Safe Human-Machine Interfaces (HMI) for Automated Vehicles

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Error Case Study 1

Error Case Study 2

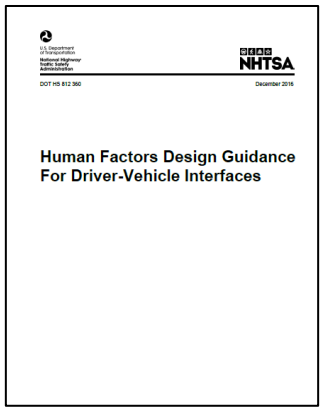
Keyless Ignition Design

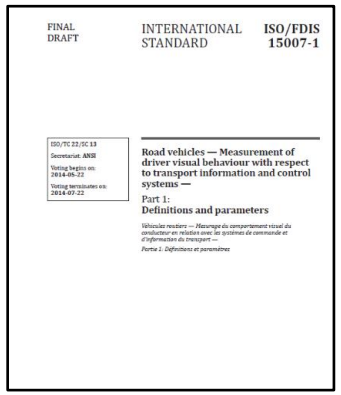
- Why were these foreseeable errors not anticipated and measures not taken to prevent such risks?
- Keyless ignition design and operation varies significantly among manufacturers and even among models from the same manufacturer.
- SAE J2948 recommended practice to “minimize user instigated errors”:
  - the inability to start and stop the vehicle,
  - exiting the vehicle in a non-parking gear,
  - exiting the vehicle while the vehicle propulsion system is enabled or electrical systems are active.
- Complementary standard being drafted within ISO because drivers have difficulty understanding how to use these systems (ISO 21956).

Relevance to Automated Vehicles

- Inadequate HMI is already an issue.
- The risk of design-induced errors will increase with:
  - system complexity
  - partial/ shared automation
  - driver inattention, monotony, confusion and overload
  - miscalibrated trust
- How can the vital need for better HMI design practices be addressed?

Need a toolkit of human factors design procedures and assessment methods





Design Process Requirements

Expert Audit

Lab Testing

Field Operational Trials

UNECE Guidelines for Keeping Drivers In-the-Loop

Principles to allow drivers to easily and accurately understand driving situations and effectively use partial-automation: e.g.,

- System actions should be easy to override at any time under normal driving situations;
- Drivers should have a means to transition from ON to OFF manually;
- Drivers should be informed of the system status when system operation is malfunctioning or when there is a failure;
- Drivers should be notified of the proper use of the system prior to general use;
- **Drivers should be notified of any system-initiated transfer of control between the driver and vehicle;**
- **Drivers should be provided with clear feedback informing them when the system is actively controlling the vehicle.**

UNECE

UNECE WP.29 ITS-IG (2013). ECE/TRANS/WP.29/78/Rev.3 See Annex 5 - Design principles for Control Systems of Advanced Driver Assistance System (ADAS) (p. 91-94)
http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29resolutions/ECE-TRANS-WP29-78-r3e.pdf

Transport Canada Research

- Automated driving system mode/ status displays vary in their salience and utility
- Research suggests design of current status displays is already an issue for L2 vehicles (e.g., Dikman & Burns, 2016; Endsley, 2017)
- How can we evaluate the safety of automation displays?

Method

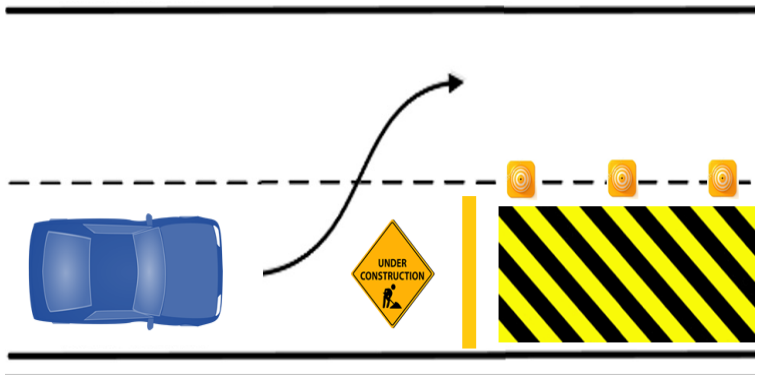
Participants:

- N = 32 (18 male, 14 female)
- Age: 20 – 58 (*M* = 34.5, *SD* = 9.27)

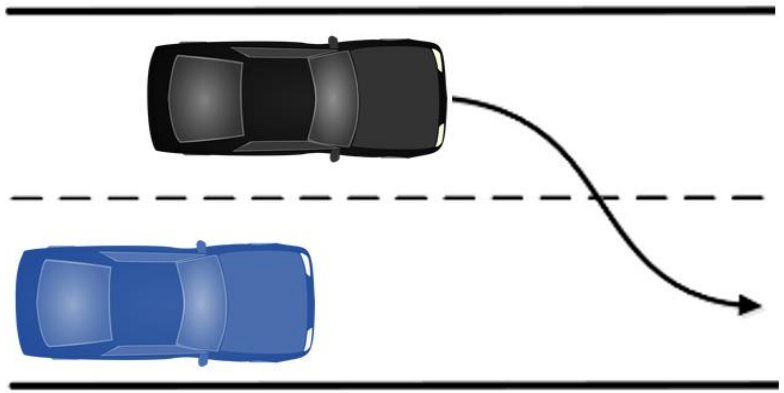
Data collection:

- MiniSim driving simulator
- Video Recordings (4 camera infrared DVR system)
- Subjective Questionnaires

Scenarios:



Scenario 1: Construction Zone in Lane



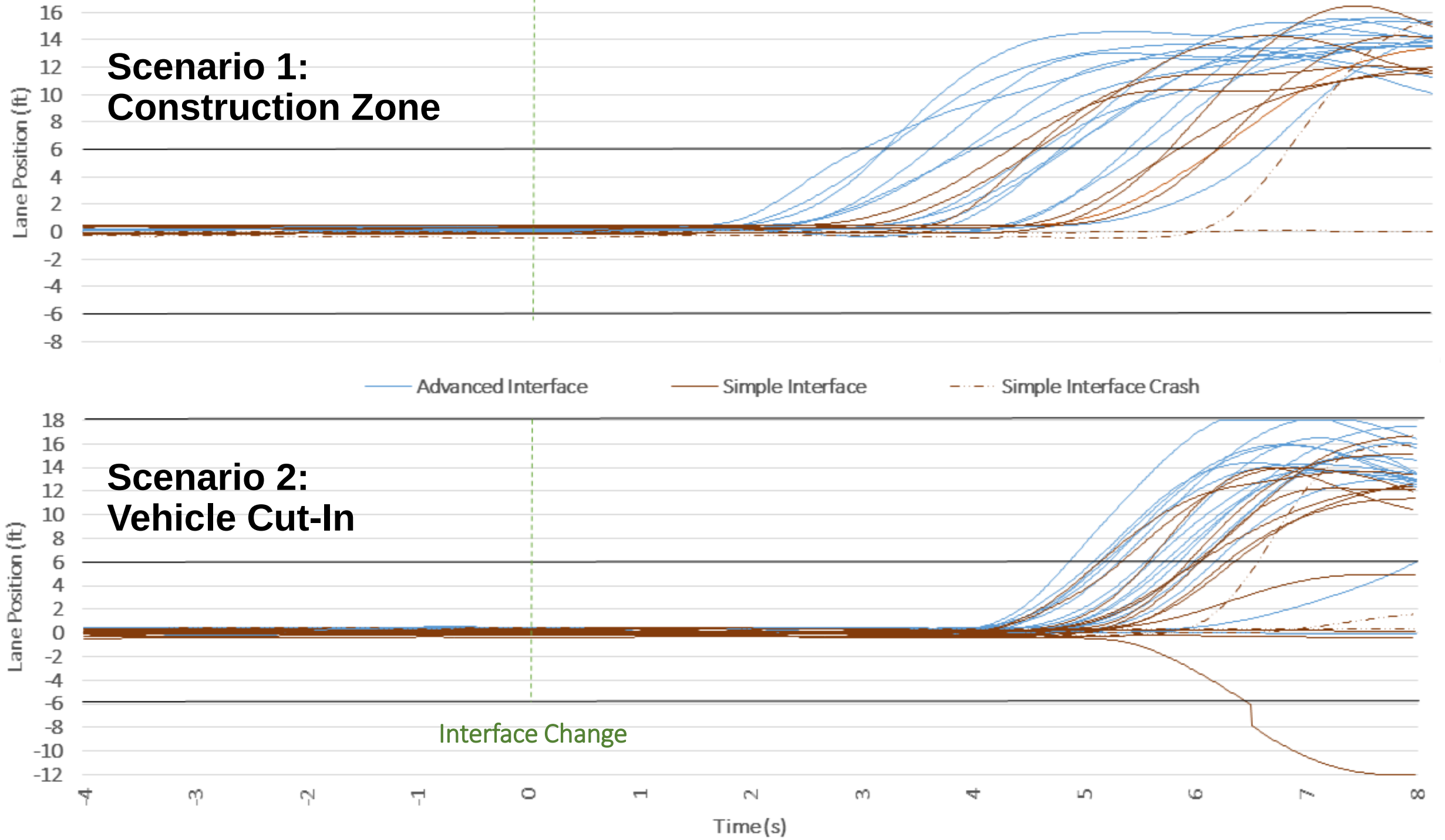
Scenario 2: Vehicle Cut-in

Interface A: Simple

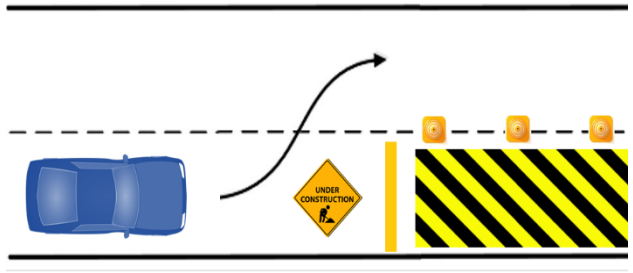
Procedure:

- Participants engaged an automated driving system on a 4-lane divided highway.
- L2 with set speed of 100 km/h.
- Performed a continuous secondary dot-counting task

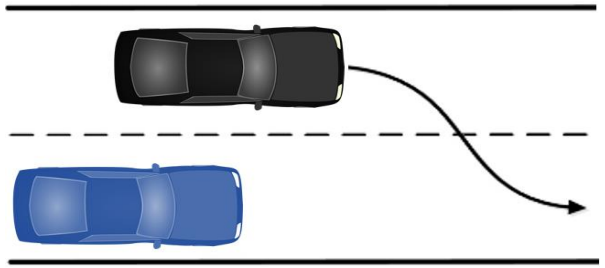
Interface B: Advanced


Scenario 1:
Construction Zone
Lane Position (ft)
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
Advanced Interface
Simple Interface
Simple Interface Crash
Scenario 2:
Vehicle Cut-In
Lane Position (ft)
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
Interface Change
-4
-3
-2
-1
0
1
2
3
4
5
6
7
8
Time (s)

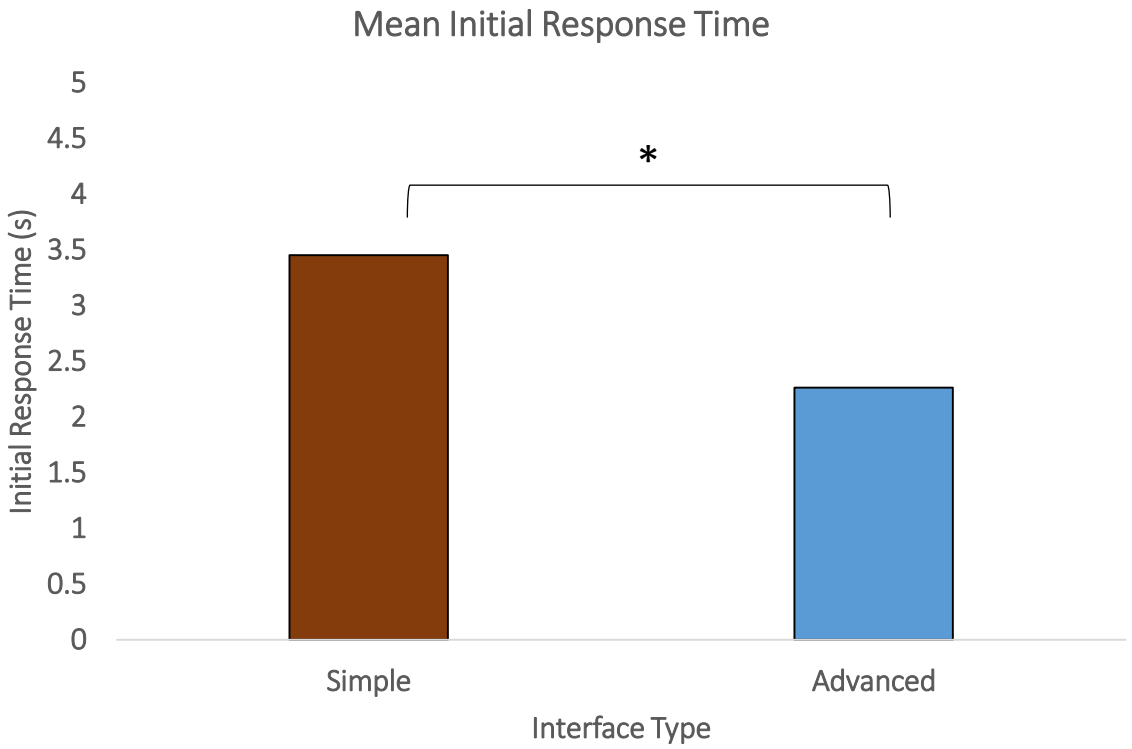
Driver Initial Response Time

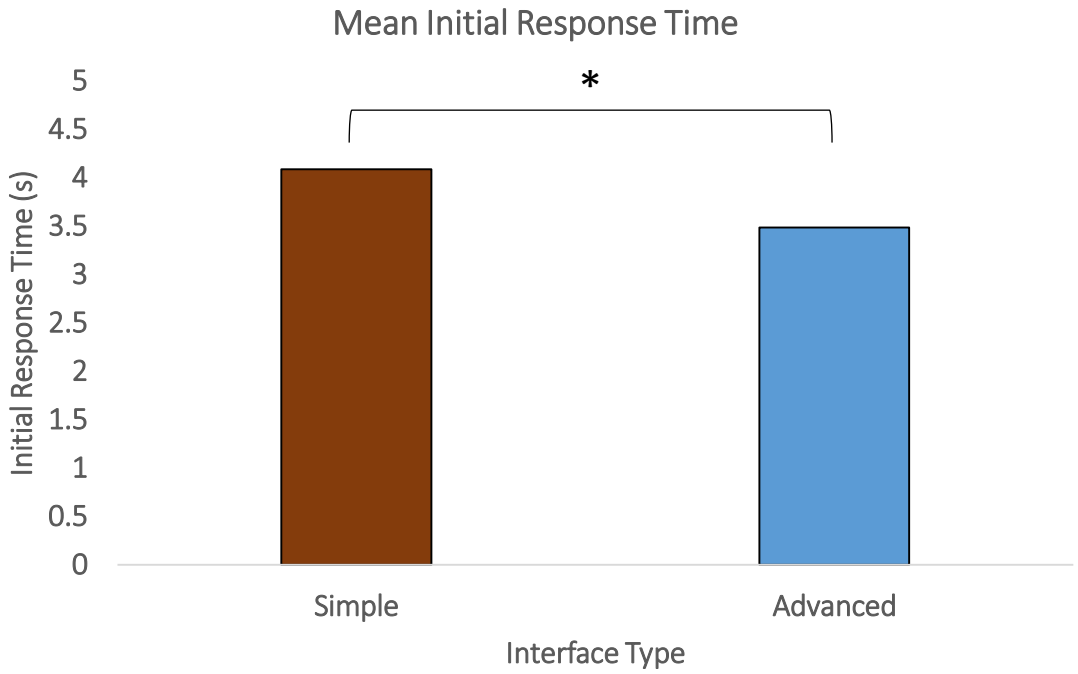


Construction Zone Scenario



Vehicle Cut-in Scenario





*$p < 0.05$

Summary

- Vehicle HMI is already an issue and risks will likely increase with more complex automated driving systems.
- Vital need to apply better HMI design practices - particularly for identifying and addressing risks.
- Display salience and content has an impact on takeover performance.
- Existing tools can help to evaluate the performance of automated vehicle HMI.
- New human factors design procedures and metrics are needed.