Evaluation of Autonomous Vehicles and Smart Technologies for Their Impact on Traffic Safety and Traffic Congestion

James Miles, PI
Thomas Strybel, Co-PI
California State University, Long Beach
Jim.miles@csulb.edu

Project Objective

Over the next several decades, highly automated driving systems (HADS) will become increasingly common on our roads, greatly reducing traffic accidents and road congestion. However, for the foreseeable future, the human driver will be required to take control of a car when automation fails. Although the benefits to HADS implementation can be substantial, human driver monitoring of and take-over from HADS can create new sources of human error and must be considered when predicting future automotive accident rates and related traffic congestion. **In other words, it is necessary to consider any potential attenuation of HADS benefits stemming from increases in human driver errors that follow HADS implementation and take steps to prevent these errors from occurring.**

Problem Statement

We considered the specific driving performance changes associated with driver take-overs from HADS. Most current research literature has focused on factors that moderate take-overs from HADS, but do not directly compare driver performance following HADS take-overs versus conventional fully manual driving. In the current project, we focused on driver performance in obstacle avoidance maneuvers following HADS take-overs.

Research Methodology

We developed a virtual-reality driving simulator to evaluate specific differences in driver performance during take-overs from HADS versus current fully manual driving (Figure 1). In a study using the simulator, a vehicle was controlled either by a human driver or by HADS along 3-lane highway tracks including obstacles (Figure 2). We recorded obstacle avoidance maneuver trajectories when the vehicle was fully controlled by a human driver and when the human driver took over control from HADS immediately before the obstacle.

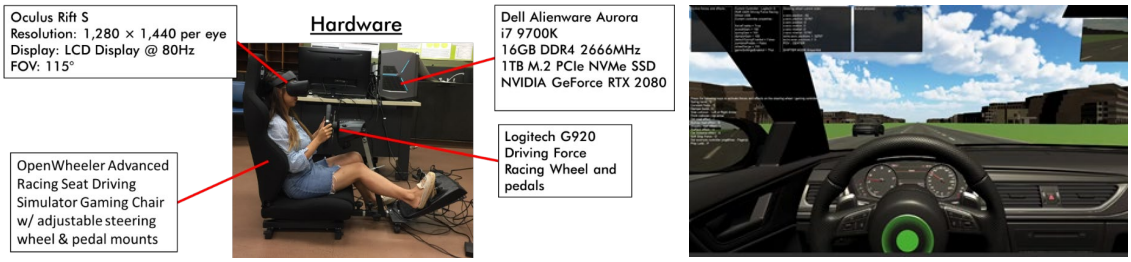

Figure 1. Simulation Hardware (Left) and view from inside VR simulation (right)

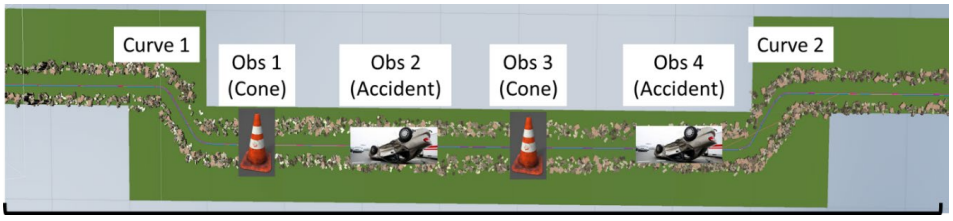

Figure 2. Sample driving track

Results

We analyzed driving trajectories during obstacle avoidance maneuvers following HADS take-overs versus fully manual driving. Figure 3 provides examples of such trajectories from one driver. Yellow lines indicate vehicle position when the obstacle appeared as well as the point of driver take-over in the HADS condition.

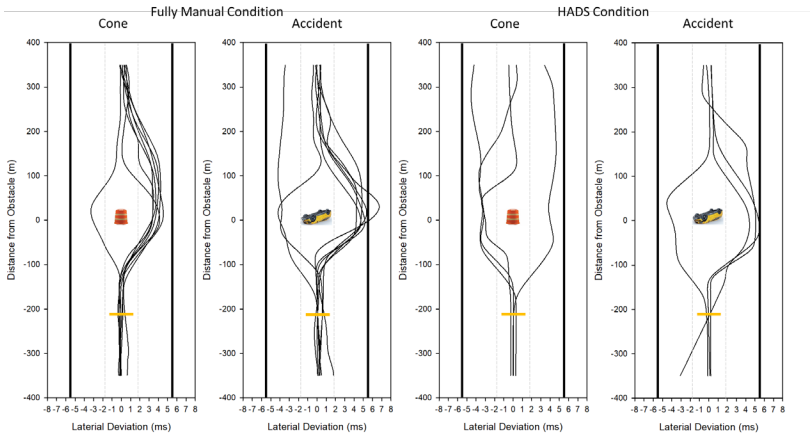

Figure 3. Sample obstacle avoidance maneuver in fully manual driving and following HADS take-overs

As shown in Table 1, drivers initiated and completed avoidance maneuvers with a greater distance and more time to obstacle contact in the HADS take-over condition compared to all-manual driving, indicating safer obstacle avoidance maneuvers following HADS take-overs.

	Fully Manual	HADS Takeover	Change
Obstacle Maneuver Initiated			
Distance to Obstacle Contact	144m	147m	2.08%
Time to Obstacle Contact	3599ms	4310ms	19.76%
Car Speed	93mph	76mph	-18.28%
Obstacle Maneuver Completed			
Distance to Obstacle Contact	72m	97m	34.72%
Time to Obstacle Contact	1878ms	2880ms	53.35%
Car Speed	91mph	76mph	-16.48%

We concluded that there was no clear difference in driver performance during obstacle avoidance maneuvers and identified several benefits that HADS take-overs provide to driver performance.

Based on our further analyses of driver performance and subjective workload ratings, we identified three characteristics of HADS take-overs that may benefit driver performance compared to all-manual driving:

1) When drivers take over from HADS, the vehicle is in a safer state. Prior to driver take-over, HADS maintained the vehicle in a more centered lane position and slower speed than in fully manual driving. In our study, vehicle speed was on average around 17% slower when performing obstacle avoidance maneuvers after a take-over from automation than in fully manual driving.

2) When HADS take-overs occur, drivers receive a take-over alert tone alerting them that the vehicle has shifted to manual mode. Since take-overs commonly occur prior to a necessary vehicle maneuver, drivers may use these alerts as a warning to prepare for an obstacle maneuver.

3) Traditional all manual driving likely leads to greater driver fatigue. When HADS is in control of the vehicle, drivers can largely ignore the road environment until the take-over alert indicates the need to intervene. This possibility is supported by subjective workload rating, which were slightly higher in fully manual driving.