Driver Behaviour Improvement with Collision Avoidance System (Project Telangana-20)

INTERNATIONAL INSTITUTE OF INFORMATION TECHNOLOGY
HYDERABAD

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HUBDATA
IIIT HYDERABAD

Abstract

A project on road-safety was conducted in the city of Hyderabad, Telangana, using Collision Avoidance Systems (CAS) installed in a fleet of vehicles. The objective of this project was to study the impact of collision alert systems on driver behaviour. The vehicles in this project operated on the roads of Hyderabad and were observed over a period of six months. The project included two phases – a control period, where drivers were observed to set a baseline performance of driving behaviour, followed by observation period, where the change in performance was observed against the baseline performance. This report presents the findings and data analysis from the study. It was observed that presence of a CAS system changed the behaviour of 54% drivers on average to adopt safer driving behaviour, and among those drivers who changed behaviour, the average improvement in driving behaviour was about 34%. From the analysis and results on various aspects in the study, it was concluded that the use of a collision avoidance system leads to a change in behaviour – improved safer driving among drivers.

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1. Introduction

In India, over 1,30,000 people lose their lives on road every year[1], making the roads one of the most unsafe in the world. Poor road safety is the result of various factors, some of which include poor driving environment and driving behaviour contributes hugely. Using technology for improving road safety and driver behaviour is of interest in the larger technical community.

Advanced Driver-Assistance System (ADAS)[2] is a technology that comprises of multiple components for improving vehicle and driver safety. One of these components is a Collision Avoidance System (CAS)[3], which monitors the speed of a vehicle and the presence of other vehicles or pedestrians ahead, to provide timely alerts to drivers about possible, imminent collisions. The timely critical alerts provide safety to the driver and others on the road.

While CAS systems have been in existence for long time in other countries, a systematic study of using CAS on Indian roads and any driver behavior change with these CAS systems on Indian roads, does not exist. This project was designed to address this gap and provide insights which help address the serious problem of road fatalities on Indian roads.

2. Objective

This study was designed to review road-safety from the aspect of driving behaviour with collision avoidance systems (CAS) in India and had an objective to analyze the impact of CAS on driver behaviour change.

3. Project Design

The project design involved installing CAS devices on a fleet of vehicles running on selected roads in the city of Hyderabad, collecting collision alert data from the vehicle and analyzing the data to derive insights. Hyderabad was chosen, as the research team was local to the city and for ease of access to vehicles.

3.1 Collision Avoidance System (CAS)

A collision avoidance system analyzes the driving behaviour of a vehicle in real time, with the pedestrians and other vehicles on road ahead of the vehicle to provide in-cabin alerts, as *visual and audio* signals about any possible collision. These alerts help to reduce the risk of collision by alerting the driver of a vehicle. A collision avoidance system provides multiple alerts or warnings for Pedestrian Collision, Front Collision, Headway Monitoring, Lane Departure and Speed Limits. These alerts or warnings are typically given 2 seconds ahead of a possible collision, and enables the driver to take any, necessary corrective action before an untoward incident. CAS offers a form of safety to the driver, vehicle, and others on the road.

In this project, Mobileye 8 Connect [4] was used as the collision avoidance system. It comprises of a camera mounted on the windshield of a vehicle looking at the road in front, an AI-powered compute system

[1] Road Accidents in India, 2020 https://morth.nic.in/sites/default/files/RA_2020.pdf
[2] Advanced driver-assistance system (ADAS) https://en.wikipedia.org/wiki/Advanced_driver-assistance_system
[3] Collision Avoidance System (CAS) https://en.wikipedia.org/wiki/Collision_avoidance_system
[4] Mobileye 8 Connect - https://www.mobileye.com/uk/fleets/products/mobileye-8-connect/

analyzing images from the camera in real time, to provide both audio and visual signals warning about possible collision events on the road. The alerts generated in-cabin to the driver were also sent to a cloud server for storage and data analysis.

4. Methodology

Figure 4.1 shows the overall methodology of the project which started with finalization of parameters, in terms of routes and drivers. The project design parameters were defined in a way to provide an adequate amount of data to capture necessary variation as would be present in a real-world scenario.

The data collection period was divided into control period and observation period. In the control period, the CAS device was configured not to provide in-cabin alerts to the driver, but the alert events were sent to the cloud server. In the observation period, the CAS device was configured for normal function giving in-cabin alerts to the driver.

4.1 Parameters of the Study

The following parameters were considered in the design.

Number of drivers: 20
Drivers: Drivers from a stratified sample of age group and with varied driving experience

Number of routes: 20 routes, each with at least 15-20 KMs distance
Time and Day of the route operations: Morning and evening peak and non-peak traffic hours of operation during typical weekdays and weekends

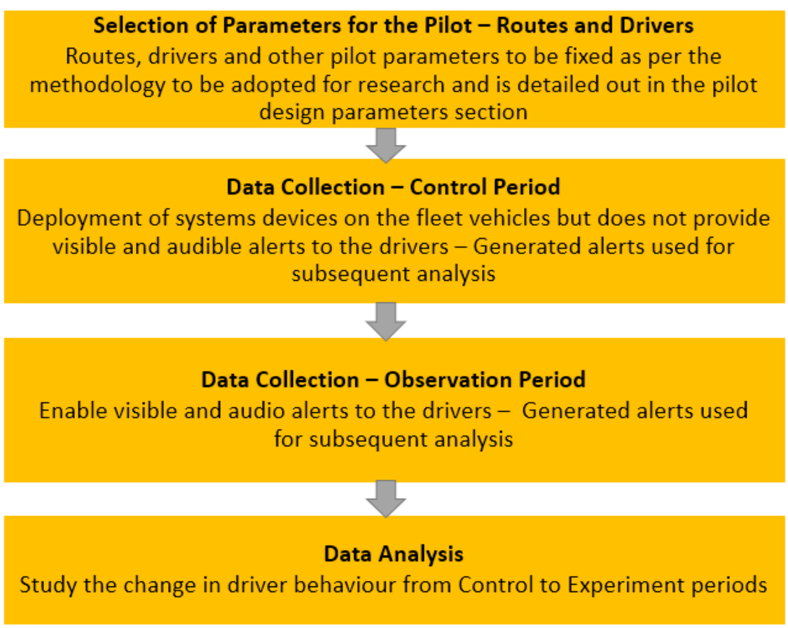


Figure 4.1 Methodology of the project describing steps in data collection and analysis.

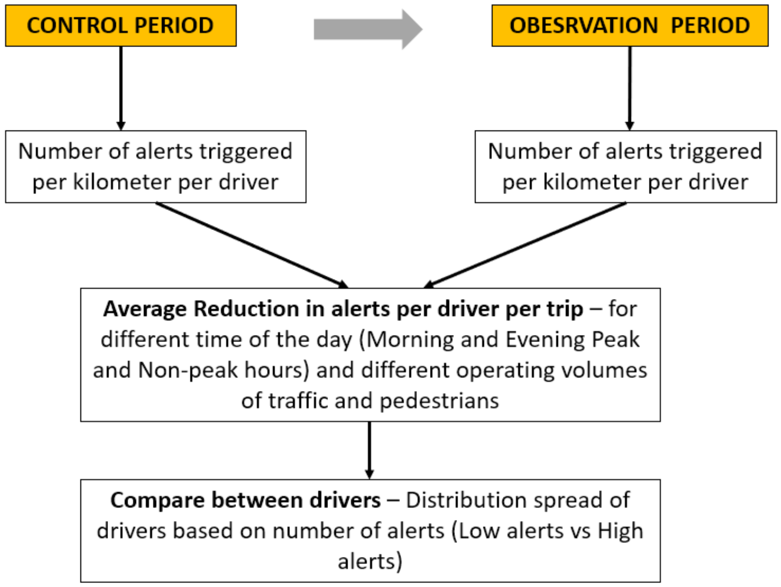


Figure 4.2 Overall methodology of the project over control and observation periods.

Duration and route length:

- Each driver traversed a single route of at least 15-20 KMs each. These routes traversed at different times of the day and at different operating traffic and pedestrian volumes. Each route covered during morning peak, morning non-peak, evening peak and evening non-peak periods will provide sufficient data for analysis. For example, each driver traversing a total of 8 trips (both directions) will cover a total approximate length of 150 KMs. This arrangement repeated twice for each driver, resulting in a total approximate length traversed as 300 KMs in a day.

These parameters were initially designed for the study, and the actual values are given in Section 5.2.

4.2 Impact of CAS on Change in Driver Behaviour

Collision avoidance system with advanced driver assistance system (ADAS) features aims to reduce the risk of a collision by alerting the driver with visual and audio alerts in real time providing the critical seconds needed to prevent or mitigate a collision. The system gives alerts in real-time based on the vehicles in lane ahead of the driven vehicle and also the driver behaviour. The different alerts that are generated from the deployed systems include the pedestrian collision alerts, headway monitoring alerts, forward collision alerts, speed limit indications and lane departure alerts. The data collection process was carried out for both control and observation periods, where the distance traversed and driving time were considered to be identical in both the periods. This analysis process is shown in Fig. 4.2.

Improvement of Driver behaviour is measured through the average reduction in alerts per driver per trip - for the different dynamic factors, for different times of the day and for different operating traffic and pedestrian volumes. It can be used to compare between drivers also looking at the distribution spread based on number of alerts (Low alerts vs High alerts segments).

5. Implementation

In this project, 20 vehicles from a private transport organization were used. These vehicles were part of a regular fleet carrying about 30 passengers daily in Hyderabad. These 20 vehicles (10 of Tata Marcopolo and 10 of Eicher) were fitted with the collision avoidance system (CAS) for the study. The drivers in the fleet were fixed to the vehicles, and hence the population of drivers in this study was also 20. This setup naturally allowed a long-term observation of driving behavior change in the drivers.

As mentioned in Sec. 4.2, the data collection period was divided into control period and observation periods. During the control period, the visible and audio alerts from the CAS were configured not to be given in-cabin to the driver but all alerts (events) were sent to the cloud server. In the observation period, the configuration was set back to normal function, and so visible and audible CAS alerts were given in-cabin to the driver. The Experiment period was split into multiple observation periods, for analysis.

After the control period and before starting the observation period, the drivers were given an in-person training on safe driving practices and awareness about the collision alert system installed in their vehicles.

5.1 Data

The two systems used in this project as described in Section 3 generated various kinds of data. Table 5-1 gives a complete list of the data used for analysis in the project.

Table 5-1: A complete list of data used for analysis in the project.

Data	Event	Description
Spatial	Location (GPS coordinates)	Latitude and longitude of the alert
Temporal	Date and time	Date and time of the alert
Alerts from Collision Avoidance System (CAS)	Front collision warning (FCW)	Alert for a potential collision with another vehicle in the lane, in front of the driven vehicle
	Head-way monitoring warning (HMW)	Alert when the distance to another vehicle in the lane, is less than a safe distance to the driven vehicle, at current speed
	Lane Departure Warning[1] (LDW)	Alert when the driven vehicle moves out of a lane, without using a lane-change indicator
	Pedestrian collision warning (PCW)	Alert for a potential collision with a pedestrian, in front of the driven vehicle

Figure 5.1 Sample images from the roads travelled by the vehicles in in Hyderabad during the study. Images used by the collision alert system were not available and only the alerts generated were available and used in the project. Hence another camera was placed next to the CAS device on some of the vehicles, to provide the sample images for visualization purposes.

5.2 Phases, Distance and Duration

As described in Sec. 4.2, the project involved control and observation periods. The observation period was split into multiple observation phases for analysis.

Table 5-2 shows the various phases, distances covered and duration of the phases in the project. The distances covered by the vehicles and duration were nearly the same. The last observation period was intentionally kept short before exiting the project.

Table 5-2: Phases of the project, distances covered and duration of each phase in the project.

Project phase	Distance covered (KMs)	Duration (in days)
Control (C)	142,165	44
Driver training	4 days	
Observation (M1)	136,798	45
Observation (M2)	133,178	45
Observation (M3)	110,197	41
Refresher training	1 day	
Observation (M4)	44,172	15
Total	**566,510 KMs**	**190 days (over 6 months)**

The vehicles operated primarily on trips between 04:30 AM and 12:00 midnight on the roads on weekdays (Monday – Friday), and some other regular trips over the weekend (Saturday, Sunday). The road network in the project spanned a distance of about 300 KMs driven multiple times over 6 months.

5.3 Geographical Coverage

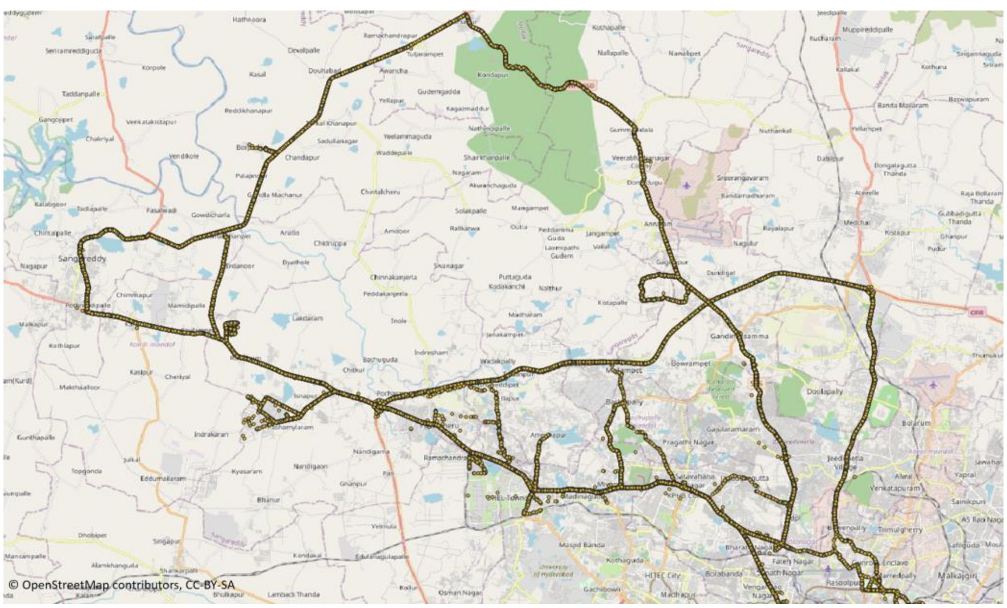


Figure 5.2. Map representing the roads covered – over 566,000 KMs by 20 vehicles in this project over 190 days in Hyderabad

6. Analysis and Results

Figure 6.1 shows a graph of the total distance travelled in various phases of the project. The minor variation in distances can be attributed to the change in number of weekdays of work in the fleet. The last phase was intentionally shortened to in the early phases except the phase after refresher training. This data was used in analyzing driver behaviour change over the project phases.

6.1 CAS on Driver Behaviour

For the first objective on studying the impact of collision avoidance system on driver behaviour, the alert data obtained from the vehicles was normalized to the distance travelled by each vehicle in every phase. This normalization of alert per kilometer helped to eliminate any possible variations in the data, and hence enables a systematic analysis on the driver behavior change.

The normalized data of collision alerts per kilometer in each phase was used to analyze the driver behavior change across observation phases, compared to each driver's own baseline performance in the control period.

Considering the objective on road safety from the aspect of driver behavior change in the project , there are two possible scenarios. The normalized alerts per KM in an observation period of each driver compared to the baseline performance of the same driver, can:

(i) Decrease – when the driver has internalized the training on road safety, using CAS alerts while driving to avoid possible collisions, and hence an improvement in safer driving behaviour, or
(ii) Increase – when the driver did not internalize the training, or did not effectively use CAS alerts while driving to avoid possible collisions, and so a lack of change or improvement in driving behaviour, or
(iii) Remain the same – when the driver did not change any practise during any phase of the project.

A reduction of collision alerts normilazed to distance was observed in observation phases (M1 – M4) compared to the control phase (C) in the project. This led to an overall change of behavior among the drivers in the study.

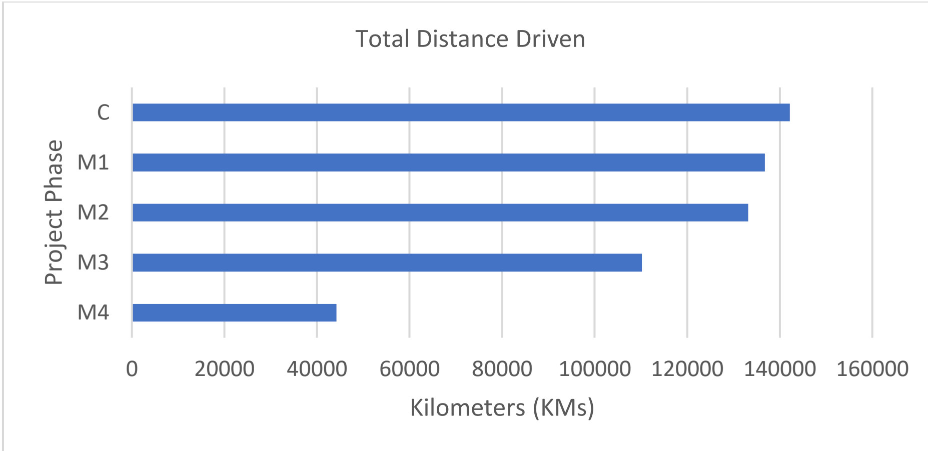
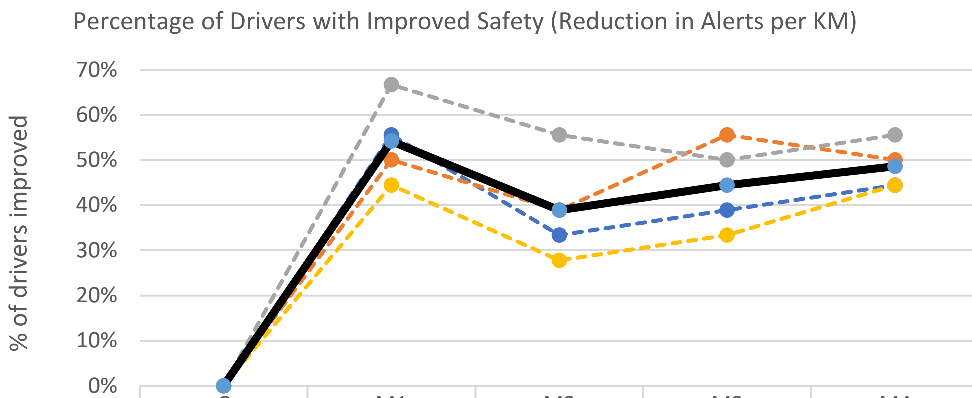


Figure 6.1 Distances travelled by the vehicles in various phases of the project. The last Observation period (M4) was intentionally kept short before final closure of the project

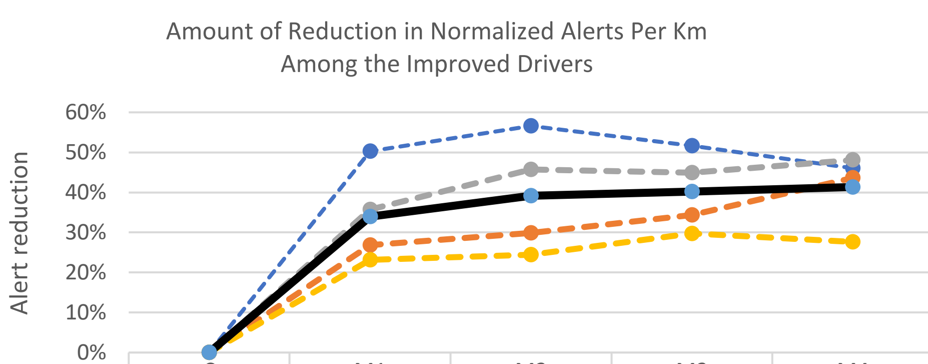
Figure 6.2 shows an aggregated level of change in the drivers as a percentage number of drivers who changed (improved, with decrease in alerts). The change is zero for the control period, as the baseline performance was being established as a reference to compare later. A sharp change in 52% of the driver population was observed, after the baseline in control during the first observation period (M1). This improvement in total population slightly decreased in the next phases, possibly due to gradual forgetting among the population. With a refresher training, the population of drivers again showed an uptick in the improvement.

Figure 6.3 shows a detailed view on the amount of aggregate reduction in drivers across the project phases. in the group changed behaviour. Among all the collision alerts, the highest reduction is with forward collisions which directly helps in preventing accidents.



	C	M1	M2	M3	M4
FCW	0.00%	55.56%	33.33%	38.89%	44.44%
HMW	0.00%	50.00%	38.89%	55.56%	50.00%
LDW	0.00%	66.67%	55.56%	50.00%	55.56%
PCW	0.00%	44.44%	27.78%	33.33%	44.44%
Average	0.00%	54.17%	38.89%	44.44%	48.61%

Figure 6.2 Aggregate change in percentage of drivers whose driving behaviour improved (i.e, a reduction in normalized alerts to distance). Over 50% of the drivers improved their driving in M1 phase after the first training. A gradual forgetting seems to have set in the population. With a refresher training after M3 phase, the driving behaviour of the population again improved.



	C	M1	M2	M3	M4
FCW	0.00%	50.30%	56.60%	51.69%	46.04%
HMW	0.00%	26.83%	29.91%	34.34%	43.61%
LDW	0.00%	35.69%	45.74%	44.91%	48.09%
PCW	0.00%	23.12%	24.40%	29.75%	27.67%
Average	0.00%	33.99%	39.16%	40.17%	41.35%

Figure 6.3 Aggregate reduction in the normalized alerts per KM, only among the drivers who improved in the population. Among all the collision alerts, the highest reduction is with forward collisions which directly helps in preventing accidents.

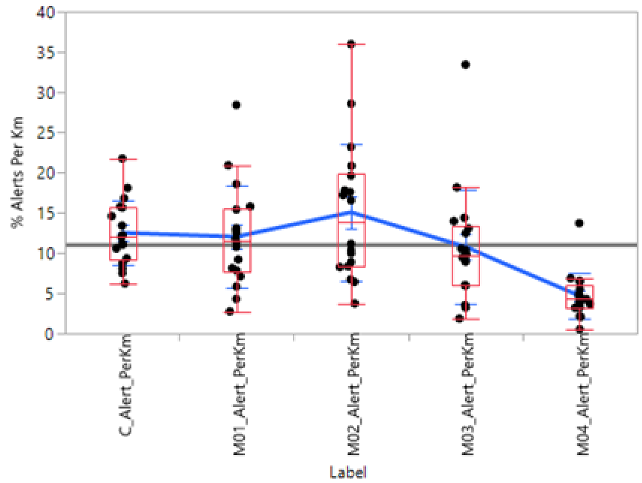


Figure 6.4 One-way ANOVA test for null-hypothesis significance testing in the population for driver behaviour change over the project phases. The p-value of < 0.005 for a 95% confidence level, indicates that the normalized alert reduction per KM observed was not random, and was due to a real change in driving behaviour among the population. This change in behaviour with the CAS system and training given to the drivers .

Figure 6.4 shows the test for null-hypothesis using one-way ANOVA. The resulting p-value of <0.005 for a 95% confidence interval, indicates that the reduction in alerts observed was not random (null) and was due to the change in behaviour of the drivers (hypothesis), and thus establishing a statistical sigifnicance of the behaviour change in the driver population.

Figure 6.5 shows the performance of one of the drivers in the project. A significant reduction in the normalized data - number of alerts per KM, can be seen from the Control period to the Observation periods. This reduction is consistent as the normalized count remains low and nearly the same in the multiple Observation periods. A refresher training after M3 phase helped to further improve this driver performance.

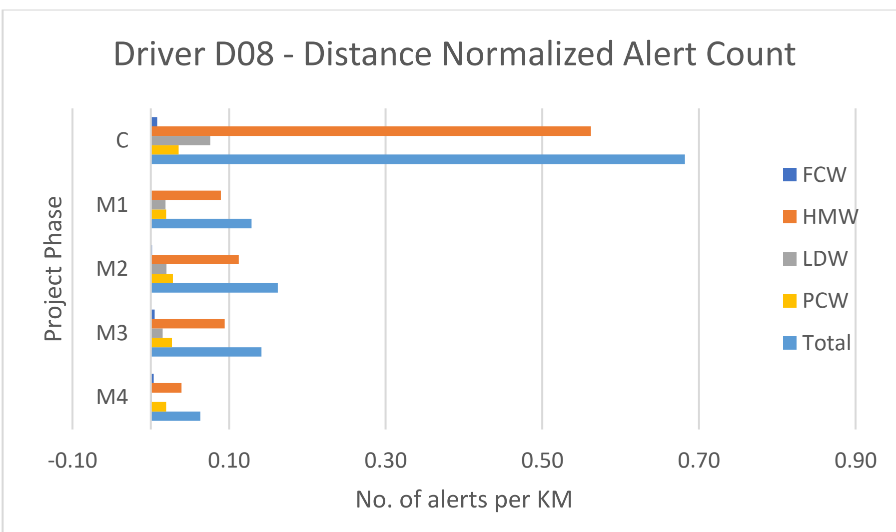


Figure 6.5 Normalized collision alerts of a driver, showing a change in driving behavior. The graph demonstrates a learning behavior after training. A significant reduction of collision alerts is observed in observation phases (M1 – M4) compared to the control phase (C) in the project..

7. Observations

From the analysis and results on the impact of CAS on driver behaviour, the following observations are made:

(i) use of a collision alert system (CAS) leads to an evident change in driver behaviour, and
(ii) on an average, 54% of drivers changed driving behaviour to become safer than earlier,
(iii) overall highest reduction in alerts of 67% was observed on lane-departure warnings (LDW), and
(iv) among the drivers who changed behaviour, average alerts reduction was 34%,
(v) over time, possibly a fatigue develops over time among most drivers and a refresher training helps in remembering the benefits of CAS alerts, and hence safer driving behaviour.

A short refresher training to drivers once in three (or six) months helps to reinforce the learning and it leads to a better, safer driving behaviour among drivers. In addition to a refresher, some rewards or incentives or penalties mechanism for the drivers may be considered for a quicker change in behaviour.

8. Summary

A road safety project was conducted using collision avoidance system (CAS) on a fleet of 20 vehicles in the city of Hyderabad. This report presented the analysis and findings from the impact of collision alert systems on driver behaviour. The vehicles in the project covered a total distance of over 550,000 kilometers and operated over a period of six months. The drivers were fixed to the vehicles and so a long-term change in driver behaviour was analyzed. The project was designed with multiple phases - a Control period, where baseline performance of the drivers was obtained and multiple Observation periods, where change in driver performance was measured. It was observed that the training and presence of CAS system led to a change in behaviour with over 54% drivers on average improving and adopting safer driving practice, and that among those who changed, the average improvement was about 34%. **The use of a collision avoidance system contributes to the adoption of a safer driving practice among drivers.**

Acknowledgements

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