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Design of an intersection decision support (IDS) interface to reduce crashes at rural stop-controlled intersections

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Abstract

Rural, stop-controlled intersections pose a crash risk to drivers, particularly elderly drivers. This paper outlines the design phase of an infrastructure-based intersection decision support (IDS) system to help drivers make safer gap acceptance decisions at rural intersections. A human factors-based design process was conducted to determine the type of information that should be presented to drivers. Information considered important for presentation to the driver included showing the presence of gaps, indicating the size of available gaps, and/or judging the safety of available gaps. This paper discusses the process used to determine the appropriate design specifications for initial testing of the IDS system interface.

Keywords: Intersections; Rural; Older drivers; Telematics; Task analysis; Infrastructure

1. Introduction

Some states in the US are currently investigating the problem of rural intersection negotiation in an effort to develop intelligent transportation system (ITS) countermeasures to reduce fatal crashes on rural roads. In particular, rural stop-controlled intersections where high-speed, high-volume roads (termed Interregional Corridors or IRCs) are intersected by lower-speed, lower-volume roads controlled by a stop sign are a major problem (see Fig. 1). In 2002, over 22,000 fatal crashes occurred on rural roads in the US, accounting for 59% of all fatalities (NHTSA, 2003). According to the American Association of State Highway and Transportation Officials (AASHTO) (1997) approximately 16% of rural fatal crashes in the US occur at intersections. At the state level, there were 34,175 reported crashes on Minnesota rural two-lane roads between 2000 and 2002 (Preston and Storm, 2003). Over 32% (11,069) of these Minnesota crashes were intersection related, with 22% of the fatal rural accidents occurring at stop-controlled intersections.

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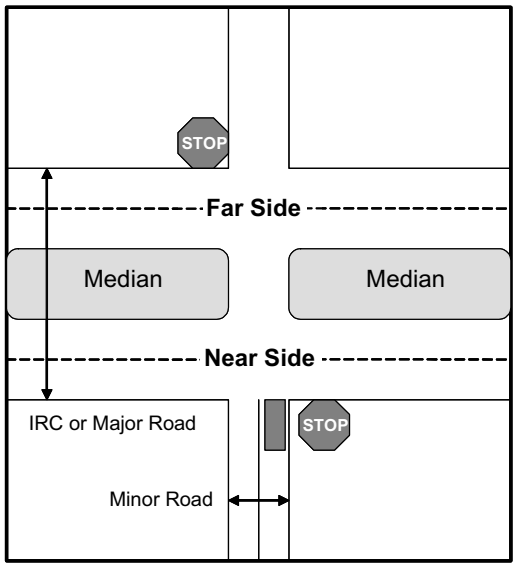

Fig. 1. Layout of a stop-controlled intersection at a rural expressway.

The issue of limited or obscured sight distances has been addressed through the use of actuated warning systems in previous research (e.g., Hanscom, 2001; Peabody et al., 2001). However, there a number of factors, including poor sight distances, that affect rural stop-controlled intersection negotiation. Therefore, a human factors effort was undertaken in Minnesota to specify an appropriate design for an infrastructure-based intersection decision support (IDS) system to aid drivers at stop-controlled rural intersections. An infrastructure-based solution provides a practical starting place for the development of an IDS system because the system can be viewed by all drivers when they arrive at the intersection. Depending on its final design, an infrastructure-based system could be modified in the future to cooperate with in-vehicle systems as those become more prevalent in vehicles. A non-cooperative system must assume general parameters to be applied to all drivers, whereas the advantage of a cooperative system is to communicate information about the vehicle and driver (e.g., age) to the infrastructure to provide more specific information.

A task analysis, which is a commonly used tool to identify driver behavior in specific situations (e.g., Caird and Hancock, 2002), was conducted in conjunction with a review of crash data and driver errors at rural stop-controlled intersections to identify contributing crash factors. These factors were used to constrain the design space and highlight information that may be critical for drivers to make safe decisions at this type of intersection. The overarching goals of the system are to focus on the minor-road driver's behavior and how best to support their decision making to enter the intersection safely and complete their intended maneuvers (i.e., crossing, turning). Once the task and error analyses were complete, design criteria were developed and prototype IDS systems were proposed then evaluated by subject matter experts (SME) in the transportation field.

1.1. Task analysis: rural stop-controlled intersections

A task analysis provides the framework necessary for synthesizing and interpreting the results of crash data. Previous intersection task analyses examined single aspects of intersection negotiation (e.g., left turns) (Chovan et al., 1994a,b; Tijerina et al., 1994) or applied the analysis broadly to all intersection types (e.g., Caird and Hancock, 2002). Because the proposed IDS system will be for use specifically at rural, stop-controlled intersections it was necessary to tailor the analysis specifically to the tasks required to navigate that type of intersection. The rural stop-controlled intersection task analysis identifies task goals, tasks, and sub-tasks that encompass the range of perceptual, cognitive and behavioral aspects of negotiating the intersection. Task goals group similar tasks together, while tasks are further broken down into sub-tasks that