TECHBRIEF

The national Intelligent Transportation Systems (ITS) program includes the development and application of advanced systems upon all parts of the transportation network, including rural areas. The U.S. DOT has developed the Advanced Rural Transportation Systems (ARTS) program to meet the needs of travelers in and through rural areas, as well as the agencies responsible for the operation and maintenance of the rural transportation system. The ARTS program complements the ITS efforts in metropolitan areas and commerical vehicle operations (CVO) by studying ways to best implement technologies that address transportation problems in rural areas.

U.S. Department of Transportation
**Federal Highway Administration**

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

# Intersection Collision Warning System

Publication No. FHWA-RD-99-103
FHWA Contact: Tim Penney, HRDS, (703) 285-2174

## Background

Safety at unsignalized intersections is a major concern. Intersection collisions are one of the most common types of crash, and in the United States, they account for nearly 2 million accidents and 6,700 fatalities every year. However, a fully signalized intersection can sometimes be hard to justify in rural areas, due to the cost of installation, maintenance, and added delays to traffic on the major through streets. The Intersection Collision Warning System (ICWS) project studied the effectiveness of an innovative and potentially less expensive approach to improving safety in these situations. This approach consists of two types of traffic-actuated warning signs linked to pavement loops and a traffic signal controller.

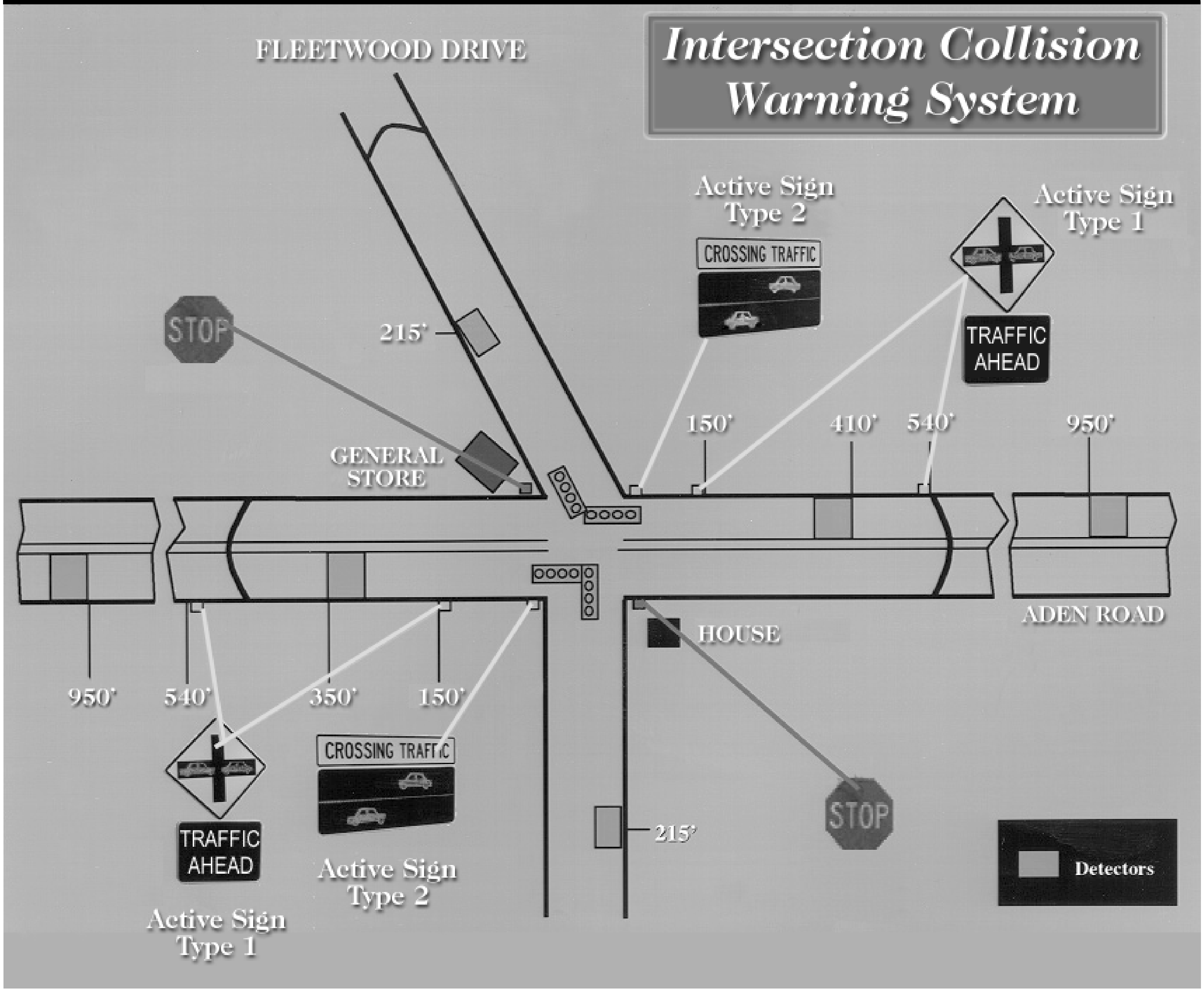
## Project Description

The purpose of the ICWS project was to enhance driver awareness of the traffic situation at the intersection by providing timely and easily understood warnings of vehicles entering the intersection. In other words, drivers approaching the intersection on a major through road are given a warning—a flashing car symbol—when there is a vehicle prepared to enter the intersection from the cross street. At the same time, drivers waiting at the stop signs on the minor approach are given a “crossing traffic” alert—with an animated car symbol—when traffic is approaching along the major approach from either direction. This system is the first of its kind anywhere, and was designed to specifically address the intersection of a major road and a stop sign-controlled cross street. Figure 1 (on the following page) illustrates a plan view of the intersection location where the ICWS was installed.

## System Capabilities

Sensors embedded in the pavement detect the presence of vehicles waiting to enter the intersection at the minor approach and measure

Figure 1. Intersection Collision Warning System




the speed of approaching vehicles on the major approach. The information is collected by a computer controller at the intersection that estimates the various vehicles' arrival times and activates the warning signs accordingly.

## Evaluation Approach

The field study was comprised of a three-phase ("before," "acclimation," and "after") ICWS evaluation based on observed vehicle behaviors immediately before, immediately after, and 4 months following ICWS installation. Results reported herein are based on a 42-day data sample, comprising approximately 97,000 vehicles traversing the intersection. However, due to the necessity of basing ICWS evaluation results on the affected driver sample (e.g., two competing motorists approaching the intersection at the same time), results were based on a targeted sample comprised of 1,652 vehicles.

Measures of Effectiveness (MOEs) were derived from ICWS operational objectives, specifically addressing vehicle behaviors that the ICWS intends to affect. The analysis applied the MOEs to rural intersection accident-avoidance requirements. Applied MOEs were: (1) drivers' ICWS speed responses in the presence of cross traffic; (2) intersection approach speed reductions; and (3) projected times to collision (PTCs), i.e., the elapsed time to which an approaching vehicle would collide with a vehicle in its path in the absence of timely avoidance response. Human factors (e.g., driver perception-reaction time) accident-avoidance requirements determined critical PTC values that were used in the analysis.

## Results

The data analysis demonstrated that the ICWS had a greater impact on driver behavior on the approach with the shorter sight distance. Specific findings were as follows:

- Lower intersection approach speeds were observed following installation and 4-month operation of the ICWS.
- The vehicle group exhibiting the shortest 10th percentile PTCs (i.e., those at greatest risk of collision) during the "before" condition averaged longer PTCs and lower intersection approach speeds during the "acclimation" (i.e., immediately following installation) and "after" periods.
- Targeted high-speed vehicle groups (i.e., 72.4-km/h and 88.5-km/h [45-mi/h and 55-mi/h] violators) demonstrated initial novelty-effect ICWS speed reductions that were not generally sustained 4 months following ICWS installation. However, fewer speed violators in both groups exhibited critically short PTCs (i.e., indicating reduced rural intersection accident potential) in the presence of cross traffic during the "after" study period.

## Measures of Effectiveness

1. Sign Response Speed—Measured vehicle-specific speeds at the intermediate loop detectors for eastbound and westbound traffic. The positioning of these loops, i.e., approximately 39.6 and 42.7 m (130 and 140 ft) beyond the activated signs, and 106.7 and 125.0 m (350 and 410 ft) in advance of the intersection, allowed motorists to react to the "Traffic Ahead" sign's message/activation and understand their proximity to the intersection.
2. Intersection Arrival Speed—Measured vehicle-specific speeds at the intersection loop detectors for eastbound and westbound traffic. These loops were placed within the intersection approaches and reflect intersection arrival speeds.
3. First Speed Reduction—Measured vehicle-specific speeds at the intersection loop

Table 1. "Before" versus "after" period MOE differences (speed is given in mi/h and time in seconds).

| Measure of Effectiveness | Before Period (N=561) | | | After Period (N=424) | | |
|---|---|---|---|---|---|---|
| | 5th Percentile | Mean | 95th Percentile | 5th Percentile | Mean | 95th Percentile |
| 1. Sign Response Speed | 36 | 44.8 | 54 | 34 | 44.3 | 53 |
| 2. Intersection Arrival Speed | 31 | 41.4 | 51 | 27 | 40.0* | 51 |
| 3. First Speed Reduction | -3.0 | 3.2 | 10 | -3.0 | 4.7* | 12 |
| 4. Second Speed Reduction | -3.0 | 3.4 | 10 | -2.0 | 4.3* | 11 |
| 5. Overall Speed Reduction | 0 | 6.7 | 17 | 0 | 9.0* | 11.8 |
| 6. Projected Times to Collision | 3.4 | 7.8 | 12.1 | 3.0 | 7.7 | |

* = Significant difference, <0.01

1 mi/h = 1.61 km/h

detectors for eastbound and westbound traffic. These speed reductions represent speed differences between points 289.6 m (950 ft) in advance of the intersection and the intermediate locations noted in MOE #1 above.

4. Second Speed Reduction—Measured vehicle-specific speed differences between the intermediate and intersection loop detectors for eastbound and westbound traffic. The speed reductions represent speed differences between sign response locations and intersection arrival points.

5. Overall Speed Reduction—Measured vehicle-specific speed differences between advance and intersection loop detectors, i.e., the intersection and points 289.6 m (950 ft) in advance.

6. Projected Times to Collision (PTC)—Theoretical elapsed times to which an approaching Aden Road vehicle would collide with an intersecting Fleetwood Drive vehicle and the simultaneous determination of an approaching Aden Road vehicle's speed and position. Derived values can also be considered as the amount of time available for potentially colliding motorists to take an accident-avoidance action. Based on reviewed literature, the two applied PTC values for avoidance-maneuver time and actual stopping time were 3.0 and 4.6 seconds, respectively.

## For More Information

The project was funded by the Federal Highway Administration and conducted by Raytheon Systems Company of Falls Church, Virginia, in cooperation with the Virginia Department of Transportation and Prince William County, Virginia.

For more information, please contact Tim Penney, Office of Safety Research and Development, (703) 285-2174.