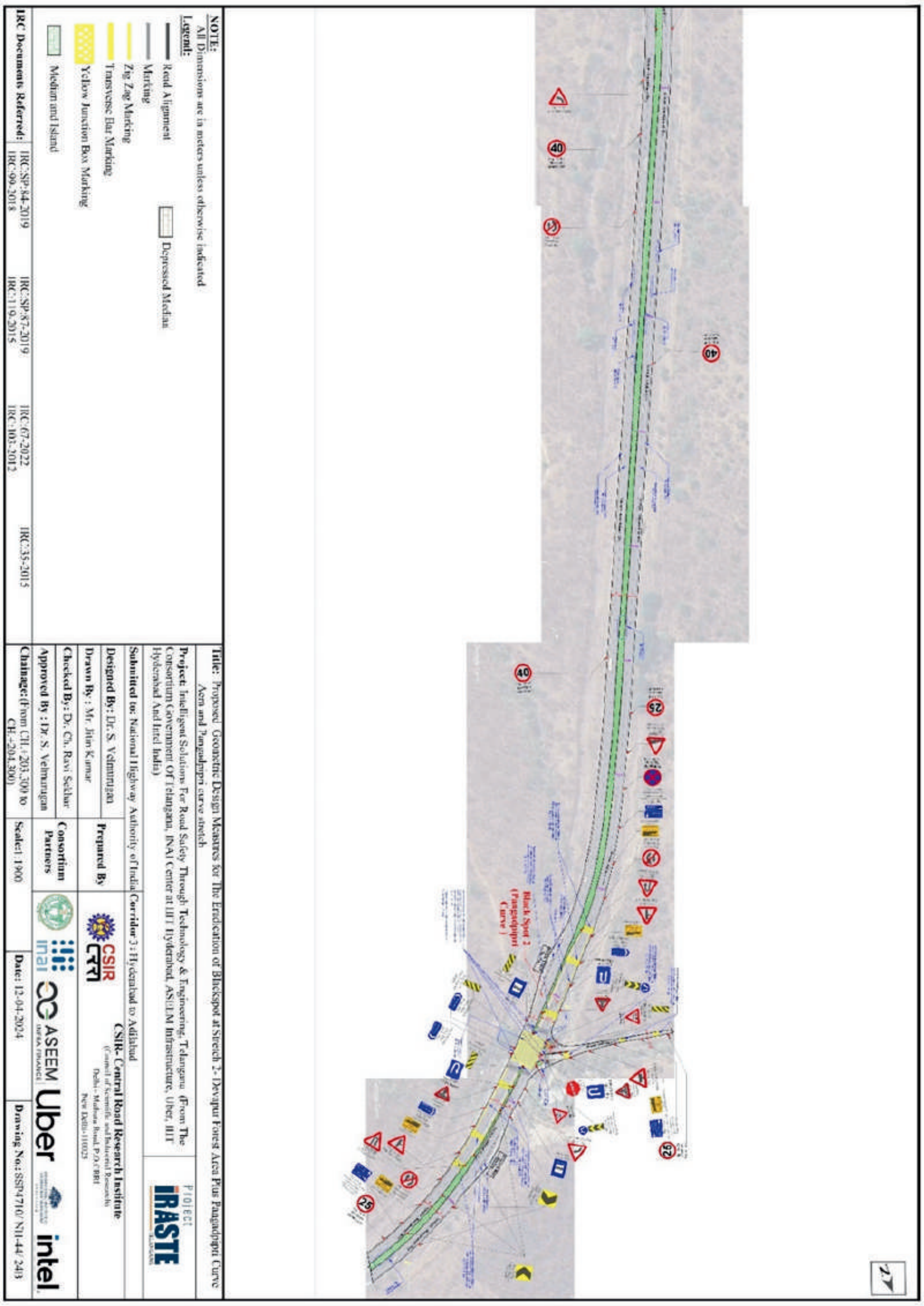


Figure 4.58 Detailed GDP of THIRAMPALLY - Proposed

4.5 Conclusions on Infrastructure Safety Vector

- In this study, a comprehensive analysis was carried out based on the collected crash data for three interurban corridors namely Hyderabad – Kodad section of NH-65, Hyderabad – Pullur section of NH-44 and Hyderabad – Adilabad section of NH-44 and thus identified the blackspots on each study corridors.
- Utilized IRC 131 (2022) manual for the identification of blackspots based on the Average Annual Total Crashes (AATC) method which has the uniqueness of considering the road length, fatal crashes, road type and the associated road parameters while determining the black spots. Based on the above analogy, multiple blackspots were identified in the study corridors of NH-65 and NH-44 highlighting the need for targeted remedial measures which can help to reduce crashes or at least the associated fatalities / serious injuries in the event of a road crash.
- It is hoped that the implementation of the recommended remedial measures for the top 5 identified black spots will enhance road safety on NH-65 and NH-44 corridors. Further, it is also suggested for implementation of the cost-effective improvement measures deduced based on the grey spot model results under the 'Mobility Safety' Vector.
- Conduct further study to evaluate the effectiveness of these recommended measures in reducing crashes and improving road safety.

4.6 Recommendations

- Regularly monitor and evaluate the implemented remedial measures to identify any emerging road safety issues and address them promptly.
- Foster collaboration between road safety practitioners, policymakers and relevant stakeholders to ensure the successful implementation of road safety measures.
- Increase public awareness and education campaigns to promote responsible road behavior, adherence to traffic rules, and the importance of road safety.

4.6.1 Short-term Recommendations (0 - 2 Years)

- Improve road signage and markings to enhance visibility and guidance for motorists.
- Improve emergency response systems and services along NH-65 & NH-44.
- Enhance street lighting in high-risk areas to improve visibility during night time in the urban areas of the corridor.
- Implement regular road maintenance and repair to address potholes and uneven surfaces.
- Conduct regular road safety audits to identify and address emerging safety issues.
- Conduct public awareness campaigns to educate road users about safe driving practices and drivers.
- Enhance the deployment of ADAS.
- Enhance intersection design and signalization to improve traffic flow and reduce conflicts.
- Construct pedestrian crossings and footpaths to ensure safe pedestrian movement.

4.6.2 Long-term Recommendations (2-5 years)

- Increase enforcement measures to curb speeding and reckless driving through the implementation of AI based Speed Enforcement System cameras.
- Implement intelligent transportation systems (ITS) to enhance traffic management and control.

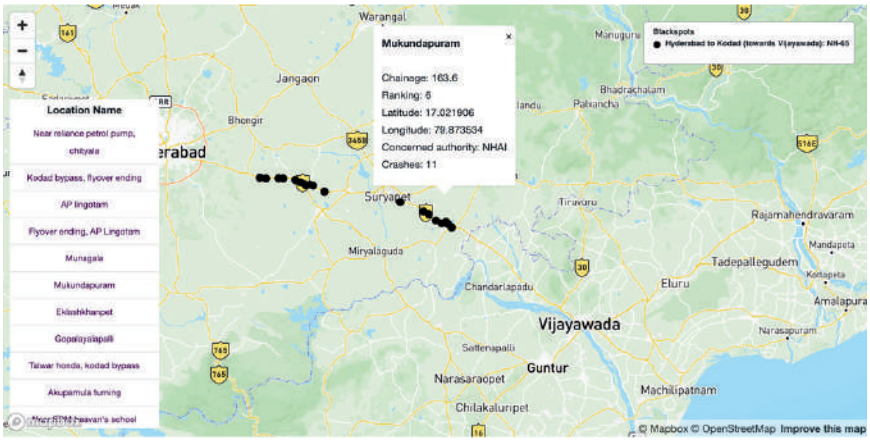
4.7 Outcomes

- Analyzed Blackspots for all 3 corridors and Identified top 15 Blackspots (5 for each corridor)
- Ranked them by severity & generated Detailed Project Report (DPR) for 15 Blackspots including corrective actions.
- 3 WIP on NH65. Tender for 3 on NH44.

Blackspot Maps

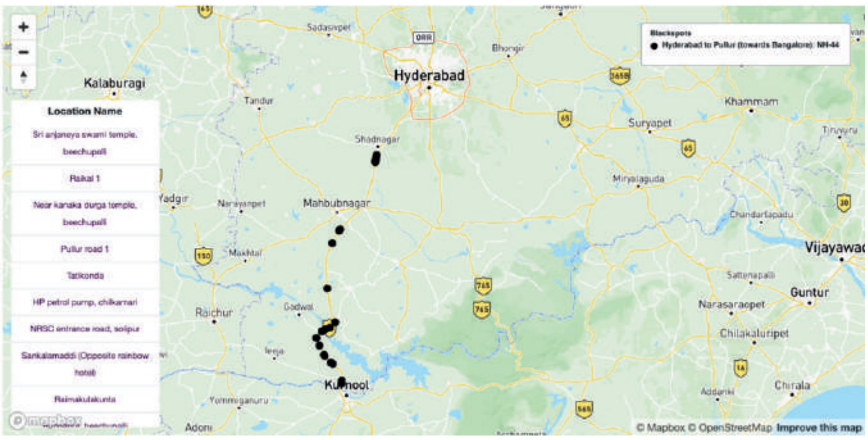
Hyderabad to Kodad (towards Vijayawada) NH-65: 18 Spots

The below map shows the top 20 identified segments of the second study corridor of NH-44 from Hyderabad to Pullur, covering a length of 180km during the quarter 4 of 2023



Hyderabad to Pullur NH-44: 23 Spots

The below map shows the top 20 identified segments of the third study corridor of NH-44 from Hyderabad to Adilabad, covering a length of 300km during the quarter 4 of 2023



Hyderabad to Adilabad NH-44: 20 Spots

Greyspots are the most unsafe locations/segments beyond the known blackspots that require corrective measures to minimize the probability/possibility of road crashes, especially road fatalities. The below map shows the top 20 identified segments of the first study corridor of NH-65 from Hyderabad to Kodad, covering a length of 150km during the quarter 4 of 2023.

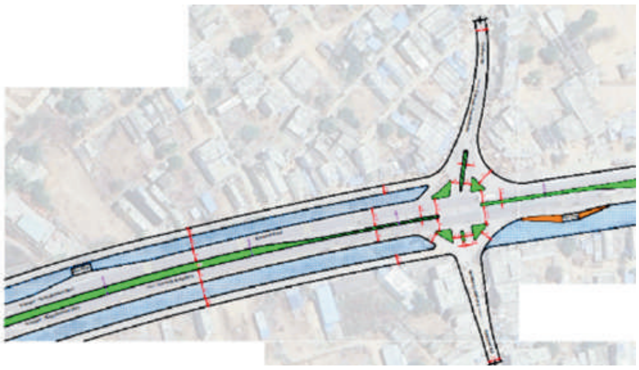
Blackspot DPRs

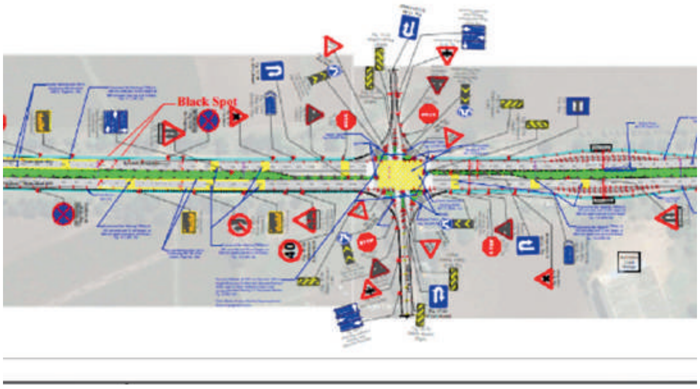
NH 64

Ranking	Blackspot Name
1	Kodad bypass, flyover ending
2	Infront of HPCL petrol pump, Mazidpur
3	Suryatej colony intersection, maruthinagar
4	Kanakadurga nagar
5	AP lingotam
6	Auto sai nagar colony (Dwarkamai)
7	Abdullapurmet
8	Flyover ending, AP Lingotam
9	Sri asta lakshmi arch
10	Mukundapuram
11	Talwar honda, kodad bypass
12	LB nagar metro intersection
13	Shanti nagar intersection, Pedda Amberpet
14	Palegars cuisine, ramoji film city
15	Tupranpet
16	Eklashkhanpet
17	Akupamula turning
18	Near SRM heavan's school
19	Medplus, hayathnagar
20	Gopalayalapalli
21	Muthyalamma Gudem
22	Hotel jayadeep, kodad bypass
23	Near reliance petrol pump, chityala
24	Chaitanyapuri metro station
25	Tharun tea point, batasingaram
26	Pedda amberpet intersection
27	Munagala
28	Gundrampally

NH 44

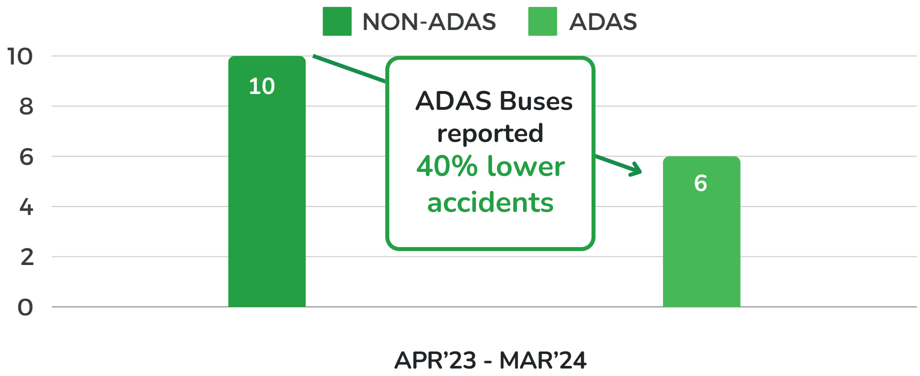
Ranking	Blackspots Location name
1	Sri anjaneya swami temple, beechupalli
2	Raikal 1
3	Near kanaka durga temple, beechupalli
4	Pullur road 1
5	Tatikonda
6	HP petrol pump, chilkamari
7	NRSC entrance road, solipur
8	Sankalamaddi (Opposite rainbow hotel)
9	Raimakulakunta
10	Rangapur, beechupalli
11	Beechupalli bridge
12	Kothakota (Mother Terressa square)
13	Sri venkateshwara hotel
14	Raikal 2
15	Annasagar
16	Vallur intersection
17	Chandapur
18	Jankalapalli (Putandoddi)
19	Bit break, pullur
20	Pullur road 2
21	Kodandapuram (Sri santh hotel)
22	Near shadnagar toll plaza busstop
23	Maddilety dhaba, pebbair



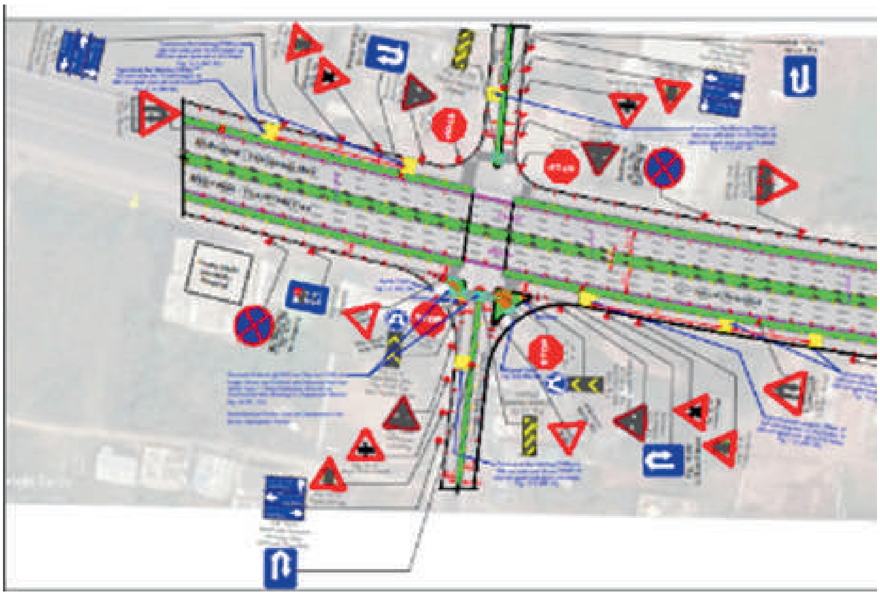


Project iRASTE is India's largest & longest-running study of ADAS for Commercial Vehicles

40% Lower Fatal Accidents in ADAS buses compared to Non-ADAS.



15 DPRs submitted to NHAI. 3 WIP on NH65. Tender for 3 on NH44



Greyspot Algo updated for Highways. 60 Greyspots identified in the 3 corridors.

EDUCATION, AWARENESS, AND EMERGENCY CARE

5

5.1. Saving Lives

For Education, Awareness and Emergency care component of iRASTE-Telangana, the Indian Institute of Public Health- Hyderabad (Public Health Foundation of India) was co-opted. Every hour, 15 lives are lost, and 17 individuals are injured in road accidents in India, according to the Ministry of Road Transport and Highways (MoRTH). Worryingly, at least one person becomes disabled every minute due to road crashes. In 2021, these numbers added up to a staggering 1,53,972 deaths and 3,84,448 reported injuries from road crashes. [i] This is not just a statistic but a critical issue that demands the nation's immediate attention and action. The time to act is now.

Addressing road crashes necessitates an interdisciplinary approach, integrating engineering, technology, public health, and clinical treatment solutions. Road Traffic Injuries (RTIs) and associated fatalities are not solely due to driver, vehicle, or road factors; they can also stem from delayed, inadequate, or substandard medical responses and socio-economic factors influencing access to optimal medical treatment and rehabilitation services.

Bystanders, the best bet: Given that India is witnessing a steady increase in fatalities and injuries from road crashes, it is crucial to recognize the pivotal role of bystanders in saving lives. Their comprehensive understanding of road user behaviour, the immediate reactions of bystanders and people in the vicinity, and their capacity to avoid hazardous situations through experiential learning are paramount. It is also critical to establish 'Trystander' cells (cabins or kiosks at identified blackspots on roads and highways equipped with first aid kits and stretchers) to empower bystanders to promptly provide essential medical assistance to crash victims. When a crash occurs on Indian roads, people in the vicinity often provide immediate assistance using methods that may lack scientific validity. Therefore, public awareness and training in first aid, and especially in Active Bleeding Control techniques, can substantially improve India's road crash victims' survival rate.

The critical Golden Hour assistance: Mass awareness and scientifically validated training that helps the first responders keep calm and render scientific first aid techniques through emergency responses such as cardiopulmonary resuscitation, bleeding control techniques, and proper handling of victims within the first few minutes or the Golden Hour of a road crash before the arrival of an ambulance and medical/paramedical staff can make a difference between life and death or disability. Readily available first aid kits from strategically located Trystander cells along the roads and highways can make passive 'bystanders' active 'Try'standers significantly mitigate road crash fatalities.

From injuries to recovery: Besides the critical emergency response and attention to crash victims during the Golden Hour, ensuring a continuum of care from the crash site through the medical care and painful rehabilitation phases can significantly mitigate the severity of injuries.

AI tools, awareness and training: Identifying best practices and use cases at the confluence of public health and technological solutions, such as the use of Artificial Intelligence (AI) in predicting crash-prone areas and the implementation of Community-based First Aid Training programs is essential for developing cost-effective interventions suitable for various environments.

5.1.1 Active Bleeding Control(ABC)

As a gravely injured person can bleed to death in approximately 5 minutes, [i] uncontrolled bleeding is a major cause of preventable deaths. Approximately 40% of trauma-related deaths worldwide are due to excessive bleeding or hemorrhage and its direct consequences. [ii] Given this scenario, training people in basic bleeding control techniques, especially bystanders who are often the first responders to road crashes, is imperative to save lives. Hands-on training through simulated scenario-building exercises can help people to be better prepared to respond during any life-threatening bleeding emergency.

Active Bleeding Control (ABC) training equips people to identify and inspect the wound, followed by three emergency bleeding control techniques:

a. Applying pressure: Use a clean pad to apply firm and constant direct pressure on the wound. If blood soaks through the pad, leave it in place and apply a second pad on top of the first. Maintain continuous, direct pressure until the bleeding is controlled.

b. Packing the wound: Once the bleeding is effectively controlled, pack the wound with a clean bandage over the dressing pad/s to stem further bleeding.

c. Placing a tourniquet: A tourniquet is a band of cloth or rubber wrapped tightly 2 to 3 inches above the source of the bleeding and between the source of bleeding and the hears. For example, the emergency response must apply a tourniquet to the upper arm if the wound is on the forearm.

5.1.2 iRASTE-Telangana Active Bleeding Control (ABC) Tool Kit

Project iRASTE-Telangana seeks to revolutionize road safety by combining the predictive capabilities of Artificial Intelligence (AI) and the power of mass awareness to improve driving behaviour and skill-building through its ABC Training module. iRASTE employs AI as a force multiplier in transforming road safety engineering by generating predictive insights to help prevent crashes from occurring. The AI system analyses factors such as road conditions, driver behaviour, and vehicle performance to predict potential chances of collisions/violations and provide timely early warnings. Under its comprehensive Safe Systems Approach (SSA), iRASTE-Telangana has equipped 200 buses with ADAS and trained over 500 bus drivers of TGSRTC to improve their driving behaviour.

The ABC Toolkit, designed for managing active bleeding in emergencies like major/minor injuries, is the result of a previous collaborative effort involving various stakeholders such as Indian Institute of Public Health-Hyderabad (Public Health Foundation of India), PediStars, the Children's Hospital of Philadelphia-USA, the Road Safety Club of Hyderabad, the Indian Development Foundation, GVK - Emergency Management and Research Institute (EMRI) and Transport Department, Government of Telangana. This collective effort underscores the shared responsibility of all stakeholders in addressing road safety.

The "*Active Bleeding Control – Stop the Bleed*" initiative aims to equip ordinary citizens with essential life-saving skills to manage severe bleeding in road traffic incidents effectively. It trains first responders, typically those who arrive/present initially at the scene of a crash, in identifying and managing life-threatening bleeding incidents using sound and proven scientific methods. It includes promptly contacting emergency services and applying pressure or using tourniquets to staunch bleeding until an ambulance arrives with professional help.

As mentioned above, studies on road injuries indicate that neglecting these immediate interventions jeopardizes a substantial number of lives and limbs that could otherwise be saved from irreparable harm.

iRASTE-Telangana's ABC training program is a distinct and successful collaborative endeavour. It identifies hotspots along highways or considered road networks and equips the potential first responders, including chaiwallahs, auto drivers, the people in the neighborhood, and emergency response teams, with essential skills to provide immediate assistance and ABC techniques to RTI victims.

iRASTE-Telangana implemented its ABC training program to reduce road crash fatalities and disabilities by employing the following measures:

a. Awareness Generation: Disseminate information about road traffic injuries in identified hotspots through a concise module based on evidence-based scientific principles. The module covers the causes, preventive mechanisms, and consequences of road traffic injuries.

b. Simulation-Based Capacity Building: Train potential first responders using simulation techniques grounded in the "learning by doing" principles of active bleeding control.

c. Communication Network: Create a WhatsApp group for trainees to share information, report the number of individuals they have assisted, discuss strategies, and follow up on incidents. This network is a real-time coordination and communication platform, ensuring the volunteers can effectively share their experiences and learn from each other's responses. It also allows for the immediate reporting of incidents, which helps in the timely dispatch of professionals who can help save lives. The communication network is thus a crucial component of the ABC training program, enhancing the effectiveness of the overall response to road crashes.

d. Evaluation of Training Effectiveness: Conduct pre and post-training assessments to measure improvements in the knowledge and skills of first responders. Such assessment includes tracking the number of successful interventions, the time taken to assist and the outcomes of the victims, validated through the collection of data through questionnaire surveys and data analysis. Such a rigorous evaluation process ensures the quality and effectiveness of the training.

e. Skill Demonstration: Demonstrate proficiency in using the ABC toolkit gained by the trainees under the program.

f. Impact Assessment: Measure the impact of the training using specific indicators.

g. Healthcare Facility Mapping: Identify healthcare facilities near selected hotspots to serve as resources for trainees and coordinate with hospitals to track patient outcomes from admission to discharge.

h. Information Consolidation: Compile comprehensive data on the outcome of the use of the ABC technique on road crash victims and care pathways from the crash site to admission in a hospital and rehabilitation/recovery.

i. Consultation Report: Prepare a brief report on findings from the pilot program to guide potential expansion to other corridors.

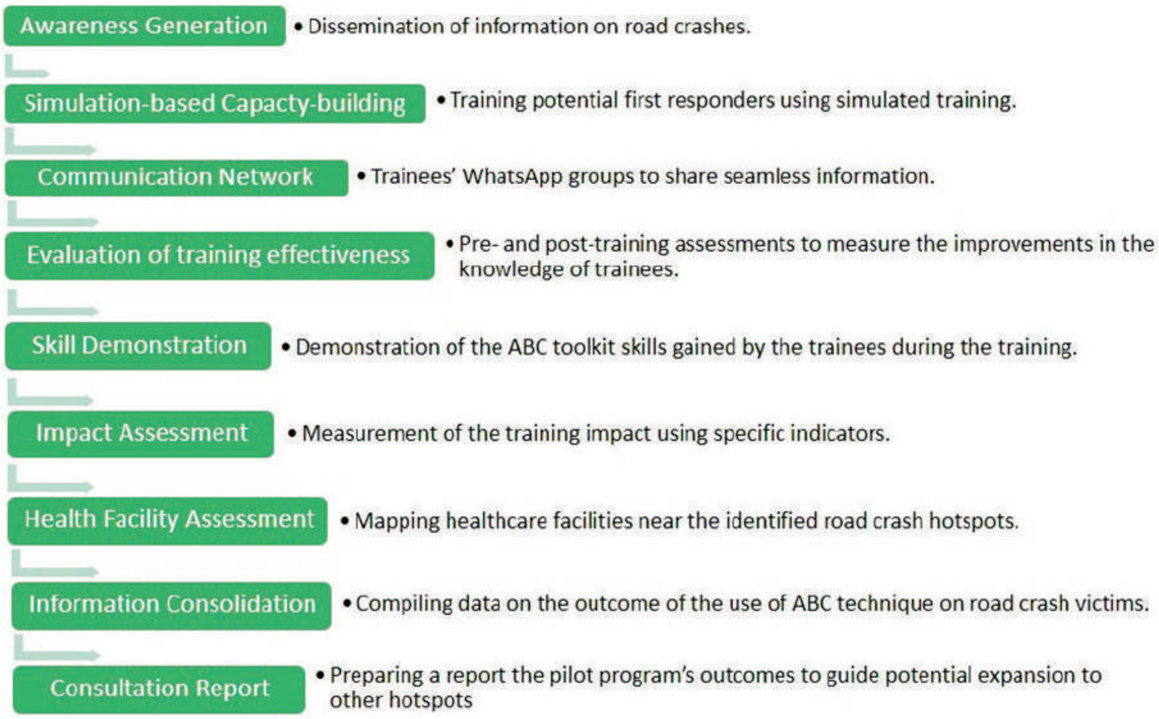


Figure 5.1: The critical components of iRASTE-Telangana's ABC training program

The pilot ABC program in 2019 effectively used simulated scenarios to train 1,005 volunteers in Hyderabad to control the bleeding of crash victims using simple ABC techniques. In a measure of the success of this initiative, 162 of the trained volunteers self-reported assisting road crash victims along selected highway corridors. The ABC training pilot program demonstrates how training potential first responders to help crash victims can transform passive bystanders into active responders. Statewide, since its inception, the ABC training program has successfully trained over 8,000 first responder volunteers, significantly enhancing the on-site capacity to reduce road crash-related fatalities in Telangana.

5.1.3 Objectives of ABC Training

iRASTE's ABC training program's primary objective is to ensure a consolidated approach to mitigate road crash fatalities and disabilities through the following integrated technological solutions, public health strategies, and clinical interventions.

- Educating participants on the individual, social and economic impact of road crashes and making them aware of the criticality of resulting injuries and deaths as a public health issue of national importance.
- To empower first responders with the skills to identify life-threatening bleeding and provide care until professional help arrives.
- Training participants in the critical steps of active bleeding control techniques to enhance their skills and improve the management of bleeding emergencies.
- To assess participant's knowledge of active bleeding control through pre and post-training surveys.

5.1.4 Methodology & Approach

The ABC training program employs a four-step methodology consisting of a pre-evaluation of participants, ABC training sessions, and a post-evaluation assessment of the trained individuals. Figure 5.2 outlines this approach:

Step 1: Pre-Evaluation of Participants	The initial step includes a comprehensive pre-evaluation of the volunteers who can be readily available at all times near a road crash site
Step 2: ABC Training	Educational videos on the five steps of Scene Safety: Call a Ambulance, Look for active bleeding, Apply direct pressure on the bleed, and Apply a Torniquet demonstration of these five steps by the ABC team. Participant skill demonstration in simulated scenarios
Step 3: Post-Training Assessment	The post-training assessment of the participants to gauge the improvement in their skills
Step 4: ABC Training Certification	All the participants are awarded iRASTE-Telangana's ABC training certificates after successful completion of the training and skill assessment

Figure 5.2: ABC training program's four-step methodology

STEP I: PRE-EVALUATION OF THE PARTICIPANTS

The ABC training program's primary goal is to educate the first responders and adequately equip them with the skills necessary to identify life-threatening bleeding and provide care until professional assistance arrives. The selection process involves identifying potential first responders from various functional groups, including ATM and other security guards, petrol station employees, auto drivers, shopkeepers, and roadside Dhaba workers or chaiwallahs. Once selected, these individuals undergo rigorous training that includes both theoretical knowledge and practical skills in active bleeding control.

STEP II: ABC TRAINING SESSIONS

The training sessions begin with discussions emphasizing the importance of Active Bleeding Control (ABC) and the need for immediate action in severe bleeding situations. The awareness campaign is conducted through the following methods:

- **Educational Videos on ABC 5 Steps:**
  Participants are shown videos explaining the five crucial steps of ABC: i) ensuring scene safety, ii) contacting emergency services (ambulance), iii) identifying life-threatening active bleeding spot/s, iv) applying direct pressure, and v) applying a tourniquet. These visual aids enhance participants' understanding and retention of key concepts.

- **Demonstration of 5 Steps by ABC Team-Simulation training**

The ABC team conducts interactive role-playing exercises to demonstrate each ABC step in real-life scenarios. This hands-on approach allows participants to observe practical applications of ABC techniques, fostering a deeper comprehension of the protocols.

- **Participant Skill Demonstration**

Participants are given opportunities to practice and demonstrate the ABC skills learned from the training program in simulated scenarios. Trainers provide immediate guidance and feedback to ensure participants master the techniques effectively. This practice continues until each participant has perfected the techniques.

STEP III: PRE- AND POST-EVALUATION ASSESSMENT SURVEYS

- Knowledge levels regarding overall knowledge of the ABC technique
- The average score of individuals regarding ABC steps
- Knowledge level improvement regarding ABC Step I: Scene Safety
- Knowledge level improvement regarding ABC Step II: Activating Ambulance
- Knowledge level improvement regarding ABC Step III: Identifying Life-Threatening Bleeding
- Knowledge level improvement regarding ABC Step IV: Application of Direct Pressure
- Knowledge level improvement regarding ABC Step V: Application of Tourniquet
- Knowledge regarding the right methods to apply direct pressure on bleeding wounds
- Knowledge level regarding situations in which to use a tourniquet.

5.2 iRASTE' S ABC Training Program In Telangana

iRASTE-Telangana's pilot ABC training program implemented in partnership with the Indian Institute of Public Health (IIPH) and the iRASTE team in the state of Telangana focused on the Hyderabad city to Kodad town (towards Vijayawada) stretch, the state's major road corridor. This corridor was selected based on its significant incidence of road traffic injuries (RTIs) and crashes, with preliminary mapping and GIS coordinates already established for the Hyderabad to Kodad corridor (towards Vijayawada). The program entailed training first responders on scientific bleeding control techniques.

The iRASTE-Telangana project implemented the pilot ABC training program in the following seven road crash hotspots identified along the Hyderabad to Kodad corridor (towards Vijayawada). The locations with the highest-risk profiles indicated by the Council of Scientific and Industrial Research's Central Road Research Institute (CRRI) and the National Highway Authority of India (NHAI) data on road crashes and fatalities were prioritized.

- Panthangi toll plaza
- Gundrampally
- Chityala
- Chilkakallu toll plaza
- Mungala
- Panthangi toll plaza to Muthyalamma Gudem
- Kodad

The iRASTE team selected the hotspots based on a detailed analysis of three years of road crash data (2020 to 2022). The Panthangi toll plaza location was chosen as the inaugural site for the ABC training program in the state.

Potential first responders, including ATM security guards, petrol pump workers, auto drivers, shopkeepers, and workers at roadside dhabas and chai shops, were identified based on lessons learned from previous ABC projects in Hyderabad city. These identified groups of responders were imparted training tailored to their functional roles, focusing on principles of road traffic injury prevention and skills for active bleeding control.

Covering a radius of approximately 500 meters around each crash hotspot identified solely for training purposes, the training sessions were conducted for about 35-40 individuals per functional group per day, organized into smaller, individual groups. Accordingly, the ABC training covered more than 600 people in the corridor hotspots within 12 to 14 weeks. This comprehensive approach ensured that a substantial number of potential first responders along these high-risk corridors were equipped to respond to road crashes, render timely assistance and first aid, employ the ABC technique, and mitigate consequential deaths and disabilities effectively.

The training sessions commenced with a senior IIPH representative highlighting the critical need for providing timely emergency care to RTI victims on Indian highways following accidents and the challenges encountered. The participants were explained the vital role of bystanders or people in close vicinity of the road crash, as the first responders, saved lives by offering immediate assistance to the injured during the crucial first few minutes after the accident. They were also made aware of the specific scenarios in which the ABC protocol must be applied, contingent on the nature of the victim's injuries and the five essential steps for administering ABC to a victim.

- Ensuring scene safety,
- Calling for an ambulance,
- Identifying life-threatening bleeding,
- Applying direct pressure and
- Utilizing a tourniquet.

The participants—in smaller groups—were then put through rigorous role-playing exercises within a simulated road crash scenario under the careful supervision of master trainers. The purpose was to internalize the lessons and standard operating procedures for responding to road crash emergencies. The participants were also taught to use the ABC kit correctly through mock demonstrations.

The participants were then evaluated to ascertain the post-training enhancement of their knowledge, understanding and skills. The participants were awarded the training certificates after the training program. They were also given the ABC tool kits for ready use in any road crash incidents they may witness in the future.

5.2.1 Panthangi Toll Plaza

The first training program was conducted on March 20, 2024, at the Panthangi toll plaza (Latitude 17.23° N, Longitude 78.95° E), located approximately 60 km from Hyderabad along the Hyderabad to Kodad corridor (towards Vijayawada). Distinguished attendees included Mr. Varma Konala, CEO of INAI – Applied AI Research Centre of IIIT Hyderabad; Mr. Govind Krishnan, Program Manager of iRASTE-Telangana; Dr. Shailaja Tetali, Professor and Dean of Research at IIPHH; Dr. Ch. Ravisekhar, Chief Scientist at CSIR - CRRI; and Mr. V. N. S Srikanth, Project Manager at GMR, among others. Forty-eight participants who were put through the pre-evaluation survey attended the inaugural two-hour training session.

Figure 5.3: ABC Training program at Panthangi Toll Plaza

The post-evaluation of participants assessed the efficacy of the training program. The evaluation revealed a notable enhancement in participant's understanding of active bleeding control after going through the training sessions. Before the training, the average knowledge score stood at 37.9%, which markedly increased to 92.2% post-training (shown in Figure 5.4 below), reflecting a significant improvement of 54.3%. This outcome underscores the positive influence of the training program on participant's proficiency in bleeding control, demonstrating substantial progress across all evaluated aspects.

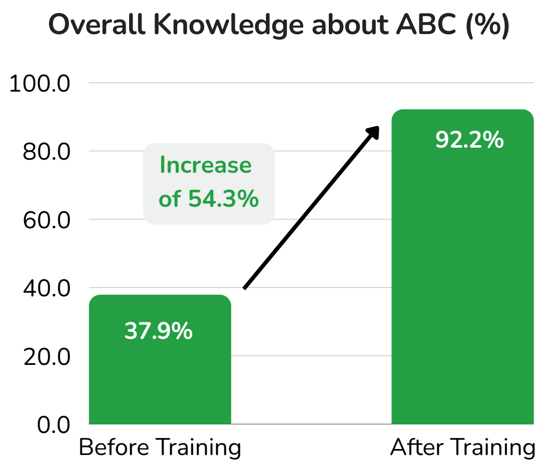


Figure 5.4: The increase in knowledge levels about ABC among volunteers from 37.9 before to 92.2% after training

A detailed microscopic assessment was conducted to evaluate the improvement in knowledge regarding each of the five steps of the ABC toolkit, aiming to assess the program's effectiveness. Before training, participant's average scores in various aspects of bleeding control were as follows:

- 51.7% in recognizing scene safety considerations,
- 57.8% in knowing how to activate emergency medical services,
- 44.8% in identifying signs of life-threatening bleeding,
- 37.9% in proficiency in applying direct pressure, and
- 36.2% in knowledge and skills related to tourniquet application.

Following the training, these averages improved significantly:

- Scene safety recognition rose to 94.8%,
- Emergency medical services activation to 98.7%,
- Identification of life-threatening bleeding signs to 94%,
- Proficiency in applying direct pressure to 92.2%, and
- Tourniquet application knowledge and skills to 93.1%.

The improvements represented increases of 43.1%, 40.9%, 49.2%, 54.3%, and 56.9%, respectively, highlighting the effectiveness of the training program in enhancing participant's capabilities in managing bleeding emergencies. Table 5.1 shows the specific results for each step:

Table 5.1: Before and after ABC Training knowledge of volunteers about the five response steps

ABC Step	Average participants' knowledge score Before training (%)	Average participants' knowledge score After training (%)
Scene Safety	51.7	94.8
Activating Ambulance	57.8	98.7
Identifying life-threatening bleeding	44.8	94
Application of direct pressure	37.9	92.2
Application of tourniquet	36.2	93.1

The substantial rise in scores observed before and after the training underscores the efficacy of the program in augmenting participant's proficiency in active bleeding control methods. The notable improvement percentages reflect the program's practical design and its success in achieving the intended educational and training goals. Furthermore, the ABC team observers verified that the participants accurately executed the five steps of the ABC training.

The participants were given an ABC toolkit intended for deployment in the event of witnessing any road crash incidents after the event. The training programme also received ample coverage from local media outlets. The relevant clippings from several local newspapers are provided below:


ఈనాడు

రక్తస్రావాన్ని ఆపితే.. ప్రాణాన్ని కాపాడినట్టే..!

Date : 21/03/2024 EditionName : TELANGANA(YADADRI BHUVANAGIRI) PageNo : 01

సాక్షి

రక్తస్రావంతోనే అధిక ప్రాణనష్టం

21/03/2024 | Yadadri(Yadadri District) | Page : 7
Source : https://epaper.sakshi.com/

Figure 5.5: Social Media Coverage (News Paper Articles)

5.2.2 Gundarampally

The iRASTE-Telangana team, in collaboration with the Indian Institute of Public Health Hyderabad, conducted the second "Active Bleeding Control" training program at Gundrampally. This location was identified as a blackspot (potential road crash spot) after analyzing three years of road crash data (2020 to 2022) from the National Highway Authority of India (NHAI). The training targeted first responders, including auto drivers, truck drivers, Dhaba owners, and patrolling police personnel, who are often the first at crash scenes. A cluster-based strategy was employed, with Gundrampally as the central blackspot, incorporating nearby blackspots Pittampally and Peddakaparthy. The program trained 38 first responders from these areas.

Dr. Srinivas, representing the ABC training team from IIPHH, highlighted the critical challenge of delivering timely emergency care on Indian highways and underscoring the pivotal role of bystanders play in saving lives during the critical first minutes after a crash. The training covered scenarios where ABC techniques could be applied, focusing on five crucial steps: ensuring scene safety, calling for an ambulance, identifying life-threatening bleeding, applying direct pressure, and using a tourniquet.

The training included role-playing exercises and simulated road crash scenarios to demonstrate the ABC steps. Participants were divided into six groups, guided by master trainers, to practice these techniques and internalize standard operating procedures for road crash emergencies. They also engaged in mock demonstrations using the ABC kit components. Figure 5.6 displays a few snapshots from the ABC Training program at Gundrampally.

Figure 5.6: Training program at Gundrampally

An evaluation of 38 participants revealed a remarkable enhancement in their understanding of ABC techniques. Before the training, the participants had an average score of 55.6%, which increased to 91.7% after the training, as shown in Figure 5.7. This substantial improvement highlights the effectiveness of the training program in enhancing participant's knowledge and skills in bleeding control. The positive impact is evident across all measured areas, demonstrating the training's success in achieving its educational objectives.

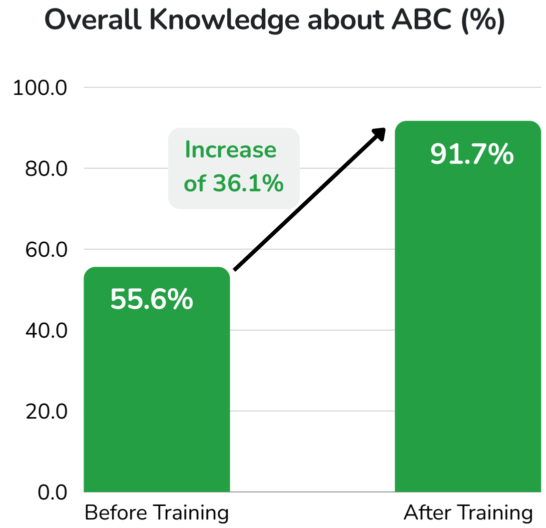


Figure 5.7: Impact of the ABC training program on knowledge levels of participants to the ABC training program at Gundrampally showing a 65% percent increase before and after training

Step-wise, too, the participants displayed a significant increase in their knowledge and understanding of the entire process of emergency response and administering ABC to a road crash victim. The step-wise knowledge levels of participants were assessed both before and after the training, as detailed in Table 5.2.

Table 5.2: Step-wise before and after ABC Training knowledge of volunteers.

ABC Step	Average before training knowledge (%)	Average after training knowledge (%)
Scene Safety	50.9	92.6
Activating Ambulance	67.6	97.2
Identifying life-threatening bleeding	45.4	93.5
Application of direct pressure	34.3	88
Application of tourniquet	29.6	92.6

Participant's knowledge of recognizing scene safety increased from 50.9% before the training to 92.6% after the training. Their understanding of calling emergency medical services (108) improved from an average of 67.6% to 97.2%. Knowledge of identifying signs of life-threatening bleeding rose from 45.4% to 93.5%. The ability to apply direct pressure to control bleeding increased from 34.3% to 88%. Knowledge and skills in tourniquet application improved from 29.6% to 92.6%.

Although responses varied regarding appropriate tourniquet use in different injury scenarios, 100% of participants correctly identified its use for severe bleeding in the arms and legs. Overall, the average knowledge quotient of participants on the five ABC steps increased from 45.6% before training to 92.8% after training. Upon completion of the course, participants were awarded ABC tool kits and certificates of completion.

The marked improvement in the participant's knowledge before and after the training demonstrates the program's success in boosting their competence in ABC techniques. The significant gains achieved suggest that the program was effectively designed and successfully met its educational goals. Observers from the ABC team confirmed that participants accurately executed all five steps of the ABC training.

5.2.3 Chityala

On May 7, 2024, iRASTE-Telangana, in partnership with the Indian Institute of Public Health Hyderabad, conducted the third "Active Bleeding Control" training session at Chityala, a site identified as a critical blackspot for road crashes. The training, targeting first responders from Chityala and neighboring blackspots—Pittampally, Peddakaparthy, and Gopalayalapalli—enrolled 46 participants. The attendees, including auto drivers, truck drivers, Dhaba owners, and police personnel, underwent a detailed program designed to enhance their skills in bleeding control.

Dr. Srinivas, from the IIPHH ABC training team, opened the session by emphasizing the challenges of delivering timely emergency care on Indian highways and the vital role of bystanders in the initial moments following a crash. The training focused on five key steps of active bleeding control: securing scene safety, activating emergency services, recognizing life-threatening bleeding, applying direct pressure, and administering a tourniquet. These steps were illustrated through practical role-playing exercises in simulated crash scenarios.

Participants were organized into six groups, each guided by master trainers, to practice these techniques through hands-on exercises and mock demonstrations using the ABC kit. After the training, each participant received an ABC kit to aid in future emergency responses. The following are some pictures of the training programme at Chityala.

Figure 5.8: ABC training program at Chityala

The pre and post-training assessments conducted by the iRASTE and IIHP trainers demonstrated a significant increase in the participant's understanding of the ABC toolkit. The average knowledge of the ABC toolkit before the training was 45.39%, which increased to 90.13% after the training, as shown in Figure 5.9.

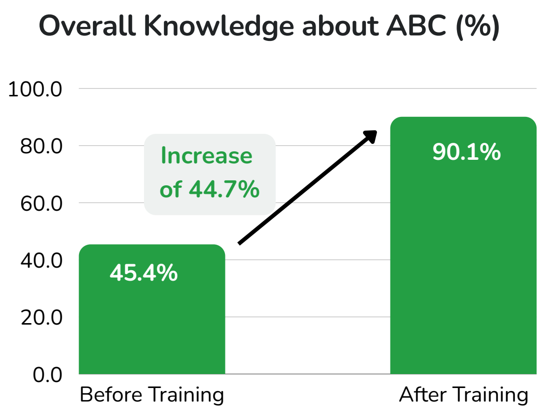


Figure 5.9: Impact of the ABC training programme on knowledge levels of participants to the ABC training program at Chityala.

Training Outcomes

The training program led to a marked improvement in participant's knowledge and competence in managing active bleeding. The following table illustrates the step-by-step enhancement in participant's understanding, as measured before and after the training.

Table 5.3: Before and after ABC Training knowledge about the five response steps (Location: Chityala)

ABC Step	Average before training knowledge (%)	Average after training knowledge (%)
Scene Safety	44.74	90.79
Activating Ambulance	60.53	94.08
Identifying life-threatening bleeding	40.13	94.08
Application of direct pressure	32.89	96.71
Application of tourniquet	28.95	94.74

Key Findings:

- **Scene Safety:** Participant's ability to assess scene safety improved from 44.74% to 90.79%.
- **Activating Ambulance:** Knowledge of how to call for emergency services rose from 60.53% to 94.08%.
- **Identifying Life-Threatening Bleeding:** Recognition of critical bleeding signs increased from 40.13% to 94.08%.
- **Applying Direct Pressure:** Proficiency in applying direct pressure surged from 32.89% to 96.71%.
- **Applying Tourniquet:** Skills related to tourniquet use improved significantly from 28.95% to 94.74%.

Notably, all participants (100%) accurately identified the use of tourniquets for severe bleeding in the arms and legs, reflecting a strong grasp of its application in various scenarios.

Outreach Efforts

The iRASTE and IIPHH teams also engaged in social media outreach via LinkedIn to increase visibility and awareness of the Chityala ABC Training Program, as depicted in Figure 5.10.

Indian Institute of Public Health Hyderabad_O... • 3rd+ **+ Follow** ...

Public Health institute offering courses such as MPH, PGDPHM ...

2mo •

Highlights from our third ABC training session in Chityala as part of the iRASTE Telangana project on May 7, 2024.

The ABC training team from IIPHH had the privilege of sensitizing and providing training to first responders on critical active bleeding control techniques. A total of 48 first responders from diverse backgrounds, including auto drivers, truck drivers, Dhaba owners, and patrolling police personnel, were trained in this training.

Their dedication to improving emergency response skills was truly encouraging, showcasing our commitment to community safety by empowering first responders.

The success of this training session was made possible through the iRASTE Telangana project and the invaluable support of GMR, NHAI, and CRRI.

#iRASTE #ABCtraining #FirstResponder #ActiveBleedingControl #RTA #IIPHHHyderabad #InternationalInstituteofInformationTechnologyHyderabad (IIIT) #CentralRoadResearchInstitute(CRRI) #IntelCorporation #GMRGroup #IndianInstiuteofPublicHealthHyderabad.

Figure 5.10: Social media outreach on awareness about the ABC Training program at Chityala.

5.2.4 Chillakallu Toll Plaza

iRASTE identified Akupamula and Mukunda Puram, equidistant from Chilkakallu toll plaza, as the fourth critical hotspots on the highway stretch. The Chilkakallu toll plaza thus was selected for the fourth ABC training session, using a cluster approach. A total of 40 participants from both hotspots attended the training program organized on May 31, 2024, from 9:30 AM to 12:30 PM. Presented below are some snapshots of the training program at Chilkakallu toll plaza.

Figure 5.11: ABC training program at Chilkakallu toll plaza

The pre and post-evaluation of the participants revealed significant improvement regarding the ABC technique and its five steps. The average knowledge of the participants regarding ABC increased from 48.8% before the training to 88.8% after the training program, as shown in Figure 5.12.

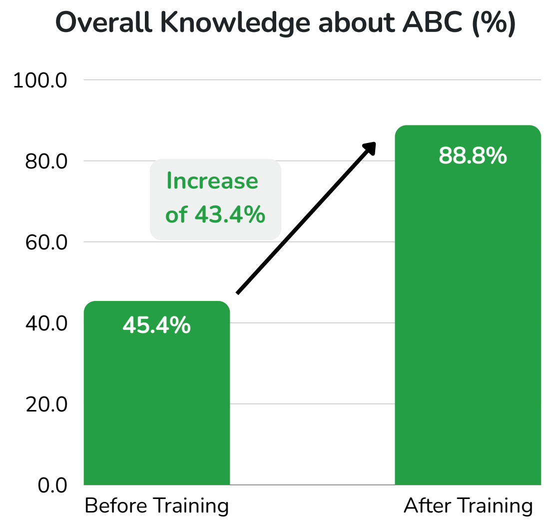


Figure 5.12: Impact of the ABC training programme on knowledge levels of participants to the ABC training program at Chilkakallu toll plaza

The microscopic evaluation of the participant's knowledge levels regarding various aspects of the ABC (Active Bleeding Control) training toolkit demonstrates significant improvements, as shown below.

Overall ABC Steps:

- Before Training: 54.83%
- After Training: 89.05%
- Improvement: 34.22%

Scene Safety Considerations:

- Before Training: 56.25%
- After Training: 88.78%
- Improvement: 32.53%

Activating Emergency Medical Services:

- Before Training: 60.62%
- After Training: 90.6%
- Improvement: 29.98%

Recognizing Life-Threatening Bleeding:

- Before Training: 48.75%
- After Training: 87.56%
- Improvement: 38.81%

Applying Direct Pressure:

- Before Training: 38.75%
- After Training: 90.52%
- Improvement: 51.77%

Tourniquet Application:

- Before Training: 34.3%
- After Training: 86.9%
- Improvement: 52.6%

Situational Use of Tourniquets:

- For Severe Arm and Leg Bleeding: Correct identification by 95% of participants
- For Severe Neck Bleeding: Correct identification by 2.5% of participants
- For Severe Chest Bleeding: Correct identification by 2.5% of participants.

The positive impact of the training program is evident from the substantial improvements observed across all measured areas.

5.2.5 Mungala

On June 1, 2024, iRASTE-Telangana, in partnership with the Indian Institute of Public Health Hyderabad, conducted its fifth "Active Bleeding Control" (ABC) training session in Mungala. This training, strategically focused on Mungala and its adjacent blackspots—Eklashkhanpet and Mukunda Puram—was attended by 38 participants from diverse backgrounds, including auto drivers, truck drivers, Dhaba owners, and police personnel.

Dr. Srinivas from IIPHH spearheaded the session, underscoring the vital role of timely emergency care on Indian highways. He detailed how bystanders can significantly impact survival rates in the crucial minutes following a crash. The training covered fundamental ABC steps: ensuring scene safety, contacting emergency services, identifying life-threatening bleeding, applying direct pressure, and using a tourniquet. These techniques were reinforced through practical role-playing exercises mimicking real-life situations. Participants were divided into six groups for hands-on practice under the guidance of master trainers. They engaged in mock drills using ABC kits and received these kits at the end of the session to equip them for future emergencies. The following are some pictures of the training programme at Mungala.

Figure 5.13: ABC training program at MUNGALA

The evaluation of the ABC training program, involving 25 participants, demonstrated a significant enhancement in their knowledge and skills, as shown in Figure 5.14 below. Before the training, participants had an average score of 44% in active bleeding control ABC techniques. Post-training, this average score surged to 93%, reflecting significant improvement in their understanding and application of bleeding control measures. The training program effectively advanced participant's expertise in critical areas of bleeding control, as evidenced by the substantial gains observed across all evaluated aspects.

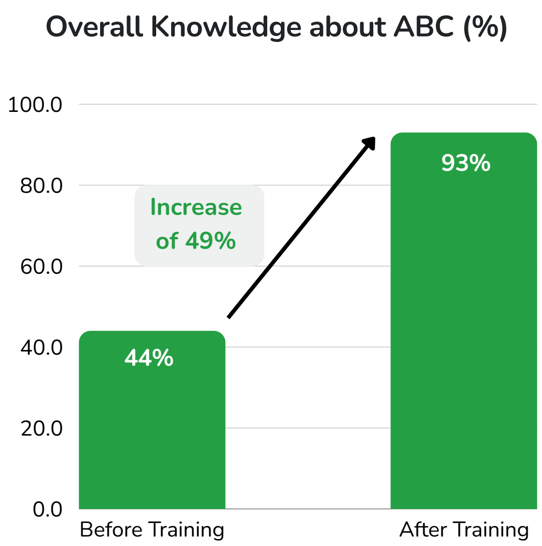


Figure 5.14: Impact of the ABC training programme on knowledge levels of participants to the ABC training program at MUNGALA

Their average understanding of the five ABC steps also showed marked improvement, from 37.6% before training to 93.6% following the training. Table 5.4 shows the comparative before-training and after-training improvement in the participant's understanding and skills about the five steps of ABC.

Table 5.4: Before and after ABC Training knowledge of volunteers about the five response steps (Location: Mungala)

ABC Step	Average before training knowledge (%)	Average after training knowledge (%)
Scene Safety	36	91
Activating Ambulance	58	90
Identifying life-threatening bleeding	40	95
Application of direct pressure	33	96
Application of tourniquet	21	96

The ability of participants to recognize scene safety considerations improved markedly, with their average score rising from 36% before the training to 91% afterward, reflecting a 55% enhancement. Knowledge of how to activate emergency medical services increased from 58% to 90%, demonstrating a 32% improvement. Participant's ability to identify life-threatening bleeding saw a substantial rise from 40% to 95%, indicating a 55% improvement. Proficiency in applying direct pressure to control bleeding improved from 33% to 96%, a notable 63% gain. The most significant increase was observed in the application of tourniquets, which surged from 21% to 96%, representing a 75% improvement.

Despite these overall gains, there was variation in the participant's understanding of tourniquet use across different injury scenarios. While 96% correctly identified the need for a tourniquet to manage severe bleeding in the arms and legs, only 4% recognized its necessity for severe bleeding from the forehead. This suggests a need for further emphasis on the appropriate application of tourniquets in varied injury contexts.

5.2.6 Panthangi Toll Plaza To Muthyalama Gudem

On June 19, 2024, iRASTE-Telangana, in collaboration with the Indian Institute of Public Health Hyderabad, conducted its sixth "Active Bleeding Control" (ABC) training program for a cluster of blackspots identified along the Hyderabad to Kodad stretch of National Highway 65. This training took place over an approximately 80-kilometer stretch from the Panthangi toll plaza to Muthyalamma Gudem. A total of 52 participants, including auto drivers and Dhaba workers, attended the session.

The training utilized a direct outreach strategy, with the IIPHH team visiting auto stands and dhabas along the highway. It covered essential bleeding control techniques, focusing on the core ABC steps: assessing scene safety, calling emergency services, recognizing life-threatening bleeding, applying direct pressure, and using a tourniquet. Participants engaged in role-playing exercises to practice these techniques in simulated crash scenarios. Figure 5.15 shows the following snapshots from the ABC training program.

Figure 5.15: ABC training program at Muthayalamma Gudem

The evaluation of 38 participants revealed significant improvements in their knowledge of ABC following the training program. Before the training, the participants had an average score of 38.8% for overall knowledge about the ABC toolkit. This score increased substantially to 82.9% after the training, demonstrating a marked improvement in overall knowledge. Specifically, the average score for the ABC steps rose from 36.6% before the training to 78.9% after.

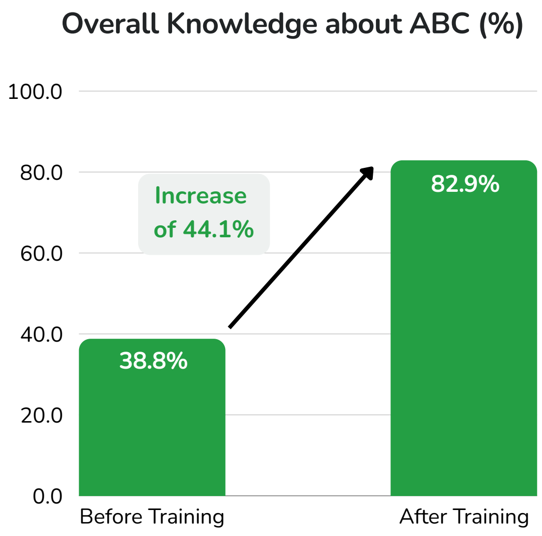


Figure 5.16: Impact of the ABC training programme on knowledge levels of participants to the ABC training program at MUTHYALAMMA GUDEM showed a 114% increase before and after training.

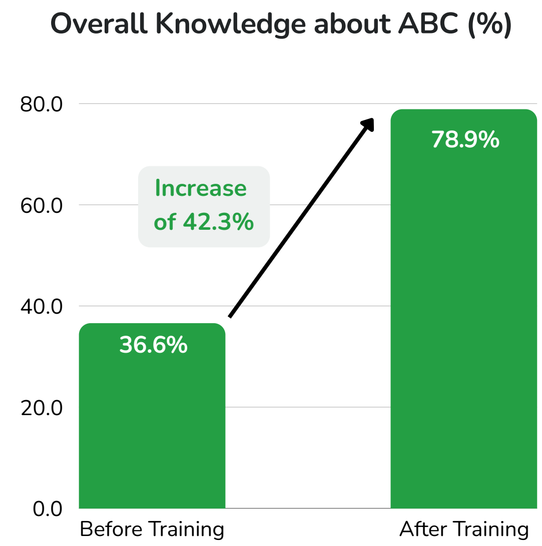


Figure 5.17: Impact of the ABC training programme on Average score ABC steps at MUTHYALAMMA GUDEM showed a 116% increase before and after training.

Participant's knowledge improvement in each step of the ABC technique is detailed below:

Scene Safety (Step 1): Before the training, participants had an average score of 32.9% in recognizing scene safety considerations. After the training, their knowledge significantly increased to an average of 77%.

Activating Ambulance (Step 2): Before the training, participants had an average score of 42.1% in understanding how to activate emergency medical services by calling the ambulance number (108). Post-training, this score significantly increased to 83.6%.

Identifying Life-Threatening Bleeding (Step 3): Participants initially scored an average of 36.2% in recognizing signs of life-threatening bleeding. After the training, their proficiency improved notably to 80.3%.

Application of Direct Pressure (Step 4): Before training, participants had an average score of 50% in applying direct pressure to control bleeding. This score rose significantly to 75% following the training.

Application of Tourniquet (Step 5): Participants showed an average score of 21.7% in tourniquet application before the training. After the session, their knowledge and skills in this area increased substantially to 78.9%.

Regarding tourniquet use, 94.7% of participants correctly identified its application as appropriate for severe bleeding in the arms and legs. However, only 5.3% recognized the need for a tourniquet in cases of severe bleeding from the chest.

Table 5.5 summarizes the knowledge improvement for each step of the ABC training. The table shows a significant enhancement in participant's knowledge across all five steps of the ABC training. The improvement in each step demonstrates the effectiveness of the training program in addressing the critical aspects of active bleeding control.

Table 5.5: Before and after ABC Training knowledge of volunteers about the five response steps (Location: MUTHYALAMMA GUDEM)

ABC Step	Average participant's knowledge score Before training (%)	Average participant's knowledge score After training (%)	Improvement (%)
Scene Safety	32.9	77.0	44.1
Activating Ambulance	42.1	83.6	41.5
Identifying life-threatening bleeding	36.2	80.3	44.1
Application of direct pressure	50	75.0	25.0
Application of tourniquet	21.7	78.9	57.2

5.2.7 Kodad

The iRASTE team identified Kodad as a road crash blackspot to conduct the seventh ABC training program on June 28, 2024. This program targeted individuals such as auto drivers, truck drivers, and patrolling police personnel, who are often the first to arrive at crash scenes. A cluster-based strategy was employed, centering on the Mungala blackspot and encompassing Akupamula and Talwa Honda Bypass, involving 335 participants.

The training emphasized the critical ABC protocol for managing crash-related injuries, focusing on five key steps: ensuring scene safety, calling emergency services, identifying life-threatening bleeding, applying direct pressure, and using a tourniquet. The training methodology included role-playing exercises and simulated road crash scenarios to enhance practical understanding and skill acquisition.

The event was honored by the presence of Mr. Mamilla Sridhar Reddy, DSP Nalgonda, along with senior police officials and representatives from the Telangana Lorry Owners Association. They underscored the critical importance of ABC training and advocated for more such sessions across blackspot locations in Telangana. Dr. Srinivas from the IIPHH team led the training, highlighting the urgent need for timely emergency care on highways. He stressed the vital role of bystanders in providing initial aid and detailed the five key ABC steps: scene safety, contacting emergency services, recognizing life-threatening bleeding, applying direct pressure, and using a tourniquet. These steps were demonstrated through role-playing exercises simulating real-life crash scenarios.

Master trainers supervised participants divided into 20 groups, facilitating hands-on practice with ABC kits and reinforcing standard operating procedures. The program concluded with the distribution of ABC kits to participants, equipping them to provide effective emergency assistance during road crash incidents. The snippets of the training program are as shown below:


Figure 5.18: ABC training program at Muthayalamma Gudem

5.3 Outcomes of iRASTE-Telangana's ABC Training Programs

The impact of iRASTE-Telangana's ABC Training programs was felt almost immediately, not only at the seven identified hotspots but also along different stretches of the state's major road corridor from Hyderabad city to Kodad town (towards Vijayawada). Presented below are the first-hand accounts of the volunteers who participated in the ABC Training programs and how their training helped them to use their scientific skills to save precious lives and limbs from road crash victims, effectively making them active and effective 'Trystanders' from passive bystanders in an event of a road crash. These personal accounts indicate the dire necessity for each state to design and implement such training programs at all the road crash hotspots countrywide to ensure timely, effective, and scientifically validated ABC assistance to save precious lives.

5.3.1 Road crash near Pantangi Toll Plaza TP1

Narrated by:

Parvatham Madhukiran, Route Patrolling Officer and Trained ABC volunteer)

The incident:

April 15, 2024, was a routine day of route patrolling for me when we got to learn about an accident near the Pantangi Toll Plaza TP1 on the GMR Hyderabad-Vijaywada Expressway. Like always, I promptly swung into action. But this time, it was with a confidence and surety that was missing earlier. I quickly did a mental recap of the training and the various scenarios we all trainees were exposed to during the ABC training program.

Details of the incident:

Upon arrival at the scene of the road crash, I observed that a truck had collided with another vehicle, resulting in significant damage and potential injuries to the occupants. My training session sped through my subconscious mind as a breezy flashback, helping me mentally refresh all the ABC steps. Prioritizing the safety of all involved, I immediately assessed the scene to ensure it was safe to approach. I noticed the injuries on the victims which prompted me to take the following actions.

Actions Taken:

Scene Safety and Initial Assessment:

- Ensured the scene was secure from the oncoming traffic by placing warning triangles and directing traffic away from the accident site.
- Checked the crash vehicles for signs of any immediate hazards such as fuel leaks or fire risks.
- Confirmed the safety of myself and any other first responders before proceeding with the next steps of ABC.

Assisting the Victims:

- I quickly identified two victims. While one of them, though injured, seemed okay, the other appeared to be in a critical condition and needed immediate assistance.
- Carefully removed the injured victim from the truck, ensuring not to exacerbate any potential injuries, and gently helped him to the ground.

Communication and Alert:

- Immediately informed the 1033,108 helplines from the Panthangi toll plaza, providing details of the accident and giving a firsthand assessment of the condition of the victims.
- Stayed on the line to give updates and receive instructions from emergency services.

Administration:

- Conducted a quick but thorough examination to locate the source of injuries.
- Noticed bleeding from the victim's hand and head. Applied first aid to the wound on the victim’s hand and head followed by constant direct pressure on the source of the bleeding.
- The emergency medical team arrived in an ambulance shortly after my call to the 1033 helpline and the injured victim was transported to the nearest hospital for further treatment.

Figure 5.19: Road crash near Pantangi Toll Plaza TP1

My swift response and adherence to safety protocols ensured that the victim received timely and effective first aid was significantly enhanced by the ABC training I received. Thanks to this training, I could remain calm and composed while evaluating the accident scene, and successfully perform the steps of the ABC training. The training enabled me to act quickly and effectively, ultimately informing the 1033,108 helplines from Panthangi Toll Plaza to ensure professional medical assistance arrived promptly. The training was incredibly helpful as it came in handy and gave me the confidence to handle the situation.

Parvatham Madhukiran, Route Patrolling Officer, GMR Hyderabad Vijayawada Expressway TP1 – Identified two victims and saved two lives.

5.3.2 Road crashes near Panthangi Toll TP1 & near Peddakaparthy Toll TP1

The impact of iRASTE-Telangana's ABC Training programs was felt almost immediately, not only at the seven identified hotspots but also along different stretches of the state's major road corridor from Hyderabad city to Kodad town (towards Vijayawada). Presented below are the first-hand accounts of the volunteers who participated in the ABC Training programs and how their training helped them to use their scientific skills in save precious lives and limbs from road crash victims, effectively making them active and effective 'Trystanders' from passive bystanders in an event of a road crash. These personal accounts indicate the dire necessity for each state to design and implement such training programs at all the road crash hotspots countrywide to ensure timely, effective, and scientifically validated ABC assistance to save precious lives.

Narrated by:

D. Madhu, an ABC-trained first responder to both road crash incidents.

The incident:

On May 15, 2024, I had just returned to work after attending to a bike accident victim near the Peddakaparthy Toll Plaza TP1. While the action I was just part of in helping the accident victim was still to sink in, I learned about another bike accident near the Panthangi Toll Plaza TP1. I couldn't thank my luck enough that I had received the ABC training, which helped me successfully deal with the accidents and ensure timely assistance to the victims. I recorded the details of both incidents in a voice note.

Details of the incidents:

Upon arrival at the road crash scenes near Panthangi Toll Plaza TP1 and Peddakaparthy Toll Plaza TP1, I observed that a bike had collided with another vehicle, resulting in significant damage and injuries to the rider. Prioritizing the safety of all involved, I assessed the scene to ensure it was safe to approach. I noticed a few injuries on the victims. I quickly recollected the ABC steps learned during the training and swung them into action.

Actions Taken:

Scene Safety and Initial Assessment:

- Ensured the scene was secure by checking the bike for any fuel leaks or fire risks.
- Confirmed the safety of myself and any other responders before proceeding with the next steps.

Assisting the Victims:

- Checked the victims in the two different bike accidents. Both the victims were injured and needed immediate assistance.
- Carefully eased the victims away from the place they had fallen, ensuring not to exacerbate any injuries, and gently helped him to the ground.

Communication and Alert:

- Immediately called the 1033,108 helplines from the Panthangi and Peddakaparthy Toll Plazas, providing the details of the accidents and the condition of the victims.
- Ensured to remain available to give updates and receive instructions from the emergency services.

Administration:

- Conducted a quick and thorough examination of the victims to locate the source of their injuries.
- Both victims were bleeding from their arms and heads. Applied first aid to the wounds and applied direct pressure to stem the blood flow.
- The emergency medical team arrived shortly after my call to the helplines, and the injured victims were transported to the nearest hospital for further treatment.

In both incidents, my training in active bleeding control was invaluable, providing me with the confidence and skills to effectively handle the situations with confidence and resolve. My swift response and adherence to safety protocols ensured that the victims received timely and effective first aid. This was possible only because of the training I received in active bleeding control at the iRASTE-Telangana program. This training enabled me to act quickly, follow the protocols and ensure that I could be of assistance till the medical teams and ambulances arrived at the crash sites. The training was incredibly helpful as it came in handy and gave me the confidence to handle the situation.

Reported by D. Madhu, a first responder identified two victims and saved two lives.

5.3.3 Near Panthangi Toll Plaza TP1

Narrated by:

Dassaratha, an ABC trained first responder

The incident:

On May 2024, an accident was reported near the Panthangi Toll Plaza TP1 I, Dasaratha promptly responded to the incident.

Details of the incident:

As I rushed to the scene, I saw an accident that had caused significant damage and injuries to the rider. I assessed the scenario, prioritized the safety of all involved, and ensured it was safe to approach. I noticed few injuries on the victim which prompted me to take the following actions.

Actions Taken:

Scene Safety and Initial Assessment:

- Ensured the scene was secure by checking for any immediate hazards, such as fuel leaks or fire risks.
- Confirmed the safety of myself and other responders and bystanders before proceeding.

Assisting the Victims:

- The victim was severely injured and needed immediate assistance.
- Carefully moved the victim away from the vehicle, ensuring not to aggravate his injuries, and gently helped him to the ground.

Communication and Alert:

- Instructed another person at the scene to call the 108,1033 helplines for additional assistance as the victim was severely injured.
- The other person provided details of the accident to the emergency helplines and described the condition of the victim. He stayed on the call to give updates and receive instructions from emergency services.

Administration:

- Conducted a quick and thorough examination of the victim to locate the source of injuries.
- Noticed bleeding from the victim's hand and legs. Applied direct pressure and used a tourniquet to control the bleeding.
- The emergency medical team arrived shortly, and the injured victim was transported to the nearest hospital for further treatment.

Thanks to the ABC training received through the iRASTE program, I could respond swiftly and adhere to the safety protocols. This training enabled me to act quickly and effectively follow the ABC steps and stop the bleeding till medical assistance arrived at the crash spot. The training was incredibly helpful as it came in handy and gave me the confidence to handle the situation.

Reported by Dassaratha, an ABC trained first responder – saved a life.

5.3.4 Peddakaparthy Toll Plaza TP 2

Narrated by:

R. Chandu, a trained ABC volunteer

The incident:

On May 2024, an accident was reported near the Peddakaparthy Toll Plaza TP 2. I promptly called the emergency helpline 108 and ensured that the ambulance arrived in time to help the victim.

Details of the incident:

Upon arrival at the scene, I observed that a vehicle accident had occurred, resulting in significant damage and potential injuries to the rider. Luckily, while the rider was in great pain, there was not too much bleeding. I assessed the situation, prioritized the safety of everyone around the site, and called the emergency helpline number 108 to activate the emergency response team and arrange for an ambulance to be dispatched to the accident spot.

Actions Taken:

Communication and Alert:

- Immediately after the accident, I called the 108 ambulance helpline to the scene and provided the details of the accident and the condition of the victim.
- Stayed on the line to give updates and receive instructions from emergency services.

The ABC training, I received significantly enhanced my prompt call to the ambulance helpline and my ability to provide the necessary details about the victims and the accident. This training enabled me to act quickly and effectively, ultimately informing the 108 helpline from Peddakaparthy Toll Plaza 2 to ensure professional medical assistance arrived promptly. I doubt if I would have responded with this alertness had I not been trained in emergency response and been of effective use in such situations.

Reported by R. Chandu, an ABC-trained first responder – saved a life.

5.4 Recommendations

In summary, iRASTE-Telangana's ABC toolkit training program has proven to be highly effective in enhancing the understanding and competencies of the participants in active bleeding control, one of the most critical components of emergency response to RTI victims. The significant improvements observed across various skill areas reflect the training's efficacy. This study proposes several specific recommendations to amplify the program's impact and efficiency further.

Strengthening EMS Activation Protocols:

Strengthening EMS Activation Protocols: The program has made commendable strides in understanding emergency medical services (EMS) activation. Continued focus through repeated drills and practical exercises are essential to ensure participants can recall and execute this crucial action effectively under pressure.

Advanced Training in Recognizing Life-Threatening Bleeding:

Significant advancements have been made in identifying life-threatening bleeding. Further enhancement can be achieved by integrating sophisticated visual aids, real-life case studies through audio-visual materials, and interactive quizzes. Prompt recognition and application of ABC techniques can be pivotal in life-or-death situations.

Augmented Skills in Applying Direct Pressure:

The notable progress in applying direct pressure underscores the success of hands-on training. To deepen these skills, increasing the frequency and complexity of practical exercises under the guidance of paramedical staff or trauma-care doctors is advisable.

Expanded Training on Tourniquet Application:

The improvement in tourniquet application skills reflects the effectiveness of hands-on training. However, the low recognition rates for tourniquet use in neck and chest injuries indicate a need for broader awareness. Developing specialized modules that address anatomical considerations and alternative treatments for such injuries could be beneficial.

Diverse Scenario-Based Training for Tourniquet Use:

The varied responses regarding tourniquet application across different injury scenarios highlight the need for more diverse and realistic training scenarios. Emphasizing context-specific tourniquet use and alternative bleeding control methods for non-extremity injuries will enhance decision-making skills.

iRASTE-Telangana's ABC Training program has markedly improved participant's proficiency in managing bleeding emergencies, establishing a benchmark in saving lives. This campaign has successfully created an exemplary participatory model of emergency response and rescue of RTI victims. Such a model is a prime candidate for nationwide adoption by the Ministry of Road Transport and Highways. By addressing and refining specific areas within the program, we can further elevate its effectiveness, ensuring that participants are exceptionally well-prepared to handle real-world situations with confidence and expertise. This will not only save lives but also set a new standard for emergency response training across India.

1. "Road Accidents in India 2021," Ministry of Road Transport and Highways, Government of India, 2022. Accessed 19 July 2024. https://morth.nic.in/sites/default/files/RA_2021_Compressed.pdf
2. "Severe Bleeding: First Aid," Mayo Clinic, https://www.mayoclinic.org/first-aid/first-aid-severe-bleeding/basics/art-20056661
3. Geethanjali Ramachandra, G.V. Ramana Rao, Shailaja Tetali, Devendar Karabu, Manideep Kanagala, Srinivas Puppala, Rani Janumpally, H.V. Rajanarsing Rao, Brendan Carr, Steven C. Brooks, Vinay Nadkarni, "Active bleeding control pilot program in India: Simulation training of the community to stop the bleed and save lives from Road Traffic Injuries," Clinical Epidemiology and Global Health, Volume 11, 2021, 100729, https://doi.org/10.1016/j.cegh.2021.100729
4. Jennifer Huizen, "How to apply a tourniquet step by step," Medical News Today, September 26, 2023, https://www.medicalnewstoday.com/articles/how-to-apply-a-tourniquet

5.5 Outcomes

5.5.1 ABC Training (Trystanders)

- PHFI Team identified 10 locations near blackspots for training local people
- ABC trainings have been completed in these 10 locations on NH-65 from Hyd – Kodad
- 600+ volunteers have been trained on ABC & each trainee has been provided an ABC kit
- These volunteers have already saved 4 lives in the last 5 months.

- The Active Bleeding Control (ABC) initiative by PHFI is to educate lay responder 'try-standers' on the importance of Road traffic injuries as a public health problem, empower them with ABC skills and respond to life-threatening bleed until professional help arrives.
- Project iRASTE partnered with PHFI to provide training to first responders on ABC near 10 Blackspots along Hyderabad to Kodad corridor on NH65. ABC Kits and certificates were provided to all trainees.
- **600+ volunteers** were trained in 10 locations.

  - The average score of the participants on ABC steps increased from **45.7% pre-training to 94% post-training.**
  - Their knowledge and skills related to tourniquet application significantly increased from 36.2% pre-training to 93.1% post-training.

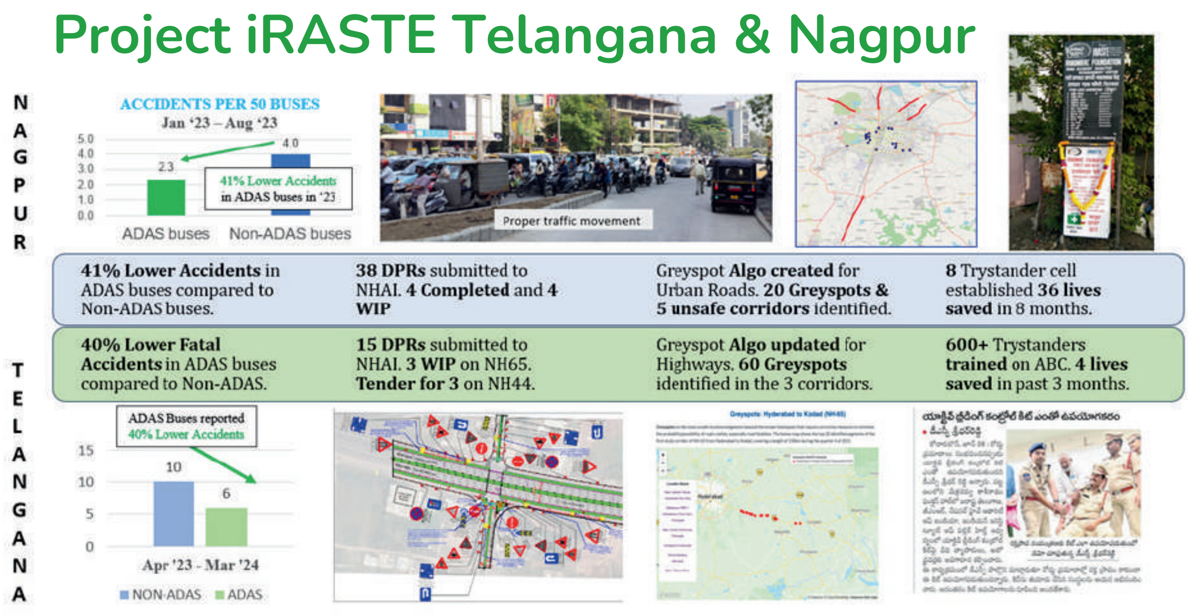
Training Events Conducted	Participants
1st Training Program (Panthangi Toll Plaza) 20th March	48+
2nd Training Program (Gudarampally) 20th April	38+
3rd Training Event (Chityala) 7th May	46+
4th Training Event (Chillakallu) 31st May	40+
5th Training Event (Mungala) 1st June	38+
6th Training Event (TP1 to Muthyalamma Gudem) 19th June	52+
7th Training Program (Kodad) 28th June	330+

4 Lives saved by trained participants in the past 5 Months.


Active

Way Forward

Project iRASTE-Telangana was the first initiative in India to integrate AI into the 4E framework for road safety on Highways. This iRASTE model has led to faster and more precise implementations with promising results: a 40% reduction in fatal accidents in the TGSRTC ADAS enabled bus fleet. The combination of Project iRASTE-Nagpur and Project iRASTE-Telangana covers both the urban and highway road networks and create a blueprint to cover any road network in the country.



Moving forward, the detailed reports for both the projects will be submitted and engage with the Union Ministry of Road Transport and Highways (MoRTH) to replicate this AI-enabled multi modal approach in other cities and metropolitan regions in India for accident reduction.


Project
iRASTE
INTELLIGENT SOLUTIONS FOR ROAD SAFETY
THROUGH TECHNOLOGY AND ENGINEERING
SAFETY
FIRST