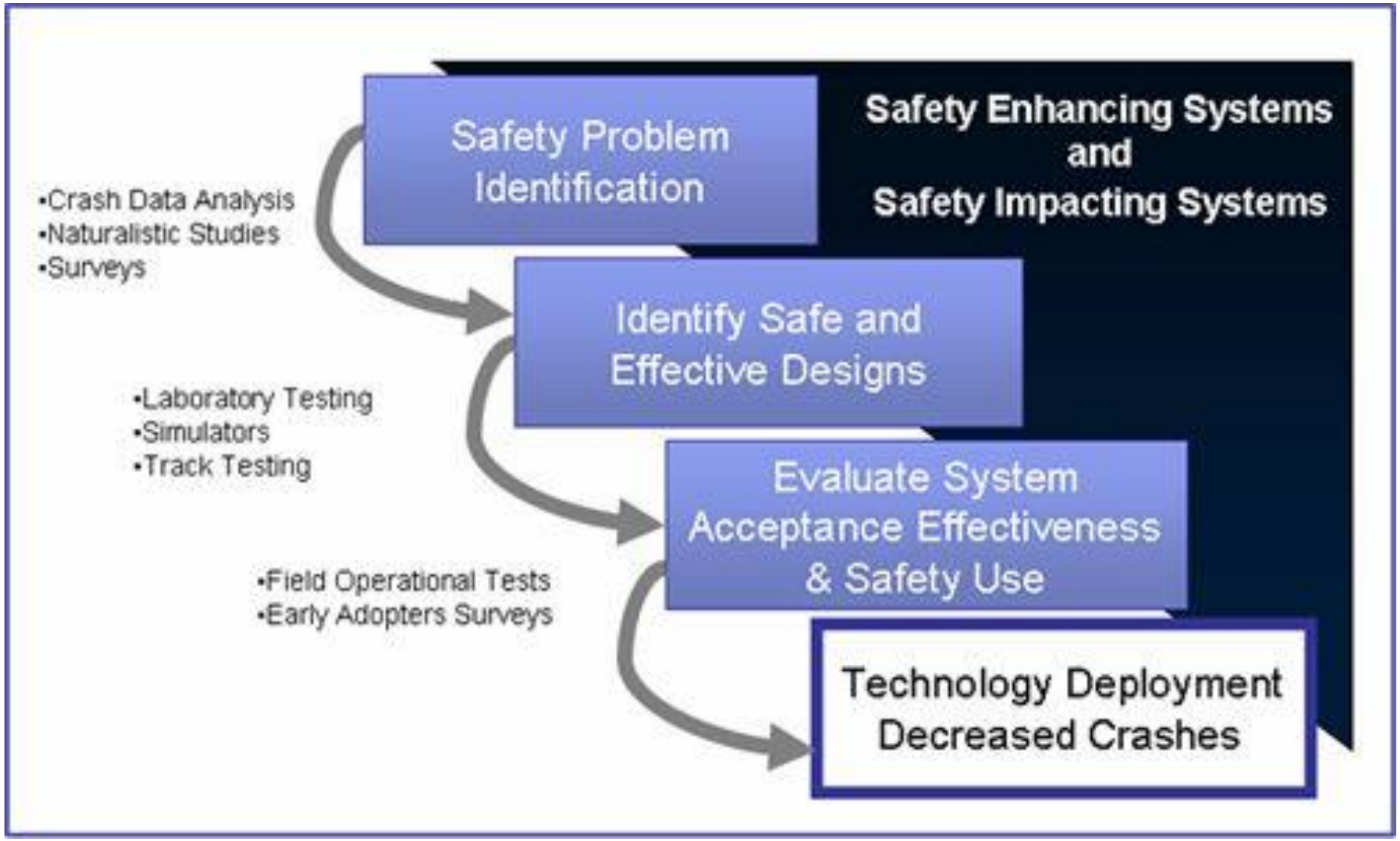
NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Human Factors Research

Human Factors Research Overview



1. Driver Interaction with Driver Assistance Technologies
2. ADS and Legacy Vehicle Interaction
3. Transition of Control and Post-Transition Driver Performance in L3 Vehicles
4. Telltales and HMI Concepts in the Development of Trust and Mental Models in ADS
5. Exploring Driver Adaptation to Lower Levels of Automation
6. Older Drivers and Rearview Video Systems

Driver Interaction with Driver Assistance Technologies

Elizabeth Mazzae

Driver Interaction with Driver Assistance Technologies

- Advanced Driver-Assistance Systems (ADAS)
  - Generally refers to Active Safety Systems designed to help drivers with certain driving tasks (e.g., staying in the lane, avoiding crashes, and maintaining a safe headway)
  - Designed to improve safety or reduce driver workload
  - With respect to driving automation, some ADAS features could be considered SAE Level 1 or Level 2, but many are Level 0 and may only provide alerts to the driver

- **Objectives:** Observe how drivers experienced and inexperienced with certain ADAS features understand HMI system state information and respond to system requests
- **Focus**: Adaptive Cruise Control (ACC) and Lane Keeping Assistance (LKA)

Driver Interaction with Driver Assistance Technologies

- **Approach:**
  - Examine driver behavior and ADAS use as a function of experience level:
    - Owners of the two ADAS-equipped study vehicle models
    - Individuals with no ADAS (ACC + LKA) experience
  - 2 ADAS-equipped vehicle models from different manufacturers
    - ADAS driver engagement strategies: Gaze, Hands-on-wheel
    - Potentially different performance capabilities
  - On-road, semi-naturalistic driving experiment
  - 3-hour route over multi-lane public highways
  - Data collected will include:
    - Eye glance location and duration
    - Driver hand locations
    - Video of surrounding traffic situation
    - Vehicle control inputs
    - Vehicle dynamics information

Experience	Driving Assignment	Group
Inexperienced Drivers	Model A	1
	Model B	2
Model A Owners	Model A	3
	Model B	4
Model B Owners	Model A	5
	Model B	6

Driver Interaction with Driver Assistance Technologies

- **Research Questions:**
  1. How effective are ADAS status displays in communicating system state?
  2. How easy/difficult is it to activate the ADAS features?
  3. How effective are ADAS HMIs in prompting efficient transfers of control
  4. How does familiarity with one ADAS “brand” affect drivers’ understanding of ADAS status information and efficiency of response to take-over requests? (Transfer of Learning)
  5. How does ADAS driver engagement strategy affect drivers’ proper and appropriate use
     - Rate of compliance with readiness prompts
     - Frequency of ADAS feature use

ADS and Legacy Vehicle Interaction

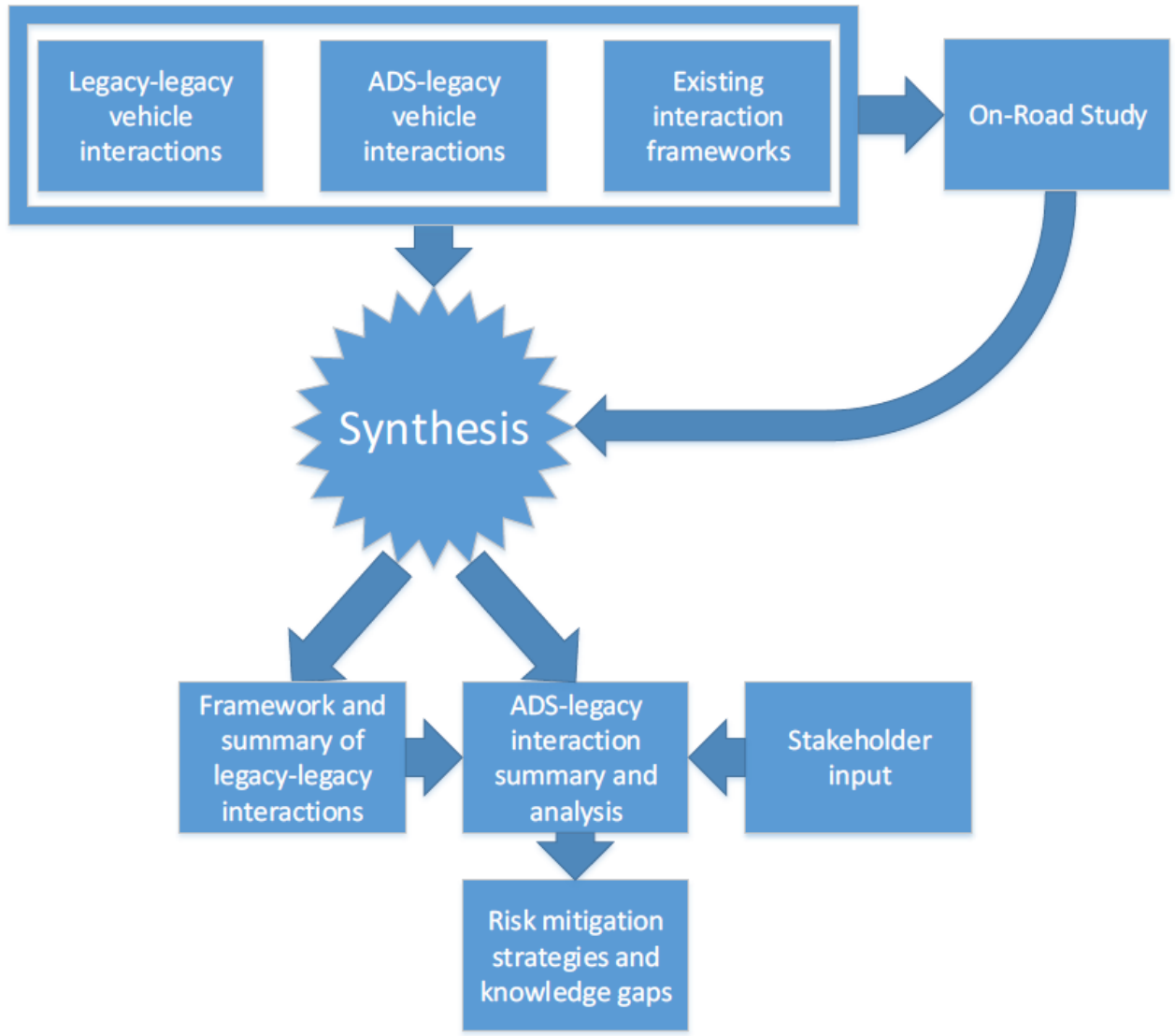
Christian Jerome, Ph.D.

ADS and Legacy Vehicle Interaction

- **Objectives:** From a human factors perspective, "… identify how Automated Driving System (ADS) equipped vehicles and legacy vehicles may interact on the highway, how these interactions may be similar to or different from legacy-to-legacy vehicle interactions, and to describe how these interactions could affect driving safety"
- **Research Questions:**
  1. How might ADS-equipped vehicles and legacy vehicles interact on the highway?
  2. How could these interactions affect driving safety?
  3. What are the sources of potential safety issues?
  4. How could the safety issues be mediated?

ADS and Legacy Vehicle Interaction

- **Approach:**
  - Review and analysis of existing knowledge:
    - Critically review literature relevant to vehicle-to-vehicle interactions for (1) legacy vehicles, and (2) Early deployments of ADS vehicles
    - Assess how ADS-to-legacy vehicle interactions may differ from legacy-to-legacy interactions from a safety perspective
    - Identify potential risk mitigation approaches to address the interaction challenges posed by ADS
  - On road study of natural traffic interaction with an ADS-equipped vehicle
    - Compare how legacy vehicle drivers interact with an ADS-equipped vehicle as compared to a legacy vehicle
    - Determine whether differences in legacy drivers' interactions with an ADS-equipped vehicle are due to driving style of the ADS or identification of the vehicle as an ADS vehicle



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

Christian Jerome, Ph.D.

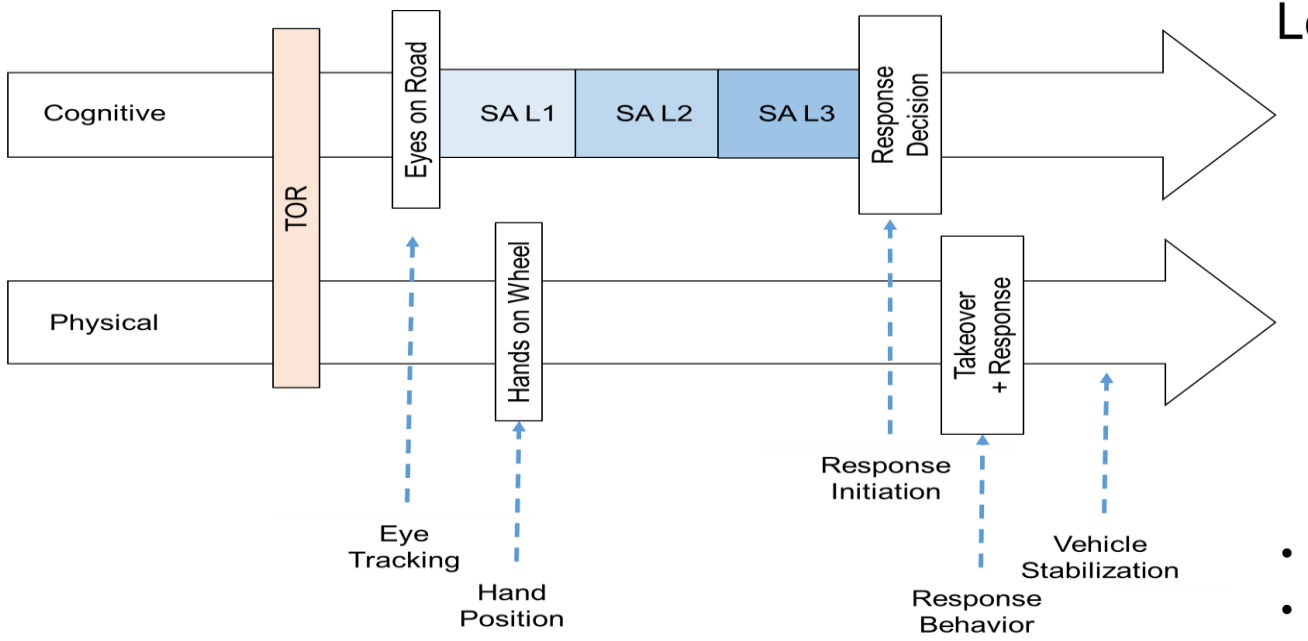
Transition of Control and Post-Transition Driver Performance in L3 ADS-equipped Vehicles

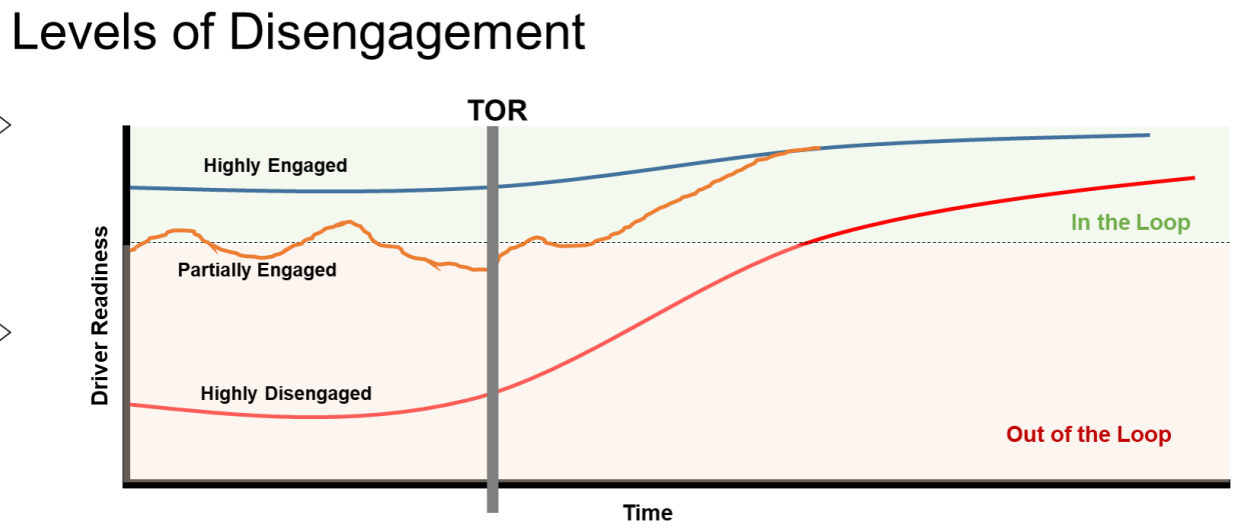
- **Objectives:** Examine the effectiveness of HMI design for transition of control and driver performance in L3 control handoff situations.

- **Research Questions:**
  - What effect do the various modalities and characteristics of take over request (TOR) notifications have on driver performance during control transitions and various edge case situations?
  - How much time does it take drivers to respond to TOR notifications and regain stable vehicle control?
  - What other behaviors and unintended consequences do drivers exhibit in response to TOR notifications?
  - What are the implications about interface design, including information about timing, sequence and presentation of elements of the TOR HMI?

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

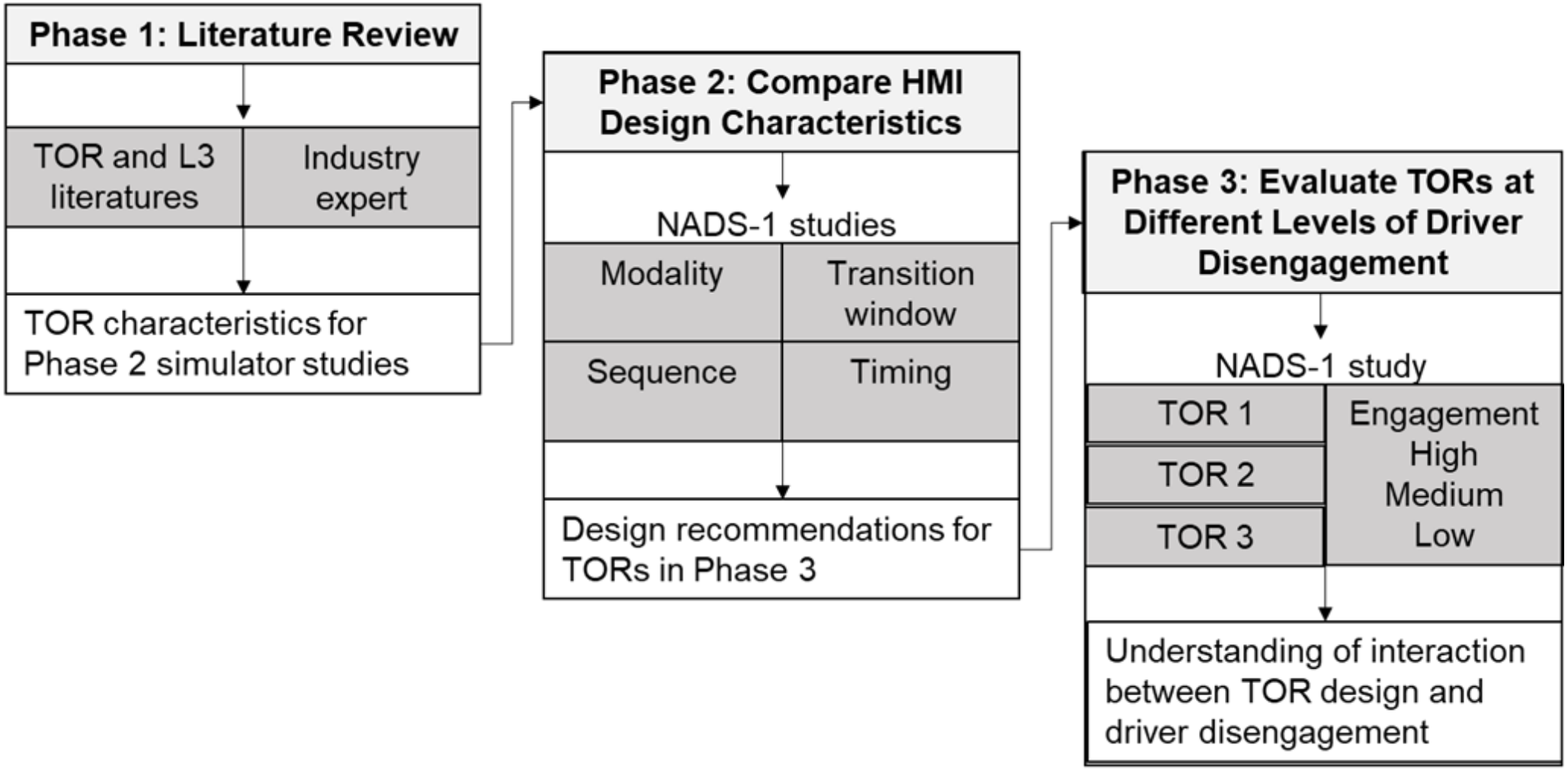
- **<u>Approach:</u>** Literature Review, State of the technology, L3 transition of control literature, Warning HMI literature. Research Plan TOR characteristics for Phase II studies on NADS-1 driving simulator. Analysis Plan Measuring transition time, quality, and unintended consequences





- Partially-Engaged: intermittent secondary task (e.g., infotainment)
- Fully-Disengaged: continuous secondary task (e.g., watching movie)

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



Telltales and HMI Concepts in the Development of Trust and Mental Models in ADS

Thomas Fincannon, Ph.D.

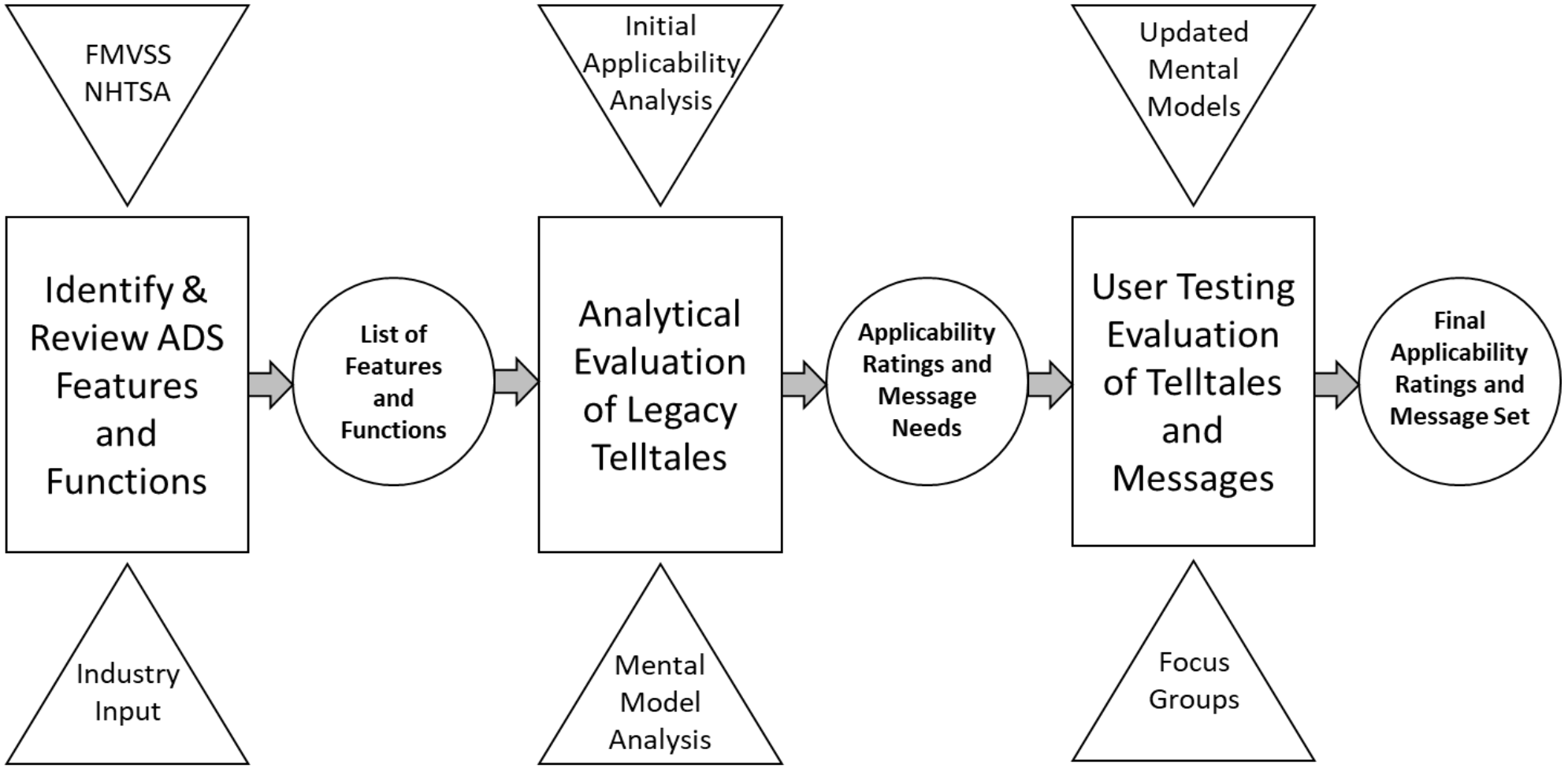
Task 1: Generalizability of Telltales to ADS

- **Objectives**: Whether and how existing telltales apply to ADS-equipped vehicles and the relationship to drivers' mental models and ADS

- **Research Questions**:
  - What telltales from vehicles are applicable to ADS, and why?
  - What new telltales may need to be considered for human occupants of ADS-equipped vehicles?
  - What are the relevant issues involved with drivers updating their mental model to accommodate any changes to telltales?
  - How does the applicability of telltales and how drivers update relevant mental models change across higher levels of driving automation (i.e., L4 and L5)?

Task1: Generalizability of Telltales to ADS

Approach:



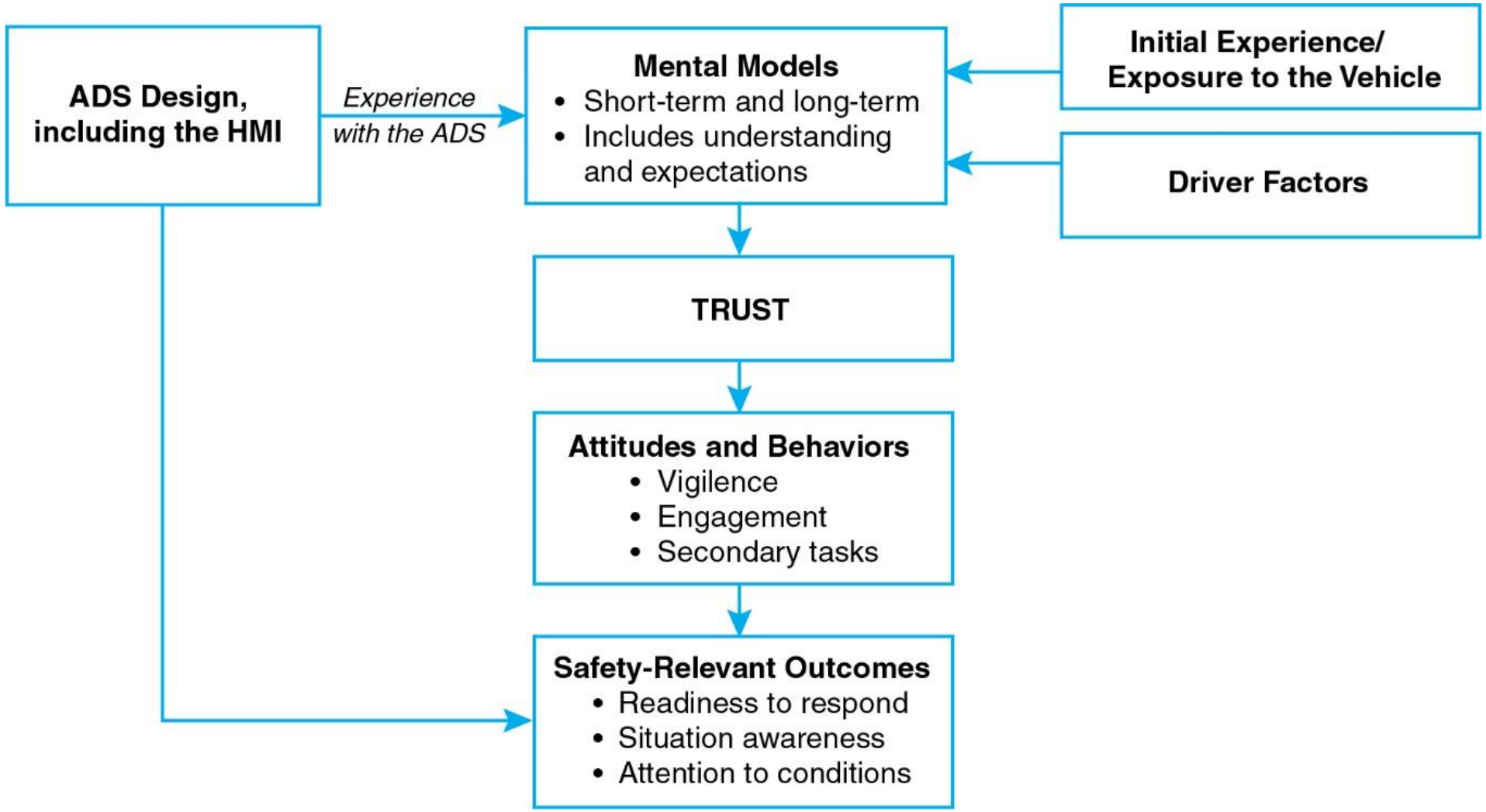
Task 2: Mental Models and Trust in ADS

- **Objectives**: Examine the relationship between drivers' mental models of ADS and how they impact the development of appropriate versus inappropriate trust in ADS

- **Research Questions**:
  - What components and/or knowledge structures of mental models are associated with trust in ADS?
  - What are candidate measures for behavior outcomes of trust in ADS?
  - What mental models are associated with the development of appropriate/inappropriate trust with ADS?
  - How do existing and/or future HMIs support and/or hinder a driver's ability update their mental models of ADS and appropriately trust ADS?
  - How do these relationships involve mental models and trust change across higher levels of automation (i.e., L3, L4, and L5)?

Task 2: Mental Models and Trust in ADS

Approach:



Exploring Driver Adaptation to Lower Levels of Driving Automation

Thomas Fincannon, Ph.D.

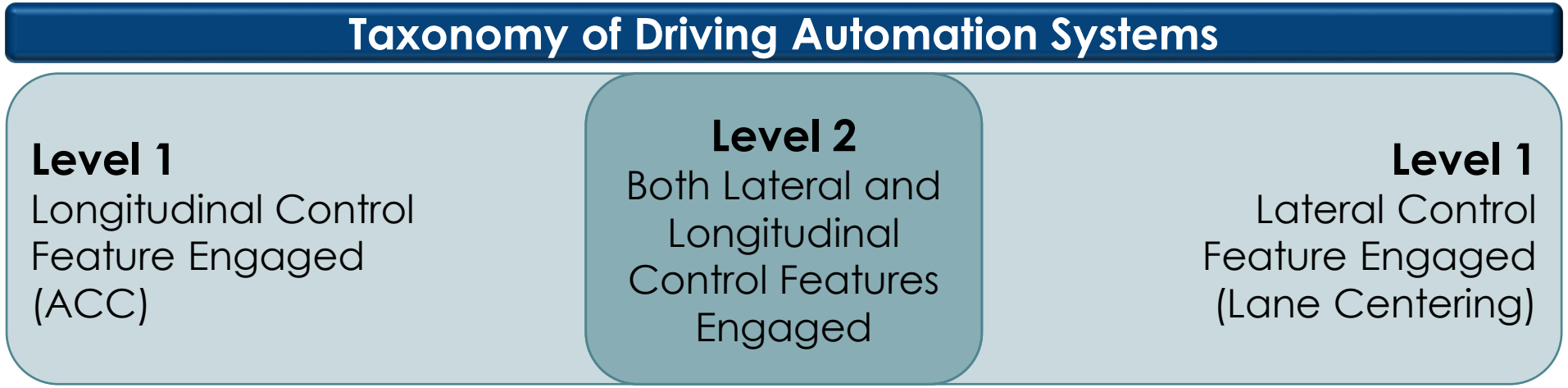
Project Overview

- **Objectives**: Investigate how drivers adapt to, and rely on lower levels of driving automation

- **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?

Driver Adaptation to ADAS

- **Approach**
  - Behavioral adaptation may occur in driver response to automated technologies
    - Drivers may look away from the forward roadway when L1 or L2 automation is engaged as they become more comfortable with that level of risk
    - The level of risk accepted under automation may change over time
  - Assessment of driving automation will focus on activation of lateral and longitudinal control systems



Sample Variables

- Independent variables
  - Level of driving automation
  - Traffic density
  - Road type (e.g., controlled vs. uncontrolled access)
  - Time related factors
    - Duration of drive
    - Time of day
    - Day of the week
    - Experience
      - 1st drive vs. end of the 1st week, month, or year

- Outcome Variables
  - Driver strategies:
    - Minimum headway selection
    - % of time speeding
  - Driver Behaviors
    - EOR time
    - Secondary task engagement
    - Hard braking behaviors

Older Drivers and Rearview Video Systems (RVS)

Kathy Sifrit, Ph.D.

Older Drivers and Rearview Video Systems (RVS)

- In 2014 NHTSA issued a final rule to expand the required field of view for passenger vehicles by specifying an area behind the vehicle which must be visible to the driver when the vehicle is placed into reverse.
- RVS installed to meet the new requirements, which became effective for all new passenger vehicles in 2018.

- 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)
- Older adults may have difficulty turning to look behind the vehicle; may benefit more than other drivers from RVS

Older Drivers and Rearview Video Systems

- **Approach:**
  1. Compare driving performance using mirrors to that using an RVS while backing among drivers 60+;
  2. Document common errors during backing tasks;
  3. Develop training to reduce those errors;
  4. Test the training on naïve participants.

- Anticipated report release: Mid-2022