NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Human Factors Research

NHTSA Safety Research Portfolio Public Meeting: Fall 2021

October 19, 2021

Panel Presentations

1. **NHTSA Efforts on Accessibility: Considerations for Making ADS Vehicles Accessible for All Road Users –** Eric Traube
2. **Transition of Control and Post-Transition Driver Performance in L3 Vehicles –** Christian Jerome
3. **Older Drivers and Rearview Video Systems: An Update –** Kathy Sifrit
4. **Drivers Use and Adaptation to L2 Driving Automation –** Thomas Fincannon
5. **NHTSA Efforts on Driver Monitoring and Alcohol Detection (DADSS) –** Eric Traube

NHTSA Efforts on Accessibility: Considerations for Making ADS Vehicles Accessible for All Road Users

Eric Traube

Presentation Agenda

- Objectives—Current Project
- Approach
- User Needs Analysis
- User Centered Design
- Empirical Research
- Objectives—New Project

Objectives

Advance Understanding of Road User Needs for ADS-equipped vehicles (SAE Levels 4 or 5).

Use principles of Universal and Inclusive Design to Improve Mobility for all Americans

Determine Features and Characteristics of Highly Usable Information and Communication Concepts through Prototype Development and Testing.

Focus on Diverse Users such as road users with disabilities and vulnerable road users

Approach

User Needs Analysis

- Literature Review
- Technology Scan
- Stakeholder Engagement

User Centered Design (UCD)

- Interfaces Inside and Outside the Vehicle
- Survey, Participatory Design, Contextual Inquiry

UCD Measures

- Comprehension; Usability
- Perceived Control; Safety/Security; Value
- Trust and Acceptance

Empirical Research

- On-Road
- Laboratory
- Simulators

Stakeholder Engagement

Includes: Pedestrians, Bicyclists, Motorcyclists, paratransit drivers, caregivers, and orientation and mobility trainers

Traveling Opportunities and Difficulties

Getting Into and Out of the Vehicle

Interactions of Road Users Outside and Inside the Vehicle

In the vehicle; outside the vehicle, and en-route

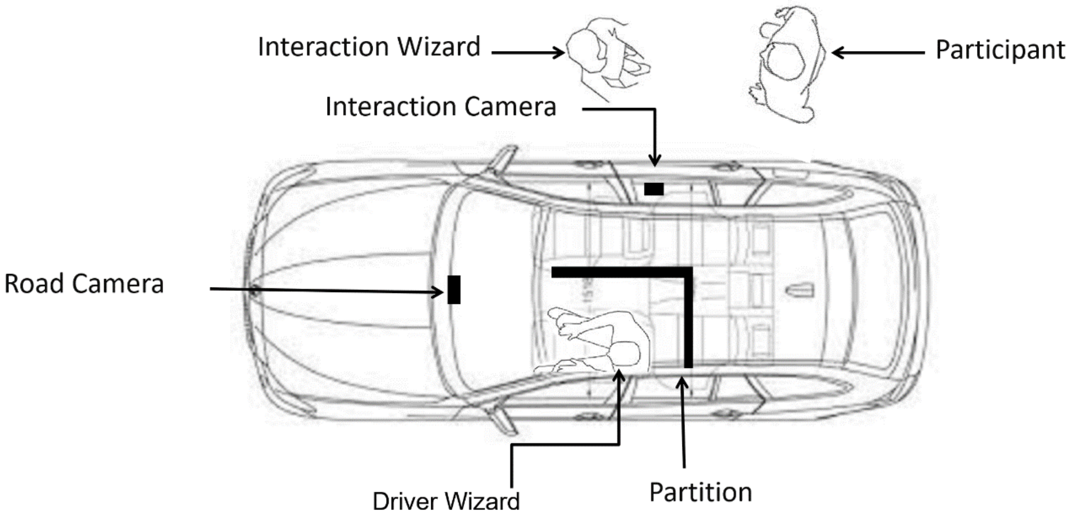
Critical Features and Design Elements of ADS

User Centered Design Activities

- Survey of Shared ADS Challenges, Preferences, and Opportunities for Individuals with Disabilities
- Participatory Design of Interaction and Design Preferences for ADS Vehicles
- Contextual Inquiry of ADS Vehicle Configurations to Support Individuals with Disabilities

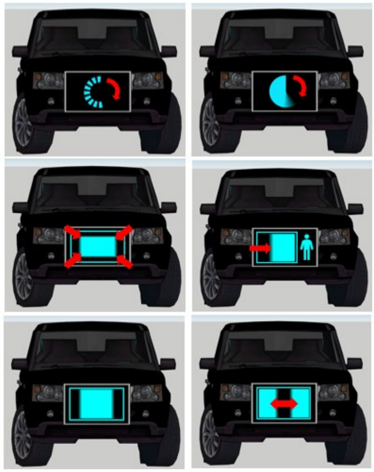
Empirical Research – 1

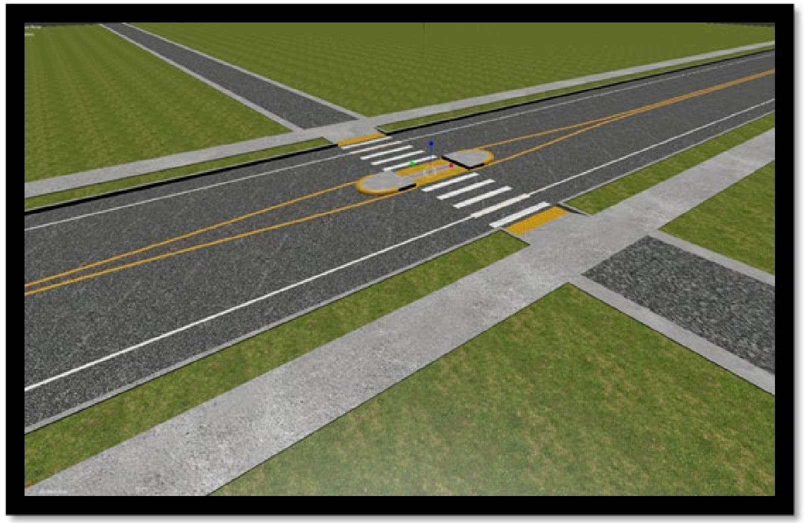
- Experimental Evaluation of ADS Interface Design Concepts
- On-Road Evaluation of Interface Components in ADS Vehicles
    - “Real Road Automated Driving Simulator (RRADS)”



Empirical Research – 2

- **External Interfaces for Bicyclist and Pedestrian Interactions** with ADS Vehicles (Simulator and Survey Studies)





Objectives: "Additional Considerations" (New Project)

Focus: Situation Awareness and Interface Design

Understand How to Establish Situation Awareness for ADS vehicle passengers during unexpected events and situations (i.e., failures in automation and emergencies)

Identify Approaches and Needs for Interface Customization, Universal Design Principles, and Common Configurations to ensure designs address the most important needs of users with disabilities

Transition of Control and Post-Transition Driver Performance in L3 Vehicles

Christian Jerome

Presentation Agenda

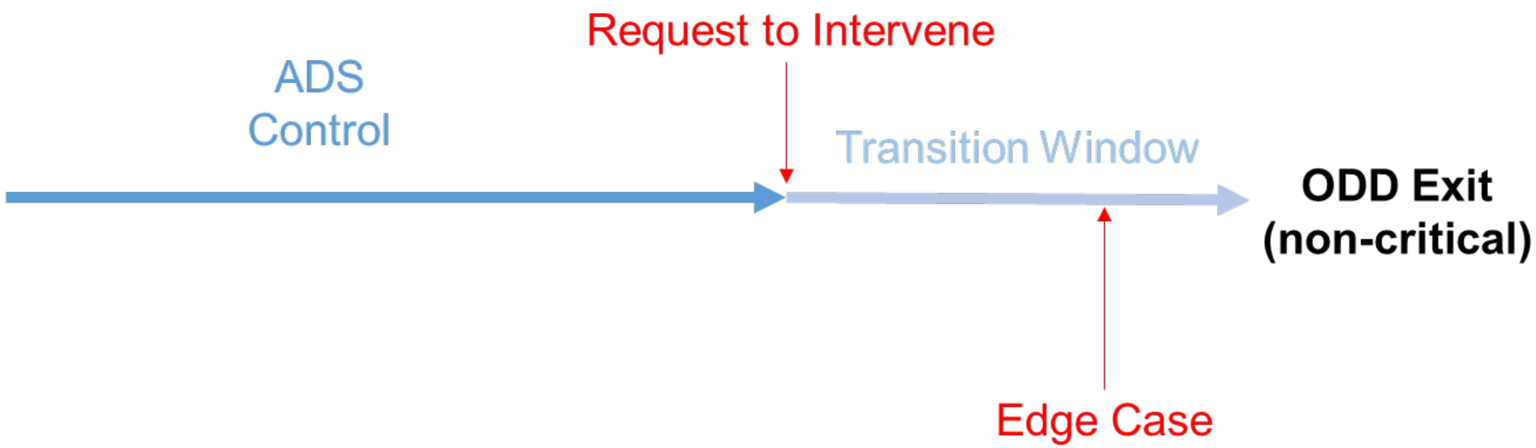
- Project Introduction
- Framework for Transitions in L3
- Simulator Test Platform
- Study Design
- Preliminary Data
- Preliminary Results

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

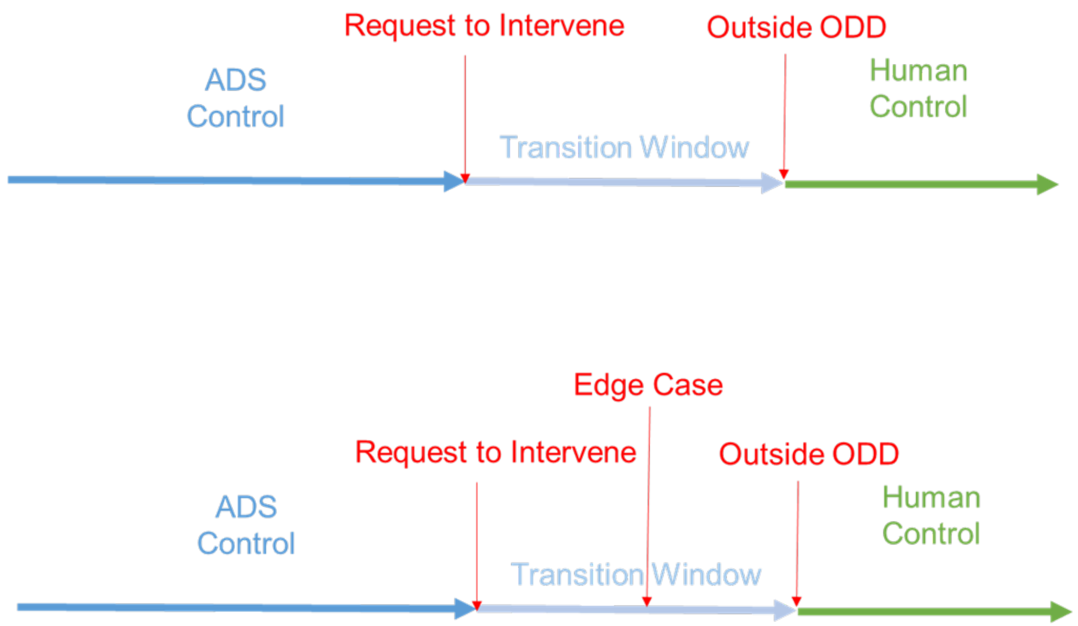
Transition Window Parameters

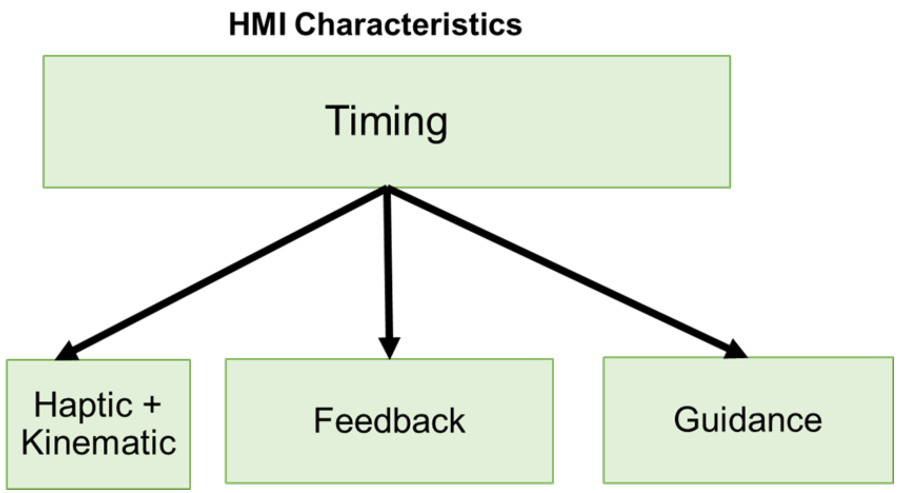
- User is never put in time-critical response situation
  - What happens when expectation is violated?
  - Edge cases



Transition of Control and Post-Transition Driver Performance

Understand impact of RTI design characteristics on transition of control in <u>normal</u> and <u>edge case</u> transitions

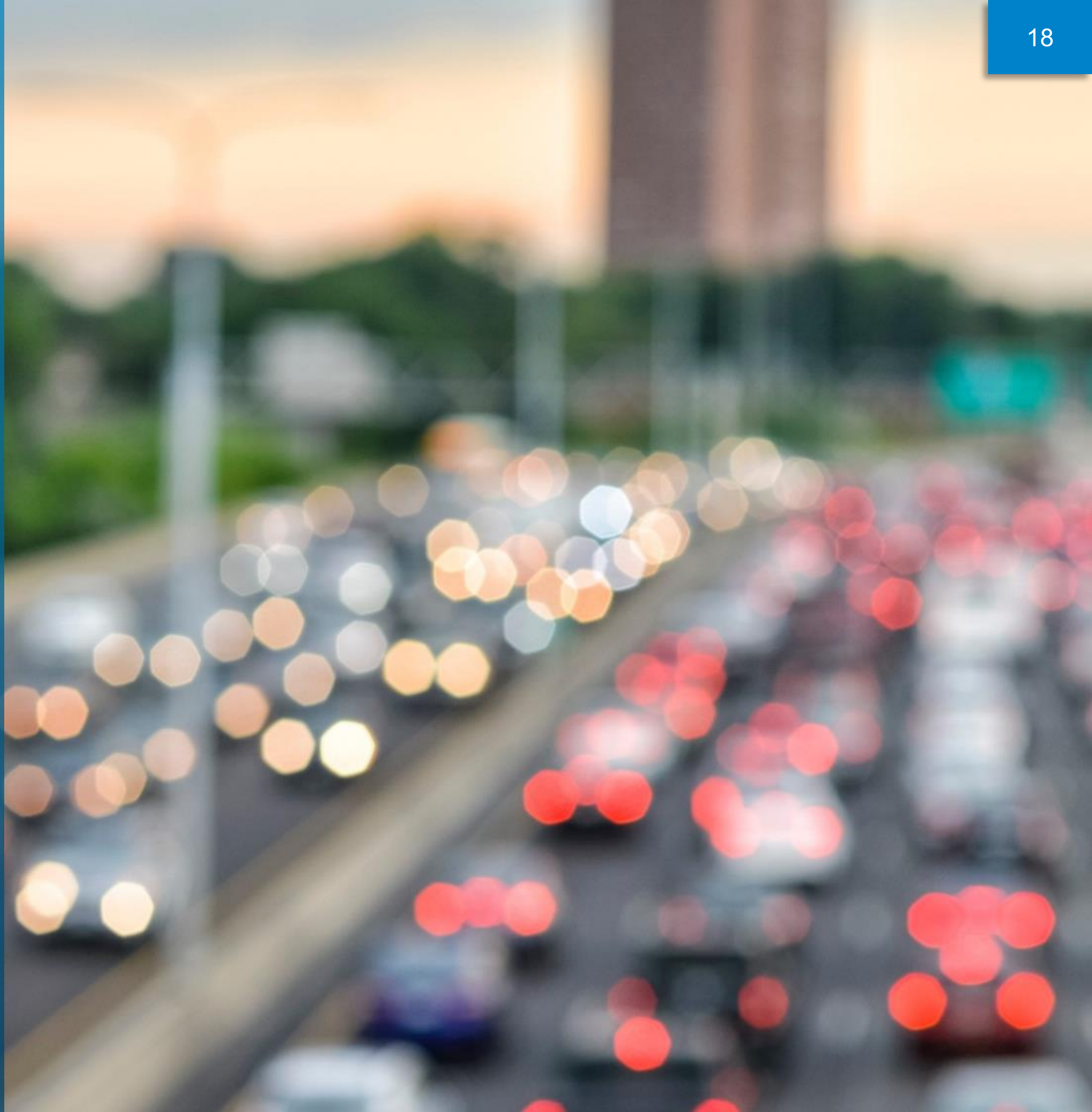




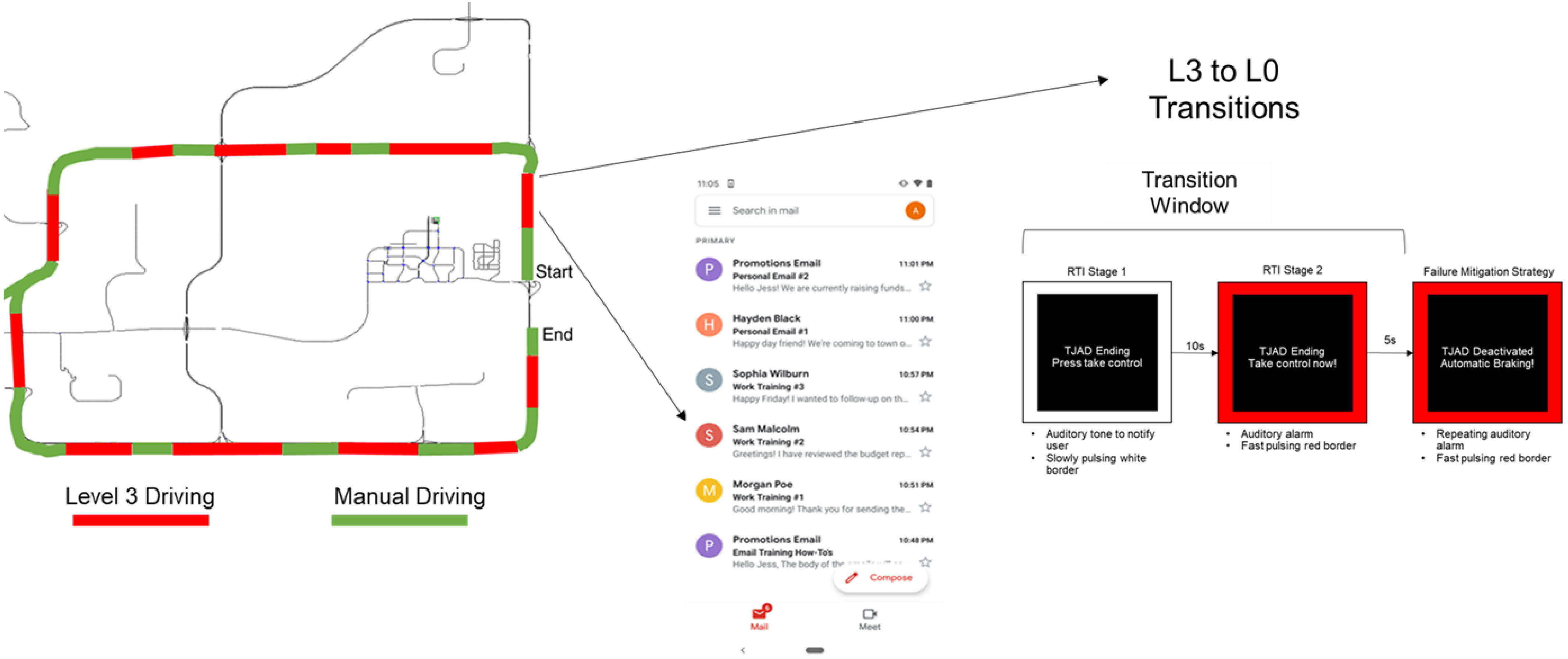
National Advanced Driving Simulator (NADS-1)

Traffic Jam Auto Drive

- Divided Traffic
- Low Speed (<35mph)
- Clear Weather
- Clear lane markings
- Moderate to heavy traffic



Level 3 Simulator Test Platform

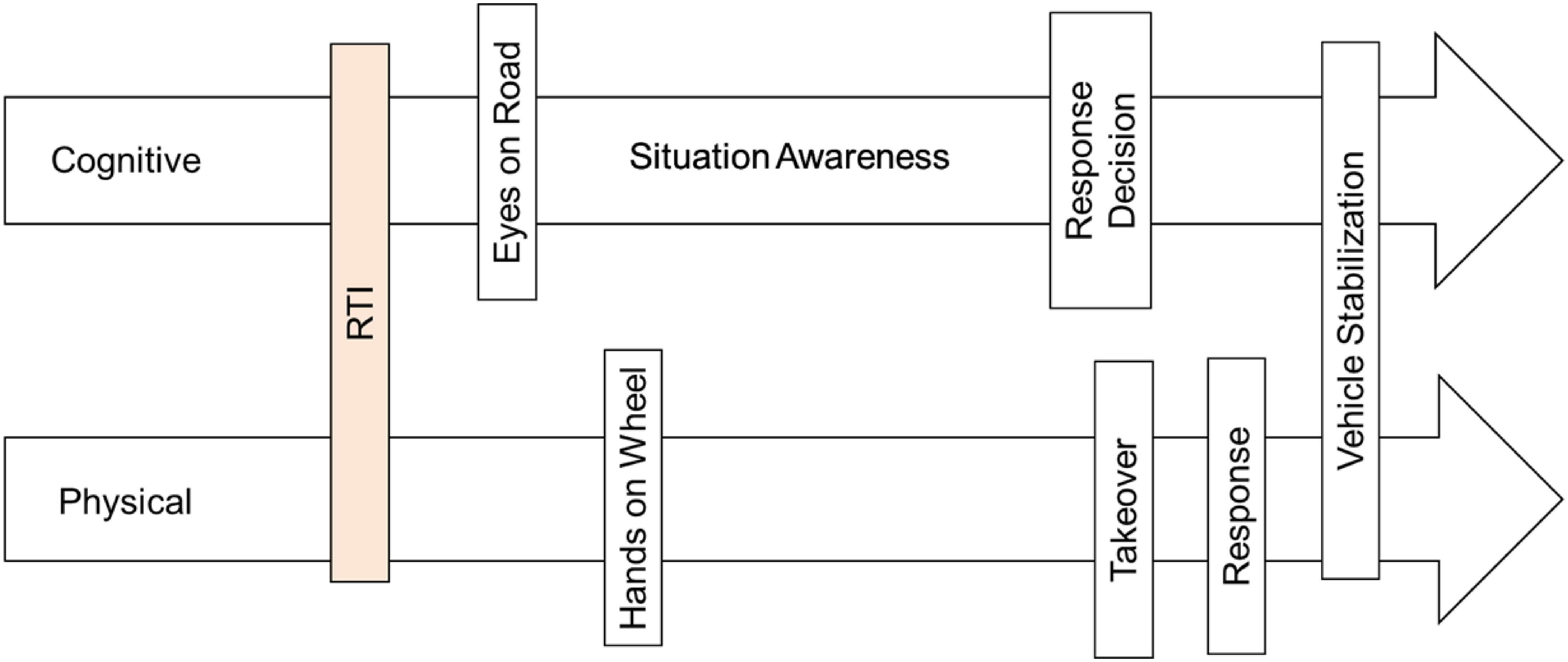


Study Design

- Goal: understand how RTI timing impacts takeover timing and quality
- N = 144 licensed drivers without L3 experience
- 7 transitions of control—5 normal and 2 edge cases
- Six conditions (between-subject)
  - Overall window duration
  - ISI—duration between stages 1 and 2

Group	Transition Window	ISI	N
1	10	5	24
2	10	8	24
3	10	Uncertain	24
4	15	5	24
5	15	8	24
6	15	Uncertain	24

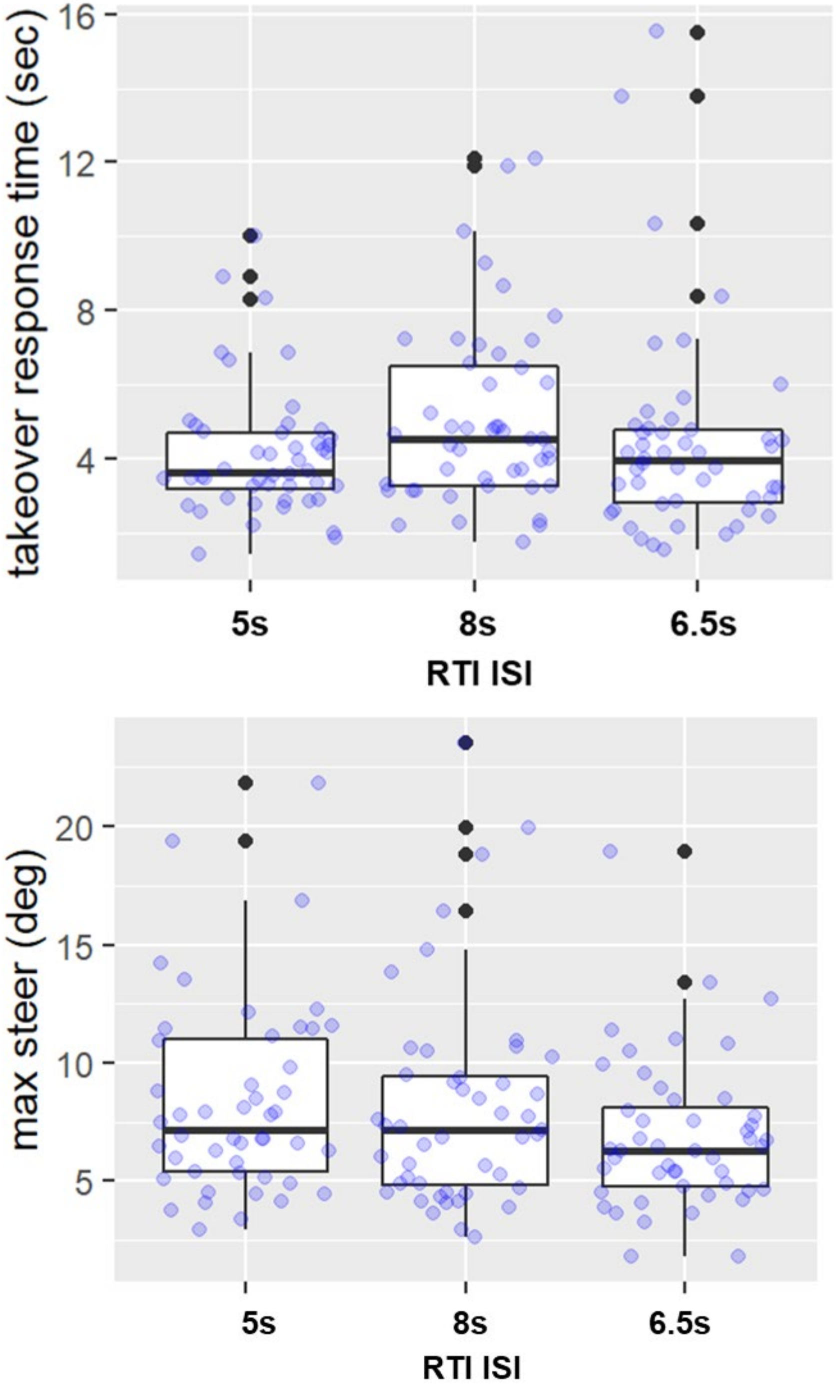
Measuring the Entire Transition



Edge Case

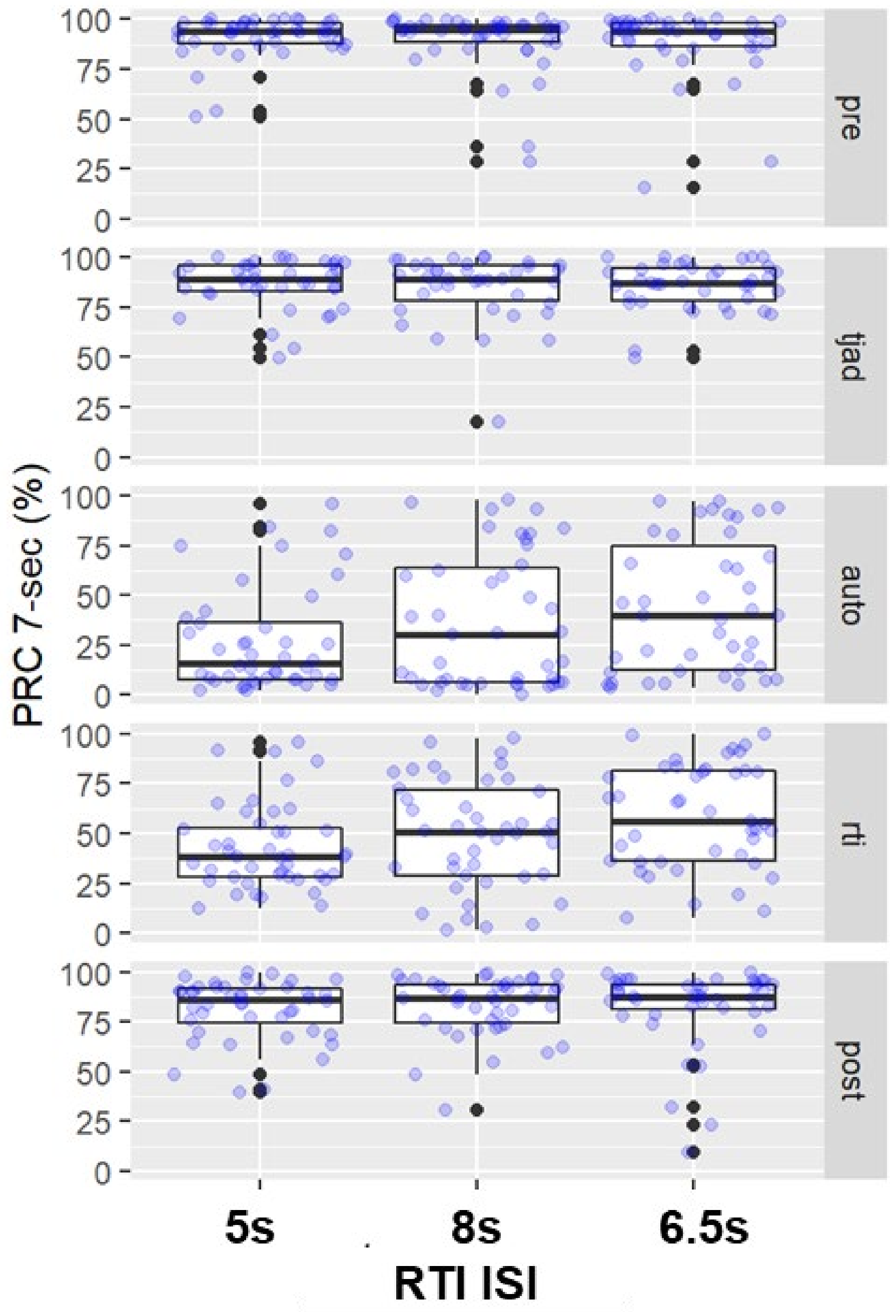
Time to Deactivate Automation and Steer Response

- Longer ISI (from first to second stage RTI) resulted in slower takeover times with less extreme steering



Visual Attention (Percent Road Center Gaze)

- PRC calculated over 7-sec window
- Longer ISI resulted in more visual attention to forward road prior to takeover



Preliminary Results

- Timing of the first stage of RTI in relation to second (i.e., ISI) seems important for transitions of control

- Drivers may utilize longer transition windows to improve quality of transitions
  - Accumulate more situation awareness of surrounding traffic situation

Older Drivers and Rearview Video Systems: An Update

Kathy Sifrit

Older Drivers and Rearview Video Systems (RVS)

- In 2014, NHTSA specified an area behind the vehicle which must be visible to the driver when backing.
- It became effective for new passenger vehicles in 2018.
- Manufacturers installed RVS to meet the requirement.

Older Drivers and Rearview Video Systems

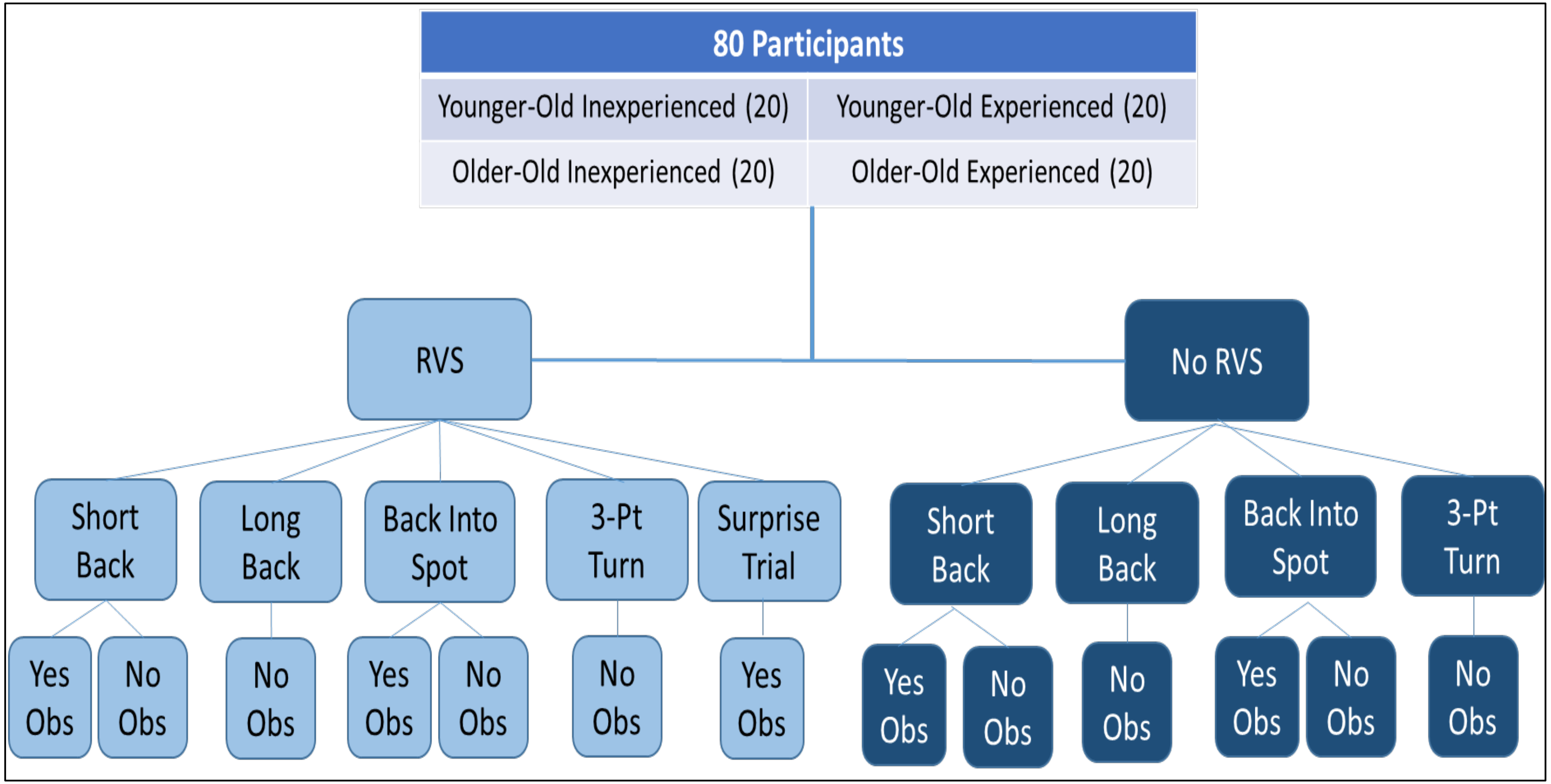
- Study 1 – completed
  - Compare driving performance using mirrors to using an RVS while backing
  - Document common errors during backing tasks
  - Develop training to reduce those errors
- Study 2 – in progress
  - Test the training on naïve participants

Older Drivers and Rearview Video Systems

Literature Review

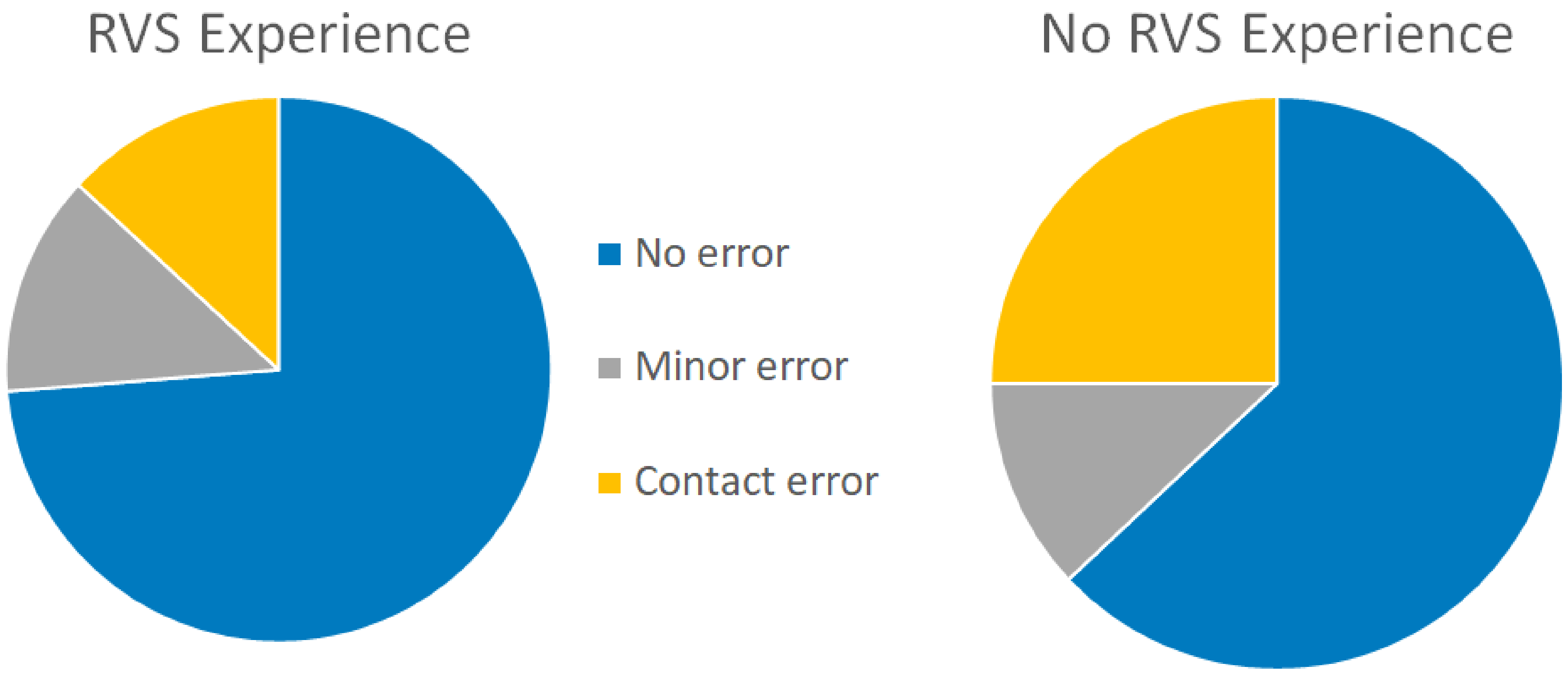
- RVS use can reduce crash risk.
  Hurwitz, Pradhan, Fisher, Knodler, Muttart, Menon, and Meissner (2010)
- Drivers vary in their attention to RVS displays
  Mazzae, Barickman, Baldwin, and Ranney (2008)
- Training may improve drivers' ability to use the systems effectively.
  Llaneras, Neurauter & Green (2011)

Study 1 Design



Backing Out of a Parking Space

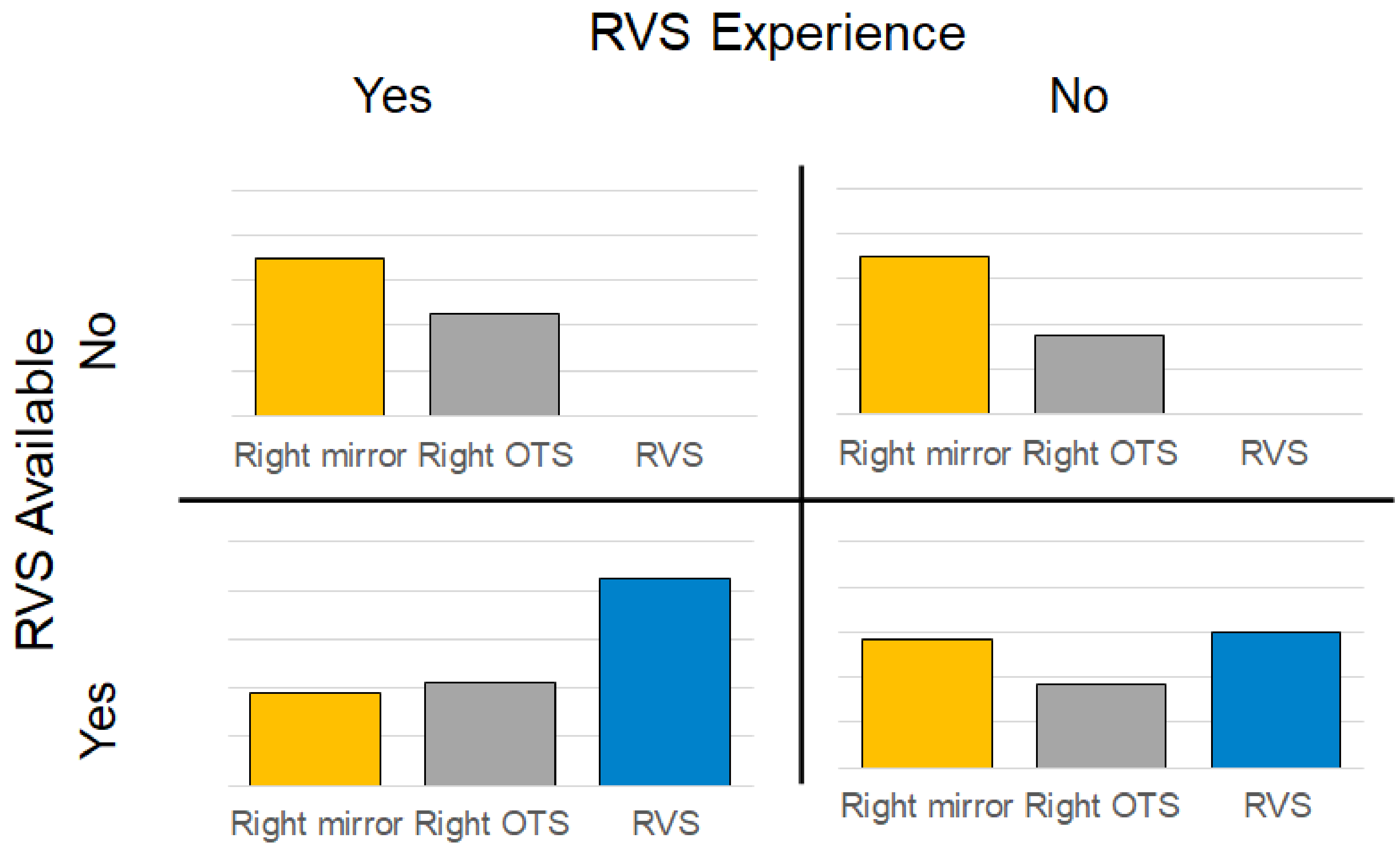
Note: RVS was available in *half* the trials



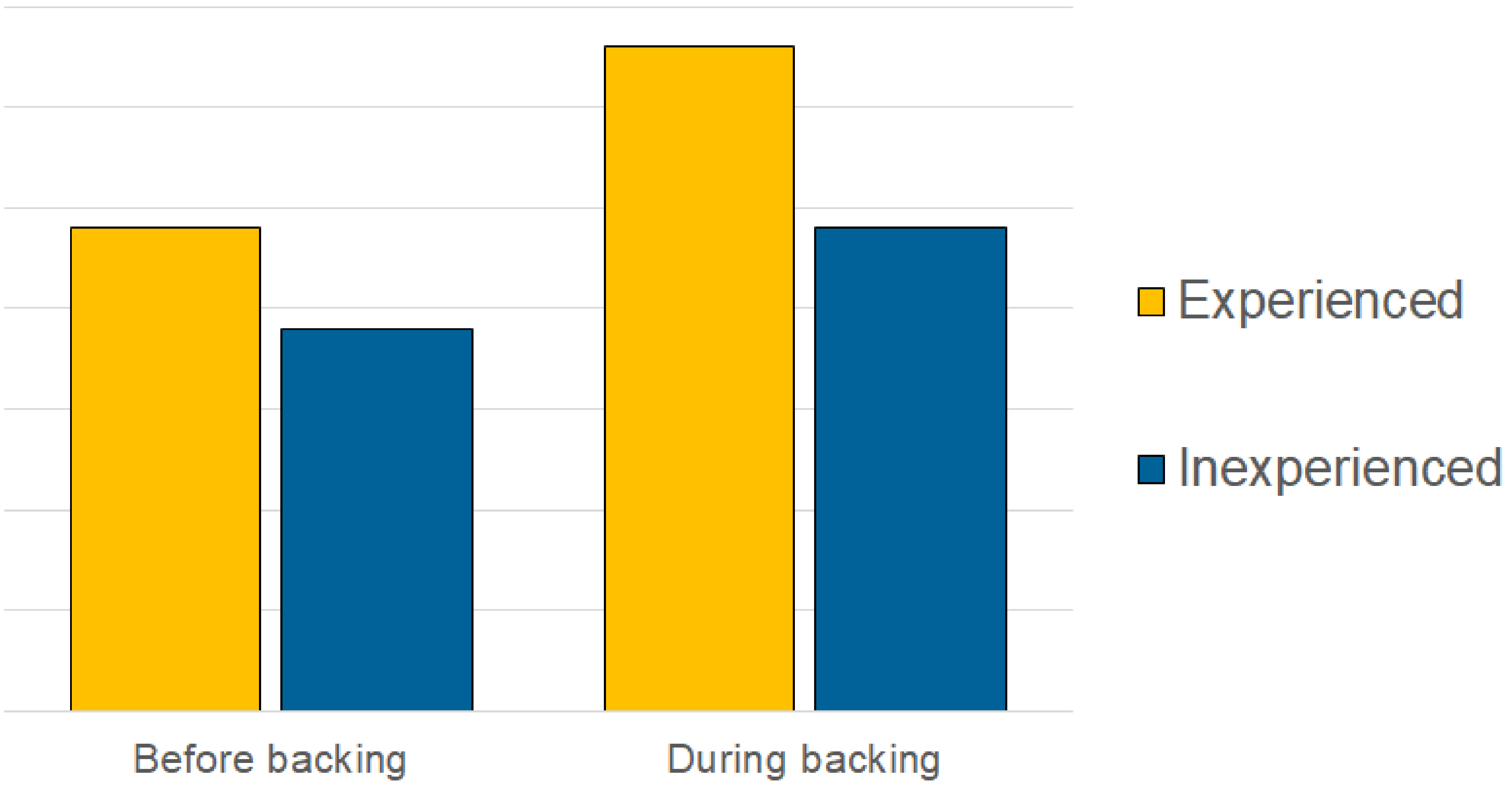
Backing Into a Parking Space – Minor Errors

Categorical Predictor Variables		Significant?
Range of Motion: Good	Range of Motion: Normal	N
Range of Motion: Good	Range of Motion: Poor	N
Experienced with RVS	Inexperienced with RVS	N
60-69	**70+**	**Y**
RVS Used	No RVS Available	N
Continuous Predictor Variables		**Significant?**
Percentage of Time Looking at RVS Prior to Movement Initiation		N
Percentage of Time Looking at RVS After Movement Initiation		**Y**
Number of Glances at RVS Prior to Initiation		N
Number of Glances at RVS After Initiation		*

Backing Into a Parking Space – Number of Glances

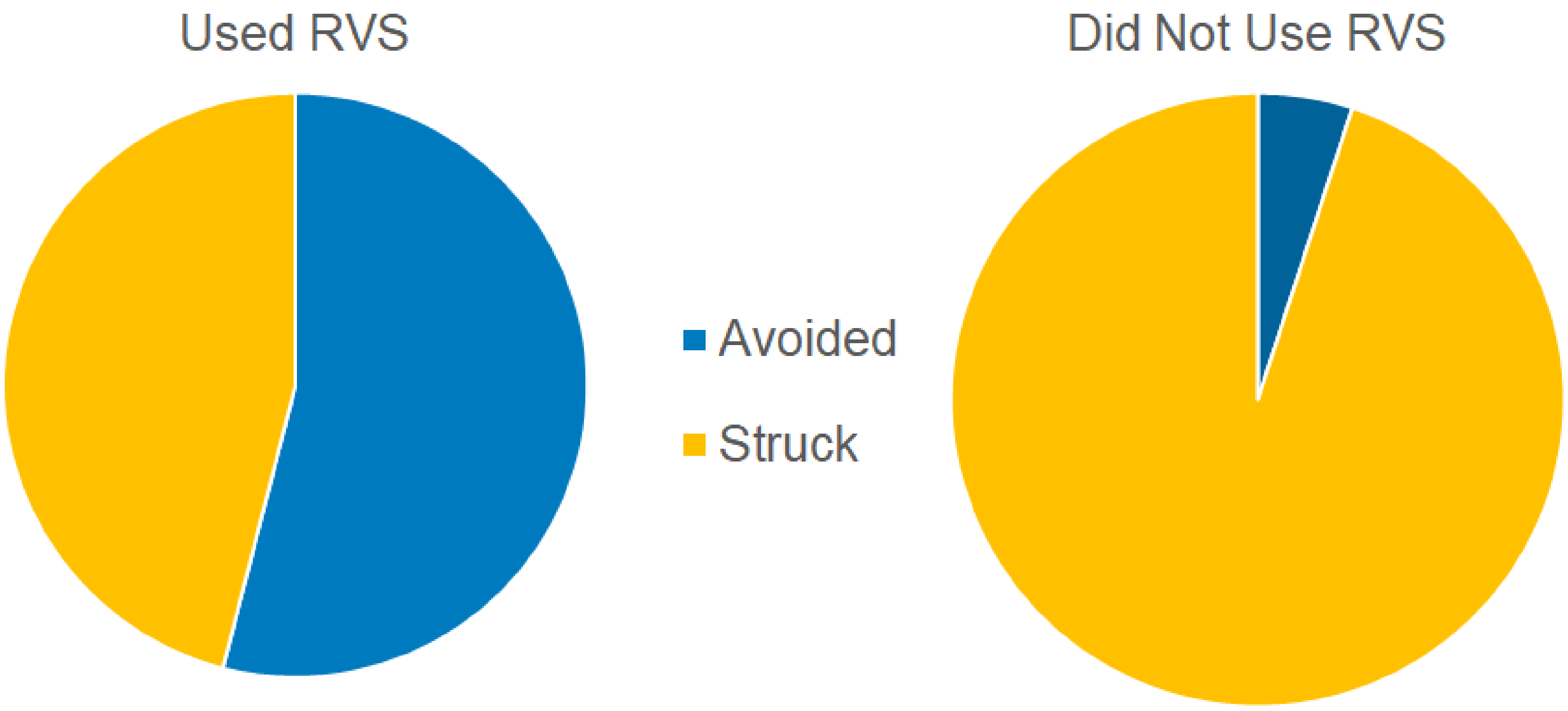


Backing Into a Parking Space – Proportion of Glances



Unexpected Obstacle

RVS was available for all trials



Summary

- Drivers using RVS were better able to avoid obstacles
- The oldest drivers exhibited poorer performance
- Those with RVS experience performed better than novices
- Next step: administer training to a fresh set of participants to see whether training can get RVS novices to perform like experienced users.

Drivers Use and Adaptation to L2 Driving Automation

Thomas Fincannon

Presentation Overview

- Project 1:
  - Exploring Driver Adaptation to Lower Levels of Automation (L2) Using Existing Naturalistic Driving Data
  - Completed work

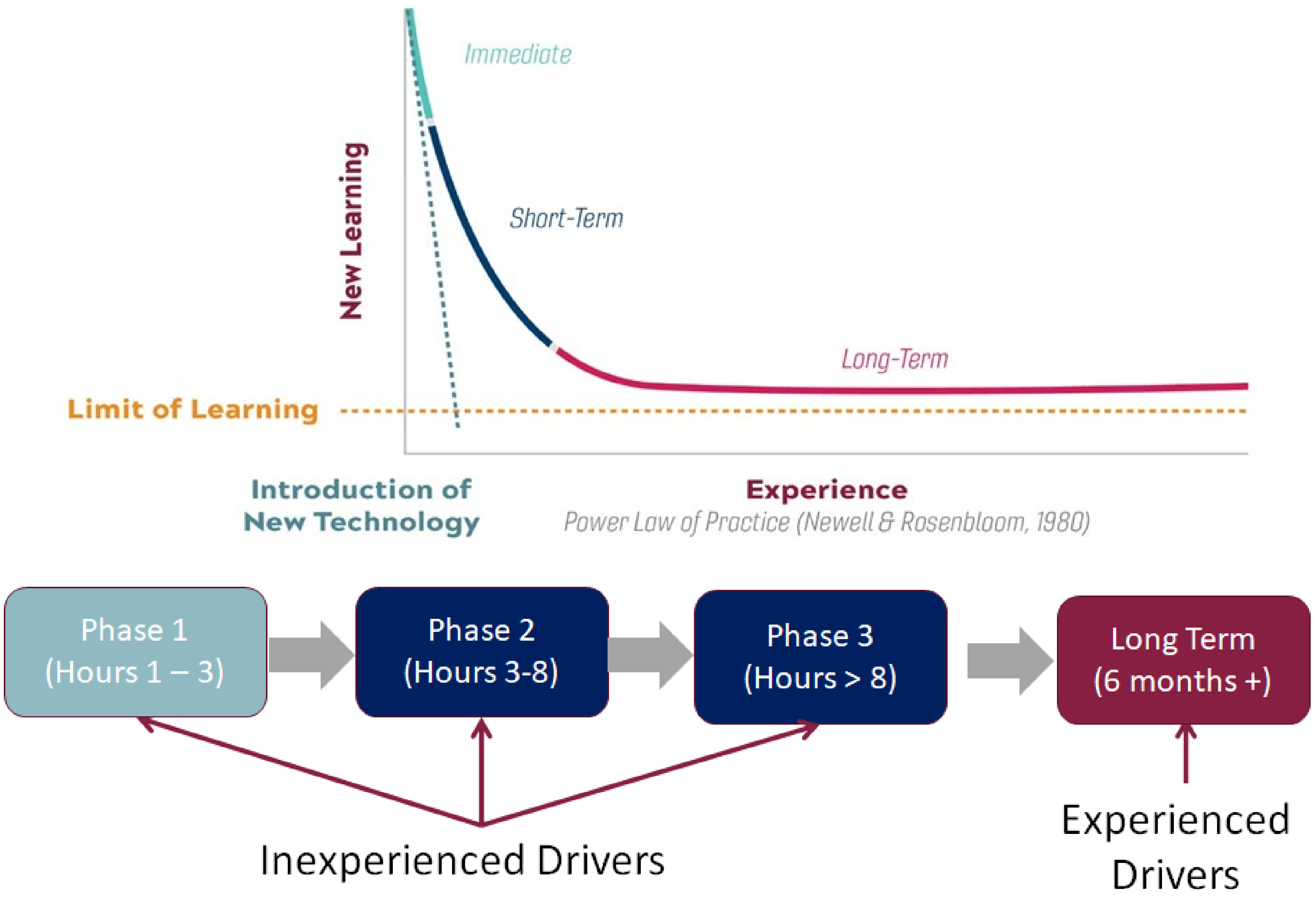
- Project 2:
  - Examination of how the duration of secondary task engagement changes over time in lower levels (L0 to L2) of driving automation
  - New project that has not collected or analyzed data

Project 1 Summary: Driver Adaptation

- Objective: Investigate how drivers adapt to, and rely on, L2 ADAS-equipped vehicles

- Research Questions:
    - How do driver strategies and behaviors for maintaining vehicle safety change over time?
    - What factors influence how drivers rely on, and adapt to, these technologies?
    - What are the relevant outcomes of adaptation and reliance upon these technologies?
    - What are the best practices and lessons learned?

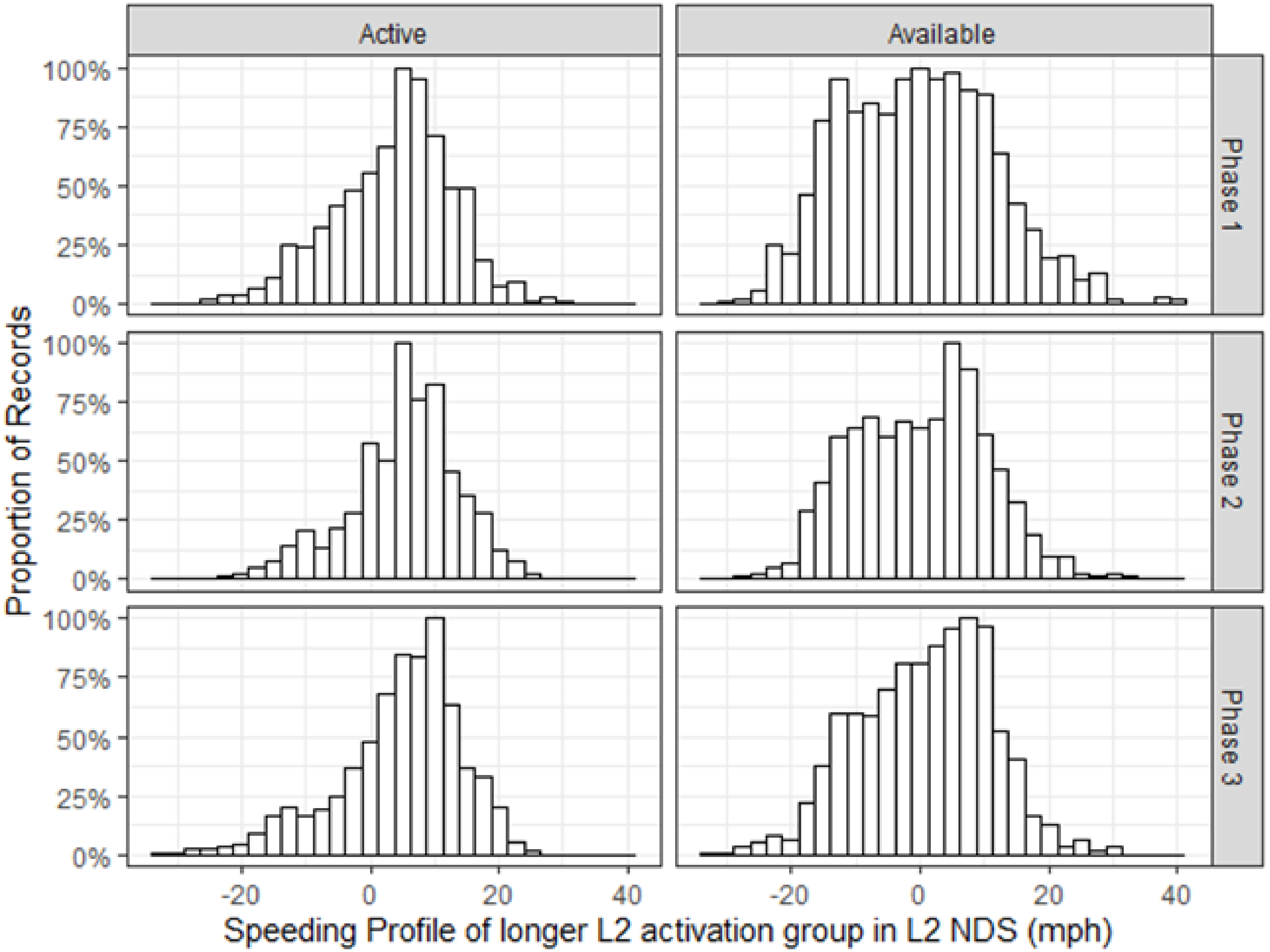
Assessing Behavioral Adaptation for Adult Drivers



Speeding Analysis

- Both inexperienced drivers and experienced drivers tended to speed more frequently when L2 systems were active (i.e., activate systems at faster speeds) than when L2 systems were available but inactive.

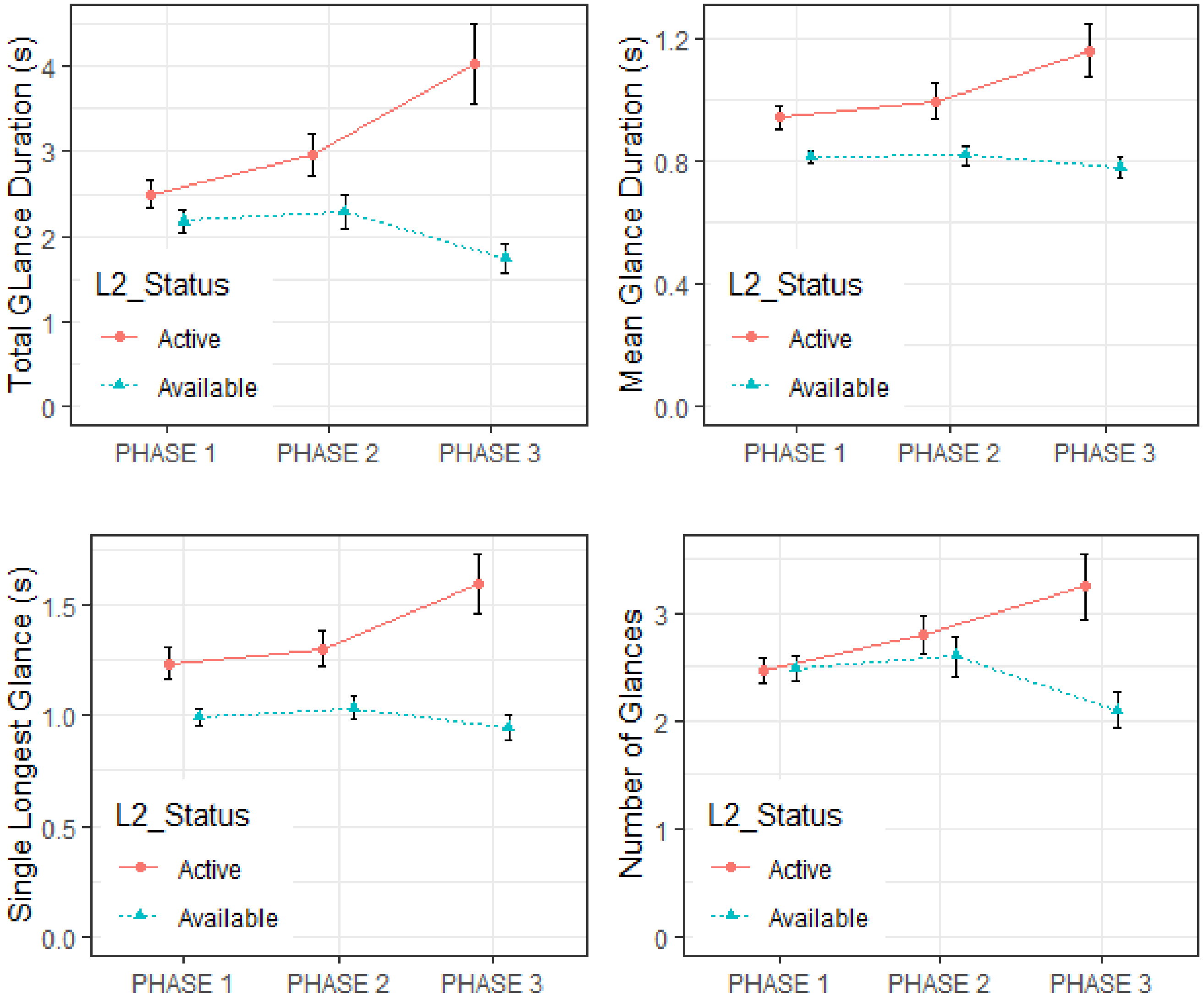
- Additional analyses also indicate that the inexperienced drivers increased speeding behaviors over time with L2 systems active.



1. Speeding = Actual speed - speed limit
2.Records represents 1Hz time-series kinematic data

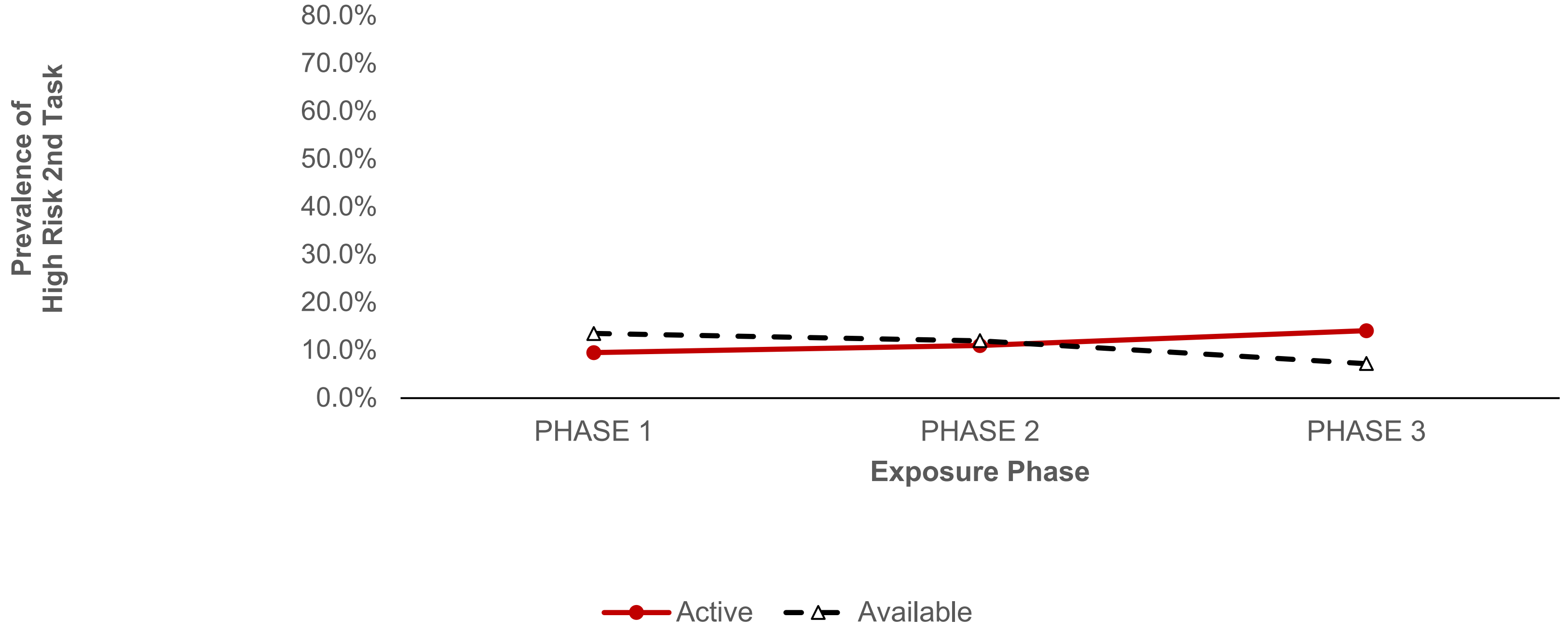
Driver Behavior: Glance Away from the Forward Roadway

- Drivers generally looked away for longer durations when L2 systems were active.
- Drivers looked away for increasingly longer periods when L2 systems were active
- Experienced drivers looked away from the forward roadway for longer durations when L2 systems were active as compared to available.



High-Risk Secondary Tasks

- Analyses focused on high visual–manual demand tasks (e.g., cell-phone activity; reaching for in-vehicle objects; etc.)
- There was a significant interaction between L2 system status and L2 exposure phase
  - High-risk secondary task prevalence increased over time when L2 systems were active.
  - High-risk secondary task prevalence decreased when L2 was available but not active.
- Findings consistent across experienced and inexperienced drivers



Project 2: Duration of Secondary Task Engagement

- Title: Examination of how the duration of secondary task engagement changes over time in lower levels (L0 to L2) of driving automation
  - Start Date: September 30, 2021
- Objectives:
  - Investigate secondary task engagement in Level 0 (No Automation) and Level 2 (Partial Automation).
  - Consider methods and metrics to examine both the quantity and duration of secondary task engagement

Project 2: Duration of Secondary Task Engagement

Research Questions

- How does the emphasis on duration, as opposed to numeric counts of instances, of secondary task engagement impact methodology for NDS data analysis?
- How do differences in driving automation impact duration of individual secondary task engagements, number of secondary task engagements, and total amount of time (or proportion of drive) engaged in a secondary task?
- What variables moderate the relationship between driving automation and secondary task engagement?
- Does the duration of secondary task engagement change over time? If yes, how is this change associated with safety-related driver outcomes?

NHTSA Efforts on Driver Monitoring and Alcohol Detection

Eric Traube

Presentation Agenda

- DADSS--Overview
- Background
- Technology Overview
- Current Status
- Driver Monitoring Strategies Project
- Summary

Driver Monitoring Strategies in Driving Automation Systems

Driver Monitoring Strategies in Driving Automation Systems

Understand what is currently known about methods to assess the effectiveness of various driver monitoring strategies.

Explore the efficacy of different approaches in successfully mitigating against the risk of *inattentive*, *impaired*, and *drowsy* drivers in advance of driver takeover in SAE L2 or SAE L3 systems.

Examine existing and prototype driver monitoring/mitigating strategies for their effectiveness in ensuring/improving driver readiness for when a driver is out of the loop

Understand the effectiveness of current and proposed strategies for driver state monitoring and mitigation

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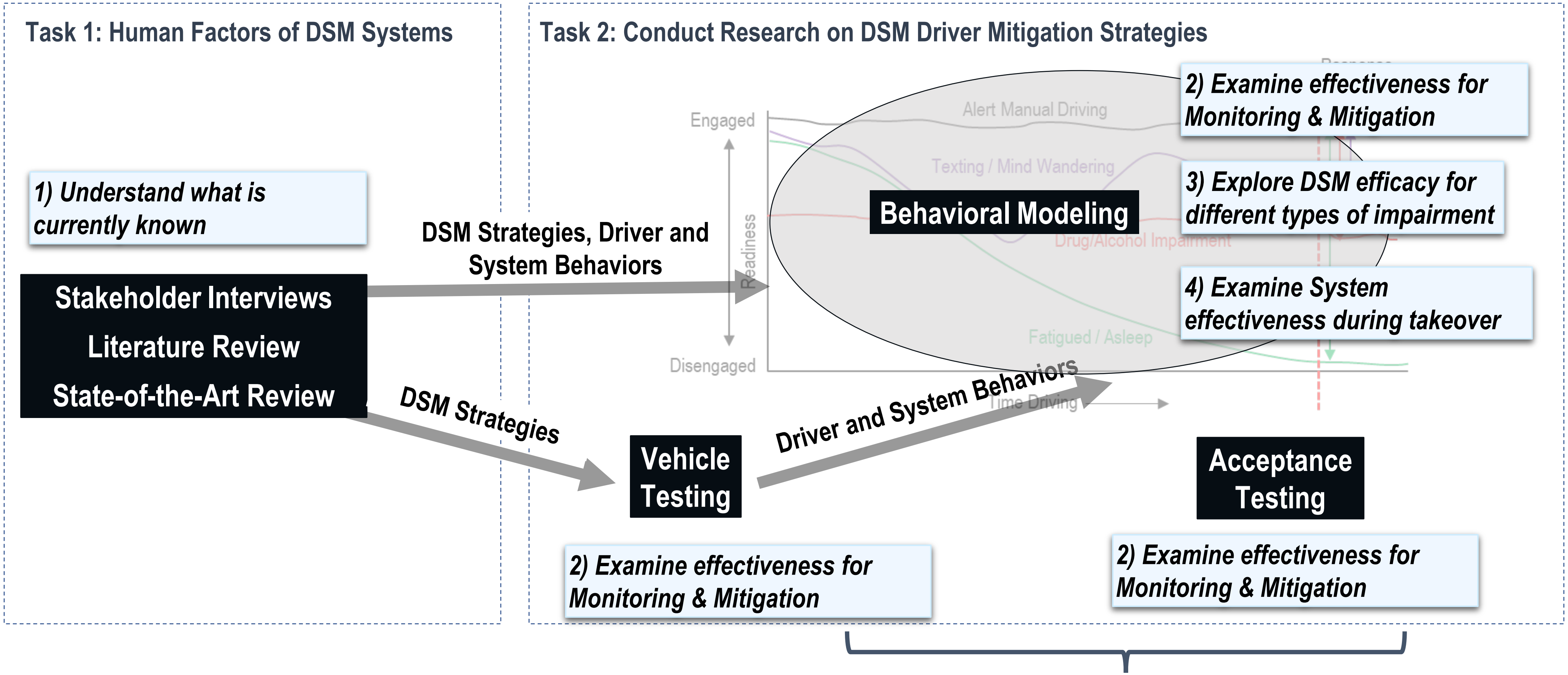
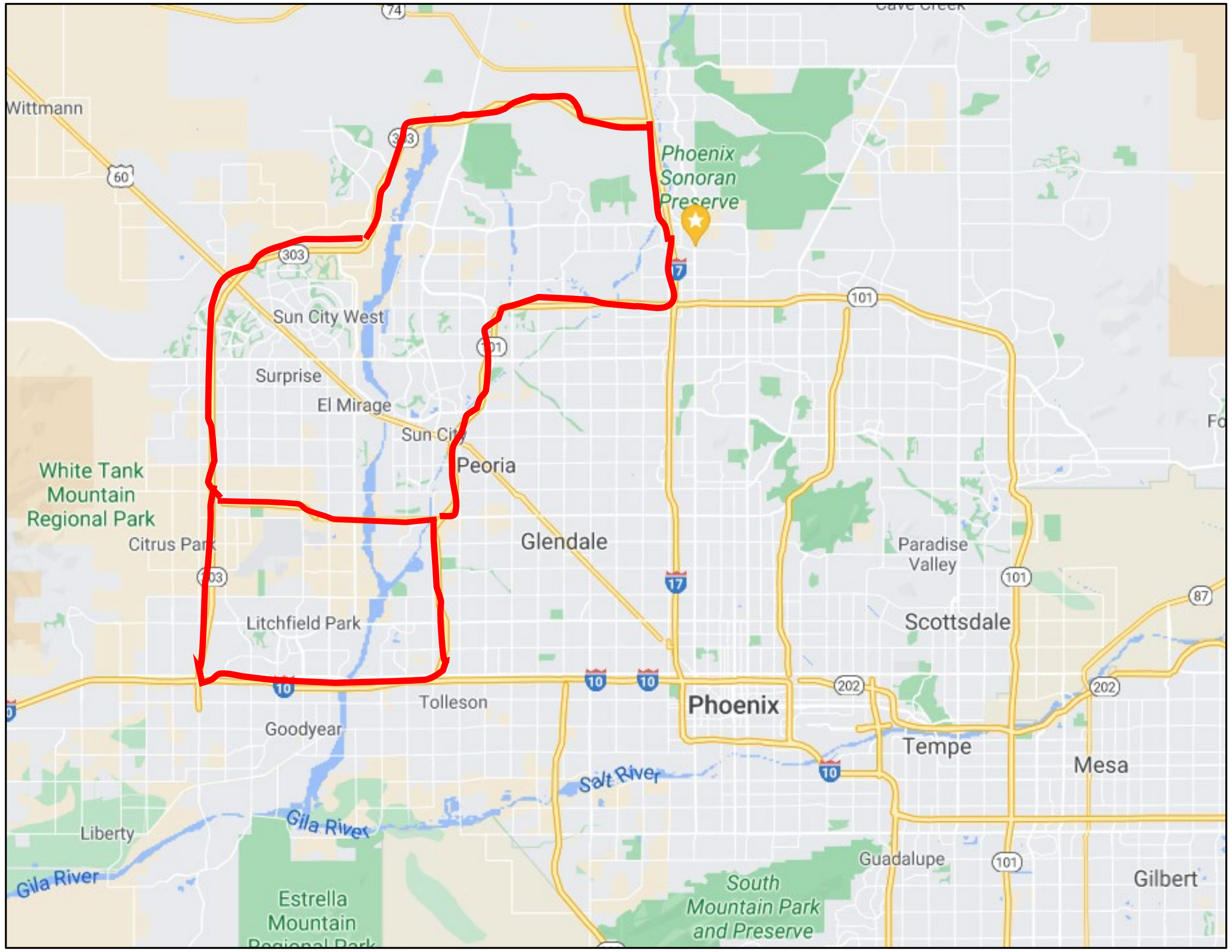
Technical Approach



Outcome: Human factors of driver monitoring and mitigation strategies for ensuring readiness

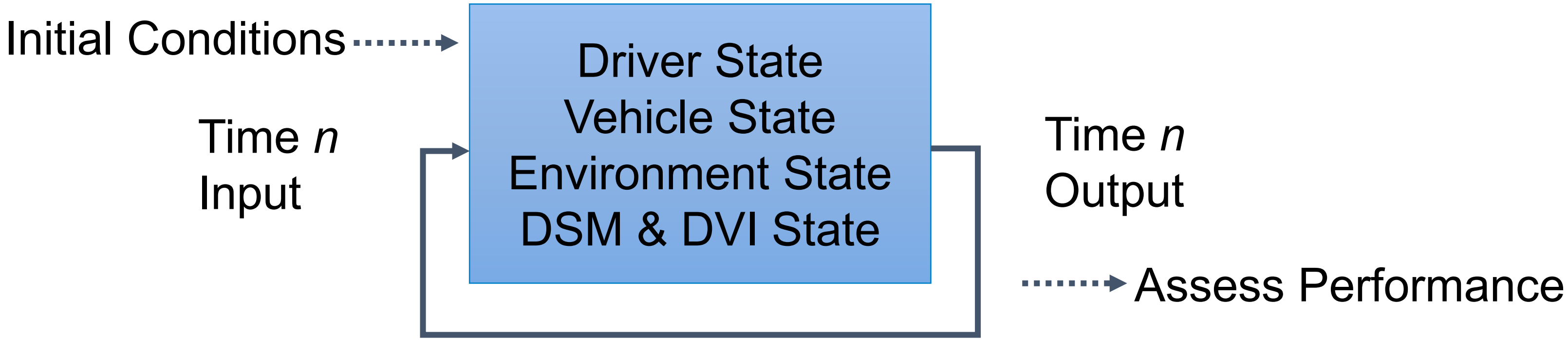
Vehicle Testing: Scenarios

- Testing conducted on the Phoenix freeway system
- Eyes-off-road and hands-off-wheel (Magnitude and Duration)
- With and without lead vehicle
- Light, medium, and high traffic
- Near on- and off-ramps (merging traffic)
- Negotiating a curve
- Hypotheses Tested



Behavioral Modeling

- **Behavioral Modeling is simulation-based approach of studying system behaviors** using a virtual representation of real-world agents
- Can help **predict system performance and answer questions** about the efficacy of driver monitoring strategies.
- **Already a common methodology** of DSM design and evaluation
- Ability to test millions of permutations of scenarios, driver, vehicle and system



Driver Alcohol Detection System for Safety (DADSS)

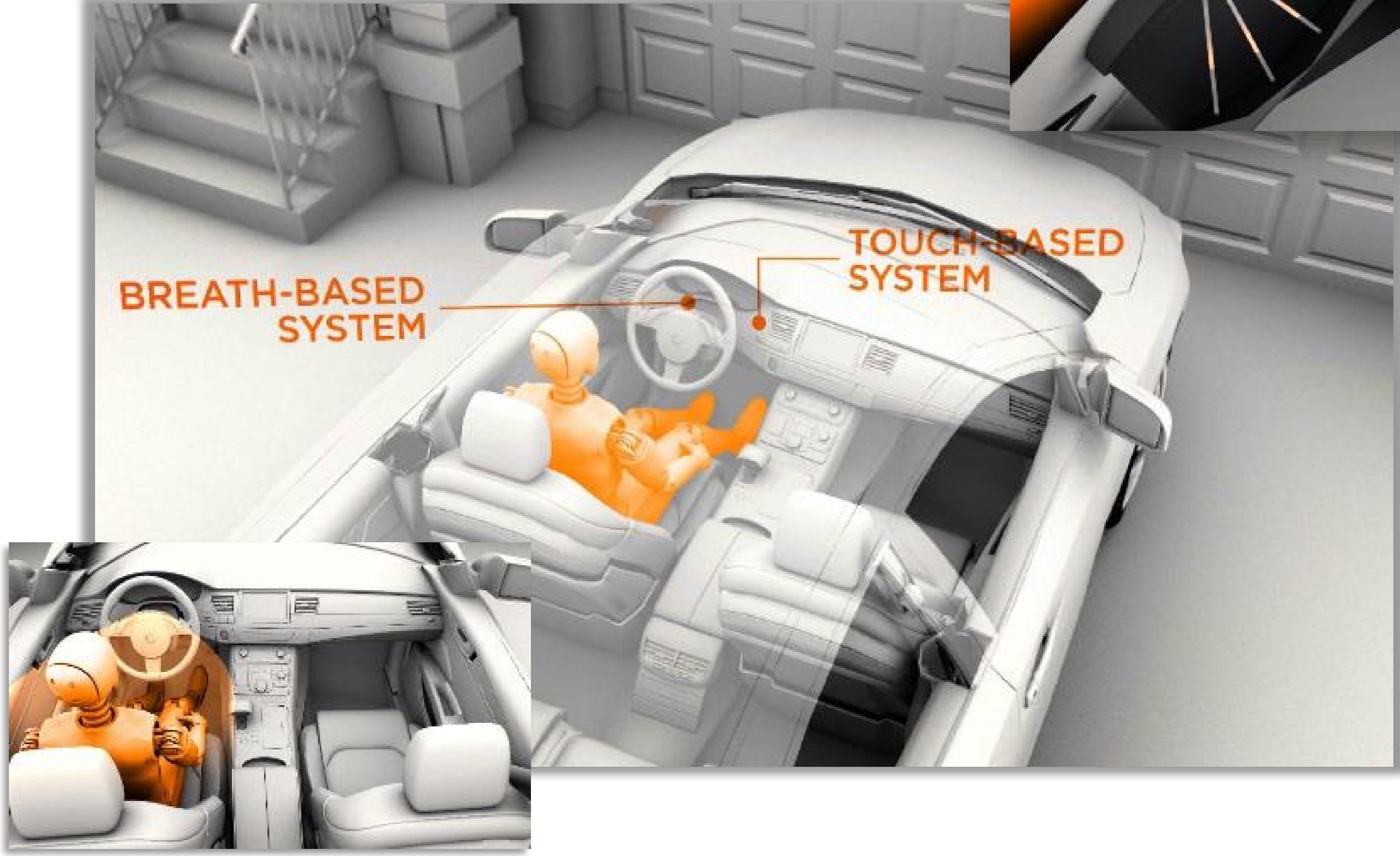
DADSS Program Overview

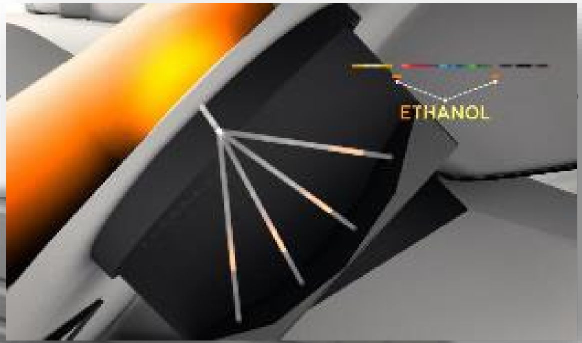
- Cooperative Agreement between the **Automotive Coalition for Traffic Safety, Inc. (ACTS)** and the **National Highway Traffic Safety Administration (NHTSA)**
- Developing first–of–its–kind technology to detect when a driver is impaired with an alcohol concentration **at or above 0.8 g/L (0.08 %BAC/BrAC in the United States except Utah)** and prevent the car from moving
- Two technologies being researched: **breath–based and touch–based systems**
- **Programmable for a zero–tolerance limit** for the underage driver
- **Goal: To develop fast, accurate, precise, reliable, non-intrusive and affordable technology**

The DADSS Technologies

http://www.dadss.org

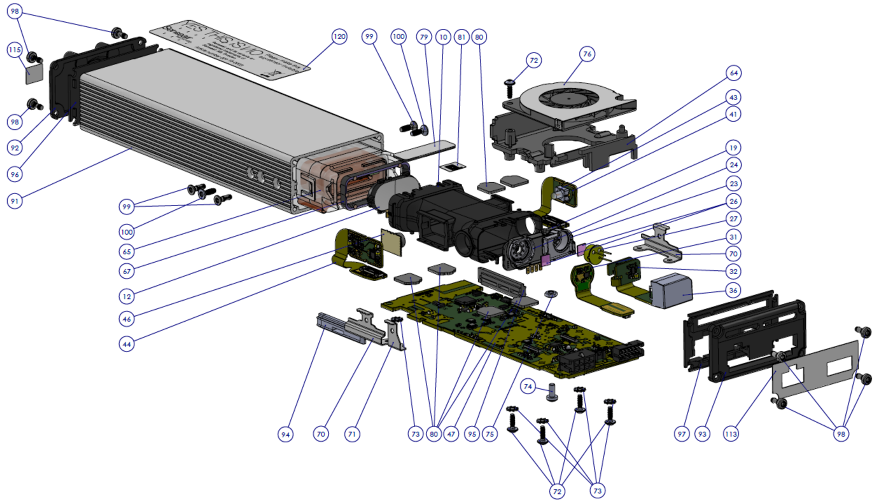
The **Breath System** measures the alcohol in a driver's naturally exhaled breath. A small sensor compares the amount of carbon dioxide molecules with alcohol molecules in the driver's breath using infrared light.

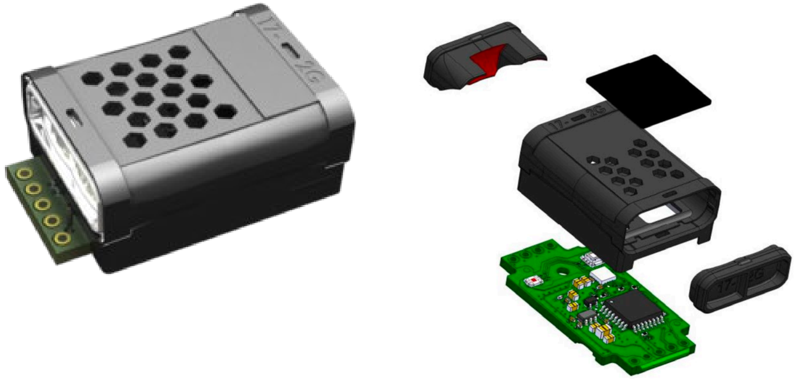




The **Touch System** measures the blood alcohol concentration under the skin's surface by shining an infrared-light through the fingertip or the palm of the driver.

DADSS Breath System





- **GEN 3.3** Directed–breath sensor/system
  - 85% reduction in size from initial Gen 1.0 prototype
  - Commercial licensing beginning in 2021

- **GEN 4.0** Passive-breath sensor/system
  - Bench prototype targeted for completion in 2021

DADSS Touch System

- **GEN 5.0** Touch system targeted with 4 lasers & single board electronics in 2021
  - Integrating prototype touch system in test vehicles in early 2022
  - Fleet licensing goal of 2023

- **GEN 6.0** Touch system targeted with 2 lasers & upgraded electronics
  - Estimated to be available for deployment in 2025

Testing

Controlled — Rigorous Acceptance Testing — Uncontrolled

Verification & Validation Lab
Marlborough, MA

Performance Testing

McLean HOSPITAL
HARVARD MEDICAL SCHOOL AFFILIATE

Belmont, MA

Human Subject Testing

Vehicle Instrumentation Lab
Marlborough, MA

Human Subject & Naturalistic Driving

DADSS Deployment Timeline Goals

CHARECTERISTIC	GEN 3.3 Breath	GEN 5.0 Touch	GEN 4.0 Breath	GEN 6.0 Touch
Estimated Commercialization	**2021**	**2023**	**2024**	**2025**
Market Application	Fleet vehicles & accessory sales		Consumer vehicles	
Vehicle Integration	After mass production (Upfitter or dealer installed)		During mass production	
Alcohol (Ethanol) Set Point	0.02%		0.05 or 0.08%	
Operating Characteristics	Contactless, Directed–breath	Passive operation, 2 to 4 tunable lasers, single board electronics	Contactless, Passive–breath	Passive operation, 2 widely tunable lasers, ASIC–level electronics

Key Websites for More Info

DADSS Program	Web Page	Web Address
DADSS Program	Publications	https://www.dadss.org/our-publications/
	Public Outreach	https://www.dadss.org/events/
	News & Updates	https://www.dadss.org/news/
	FAQ	https://www.dadss.org/faq/
Driven to Protect Initiative		https://www.dadss.org/driventoprotect/
Virginia	Initiative	https://www.dadss.org/virginia/
	Discovery Hub	https://www.discoveryhub.actsautosafety.org
Maryland	Initiative	https://www.dadss.org/maryland/

Thank you for your time and attention

Eric Traube: eric.traube@dot.gov

Christian Jerome: christian.jerome@dot.gov

Kathy Sifrit: kathy.sifrit@dot.gov

Thomas Fincannon: thomas.fincannon@dot.gov

Stacy Balk: stacy.balk@dot.gov