Research
Report Summary

SAFETY RESEARCH USING SIMULATION
UNIVERSITY TRANSPORTATION CENTER

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Safely and Effectively Communicating Non-Connected Vehicle Information to Connected Vehicles through Field- and Driving-Simulator-Based Research

Red-light-running crashes present a safety problem for road users, especially in blind-spot scenarios. If drivers receive help from their vehicles in detecting red-light-running vehicles, red-light-running crashes could be reduced.

Research Objectives

The research objectives were (1) to evaluate the effectiveness of a system warning of a potential non-connected red-light-running vehicle crossing from a blind spot, and (2) to evaluate the feasibility of communicating data from a radar-based vehicle detection (RVD) system to connected vehicles (CVs) over dedicated short-range communications (DSRC).

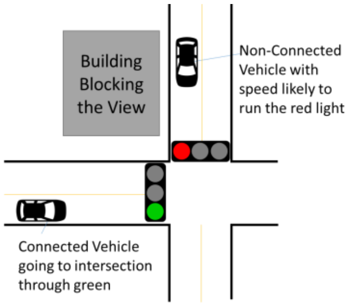

Figure 1. Blind-spot scenario example

Driving Simulator Scenario

An experiment was conducted in a virtual environment in which subjects drove through an urban environment. As a secondary task, subjects were asked to push a button on the steering wheel when they spotted a pedestrian.

Data Analysis Procedures

Locations and timestamps when subjects reacted to the warning system were analyzed.

Driver behavior was analyzed for a group of subjects exposed to a warning system triggered at different locations: at the stop bar and at 50, 100, and 150 ft before the stop bar.

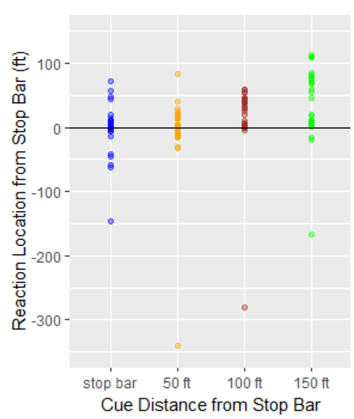

Figure 2. Location of reaction to the warning system

Display of Warning Messages

Warning messages indicating the presence of a red-light-running vehicle ahead were displayed to the subject as a head-up display (HUD) as shown in Figure 3. Each warning message was accompanied by an auditory cue in the form of a beep.

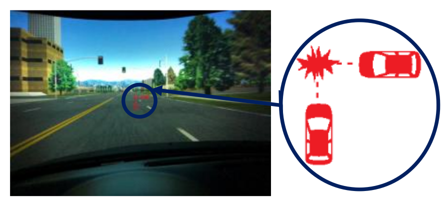

Figure 3. HUD warning message

Secondary Task Instrumentation

Responses to spotting pedestrians as a secondary task were collected using a cellphone connected to a push button (Figure 4) via a Bluetooth™ connection.

Figure 4. Bluetooth push button

Speed Behavior

Subjects saw the red-light-running vehicle and reacted to it before the warning system was activated at the stop as shown in Figure 5. Subjects reduced their speeds after the warning system was activated and sometimes came to a complete stop (Figure 6).

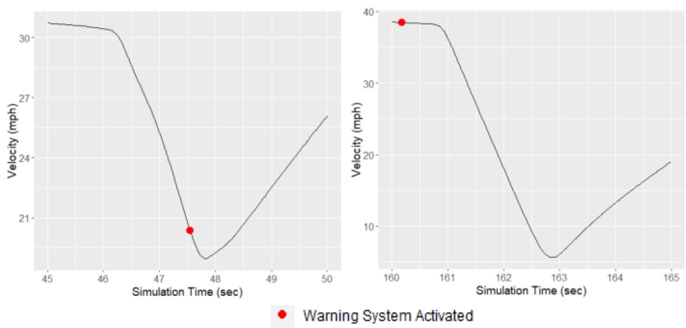

Figure 5. Warning system activation moment: at a stop bar(left) and 30 ft before the stop bar (right)

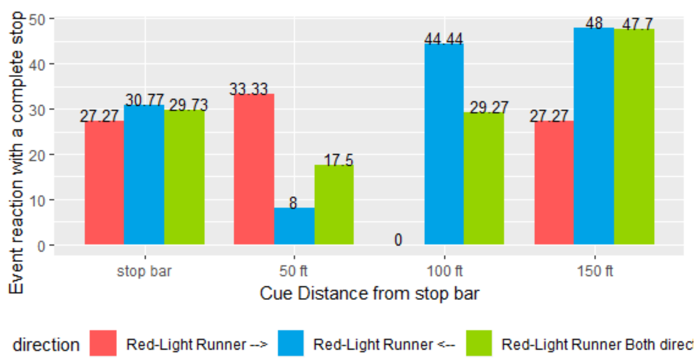

Figure 6. Percentage of subjects that completely stopped

Location of Warning Message Activation

A statistically significant difference was observed in the reaction time between the warning system activated at the stop bar and at 50, 100, and 150 ft upstream of the stop bar. A density plot and a box plot are shown in Figure 7 to visually summarize the data. The research team suggests activating such a warning system at 50 ft or 100 ft upstream of the stop bar.

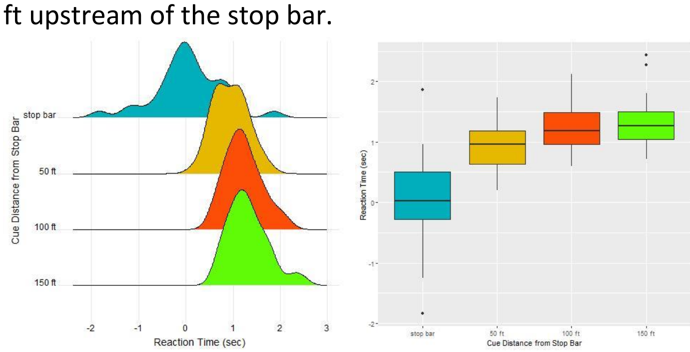

Figure7. Visual summary of results for activation location

The relationship between the different activation locations of the warning system and the location of reaction is shown in Figure 8.

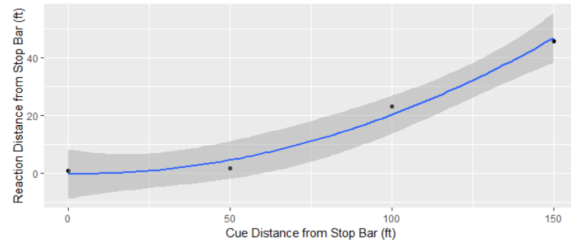

Figure 8. Reaction distance from stop bar

Implementation Feasibility Analysis

The feasibility of monitoring red-light-running behavior using an RVD device was evaluated. The proposed flow of information is described in Figure 9 and detailed in the report. In summary, since the RVD can constantly monitor the position of multiple vehicles, by merging the information with vehicles the presence of a potential red-light runner can be communicated as a basic safety message (BSM) over DSRC.

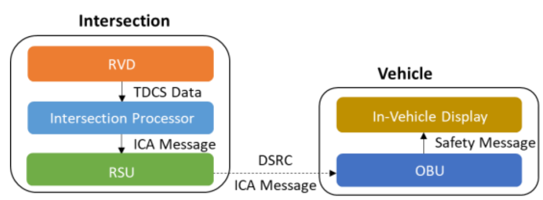

Figure 9. Information flow of the system design

As part of the feasibility exploration, test drives were conducted along a corridor in Madison, Wisconsin, that is instrumented with DSRC radio to confirm that the type of data streamed can accommodate the information flow diagram shown in Figure 9. Photos of a test drive showing signal status information received through a DSRC onboard vehicle unit are shown in Figure 10.

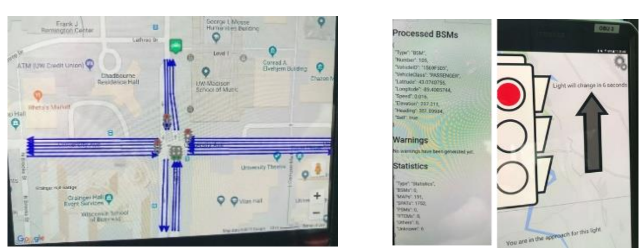

Figure 10. Photos of data received over DSRC