Human Factors for Limited-Ability Autonomous Driving Systems

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Disclaimer

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Introduction

- Project Background
  - Premise: The first autonomous systems introduced to the driving public will not be perfect
  - Definition: Limited-Ability Autonomous Driving Systems (LAADS)
    - can control vehicle speed and steering on public roads for substantial distances and times
    - in some situations requires that the driver/operator intervene to assure a safe and comfortable trip
- Project Goals
  - Investigate driver interactions with a Limited-Ability Autonomous Driving System (LAADS)
  - Determine impact of a LAADS on
    - driver visual attention to the driving task
    - willingness to engage in secondary non-driving related tasks
    - ability to respond to events
  - Understand the factors that impact the effectiveness of alternative concepts of operation
    - human-machine interfaces
    - control transition strategies

Research Phases & Environments

Research Phases

I: Problem Identification Research

II: Alternative Driver-Vehicle Interaction Concept Research

III: Integrated Countermeasure Concept Research

Study Environments

- Surveys
- Expert Panel Studies
- Driving Simulator Studies
- Track Studies

GM Milford Proving Grounds Circular Track

- Radius: 1178m, 3865 ft.
- Circumference 4.6 Miles, 7.4 Km
- 5 Lanes

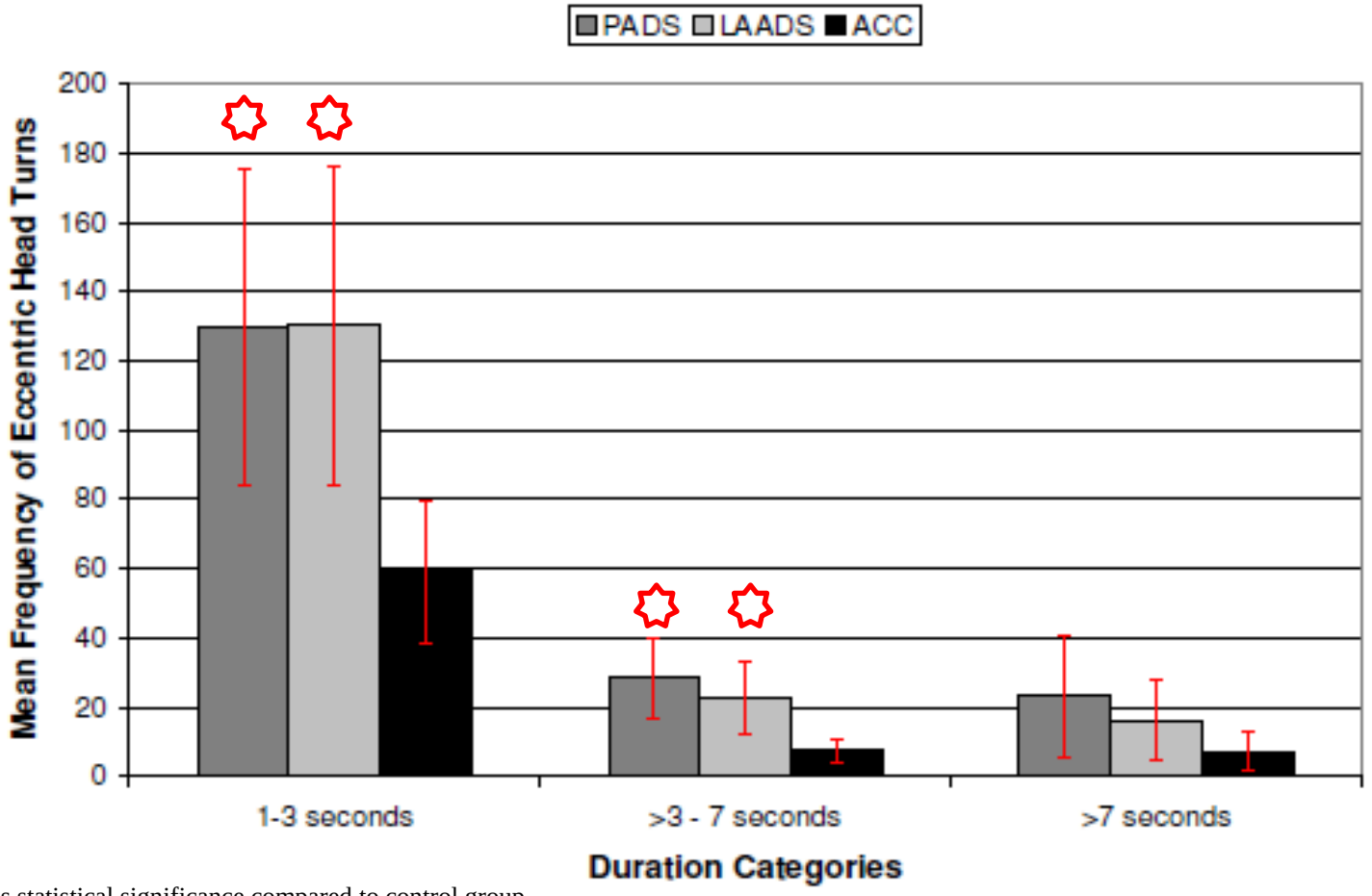
Problem Identification Research Approach

- Treatment Conditions
  - ACC only (manual steering)
  - ACC and perfect Lane Centering (PADS)
  - ACC and imperfect Lane Centering (LAADS)
- Limitation Events Used to Measure Impact of Different Systems on Driver Performance
  - Poor lane markings – system requests driver take control
  - Lateral drift within lane with adjacent vehicle,
  - Lateral drift within lane with no adjacent vehicle
  - Excessive curve – vehicle leaves lane
  - Construction
  - Lead vehicle hard braking

Behavior Sample

Head Turn Frequency by Duration Category during Simulator Study

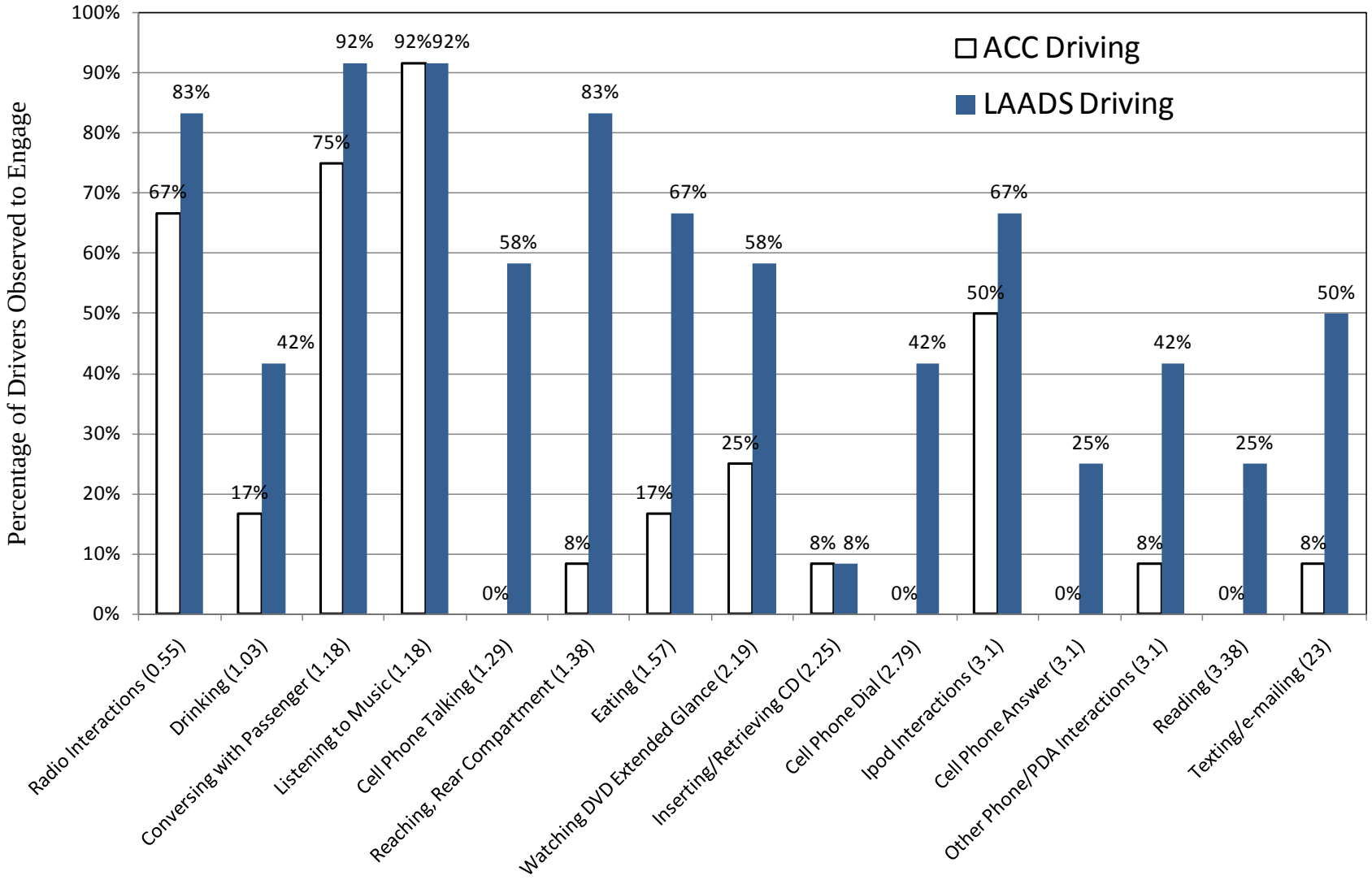
- Frequency of Eccentric Head Turns by duration categories



Denotes statistical significance compared to control group

Riskier Tasks Tended to be Limited to LAADS Driving

(those with relative risk values above 1)



Relative risk values based on 100-Car Study (value of 1 is crash risk normally associated with typical driving)

Phase I Results

- Two targeted and complimentary experiments were performed:
  - Simulator-based driving study with sixty-three subjects
  - Test track study with twelve subjects.

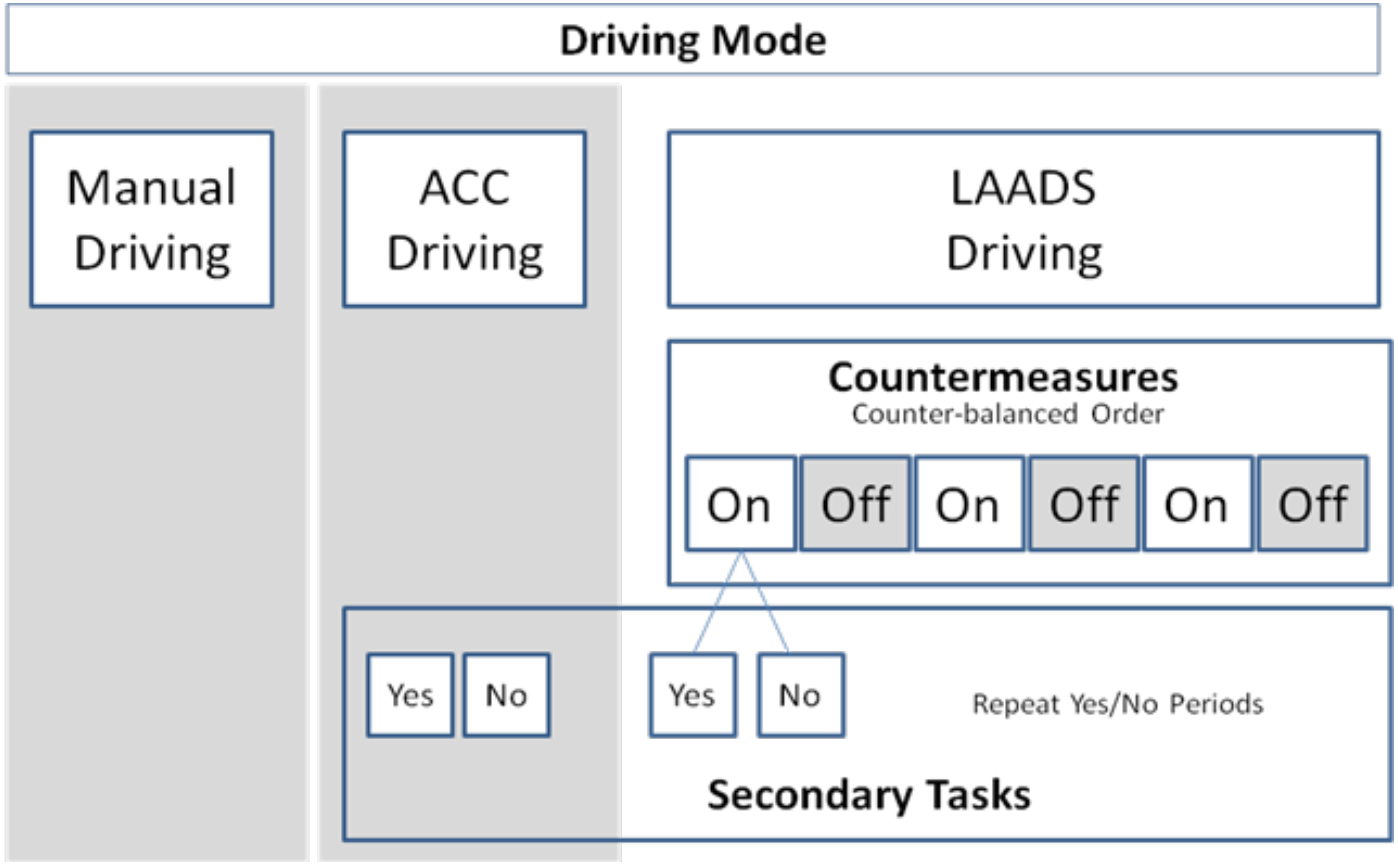
The studies quantify the difference in drivers' behaviors between ACC and LAADS

- Increase the propensity of secondary task engagements,
- Increase riskier behaviors (those requiring extended off-road glances) such as reading, reaching for object in back seat, texting,
- Negatively impact the degree of visual attention drivers devote to the forward roadway (increases off-road glances).

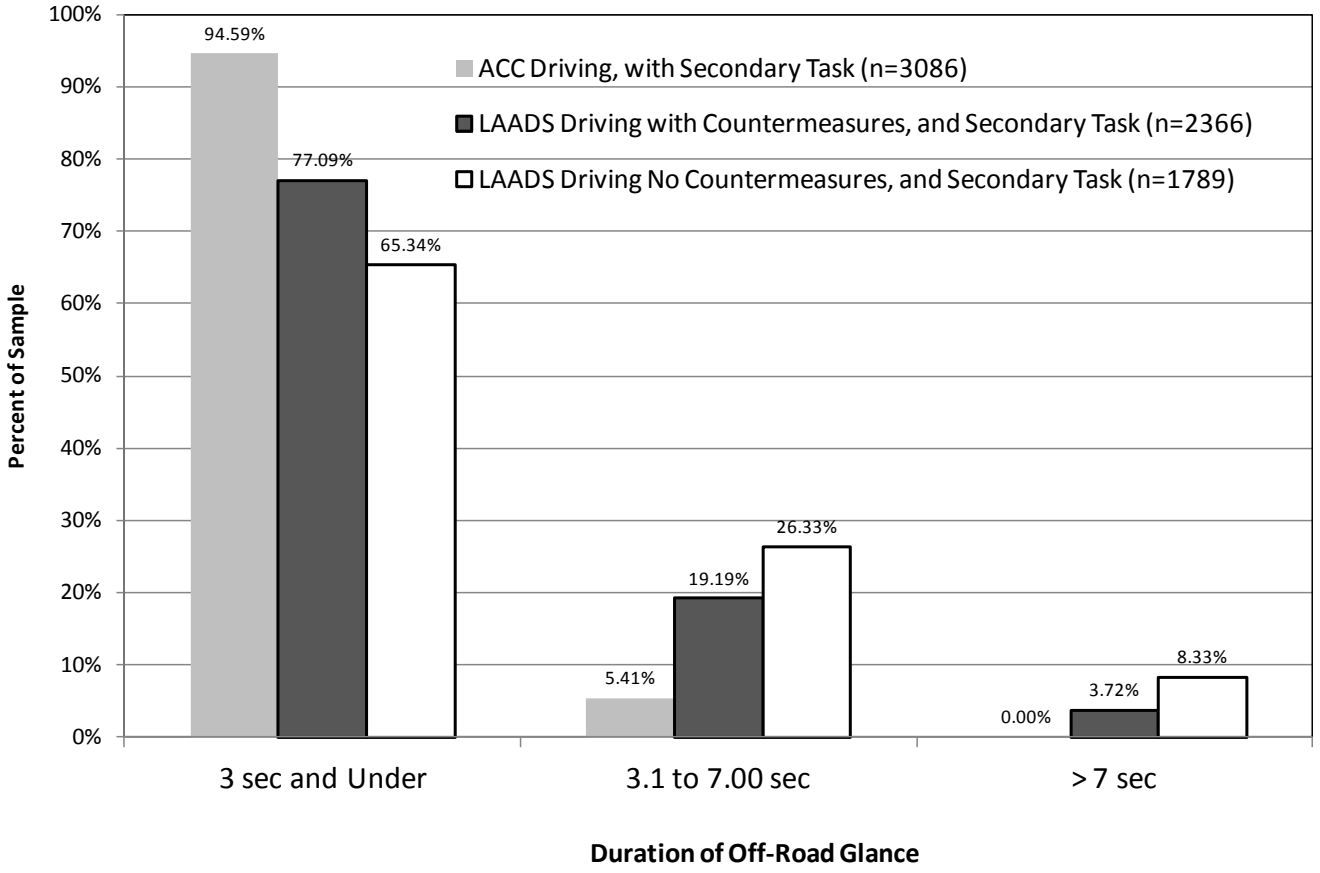
Countermeasure Research Approach

- Phase II: Formative Studies
  - High levels of interaction between researchers and subjects
- Phase III: Quantitative Countermeasure Performance Analysis
  - Low levels of interaction between researchers and subjects
  - Periods with and without secondary tasks

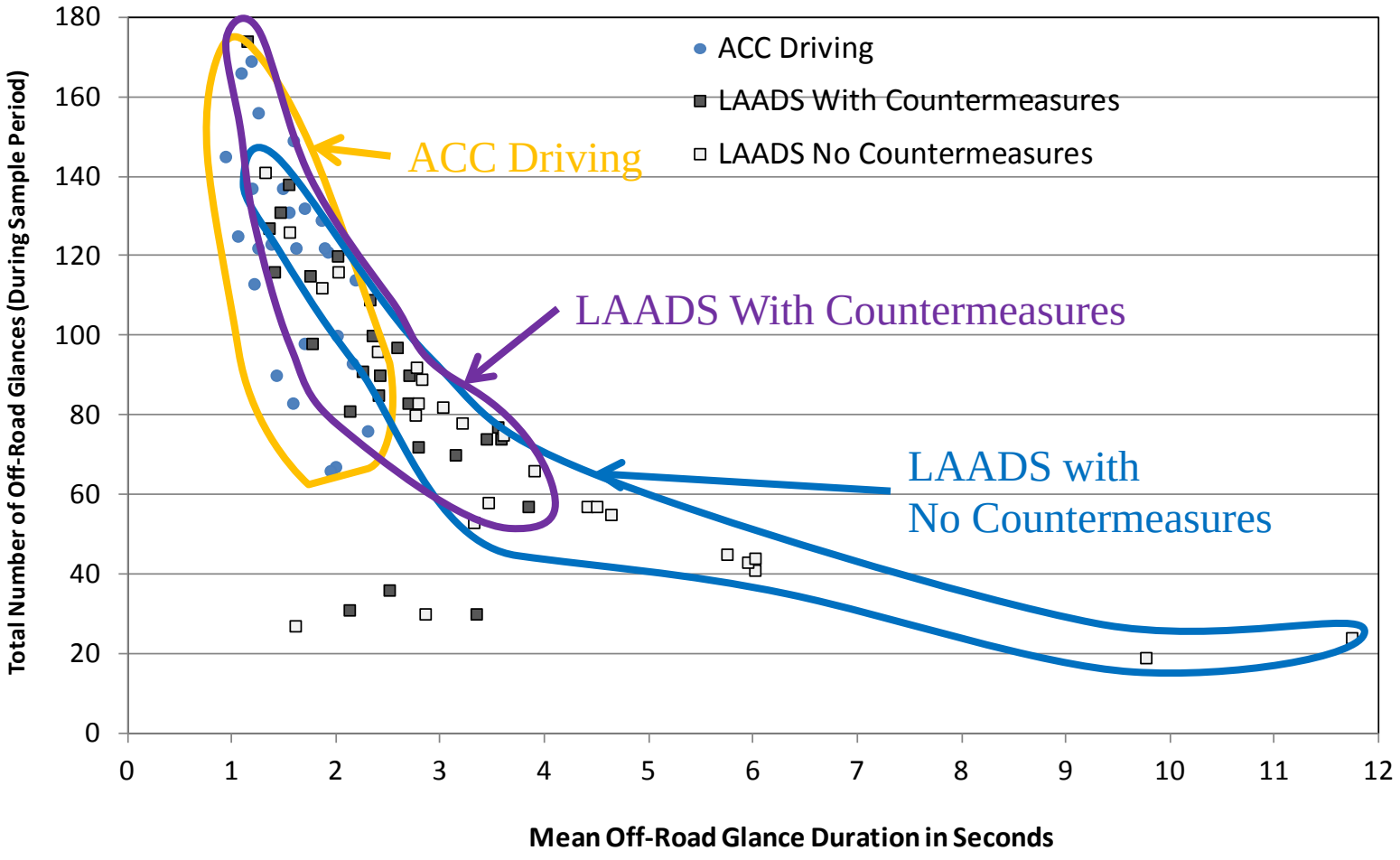
Track Study 4 Design



Percentage of Off-Road Glances Across Driving Mode for Short, Intermediate and Long Duration Time Bins



Relationship Between Glance Frequency and Mean Glance Duration for Off-Road Glances Under Each Driving Mode (n=26 Under Each Driving Mode)



Conclusions

- Driver's engagement in secondary tasks is likely to increase when driving automation affords the opportunity
- LAADS systems should be designed to
  - Clearly indicate the mode of operation
  - Monitor driver's attention to traffic conditions and vehicle operation
  - Encourage drivers to attend to forward roadway conditions
- HMI components that can improve driver attentiveness to the driving situation
  - Means to engage driver in driving task when system is engaged
  - Means to encourage visual attention to forward roadway
  - Active alerts for system failures and limitations