Examining visual behavior of drivers while using adaptive cruise control on commercial motor vehicles

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Adaptive Cruise Control (ACC)

- Automation technology that can control speed *and* headway on heavy vehicles
  - Radar mounted on front bumper tracks lead vehicle
  - Included in heavy vehicle ADAS products such as OnGuard™ or Wingman®
  - Newer generations include cameras with object detection for alerts, but not for ACC

ACC Operation

- Driver selects a speed setting
- If *slower* lead vehicle present, ACC will reduce speed to maintain a safe headway
- If *faster* lead vehicle present or *no* lead vehicle present, maintains set speed

How Do Drivers Use ACC?

- ACC allows driver to "follow" a lead vehicle with headway control
- As a low level automation technology, drivers should maintain full awareness
- In the real world, drivers attention may be different when using ACC
- Could impact ability to react in critical situations

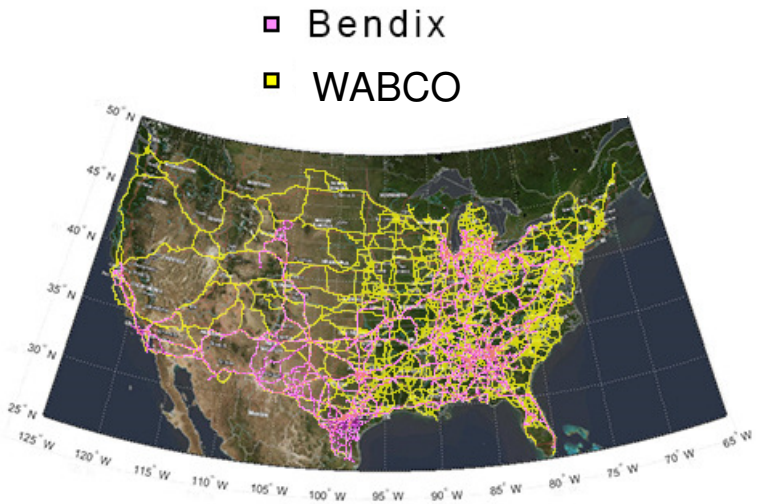
Data on ACC Usage

- As part of a NHTSA study VTTI collected naturalistic data from 150 trucks equipped with OnGuard™ or Wingman® Advanced™ products
- Video of driver's face whenever truck in motion
- Possible to evaluate visual behaviors
  - With and without cruise control active
  - During car following and non-car following

VTTI's Data Collection

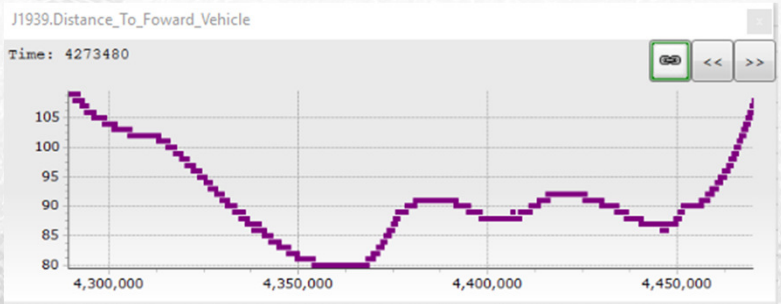
Location of
Meritor WABCO
OnGuard™

VTTI's Data Collection



Defining Car Following

- Defined "car following" based on radar data of lead vehicle
  - Car following with ACC if system controlled headway for at least 30 seconds
  - Manual car following if driver keeps truck within 4.5 seconds headway for 30 seconds while distance oscillated



Data Sampling and Analysis

- Sampled 3,000 thirty second windows across four conditions

Status of Cruise Control	Status of Lead Vehicle: Following Lead Vehicle	Status of Lead Vehicle: Not Following Lead Vehicle
Cruise Control Active	Adaptive Cruise Control (1000)	Standard Cruise Control (500)
Cruise Control Inactive	Manual Car Following (1000)	Manual Driving (500)

Visual Metrics

- Total eyes off road time (TEORT)
  - Within each 30 second window
- Average duration of off-road glances
  - With incomplete glances at the start or end of 30-second windows removed
- Rate of off-road glances
  - With incomplete glances at the start or end of 30-second windows removed

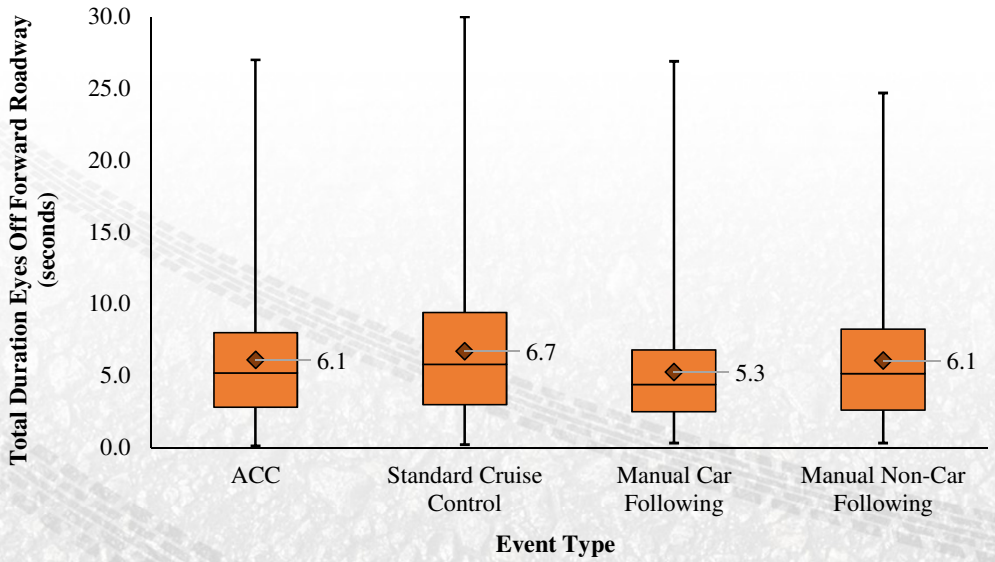
One-factor Comparisons

- ACC vs. Standard cruise control
- Manual car following vs. Manual non-car following
- ACC vs. Manual car following
- Standard cruise control vs. Manual non-car following

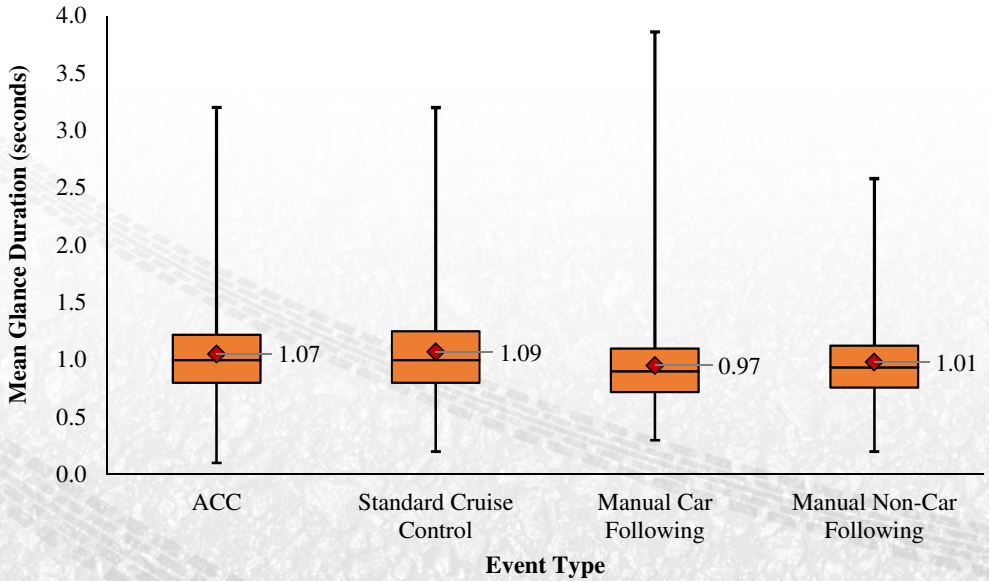
Two-factor Comparisons

- All cruise control usage vs. All manual driving
  - Combine ACC and standard cruise control
  - Combine Manual car following and manual driving
- All car following vs. all non-car following
  - Combine ACC and manual car following
  - Combine standard cruise control and manual driving

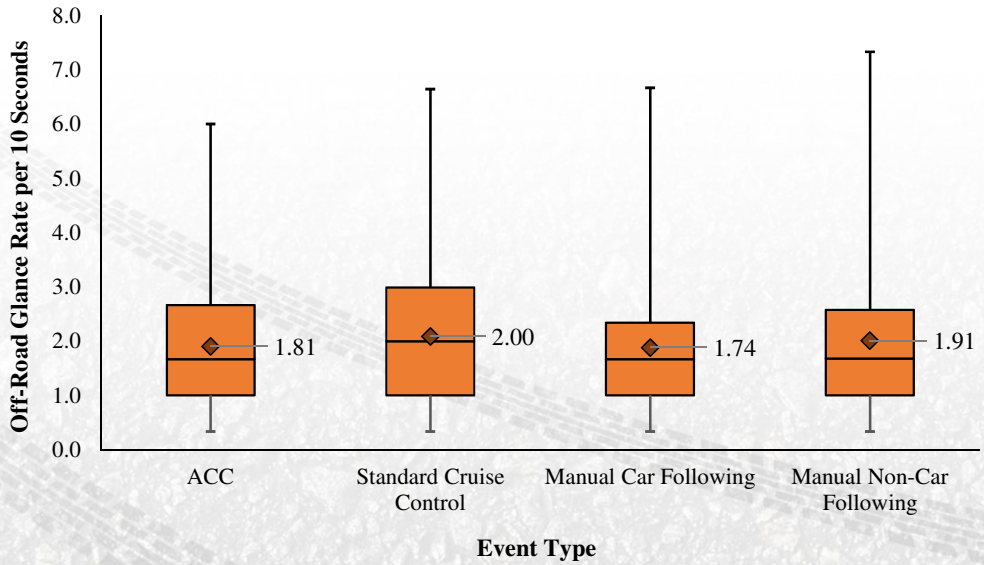
Average TEORT



Average Glance Duration



Average Rate of Off-road Glances



ACC vs. Manual Car Following

- While following vehicles drivers spent *more* time looking away from the road when using ACC

- The additional time was due to longer glances away from the road
  - No difference in rate of glances away from road

ACC vs. Standard Cruise Control

- While ACC controlled headway drivers spend *less* time looking away from the road
- The additional time was due to more frequent glances away from the road
  - No difference in average glance duration off-road
- Have a lead vehicle present makes drivers pay more attention

Takeaways

- Visual behaviors during ACC usage was different compared to standard cruise control or manually following a vehicle

- While differences were small across the sampled drivers, worth investigating further
  - Conditions such as drowsiness could have additional impact
  - Individual drivers could exhibit larger differences

Takeaways

- ACC a popular technology with truck drivers and has been available on heavy vehicles for several years

- As ADAS technology develops there could be new additions that take over additional functions
  - Steering control
  - Platooning

Takeaways

- Relatively minor differences observed here could become larger as automation takes over additional functions
- As automation progresses we need to ensure drivers stay engaged when they are expected to
- Particularly important on heavy vehicles that could weigh 80,000 pounds or have compromised brakes

Thank you!