

## Executive Summary

Roadway departure fatalities accounted for 55 percent of all roadway fatalities in the United States in 2003. In an effort to reduce the number of roadway departures, many transportation agencies have introduced static rumble strips using physical alterations of the roadway surface in shoulder and/or centerline sections of the roadway. Recently, more advanced technology has been developed in the form of in-vehicle advanced lane departure warning systems that automatically detect the vehicle's lane position and warn of possible roadway departures. These systems are currently showing their value in some commercial trucks in Europe, and are now available in some U.S. passenger cars. Two critical factors will govern their ultimate success; (1) their ability to warn the driver in an effective and timely manner to make the correct action, and (2) their success in gaining driver trust and acceptance. The primary goal of this research was to better understand basic human factors principles of haptic and auditory interfaces as a collision avoidance technique during run-off-road and head-on collisions and driver perception of these modalities. In this simulator study, fifteen participants received alerting cues in three sensory modalities; haptic (seat vibration), auditory ("rumble strip" sound), and combined auditory and haptic sensory warnings. A preliminary psychophysical study was conducted to determine appropriate and comparable intensities of the warning modalities. The results of this study determined that the haptic modality produced significantly faster reaction times than both the auditory and combination modalities. The auditory modality produced significantly more maximum steering response than the haptic and combination condition. Drivers perceived the haptic modality to be the least annoying with least interference, while the combination modality was the most preferred in benefit of driving, most likely to purchase, level of trust, level of appropriateness, level of urgency, and overall preference. Haptic (seat vibration) warnings demonstrate promise as an alerting strategy over auditory and combination modalities in reducing roadway departures. With a decrease in reaction time, less erratic steering responses, and relatively advantageous perceptions from drivers, haptic warnings have the potential to better assist drivers in returning to the lane more quickly and safely.