

Rural Intersection Collision Warning System (RICWS) Evaluation and Design Investigation

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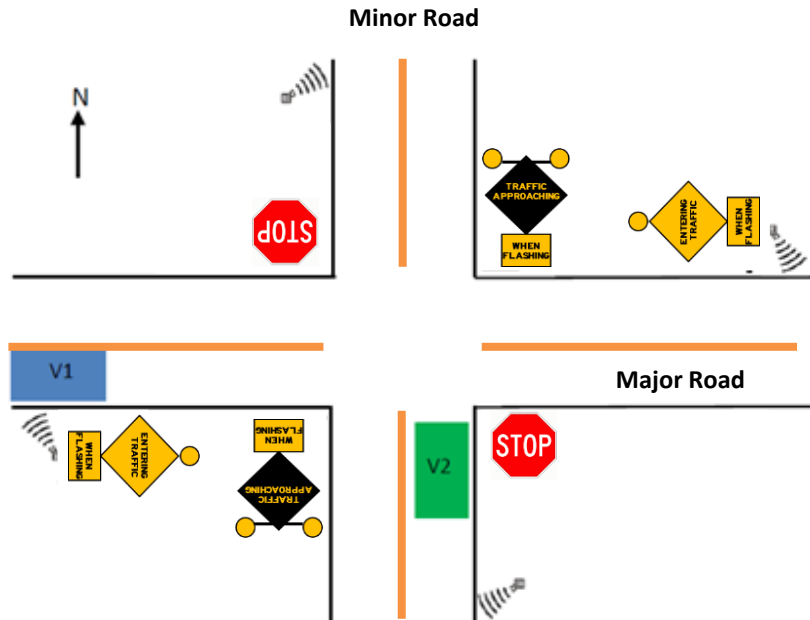
Outline

- Background
- Rural Intersection Collision Warning System (RICWS)
- Primary Human Factors Concerns
- Project Goals
- Usability Test Results
- Driving Simulator Study
- Preliminary Findings

Background

- 55% of rural thru-STOP intersections in Minnesota has had at least one crash (Preston & Storm, 2003).
- Drivers' failure to select sufficient gaps has been identified to be a major contributing factor for crashes at thru-STOP intersections.
- More than 50 RICWS signs have been deployed across the state of Minnesota to aid motorists to safely cross these intersections.

RICWS System



RICWS System Layout



Major Road
Warning System



Minor Road
Warning System

Source: <http://www.dot.state.mn.us/its/projects/2011-2015/ricws.html>

Primary Concerns

- Primary concerns:
 - Complaints reported from local road users
 - Potential road user confusion about signs
 - Ordering of message components
 - Saliency of “Traffic Approaching” component
 - Sign status
 - Overreliance on the sign
 - Behavioral Adaptation to Sign

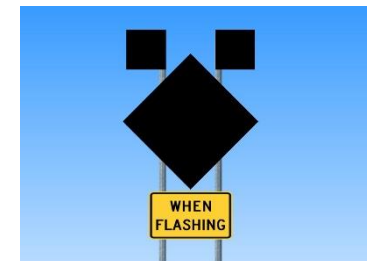
Sign State 1



Sign State 2



Sign State 3

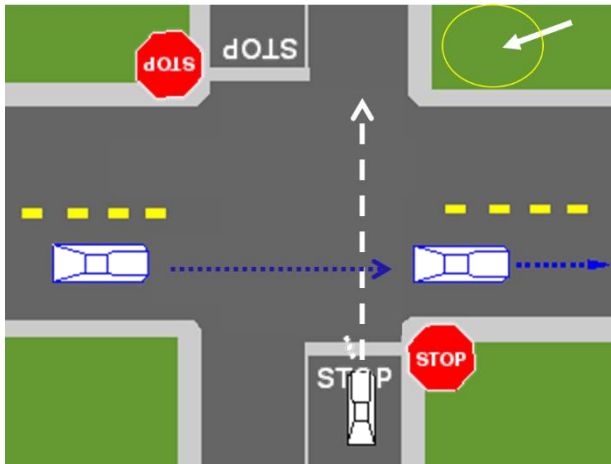


Project Goals

- Use iterative design modifications and usability tests to:
 - Identify critical human factors issues associated with the original RICWS sign and develop alternative design options
 - Evaluate the effectiveness of each sign's ability to convey information for traffic approaching, sign-on, and sign-off states
 - Understand driver's cognitive processes and decision making regarding each sign
 - Evaluate the clarity and appropriateness of terminology and other design elements
- Determine the most appropriate design that:
 - Best captures driver's visual attention
 - Promotes sign acceptance
 - Promotes safe gap acceptance at rural thru-STOP intersections

Usability Testing

- 3 rounds of usability tests
 - Total N=30
 - Mean age=43.3, SD=16.5



Intersection layout provided to participants

Sign States	Traffic is too close to safely cross	Sign is on/operating	Sign is non-operational
Police Examples			
Message Conveyed	<i>There is <u>not</u> enough time to cross.</i>	<i>There is enough time to cross.</i>	<i>This officer is not operational, like signs can sometimes be.</i>

Comparison examples of 'sign states' using a police officer

Usability Test

- Sign comprehension
- Decision making
- Overall design preferences
- Terminology preferences
 - Not safe to cross
 - Sign is on/operating
- Likes/Dislikes

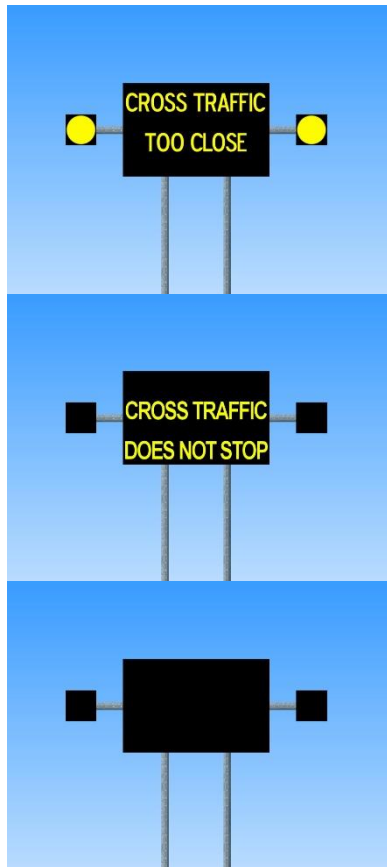
Sign A

Red Frame Flashing

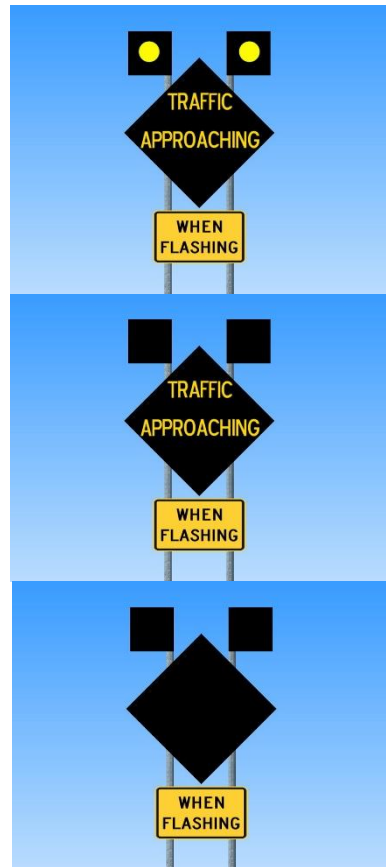


Final Usability Test Results

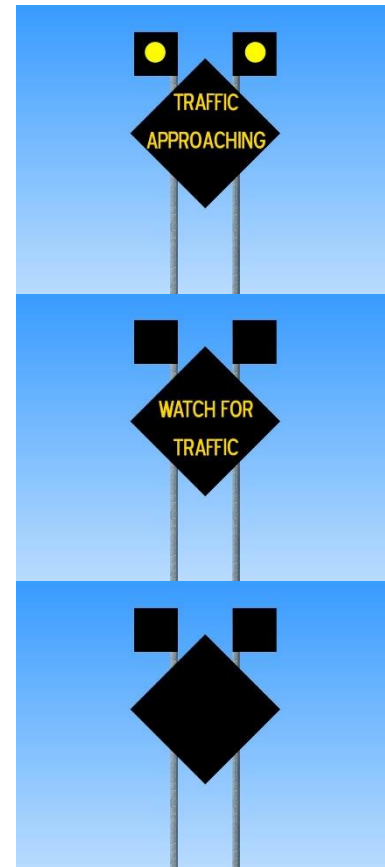
Sign B



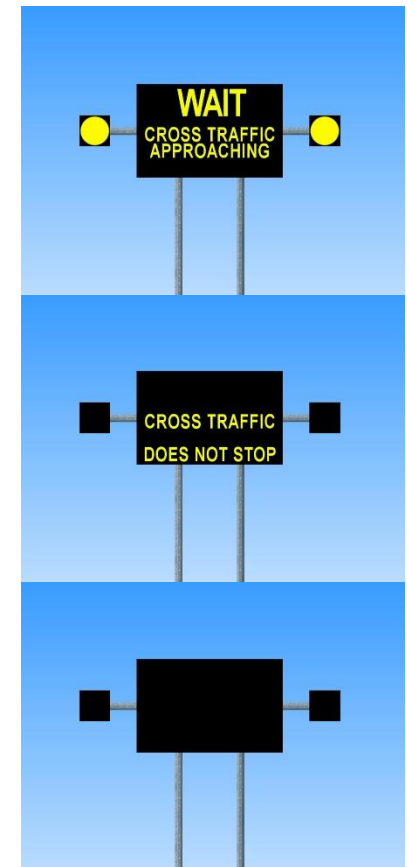
Sign C



Sign F



Sign G



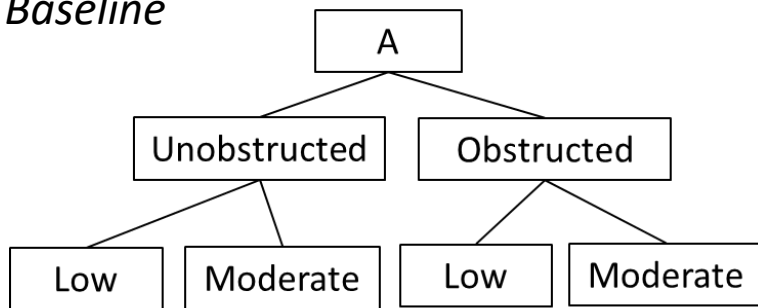
Driving Simulator Study

- Recruitment goals (N=80)
 - 2 age groups (40 per group)
 - Older drivers (65-77)
 - Novice teenage drivers (<18)
- Experimental design
 - Randomly assigned to one sign option
 - ABAB design (reversal design)
 - 2 levels of visibility
 - 2 levels of traffic volume condition
 - Sign-off state

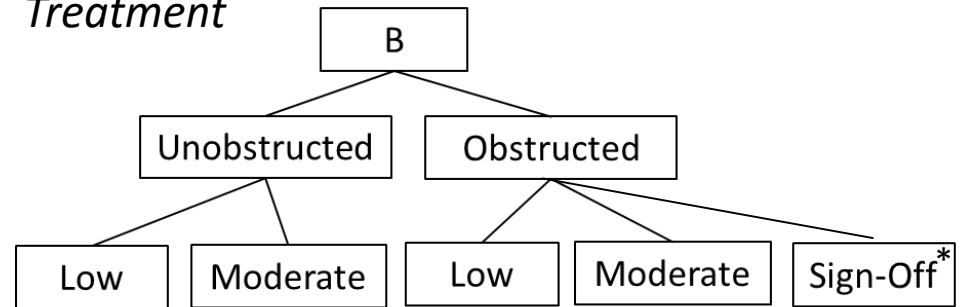
Driving Simulator Study

- Experimental design

Drive 1 & 3:
Baseline



Drive 2 & 4:*
Treatment



Unobstructed View



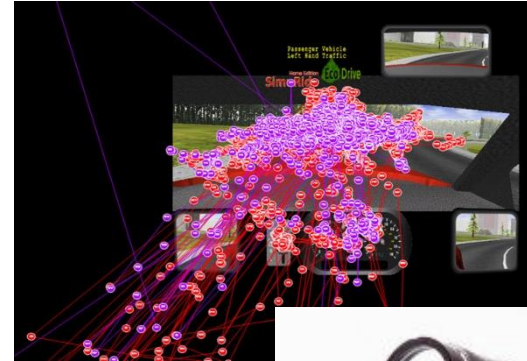
Obstructed View

Driving Simulator Study

- Materials and Apparatus



HumanFIRST partial motion-based driving simulator set up



Smart-Eye Pro Eye Tracking Camera

Data Collection

- On approaching the intersection:
 - Speed
 - Braking
 - Wait time
 - Stop sign violations
- When crossing the intersection:
 - Gap acceptance
 - Acceleration
 - Crossing behavior
 - Sign compliance
 - Collision rate

Data Collection

- Visual Attention
 - Percent of eyes-on and -off road
 - Frequency and duration of fixations on signs
 - Visual search patterns
- Subjective Measurements
 - Sensation Seeking
 - Driving History
 - Driving Behaviors
 - Mental Workload
 - System Trust
 - Usability Test

General Research Questions

- Which sign design most clearly conveys the information being presented to road users?
- Which sign design best captures drivers' attention and requires less visual workload?
- Under which environmental (visibility and traffic volume) condition does the warning sign best aid road users to safely cross the intersection?
- To which extent do road users rely on the signs at these intersections?
- Do road users continue to adhere to stop signs once they become familiar with the signs' operations?

Research Hypothesis

- Gap Acceptance Hypothesis
 - Older drivers are expected to be more likely to:
 - Misjudge the size of gap
 - More frequently reject a gap
 - Longer total wait time at intersections
- Visual Attention Hypothesis
 - Older drivers are expected to be more likely to:
 - Take longer time to process
 - Use more fixations
 - Higher visual workload
 - Less eye-off-road behavior

Preliminary Findings

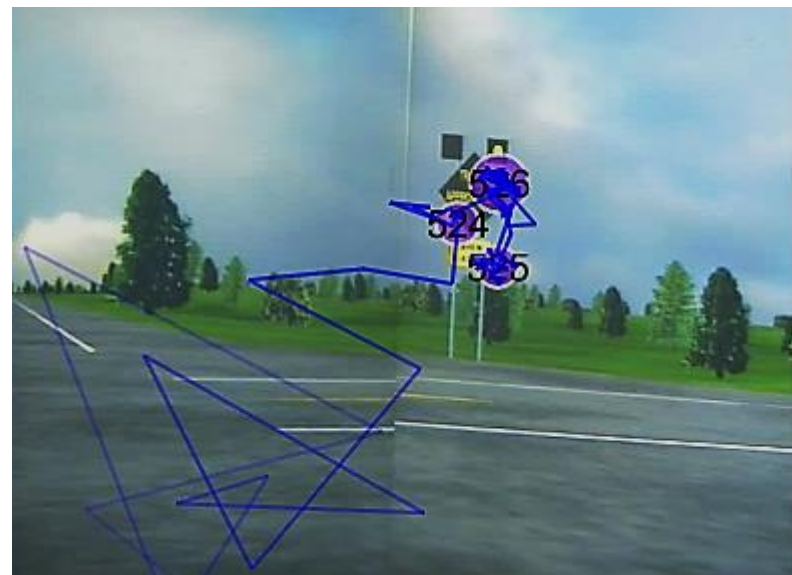
- Sign Comprehension
 - Misinterpretations of sign states
- Sign Acceptance
 - Teenage Drivers
 - Overconfidence on signs
 - Less reliance on signs
- Sign Acquisition

Preliminary Findings

- An Example:
 - Eye Tracking on Sign C (*Original RICWS*)



Teen Driver



Older Driver

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