The Future of Transportation: Achieving Equity and Mobility through Self-Driving Vehicles

Japan-America Frontiers of Engineering Symposium

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Advancing Transportation Through Innovation

Virginia Tech Transportation Institute

Overview

- Levels of vehicle automation
- Concept vehicle and transportation system
- Motivating factors for improved transportation
- Potential benefits of self-driving vehicles
- Trends: Transportation in the year 2045
- Opportunities
- Challenges
- VTTI's Automated Vehicle Research

Are we there yet? Are we there yet? Are there yet?

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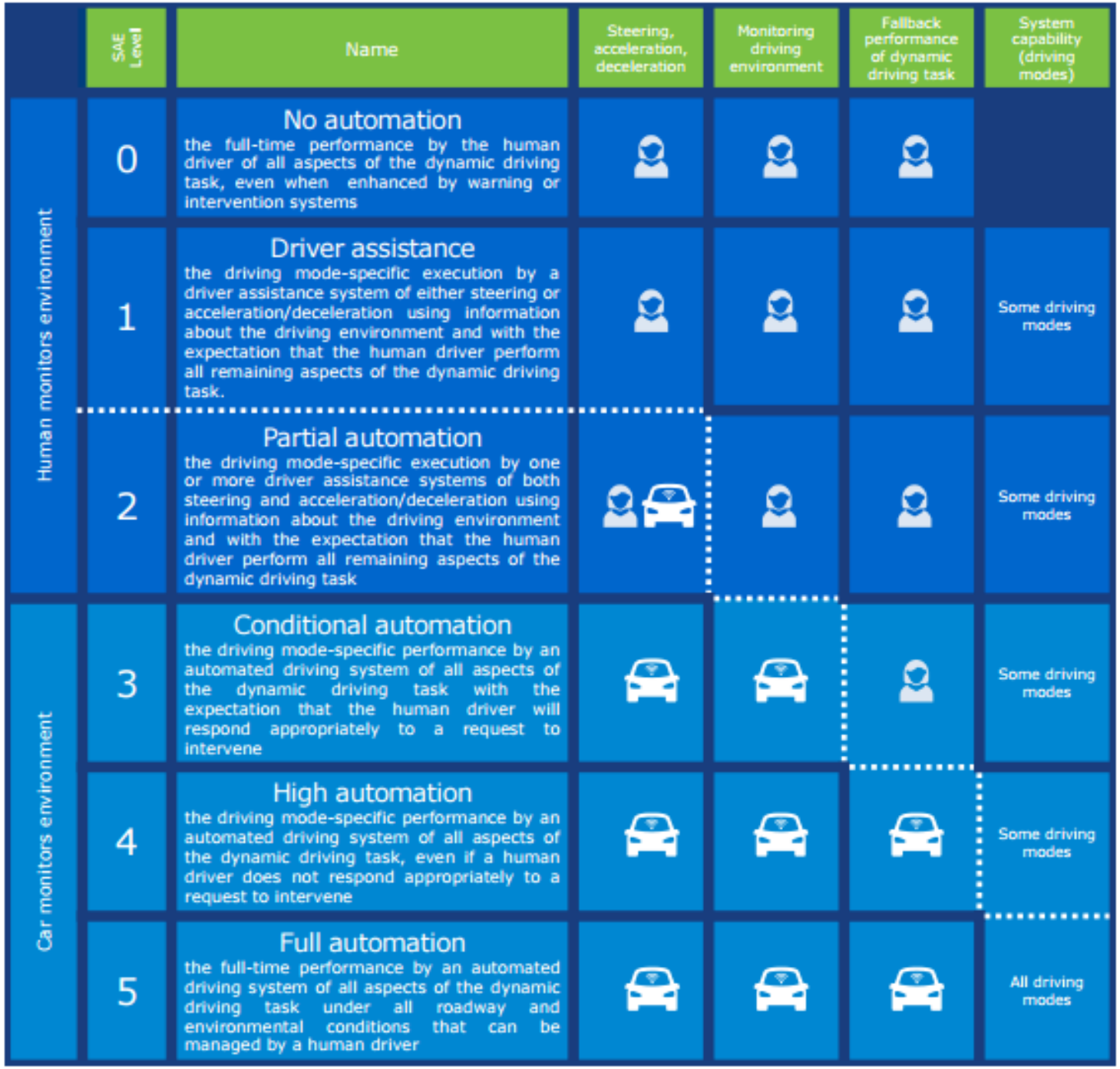

Source: Adapted from SAE Standard J3016 (SAE, 2014).

SAE J3016: Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems

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Nissan IDS Concept Technology

- Connectivity
- Mapping
- Machine vision
- 360 recognition
  - Radar, Lidar, other
- Dynamic scheduling
- Pedestrian/cyclist
- Wireless charging lanes/parking
- Transfer of control
- Piloted parking

Video Courtesy of Nissan Newsroom

What's the Future of Transportation?

We need new or extended connections to employment, education, healthcare, and other essential services

Second only to housing, currently transportation costs are the largest expense for American households – costing more than food, clothing, and healthcare

(Bureau of Labor Statistics, 2015)

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Motivating Factors for Improved Transportation

- Communities designed with the car in mind
- Urban sprawl
  - Difficult to get anywhere without a car
  - Highest transportation expenditures
- American Public Transportation Association
  - Small towns and rural communities
    - 2/3 of all residents have limited transportation options
    - 41% of residents have no access to transit
    - 25% have below-average transit services
- Who's living without a car? (Berube, Deakin, & Raphael, 2006)
  - 20% of African-American households
  - 14% of Latino households
  - 13% of Asian households

Potential Benefits of Self-Driving Vehicles

- Health
- Employment
- Age in place
- Quality of life
- Safety
  - ~32,000 vehicle related fatalities
  - ~5,000 pedestrians and bicyclist

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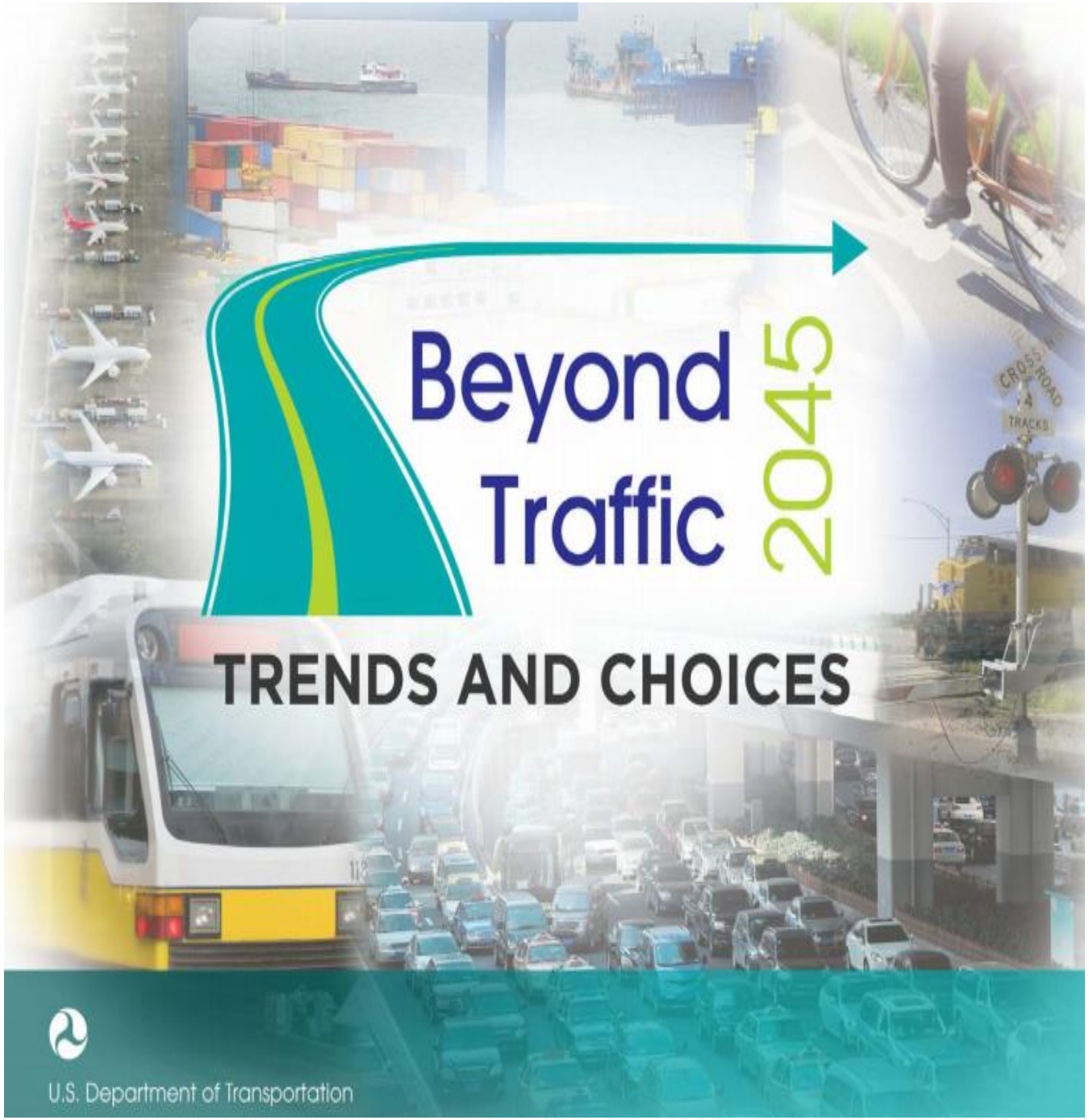

How will the future look if we don't invest in a new transportation system?

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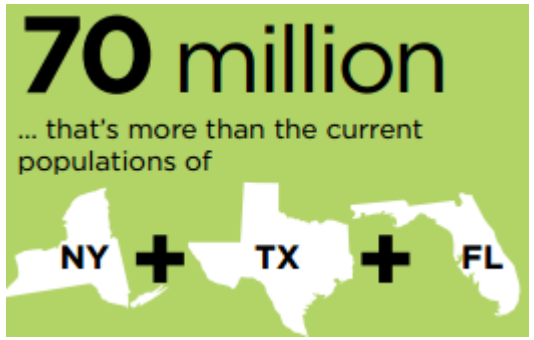
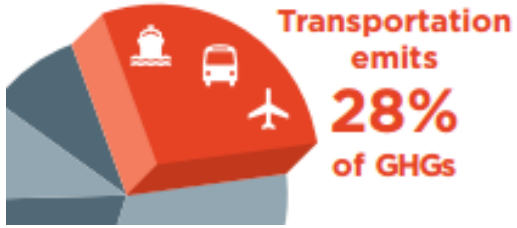
Trends: 2045

- Population will grow by **70 million** and will have **twice** the number of **seniors**
- People will start moving towards **megaregions**
- **Freight** will increase by **45%** due to online shopping
- People will **reduce trips** by **private car** in favor of other modes of transportation
- Consolidation of airline hubs and many mergers will make us **rethink traditional travel**
- **Robotic** systems will assist with infrastructure maintenance
- **Climate change** will alter sea level, increase temperatures, and develop more frequent and adverse climate events (e.g., hurricanes)





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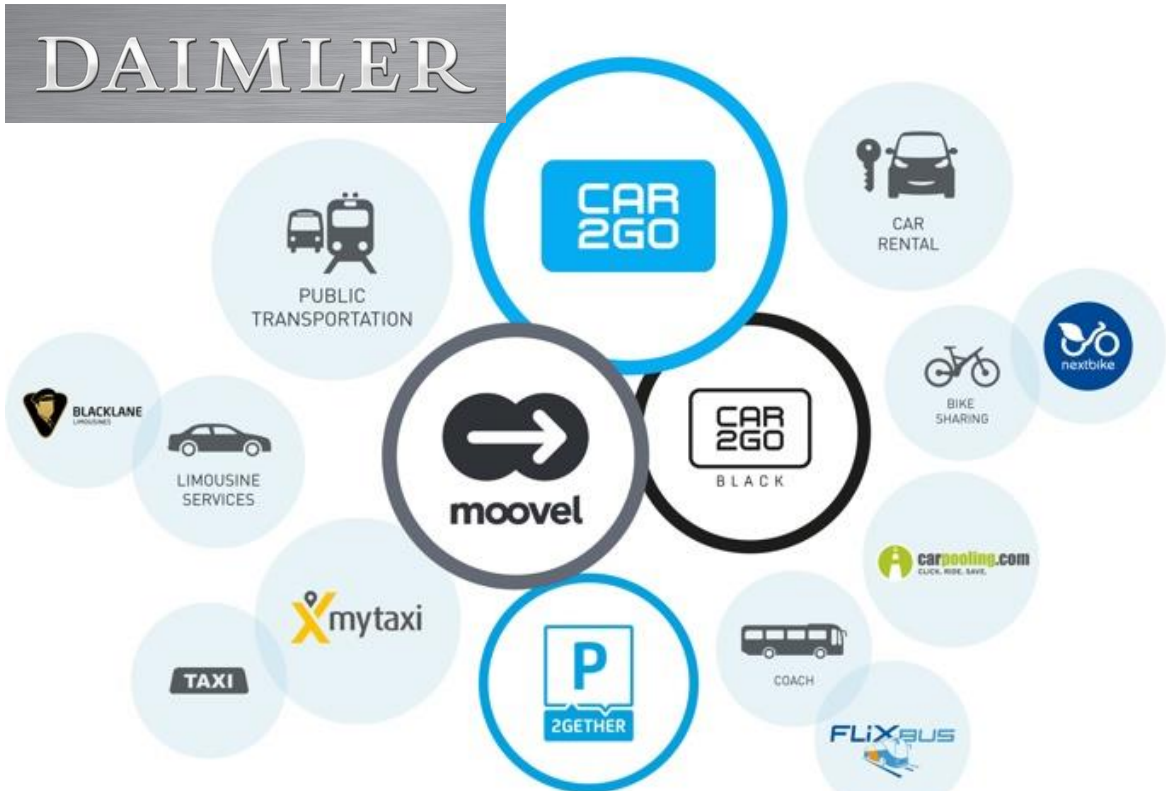
Opportunities for Current and Emerging Self-Driving Vehicle Applications

- Mobility On-Demand
  - **Group rapid transit**: public transportation, vanpools, and ridesharing
  - **Personal rapid transit**: personal vehicles, last-mile services (including parking valet alternatives), taxi and on-demand services



GM lyft

Potential Challenges Associated with Implementation

- Legacy vehicles
- Fail-safe & fail-operational states
- Safe harbor
- External communications
- Security
- Accessibility
- Multi-jurisdictional collaboration
- Policies

Automated Vehicle Research

- Sample studies
  - Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts
  - Automated Vehicle Crash Rate Comparison Using Naturalistic Data

Human Factors Evaluation of Level 2 and Level 3 Automated Driving Concepts

Experiment 1 (L2 ADS)	 2009 Chevy Malibu	GM
Experiment 2 (L2 ADS)	 2010 Cadillac SRX	GM
Experiment 3 (L3 ADS)	 2012 Lexus RX450h	Google

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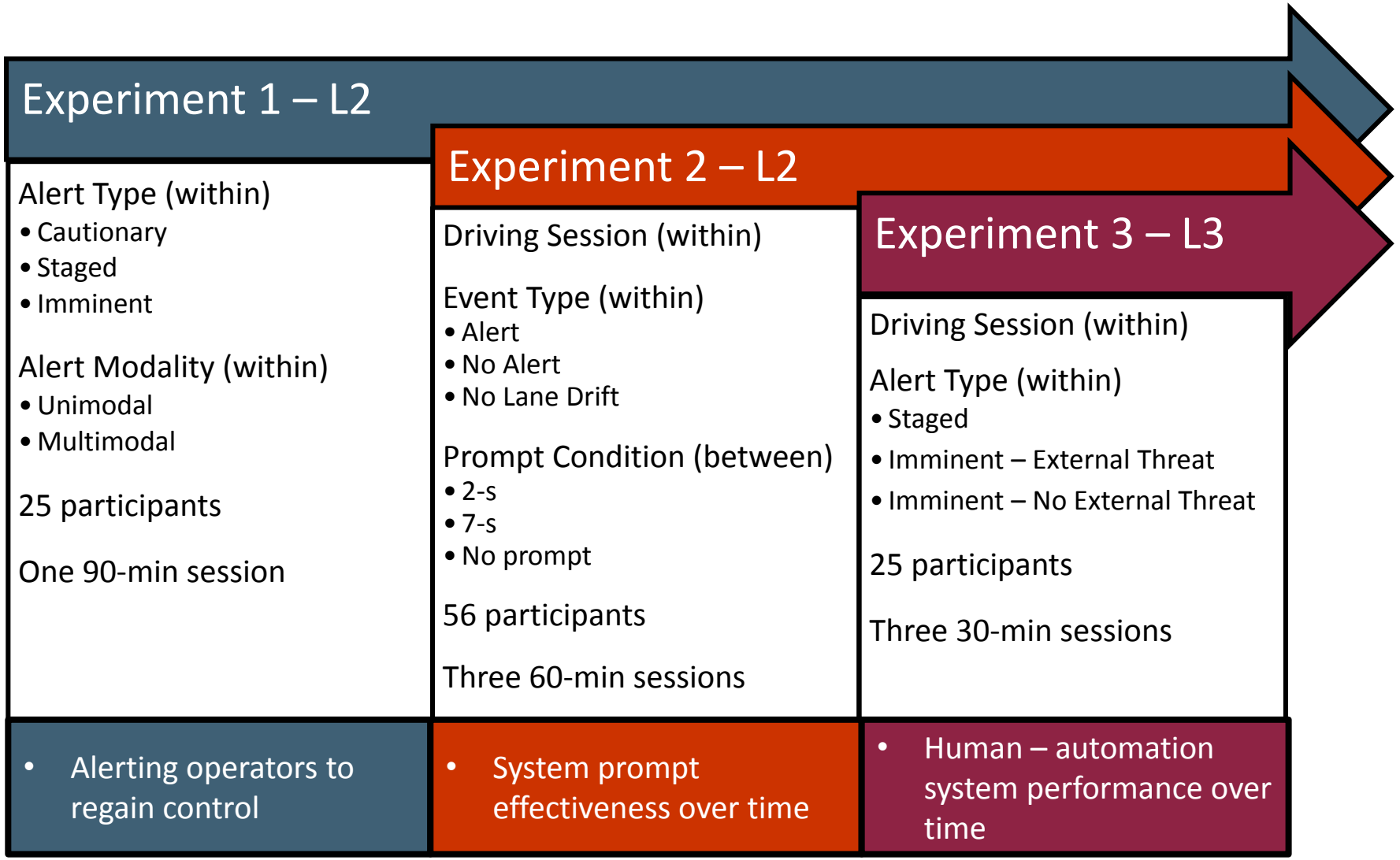
NHTSA NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Experimental Design



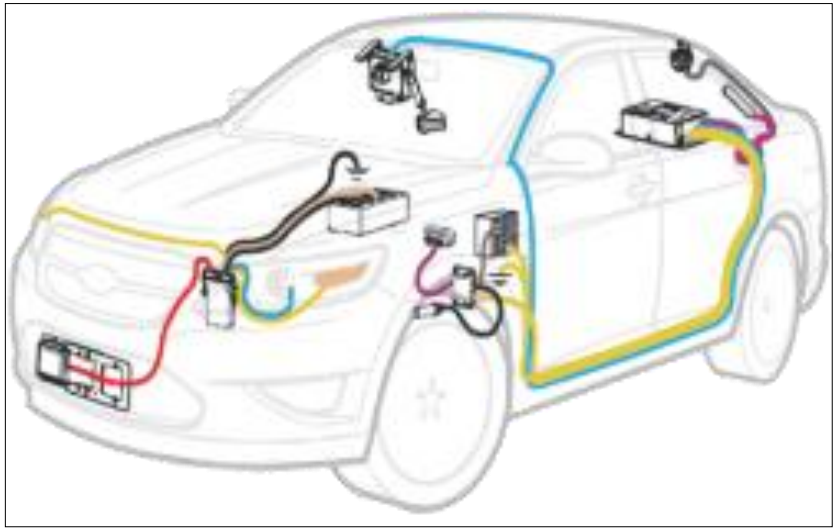
Key Takeaways

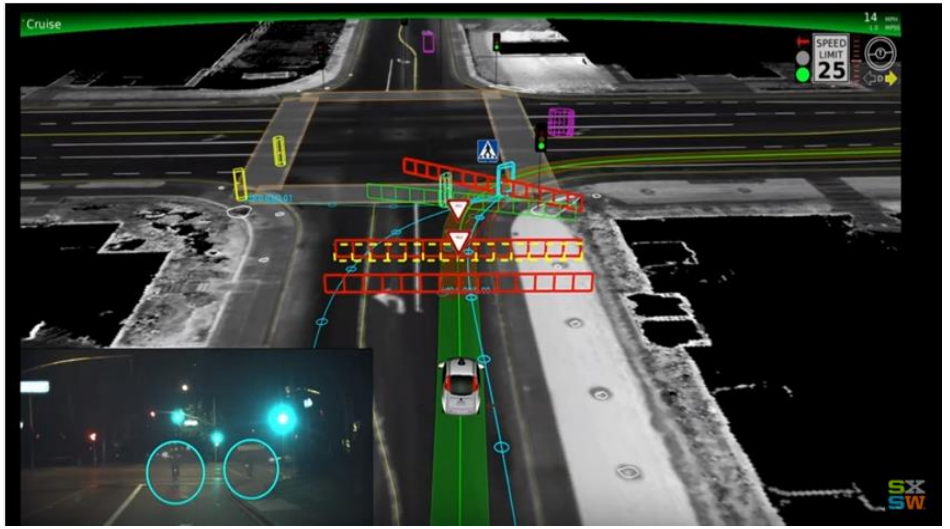
- Take Over Request
  - Most effective hand-off strategies were those that incorporated nonvisual components
    - Effective countermeasures to primary task reversals when drivers performed non-driving tasks
- Regain Control
  - L2 mean of 1.3 s (S.E. = 0.1 s)
    - Imminent visual and haptic alert
  - L3 mean of 2.3 s (S.E. = 0.2 s)
    - Imminent visual plus auditory alert
- Trust
  - High trust in automation for both levels of automation but calibrated
    - Trust was reduced after events where something occurred unannounced

Vehicle Automation Theories

- Primary Task Reversal
- Alert Annoyance Habituation

Automated Vehicle Crash Rate Comparison Using Naturalistic Data





SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM
TRB TRANSPORTATION RESEARCH BOARD

Google
Self-Driving Car Project

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SHRP 2 Naturalistic Data Study

- 34 million VMT
- 2 petabytes of data
- 3,542 drivers
- > 3,300 vehicles
- > 1,600 crashes
- 4,368 data years
- 5,512,900 trip files

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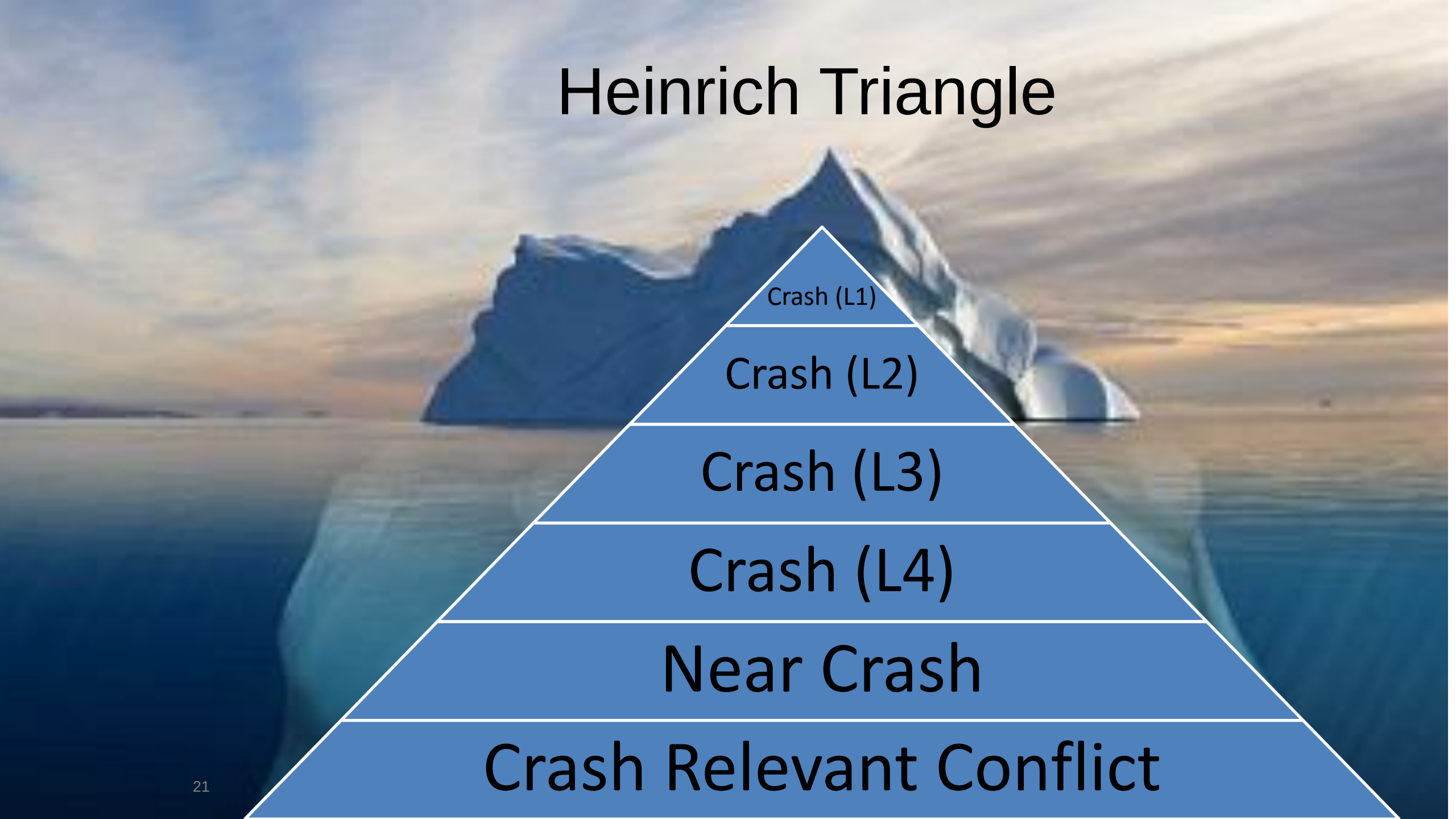
What can 1,000,000 hours of watching and measuring drivers can tell you?

Heinrich Triangle



Self-Driving Car Project Data

- Data received for period 2009 - October 31, 2015
  - Mountain View, CA
  - 1,266,611 miles
  - 2010: First crash
  - 2012: First crash in autonomous mode
- 16 Crashes
  - 5 driver in control
  - 11 autonomous
    - None at-fault

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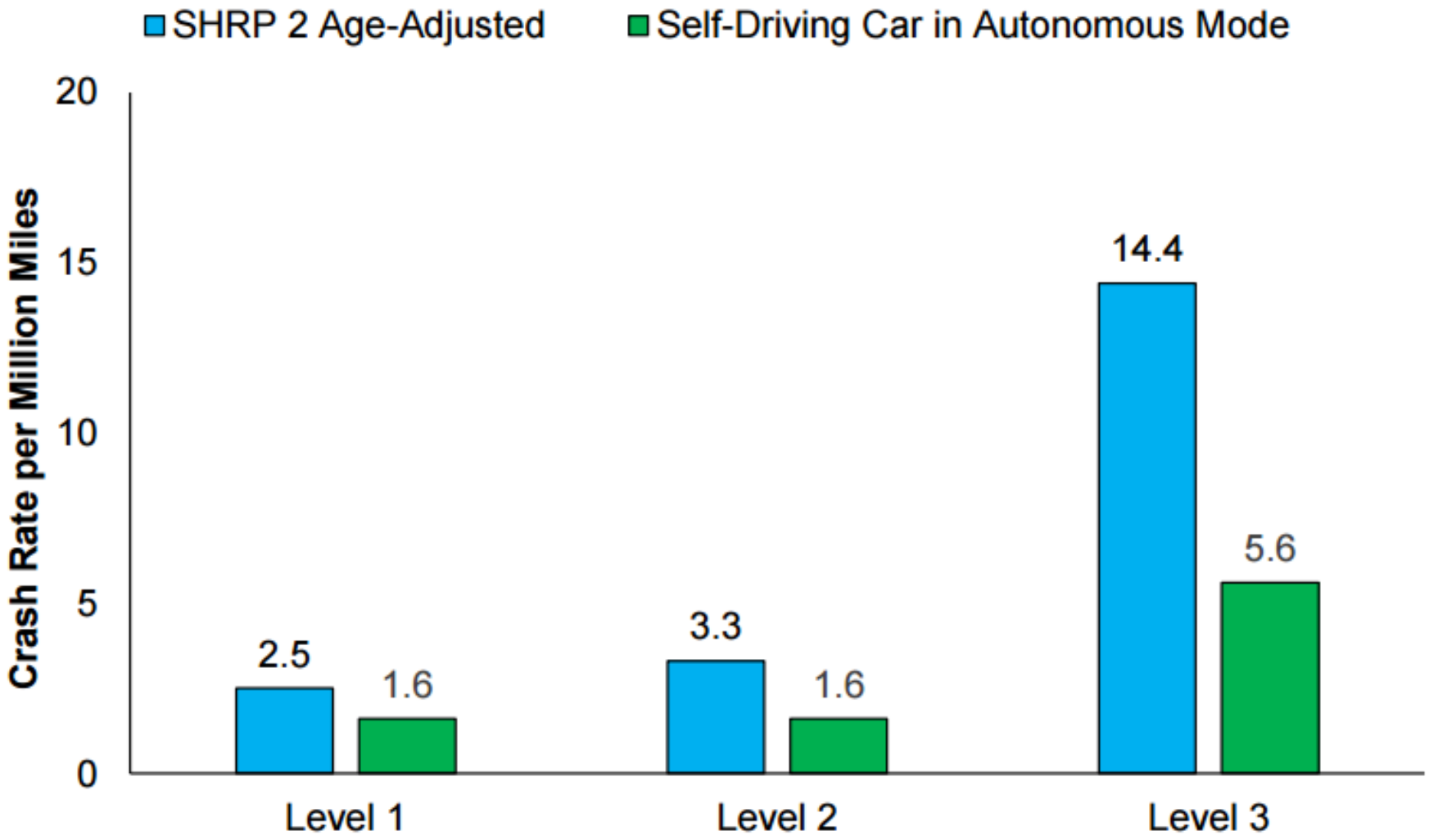
SHRP 2 and Self-Driving Car Crash Summary

Crash Severity Level	SHRP 2 - Overall	SHRP 2 - with Police Report	Self-Driving Car
Level 1	120	34	2
Level 2	179	12	2
Level 3	633	0	7

Crash Comparison



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What else is VTTI doing?

- Policy impact
- Develop advanced testing facilities
- Perform pragmatic research

Governor Terry McAuliffe | Building a New Virginia Economy

About The Governor | The Administration | Constituent Services | Policy Priorities | Newsroom | Executive Actions

Home > Newsroom > Proclamations > Proclamation > Support for Virginia Tech Transportation Institute and Automated and Autonomous Vehicles

Archive

2015

Support for Virginia Tech Transportation Institute and Automated and Autonomous Vehicles

3/4/2015

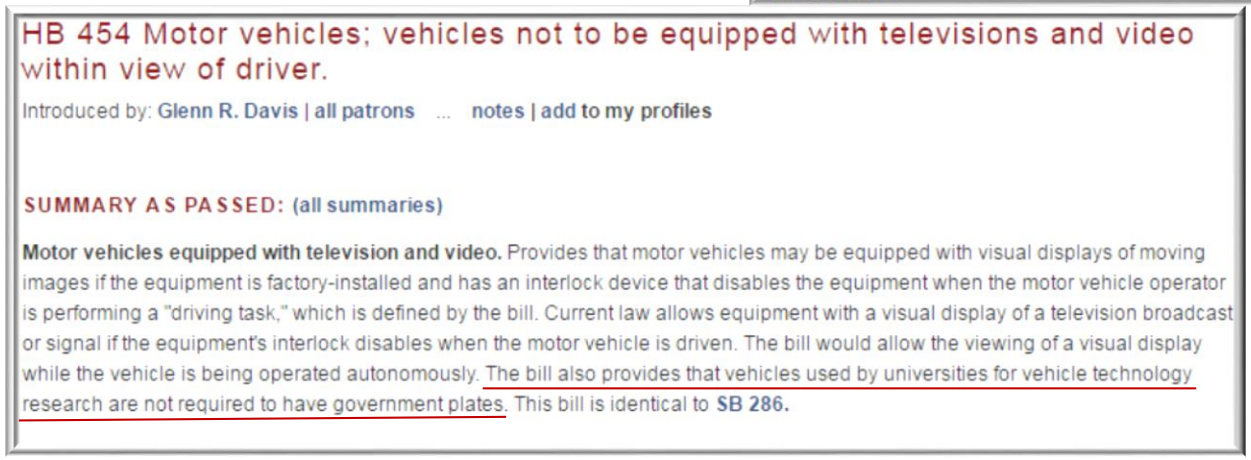
WHEREAS, the Commonwealth of Virginia is on the cusp of the next revolution in the automobile industry with automated and autonomous vehicles, also known as "self-driving" cars; and

WHEREAS, the Commonwealth has an unparalleled higher education system with world recognized research facilities and a mission to be leaders in innovation; and

WHEREAS, the Commonwealth is in a position to be a leader in welcoming, supporting and developing the automated vehicle industry, the emerging technologies used in such vehicles, and the business that will provide the support necessary to make the innovations a reality; and

WHEREAS, the Virginia Tech Transportation Institute Center for Automated Vehicle Systems is providing the necessary leadership to study all aspects related to automated and autonomous vehicles, and to develop partnerships with groups involved in researching, planning, and producing automated vehicles;

NOW, THEREFORE, I, Terence R. McAuliffe, do hereby declare that the **COMMONWEALTH OF VIRGINIA** supports the mission of the Virginia Tech Transportation Institute Center for Automated Vehicle Systems and its self-driving on-road studies, and is open for business for the vehicle and technology manufacturers and researchers committed to the development, testing and deployment of automated and autonomous vehicles, and I call this observance to the attention of all our citizens.



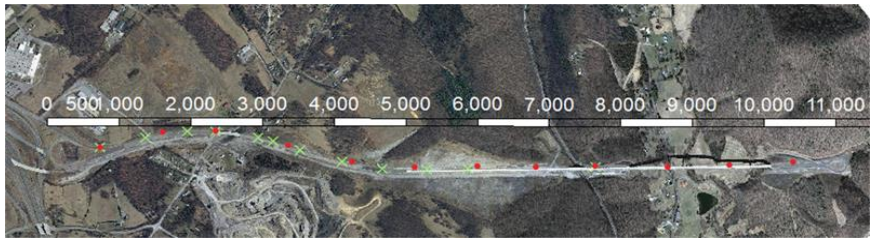
HB 454 Motor vehicles; vehicles not to be equipped with televisions and video within view of driver.

Introduced by: Glenn R. Davis | all patrons ... notes | add to my profiles

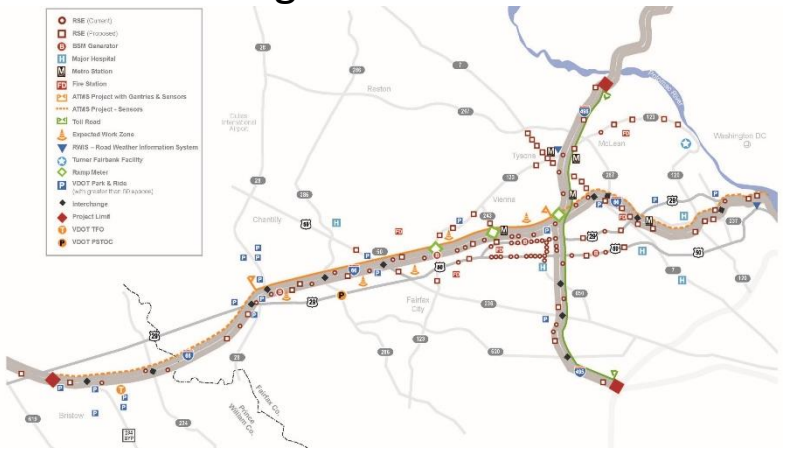
SUMMARY AS PASSED: (all summaries)

Motor vehicles equipped with television and video. Provides that motor vehicles may be equipped with visual displays of moving images if the equipment is factory-installed and has an interlock device that disables the equipment when the motor vehicle operator is performing a "driving task," which is defined by the bill. Current law allows equipment with a visual display of a television broadcast or signal if the equipment's interlock disables when the motor vehicle is driven. The bill would allow the viewing of a visual display while the vehicle is being operated autonomously. The bill also provides that vehicles used by universities for vehicle technology research are not required to have government plates. This bill is identical to **SB 286.**

Smart Road Test Track & All-Weather Testing



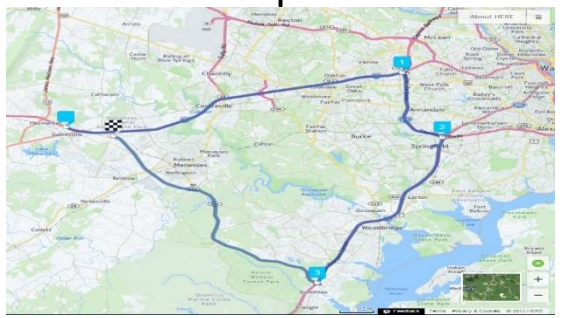
Virginia Connected Corridor



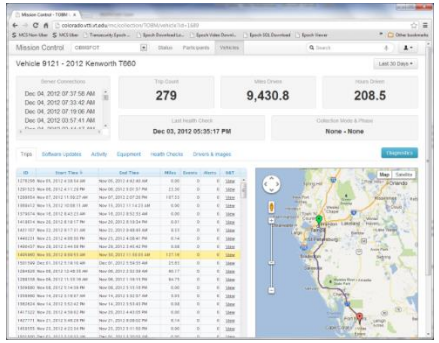
NextGen DAS

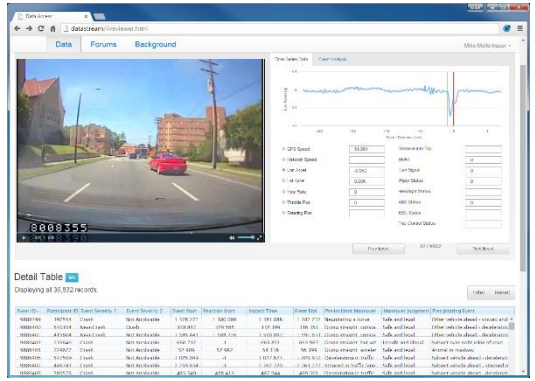
Virginia International Raceway

Virginia Automated Corridor Sample Test Route



MiniDAS





Virginia Automated Corridors

Questions?

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