Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts

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Levels of Automation

- Level 0: No-Automation
- Level 1: Function-specific Automation
- Level 2: Combined Function Automation
- Level 3: Limited Self-Driving Automation
- Level 4: Full Self-Driving Automation

Vehicle Control

Operator Control
Background

- Automation allows some degree of vehicle control to be shifted from the driver to the vehicle
- Enormous potential for safety benefits
- Not a new concept:

*Science Digest, April 1958*
Overview and Objective

• Different levels of automation could provide varying levels of system and driver engagement

• Goal
  • To improve roadway safety

• Focus
  • Human Factors needs for Level 2 and 3 automated driving

• Output
  • Human Factors DVI guidelines
    • Timing, sequence, and presentation
Research Question 1

Can drivers safely interact with and operate vehicles that offer automation Level 2 and Level 3 systems, e.g., what is the driver performance profile over length of time in continuous or sustained automation?
Research Question 2

What are the system performance risks from driver involvement with and interruption from secondary tasks (such as portable electronic device use) that could arise when operating Level 2 or Level 3 automated vehicle system?
Research Question 3

What are the most effective hand-off strategies between the system and the driver including response to faults/failures?
Research Question 4

How do drivers engage, disengage, and reengage with the driving task in response to the various states of Level 2 and Level 3 automation?
Research Question 5

How do drivers perform under various operational concepts within Level 2 and Level 3 automation?
Research Question 6

What are the most effective human-machine interface concepts, guided by human factors best practices, which optimize the safe operation of Level 2 and Level 3 systems?
## Overview and Objective

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<th>Overall Description of the Different Data Collection Efforts</th>
<th>Research Questions</th>
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<td>Interaction with Levels 2 and 3 under Prolonged Exposure</td>
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<td>Levels 2 and 3 Performance Risks due to Secondary Task Engagement</td>
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<td>Effective Strategies for Transfer of Control in Levels 2 and 3, including faults and failures</td>
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<td>Mechanism for Transfer of Control in Levels 2 and 3</td>
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<td>Driver Performance under Levels 2 and 3 Concepts of Operation</td>
<td>✓</td>
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<td>Effective DVI Concepts for Levels 2 and 3</td>
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### Research Questions

- Synthesis of Past Research, State of Automation Technology, and Emerging System Concepts
- Develop ConOps for Levels 2 and 3
- Human Factors Industry and Academia Advisory Group Review
- LAADS Data Mining
- DVI Concepts: Situational Awareness and Attention
- Control Transfer Strategies and Effective Countermeasures
- Prolonged Driver-Vehicle Interactions
- Levels 2 and 3 DVI Guidelines
Project Phases Overview

• **Phase I – Project Planning**
  • Task 1. Project Planning
  • Task 2. Finalize Vehicle and Facility Needs
  • Task 3. System Assessment
  • Task 4. Finalize Experimental Designs

• **Phase II – Project Execution**
  • Task 5. Data Collection
  • Task 6. Data Reduction and Analysis
  • Task 7. Levels 2 and 3 DVI Guidelines
  • Task 8. Reporting
Phase II: Experiments

• Three experiments
  1. Driver Responses to Staged Warnings
  2. System Prompt Effectiveness Over Time
  3. Human-Automation System Performance Over Time
Key Facilities and Resources

• Research facilities:
  • Virginia Smart Road
  • GM Milford Proving Ground
• GM Level 2 automated vehicle
• Google Level 3 automated vehicle
Vehicle and Instrumentation

- 2009 MY Chevrolet Malibu
  - Used in prior US DOT collaborative research with GM
  - L2 automation:
    - ACC and lane centering
    - Researcher console
    - GM data collector
Video Views

• Video recorded by the GM data collector:
Venue

- GM Milford Proving Ground
  - Circle track
  - ~4.5 mi banked circle
  - Five speed ranged travel lanes
  - Other traffic may be present
    - Approved drivers only
Vehicle and Instrumentation

• 2010 MY Cadillac SRX
  • Advanced L2 automated driving system
  • VTTI data acquisition system
Vehicle and Instrumentation

- 2012 MY Lexus RX450h
  - L3 automated driving system
  - VTTI data acquisition system
Video Views

- Video collected by the VTTI DAS:
  - Face
  - Foot
  - DVI
  - Forward
  - Over the shoulder
  - Left and right lane
Venue

- VTTI Smart Road test track
  - 2.2 mi
  - Federal/state compliant construction
  - Network coverage
  - Signalized intersection