Chapter 12

Behaviour Change by Traffic Information

Introduction

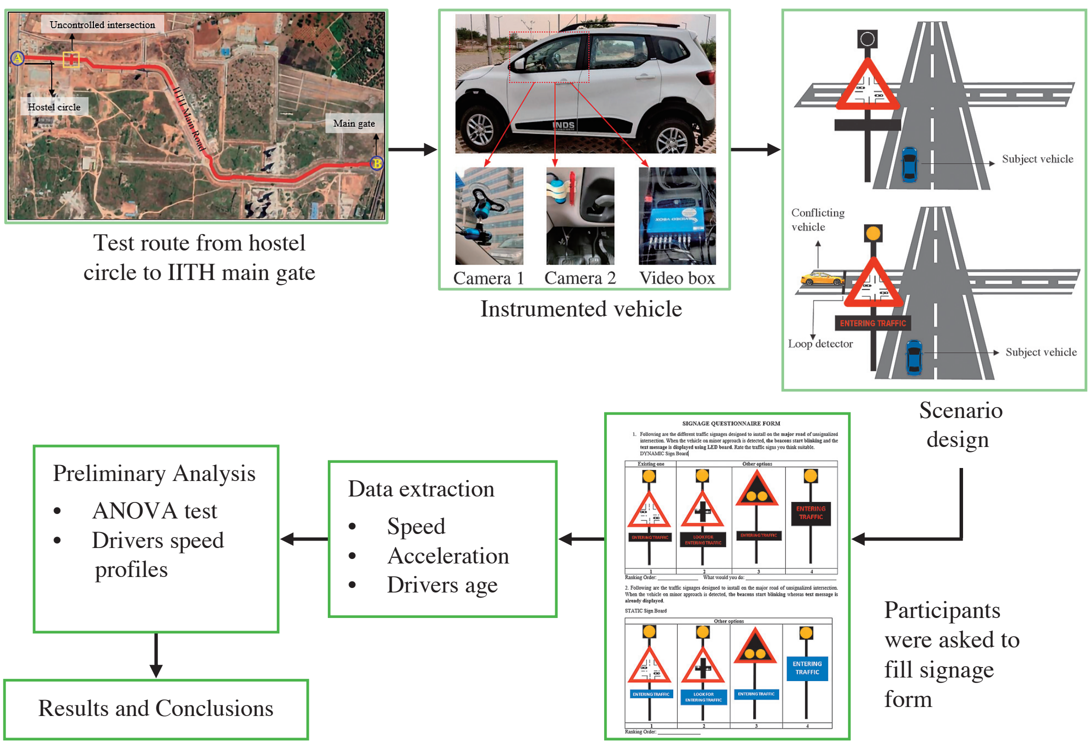
Intersection crashes, particularly right-angle crashes play a significant role in traffic accidents. According to the Indian Ministry of Road Transport and Highways, 449,002 road crashes were recorded in 2019, out of which 28% of the crashes occurred at the intersections [1]. Unsignalized intersections account for 20.6% of total intersection crashes and most of these resulted in serious injuries or fatalities. Crashes at unsignalized intersections mainly occur when a vehicle on minor road attempts to enter or cross the intersection with an unsafe gap condition. Poor sight distance, wrong judgment in gap acceptance by minor road vehicles, and priorities not being respected by the road users are the causes for the crashes at unsignalized intersections. To reduce frequency and severity of crashes and enhance road safety, Intersection Conflict Warning System (ICWS) is found to be effective. ICWS consists of an activated warning sign and sensors which detect the vehicles approaching the intersection. It warns the drivers on the minor road about presence of vehicles on major road and informs the drivers on the major road about presence of vehicles on the minor road. This situation results in reduced conflicts as drivers get alert about the possible approaching vehicle, resulting in lower intersection approach speeds and improved driver gap acceptance.

This chapter shows to evaluate the performance of ICWS for a typical uncontrolled intersection by examining the responses of major road drivers towards the designed warning system. Different scenarios were designed to assess the behaviour of the drivers on the major road approach and driving performance measures such as speed and acceleration were evaluated.

Study area and experiment design

The experimental methodology for evaluating the response of major road drivers towards intersection conflict warning system is shown in Figure 12-1. The study area selected is of 2.1 km road stretch starting from

Figure 12-1 Methodology for evaluating ICWS at uncontrolled intersections



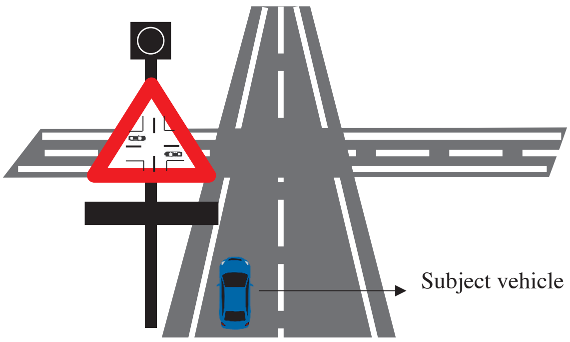
IITH hostel circle (point A) to the main gate (point B). It consists of uncontrolled intersection, roundabout, and side roads. Intersection conflict warning system was installed at a four-legged uncontrolled intersection, which is 230 meters away from the hostel circle (point A). A loop detector was installed on a minor road and a warning signboard installed on the major road. Twenty-nine participants with age ranging from 22 to 57 years were recruited for this study. Socio demographic characteristics such as age, gender, education qualification, driving license and occupation were collected.

Four scenarios were designed to evaluate the response of major road drivers towards intersection conflict warning system. In the first scenario, no vehicle was present on the minor approach and therefore warning sign was not activated on the major road (Figure 12-2 (a)). In the second scenario, crossing vehicle was present on minor road and warning sign was not activated on the major road. In the third scenario, crossing vehicle was present on the minor approach and entering traffic warning signal was given to the major road approach as shown in the Figure 12-2 (b), however no prior information was given to the participant driver regarding the entering vehicle from minor approach. In the fourth scenario, the participant driver was educated about the deployed warning system and was asked to drive through the intersection with entering traffic warning signal on. The fourth scenario was designed to assess the drivers understanding of the warning system by examining their responses towards the system.

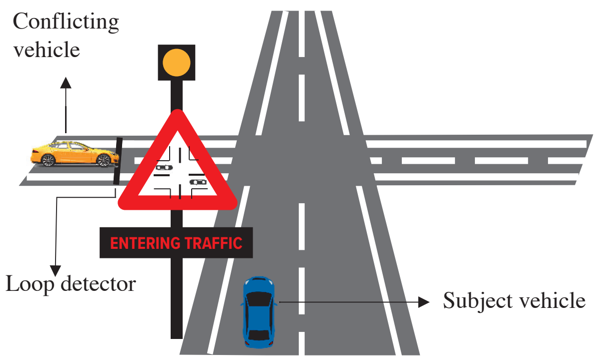
Procedure

A passenger car instrumented with video box was used for collecting the data. The video box (v- box) consists of a GPS receiver that records the position movements at 10 Hz and has two video cameras for recording videos as desired. One camera fixed to the windscreen records the road features and moment when the warning sign is activated. The second camera placed below the steering wheel records the driver's brake movements. Figure 12-3 represents the image of an instrumented vehicle used for the study. Participants were asked to sign on the consent form before they start the experiment. Each participant has to perform four test drives in order to provide responses to the four different scenarios. At the end of the experiment, participants were asked to fill a post signage questionnaire form to assess the degree to which the warning system helped them in crossing the intersection safely. Further, they were asked to complete a signage questionnaire in which they have to rank the warnings signs that they think suitable for placing near uncontrolled intersection from better to worse.

Figure 12-2 Experiment design with different scenarios



(a) Scenario 1: No conflicting vehicle with warning sign not activated



(b) Scenario 3: Conflicting vehicle present with warning sign activated

Figure 12-3 Instrumented vehicle used for the study

Camera 1 Camera 2 Video box

Table 12-1 Driving performance with different scenarios

ICWS Scenarios	Speed (km/h)			Deceleration (m/s^2)		
	Mean	Standard deviation	Number of observations	Mean	Standard deviation	Number of observations
Scenario 1	39.21	5.80	29	0.05	0.12	29
Scenario 2	38.94	4.95	29	0.22	0.26	29
Scenario 3	37.78	5.18	29	0.32	0.24	29
Scenario 4	32.86	4.91	29	0.27	0.21	29
ANOVA p-value	0.000*			0.000*		

*$p < 0.05$

Data Analysis

Drivers speed and acceleration profiles were extracted at a distance of 80 meters from the uncontrolled intersection. One way ANOVA was employed to study the statistical differences in driving performance against three scenarios. A post-hoc test Tukey's Honesty Significant Difference was conducted to determine any interaction exists between the two scenarios. A significance level $\alpha = 0.05$ was considered in the study. To assess the best warning sign from the signage questionnaire form filled by drivers borda count method was employed.

The summary statistics of driving performance measures and one-way ANOVA results are shown in Table 12-1. A statistical difference was observed among four scenarios ($F = 9.30$, $p = 1.52E-05$) for mean speed. The post comparison revealed that the difference between the mean speed of scenario 2 and scenario 4 ($p = 0.0001$) as well as the difference between the mean speed of scenario 3 and scenario 4 ($p = 0.002$) was statistically significant. This demonstrates that the drivers with a better understanding of the warning system resulted in lower mean speed in scenario 4 compared to scenario 2 and scenario 3. There was no significant difference observed between the mean speed of scenario 2 and scenario 3. The reason could be that drivers did not pay much attention to the warning system in scenario 3, and the mean speed for scenario 2 and scenario 3 was almost the same.

A statistical difference was observed among four scenarios ($F = 9.24$, $p = 1.62E-05$) for mean acceleration. The post comparison test revealed that the difference between mean acceleration of scenario 2 and scenario 4 as well as the difference between the mean acceleration of scenario 3 and scenario 4 was statistically not significant.

Figure 12-4 represents the boxplot of mean speed of all drivers for four scenarios. The quartiles of the box presented here are the 15^{th} and 85^{th} percentile, and median is 50^{th} percentile. The vertical line in the figure represents the intersection where a minor road vehicle enters.

From the figure we can observe that the mean speed of all drivers for scenario 1 was almost constant. For scenario 2 there was a slight reduction in speed when they approached the intersection. In scenario 3 there was a reduction in speed compared to scenario 2 when they approach the intersection. In scenario 4 drivers tend to reduce more speed compared to scenario 2 and scenario 3 when they approach the intersection. This indicates that the drivers with a better understanding of the warning system could respond before they approach the intersection and can avoid sudden braking at the intersection.

A post signage questionnaire form consists of two sets of warning signs i.e., dynamic and static warning signs. In dynamic warning signs when a vehicle is detected by the sensor, warning light starts blinking and message will be displayed. In static warning signs when a vehicle is detected by the sensor, only warning light blinks and message was already displayed. Four different warning signs were designed for both dynamic and static, and participants were asked to rank the signs from best to worse. Figure 12-5 represents the image of a signage questionnaire form.

A ranking analysis was carried out to identify the best warning sign based on the ranking order provided by drivers in the signage questionnaire form. Borda count method was considered to evaluate the rank data. In the dynamic warning signboard, the first sign got more points, which has a LED light and message to be displayed as 'ENTERING TRAFFIC', and a sign symbol representing a four-legged intersection with vehicles approaching on the minor road. For static sign warning signboard, second sign got more points, which has a LED light and message displayed as 'LOOK FOR ENTERING TRAFFIC' and sign symbol representing intersection with the direction of approach of minor road vehicles. Further, a question was asked to select either dynamic or static signs that they think more suitable. 78% of drivers opted for dynamic signboards explaining that

Figure 12-4 Average speed profiles of drivers for different scenarios (a) Scenario 1 (b) Scenario 2 (c) Scenario 3 (d) Scenario 4

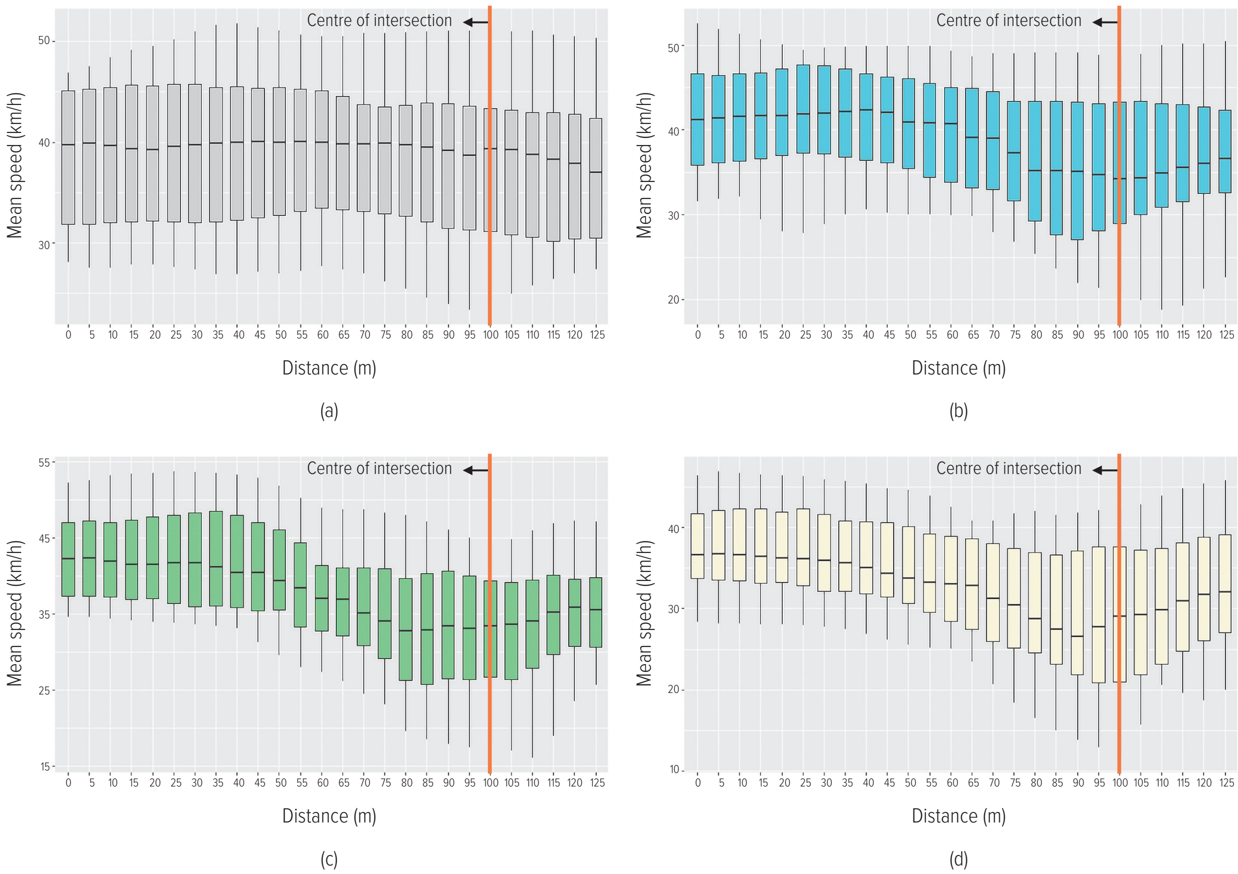
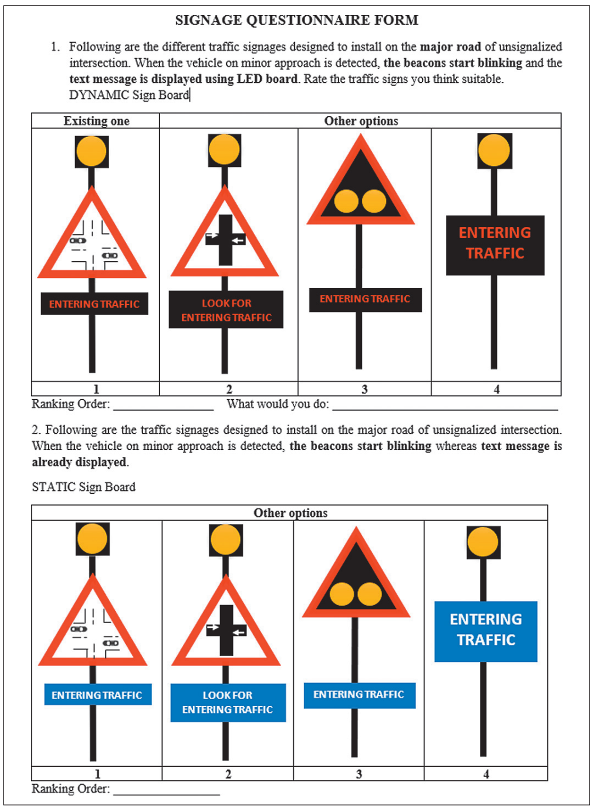


Figure 12-5 Signage questionnaire



SIGNAGE QUESTIONNAIRE FORM

1. Following are the different traffic signages designed to install on the **major road** of unsignalized intersection. When the vehicle on minor approach is detected, **the beacons start blinking** and the **text message is displayed using LED board**. Rate the traffic signs you think suitable.
DYNAMIC Sign Board

Existing one	Other options		
ENTERING TRAFFIC	LOOK FOR ENTERING TRAFFIC	ENTERING TRAFFIC	ENTERING TRAFFIC
1	2	3	4

Ranking Order: _______________ What would you do: ___________________________________

2. Following are the traffic signages designed to install on the major road of unsignalized intersection. When the vehicle on minor approach is detected, **the beacons start blinking** whereas **text message is already displayed**.

STATIC Sign Board

Other options			
ENTERING TRAFFIC	LOOK FOR ENTERING TRAFFIC	ENTERING TRAFFIC	ENTERING TRAFFIC
1	2	3	4

Ranking Order: ________________

the activation of LED light blinking and display of message when they approach the intersection attracts their attention to the signboard and make them more cautious.

Conclusions

The chapter analyzed the responses of major road drivers towards the conflict warning system installed at a typical four-legged uncontrolled intersection. Results indicate a statistical difference among four scenarios for mean speed and mean acceleration was observed. The average mean speed of drivers for scenario 4 was lowered by 6 km/h compared with scenario 2. This implies that the drivers after being educated by the warning system could result in lower mean speed because drivers were alert about the approaching vehicle and responded before they approached the intersection. A post signage questionnaire form results show a positive response from drivers saying that the warning system would be helpful in reducing collisions at uncontrolled intersections.

When an accident takes place at intersection there will be a delay in the movement of vehicles results in congestion and an increase in more fuel consumption and CO_2 emissions will be observed. With the help of ICWS we can reduce accidents, traffic congestion, CO_2 emissions and ensure safe travel of people on road. ICWS also avoids sudden braking behaviour of drivers which results in reduction in COF emissions. When driver applies sudden braking behaviour a number of deceleration events takes place which can increase fuel consumption and CO_2 emissions.

Reference

[1] Ministry of Road Transport and Highways: Road accidents in India 2019. 197pp, 2020.