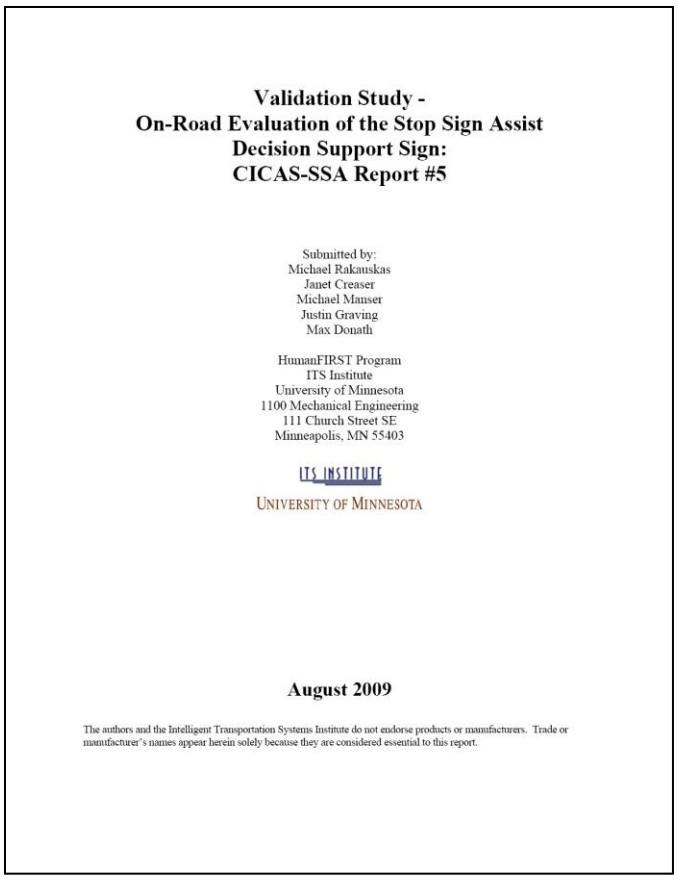

Validation Study -
On-Road Evaluation of the Stop Sign Assist Decision Support Sign:
CICAS-SSA Report #5

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EXECUTIVE SUMMARY

In the United States it is recognized that crashes in rural areas are a cause for concern, especially crashes at rural intersections where inherent speeds may be associated with higher fatality rates (FHWA, 2004). Recent work has shown gap acceptance problems to be the key factor contributing to these crashes (Laberge, Creaser, Rakauskas, & Ward, 2006) as opposed to stop sign violation (Preston & Storm, 2003). However, the majority of intersection decision-support systems implemented at intersections have not attempted to provide specific information about the nature of available gaps in the approaching traffic or provide adequate information that supports a driver's gap acceptance decision. To reduce the crash risk at rural stop-controlled intersections, it has been recommended that intersection decision-support systems be developed and deployed to assist drivers in responding to safe gaps (Preston, Storm, Donath, & Shankwitz, 2004).

The Cooperative Intersection Collision Avoidance System-Stop Sign Assist (CICASSSA) sign is an infrastructure-based driver support system that is intended to improve gap rejection at rural stop-controlled intersections. The CICAS-SSA system tracks vehicle locations on a major roadway and then displays a message to a driver on a minor road via a changeable message sign. The basis of this sign is a "Divided Highway" sign that is commonly presented in traffic environments. Overlaid on the roadways of the sign are yellow or red icons that represent approaching vehicles that are at a distance at which the driver on the minor road should proceed with caution or at a distance that is considered unsafe to enter the intersection. Previous research conducted in a driving simulation environment indicated potentially beneficial changes in driver decision making relative to approaching vehicle gap sizes and indicated that drivers perceive the system as being both useful and satisfying. While simulation-based evaluations provide a wealth of useful information, their ability to replicate the full array of behavioral, cognitive, and perceptual elements of a driving environment do have some limitations. It is because of these limitations that it is useful to confirm simulation-based findings in a real-world environment.

The primary goal of the current work was to evaluate the candidate CICAS-SSA sign in a real world setting to confirm previously identified benefits and identify any unintended consequences of sign usage. This goal was accomplished through the conduct of a validation field test performed at the intersection of MN Highway 52 and County Road 9 in Southern Minnesota. In this study, 48 participants from three target age groups (young, middle-age, and senior) were recruited in order to determine the influence of driver age on performance while using the CICAS-SSA sign. An additional 13 truck drivers completed the study using a large truck to better understand the value of the CICAS-SSA sign to drivers of heavy vehicles that react slowly to driver input and provide for a significantly higher viewpoint when

compared to passenger vehicles. The intersection, instrumented vehicle, and instrumented truck were outfitted with recording equipment that collected data while drivers made gap decisions in relation to actual traffic at the intersection while making crossing and turn maneuvers. Data included rejected gap size, lead gap size, maneuver type (one-stage vs. two-stage), crossing and wait times, and safety margins.

Overall, results indicated that participants used the CICAS-SSA sign to reduce their risk level at the intersection and that drivers had a positive opinion of the sign. The use of the CICAS-SSA sign was associated with the rejection of shorter, unsafe gaps as evidenced by the increase in 80th percentile rejected gap. In addition, the 7.5 second critical gap threshold used by the CICASSSA sign was shown to be in agreement with the driver's gap selection performance. The sign did not appear to have an effect on the intersection crossing metrics of accepted gap length, lead gap length, or time-to-contact. The lack of significant differences across these metrics (which provide an indication of crossing performance) along with the differences observed in the 80th percentile rejected gap suggests that the CICAS-SSA sign can have a positive effect on performance at the intersection through reduced decision making risk while not drastically altering how drivers make maneuvers at the intersection. This finding is promising because it indicates the CICAS-SSA sign can be implemented without influencing how drivers perceive their task of maneuvering their vehicle through an intersection. It also suggests that there were no unintended consequences of using the sign while making a crossing decision. Subjective measures were collected and analyzed in order to determine how drivers understood the CICAS-SSA sign functioning and served to assess whether the sign assisted drivers' perceived confidence, safety levels, and usefulness; poor subjective measure ratings would indicate general dislike of the sign that may result in non-use. Subjective measures included mental effort, comfort/stress, usefulness, satisfaction, and comprehension related to CICAS-SSA sign use. Results of the subjective response analyses indicated that the CICAS-SSA sign was perceived as being usable and that it served an advisory role. Specifically, a majority of drivers reported that they used the sign to validate their own decisions and perceptions of safety while entering the intersection. This is promising because it affirms the intent of the CICAS-SSA sign, that being to confirm/facilitate drivers' own perceptions of safety before entering the intersection as opposed to controlling their actions. Overall, 66% of all car drivers and 50% of drivers in the older age group reported that they used the CICAS-SSA sign. This is promising because older drivers are typically less willing to accept new technologies and they are more likely to be involved in a crash at the test intersection. Given that some drivers may never accept the CICAS-SSA sign, it may be necessary to deploy a positive advertising campaign (particularly aimed at older drivers) in order to inform drivers of the benefits of using this particular ITS application. Collectively, the results of this study suggest that the information presented on the CICAS-SSA sign is beneficial to drivers' gap decision-making process while not adding undue stress.

Findings from the current work examining the utility of the CICAS-SSA sign were consistent with those observed in previous studies conducted in the HumanFIRST driving simulator. In particular, findings from the Random Gap study (Creaser, Manser, & Rakauskas, 2008) indicated that drivers using the CICAS-SSA sign reduced their risk while making gap selection decisions. Continuity of results across studies suggests increased confidence that the results obtained are robust and may be used to make tentative predictions regarding driver performance if the CICAS-SSA sign is deployed. The predications of driver performance are tentative due to limitations in the simulation and on-road testing methodologies, including 1) modified perception of driver risk due to the lack of actual risk in a simulated environment or perceptions of reduced risk within the on-road study due to needed safety precautions, 2) an inability to exhibit absolute normative behaviors due to participant's use of a vehicle that was different from their "daily driver", 3) potential imposition of experimental equipment (e.g., eye tracker) on performance, and 4) potentially modified behaviors because participants were aware they were being observed while making maneuvers. Finally, it is important to note that the simulation and on-road based studies evaluated driver performance, workload, and usability across a relatively short period of time. A longer-term field operational test would provide valuable information regarding "how" drivers adapt to the CICAS-SSA over multiple exposures (e.g., days, weeks, months). In light of the notion that long-term testing in a naturalistic environment that allows drivers to use their own vehicles and interact with the CICAS-SSA will provide insight into the veridical utility of the CICAS-SSA, we recommended that a field operational test be conducted. The results of a field operational test will validate the utility and the absence of unintended consequences due to CICAS-SSA sign use.