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National Advanced Driving Simulator Measures Driver Interactions with Automated Driving System

One of the largest simulators in the world, the National Advanced Driving Simulator (NADS) at the University of Iowa, was recently used to conduct a study of automated driving as part of a SAFER-SIM University Transportation Center research project. The Center is dedicated to promoting interdisciplinary research using simulation techniques to address safety issues prioritized by the U.S. Department of Transportation.

USDOT's National Highway Traffic Safety Administration (NHTSA) recently adopted the Society of Automotive Engineers' levels for automated driving systems, which range from complete driver control (Level 0) to full autonomy (Level 5). The project sought to study transfers of control between the driver and automated vehicles at conditional, or Level 3, automation. At this level drivers can shift both the physical and mental aspects of driving to the automated driving system but can still intervene if necessary.

NADS, 2016

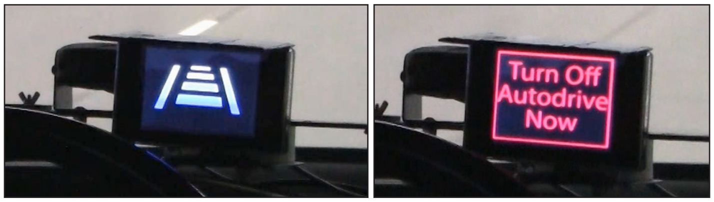
The NADS high fidelity driving simulator is owned by USDOT NHTSA and operated by the University of Iowa.

Driver performance and measured comfort were observed as indicators of the development of trust in the system. Two scenarios were used, one with an automation system that was able to respond to most events by slowing or changing lanes on its own. In the other scenario, the automation system issued takeover requests (TORs) to the driver in all events. Thus there was a change in reliability over the course of the study drives, where some participants experienced the more-capable system first and others the less-capable.

The study events included a work zone, a section with missing lane lines, an elevated ramp curve, a slow lead vehicle, and an exit ramp as the final event. Extra events with lead vehicles that changed speed caused the automation to intervene and built up a driver's trust in the system.

A trivia task from www.triviaplaza.com was used to engage the operator while in automated mode. Rather than being thought of as a secondary task, this was the operator's primary task during periods of automation.

Takeover requests were modeled after the interfaces used in recent NHTSA research on Level 2/3 automation (Blanco et al., 2015). There were three possible stages of alerting: informational, cautionary, and imminent.

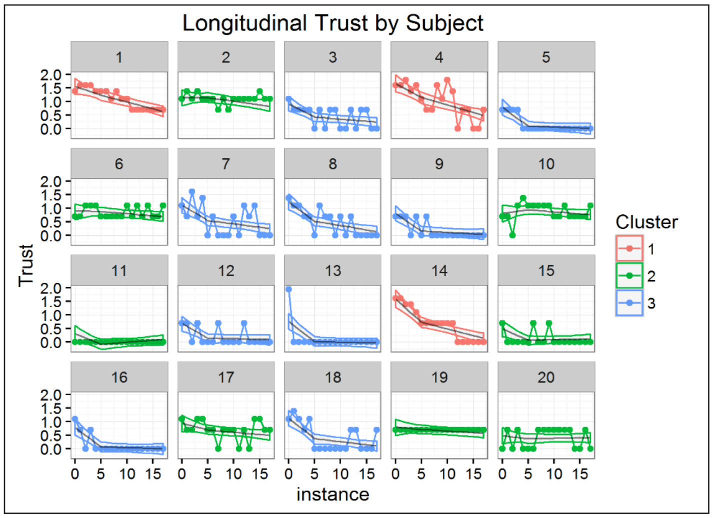


NADS, 2016

A high heads up display indicated the status of the automation and issued take over request alerts.

We observed three types of people with respect to their comfort profiles over the course of three drives. Some started out very comfortable, others took a long time to become comfortable, and others increased in comfort fairly quickly.

Takeovers were split into physical takeover, visual attention, and vehicle stabilization. No attempt was made to quantify the time required to regain full situational awareness, which includes cognitive processes that are not easily observable. Measures of speed and control were sampled every five seconds for up to a minute after manual takeovers to get an idea of when and how drivers performed in the take-over task.



NADS, 2016

Three types of comfort profiles showed differences in how quickly people trust a new automated driving system. Lower values indicate greater comfort .

Drivers were able to physically take control less than five seconds after being requested to. However, response time and performance measures showed that there was a 15- to 25-second period between the physical takeover and a return to normal driving performance and gaze patterns. This confirms some observations in previous studies on transfer of control (Gold et al., 2013; Merat et al., 2014).

No other event exposed differences between the study groups as well as the slow lead vehicle event with the less capable automation system. Women were seen to achieve lower minimum speeds than men. Men spent more time in manual mode than did women. Younger drivers had a lower rate of steering reversals and larger standard deviation of lane position than did the older group. Finally, when drivers experienced this event in their first drive, they tended to have larger amounts of high-frequency steering than when they experienced it in their second drive.

It was not possible to assess the potential safety impacts of the 15-25 second vulnerable window of time, and this is an important question for future research. Additionally, this research could help inform designers on building system interfaces that promote the right degree of trust in the system.

The human factors of automated driving offer critical research questions to help ensure their safe use. This study has contributed to the understanding of how long it takes drivers to place their trust in an automated driving system, as well as how well they perform when they have been requested to take back manual control in a short period of time.

References

Blanco, M., Atwood, J., Vasquez, H.M., Trimble, T.E., Fitchett, V.L., Radlbeck, J., Fitch, G.M. et al. (2015). *Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts*. Final Report DOT HS 812 182. Washington, D.C.: NHTSA.

Gold, C., Damböck, D., Lorenz, L., & Bengler, K. (2013). 'Take over!' How long does it take to get the driver back into the loop?" *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 57 (1): 1938–42.

Merat, N., Jamson, A. H., Lai, F. C. H., Daly, M., & Carsten, O. M. J. (2014). Transition to manual: Driver behaviour when resuming control from a highly automated vehicle. *Transportation Research Part F: Traffic Psychology and Behaviour*.

About This Project

The study, *Transfer from Highly Automated to Manual Control: Performance & Trust*, was funded by SAFER-SIM and led by Chris Schwarz, Ph.D., and Timothy Brown, Ph.D. For additional information, please contact us at chris-schwarz@uiowa.edu or 319-335-4642. The complete report and webinar can be accessed through the SAFER-SIM website (http://safersim.nads-sc.uiowa.edu/).