Transitions of Control in Level 3 Automation

John Gaspar
National Advanced Driving Simulator
University of Iowa
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• Omar Ahmad
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• Cher Carney
• Chris Schwarz
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DISCLAIMER
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Our Mission: enhance safety through understanding the human-vehicle relationship

**Technology**

Understand and advance vehicle technology and simulation science

- Distributed cross-modal simulation
- Instrumented on-road vehicles
- Digital twins

**Understanding**

Explore methods for improving driver performance and understanding of technology

- Driver training and exposure
- Mental models
- Naturalistic data collection

**Performance**

Identify and shift the limits of the human-machine relationship

- Edge case evaluation
- User interface evaluation
- Data reduction and analysis

**Mobility**

Enhance road user mobility through research and outreach

- ADS for Rural America
- Connected vehicles
- Technology demonstrations
Level 3 Automated Driving Systems (ADS)

• Perform entire dynamic driving task in operational design domain (ODD)
  • Lateral and longitudinal control
  • Object and event detection and response

• User can disengage but remains receptive to request to intervene (RTI)

• ADS issues RTI when approaching ODD exit
Transition Window Parameters

• **Sufficient** transition window for user to reengage
  • What is sufficient?

• User is never put in time-critical response situation
  • What happens when expectation is violated?
  • **Edge cases**
NHTSA Projects on L3-L0 Transition of Control

• Temporal Components of Warnings and Notifications for Safe Manual Re-engagement with the Driving Task in Automated Driving
  • Thomas Fincannon
  • Define the minimum sufficient transition window (MSTW)

• Transition of Control and Post-Transition Driver Performance in Level 3 Automation
  • Christian Jerome
  • Examine the effectiveness of HMI design characteristics for transition of control in normal and edge case situations
National Advanced Driving Simulator, University of Iowa
Traffic Jam Auto Drive

Clear lane markings

Moderate to heavy traffic

Clear weather

Divided Traffic

Low Speed (<35mph)

The National Advanced Driving Simulator

The University of Iowa
TJAD Operating
Level 3 Simulator Test Platform

L3 to L0 Transitions

Transition Window

RTI Stage 1
- TJAOD Ending
- Press take control
- Auditory tone to notify user
- Slowly pulsing white border

10s

RTI Stage 2
- TJAOD Ending
- Take control now!
- Auditory alarm
- Fast pulsing red border

5s

Failure Mitigation Strategy
- Repeating auditory alarm
- Fast pulsing red border

Start
End

Level 3 Driving
Manual Driving
Measuring the Entire Transition
Measuring Transition Timing and Quality

Attention returns to road

Eye Tracking

Automation Deactivated

Simulator Data

Control Stabilized

Simulator Data

Schwarz et al. (2016)
Focus on Response Distributions

DinparastDjadid et al., 2019
Temporal Components of Warnings and Notifications

**Define the minimum sufficient transition window**

<table>
<thead>
<tr>
<th>Phase 1: Review</th>
<th>Phase 2: Sufficient Window</th>
<th>Phase 3: RTI Design</th>
<th>Phase 4: Moderating Factors</th>
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<tbody>
<tr>
<td>Review L3 literature on</td>
<td>S1: Adaptive NADS-1 study</td>
<td>S2: NADS-1 content study</td>
<td>S5: NADS-1 study on moderating</td>
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<tr>
<td>transition windows</td>
<td>on MSTW</td>
<td>S3: NADS-1 mode study</td>
<td>situational factors</td>
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<tr>
<td>Review existing NADS data</td>
<td></td>
<td>S4: NADS-1 urgency study</td>
<td></td>
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</tbody>
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Temporal Components of Warnings and Notifications

**Simulator experiments with adaptive transition window**

![Diagram showing ADS Detects Work Zone and Revealed Work Zone with transition windows for events 1 to 5:]

- **Event 1**: 10s Transition Window
  - Successful Transition
- **Event 2**: 8s Transition Window
  - Successful Transition
- **Event 3**: 6s Transition Window
  - Unsuccessful Transition
- **Event 4**: 7s Transition Window
  - Successful Transition
- **Event 5**: 6.5s Transition Window
Transition of Control and Post-Transition Driver Performance

Understand impact of RTI design characteristics on transition of control in normal and edge case transitions.
Edge Case
Project Outcomes

• Temporal Components of Warnings and Notifications
  • Estimate of the minimum sufficient transition window (MSTW), both in traffic jam pilot and more expansive ODD
  • Understanding of how RTI design characteristics could minimize MSTW

• Transition of Control and Post-Transition Driver Performance in Level 3 Automation
  • Understand how HMI design characteristics impact transition of control timing and quality
  • Both in normal and edge case situations
Thank You

John Gaspar
Director of Human Factors Research
National Advanced Driving Simulator
University of Iowa

john-gaspar@uiowa.edu