Impacts of Automated Vehicles (AVs) on Highway Infrastructure

FTBA Construction Conference
February 7, 2020 – Orlando, FL

ICF

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CAVita

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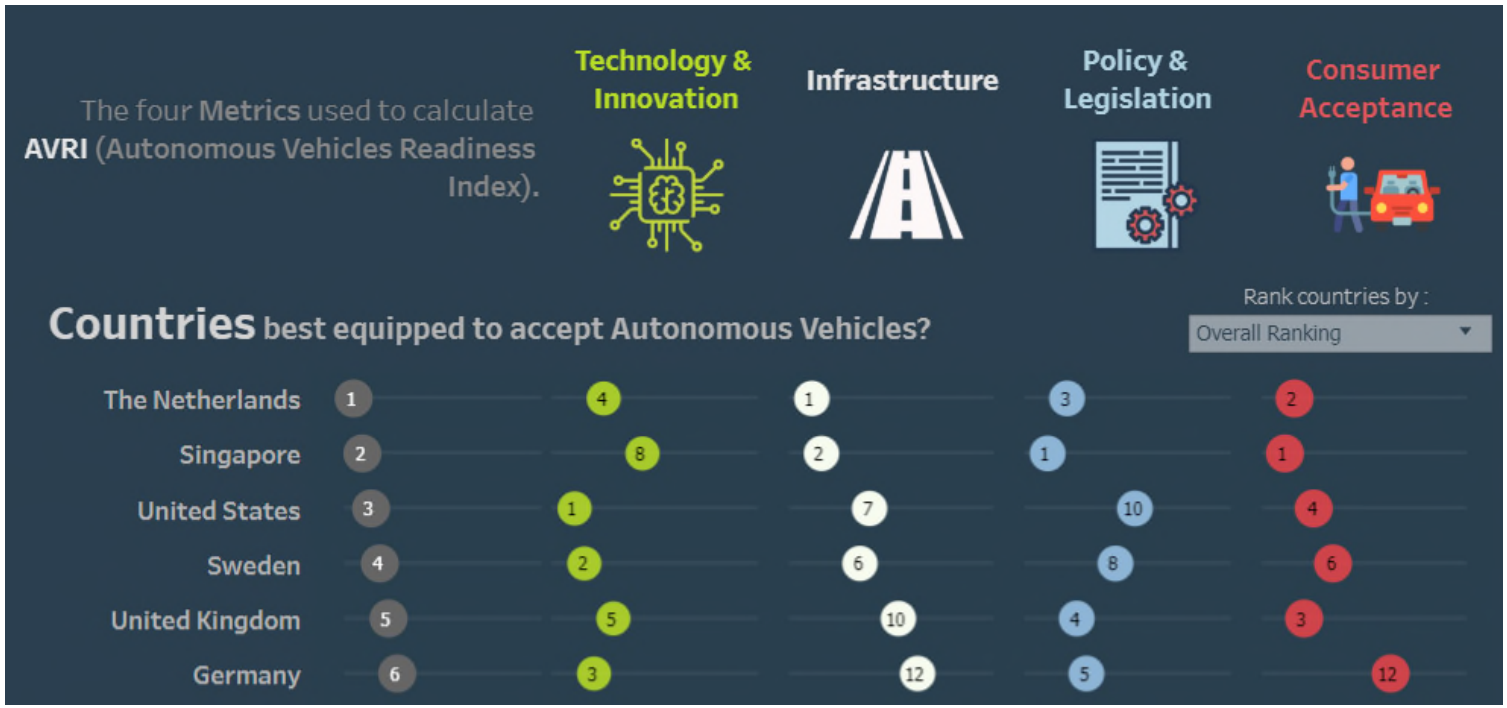
Automated Vehicle Readiness Index



Source: Visual Analytics Aug 27, 2019

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Project Overview

U.S. Department of Transportation
Federal Highway Administration

GOAL

To develop practicable documentation and webinars to educate and inform DOT stakeholders about AV-related infrastructure needs.

OBJECTIVES

1) To assess and understand the demands and potential impacts of AVs on our current & future infrastructure assets.
2) To guide and assist DOTs on how to determine their “Readiness” for AV use on its highways.

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Common Agency Questions

- What should DOTs be doing right now with existing infrastructure to prepare for the needs of increasing CAV use?
- What will the impacts be of CAV use on the existing highway infrastructure, and how does the concept of “state of good repair” play into these impacts?
- Based on input from the CAV sector, what will the design and maintenance needs of future highways be?
- How should DOTs be preparing their physical infrastructure for the future needs of potentially high levels of CAV usage on the national highway network?
- How should a DOT determine its “Readiness” for CAV use on its highways?

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Approach

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Infrastructure Categories and Definitions

Highway Infrastructure Categories

Physical Infrastructure	Traffic Control Devices	TSMO and ITS Infrastructure	Urban Multimodal Infrastructure
Pavements, Bridges and Culverts	Pavement Markings, Traffic Signs, Traffic Signals, Temporary Traffic Control, Roadside Hardware	ITS Roadside Equipment, TSMO Strategies, TSMO Systems	Bicycle, Pedestrian, and Transit Infrastructure, Curb Space

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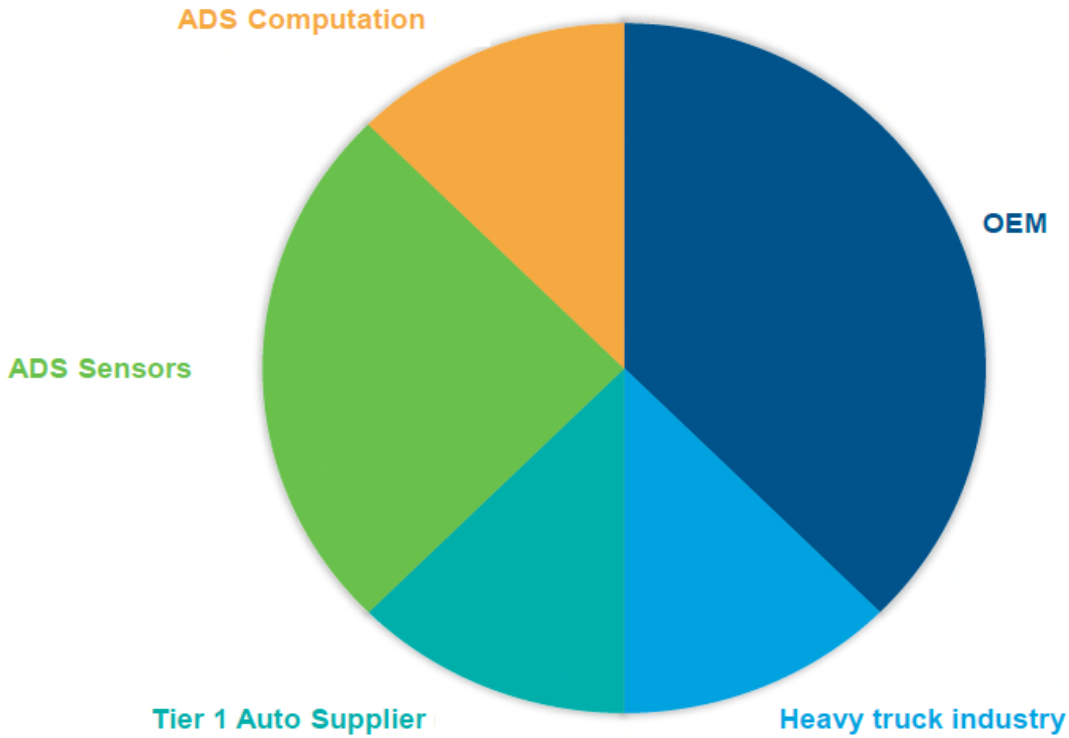
AV Industry Interviews



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AV Industry Interviews: Key Observations

Implications of Sensor Evolution	• Rapid evolution and regular maintenance needs of sensors favors fleet operations in the near-term and presents challenges to future proofing infrastructure.
Quality and Uniformity of Physical Infrastructure	• Physical infrastructure should be well-maintained and consistent, especially regarding road markings and signage.
Digital Information Standards	• Digital information relayed to AVs should be standardized, secure, and specific to AV operational challenges (e.g., work zone related issues).
Urban Fleet Operations	• Urban fleet operations will be an important early application of AV and will offer near-term and non-traditional partnership opportunities between fleet operators and IOOs.

Key Observations (cont.)

Operational Design Domains	• OEMs are responsible for defining their operational design domain (ODD) and assume ultimate responsibility for safe operation within the ODD regardless of IOO actions.
Connectivity Between Vehicle and Infrastructure	• CV applications such as V2I can alert AVs on the presence of humans, however, industry is not relying on IOO support and is skeptical that V2I deployments will occur widely.
IOO Role of Traffic Systems Management and Operations	• AVs may exacerbate congestion in the short-term, making it increasingly important for IOOs to implement advanced traffic systems management and operations strategies.
Freight	• Freight is an early and incremental adopter of lower-level AV with its own path to deployment.
Governmental and Institutional Issues	• Clear guidance and policies are needed at the Federal level, while interagency and intergovernmental coordination are needed at the State and local levels.

Stakeholder Workshops

- **AASHTO Maintenance Mtg, Grand Rapids, MI, July 17, 1 – 4 PM**
- **TRB Automated Vehicle Symposium, Orlando, FL, July 18, 4 – 6 PM**

- FHWA Introduction
- Project Overview
- Setting the Stage
- Discussion of Impacts on Infrastructure Categories
  - Traffic Control Devices
  - TSMO and ITS
  - Multimodal infrastructure
  - Physical Infrastructure
- Readiness Actions
- Wrap Up

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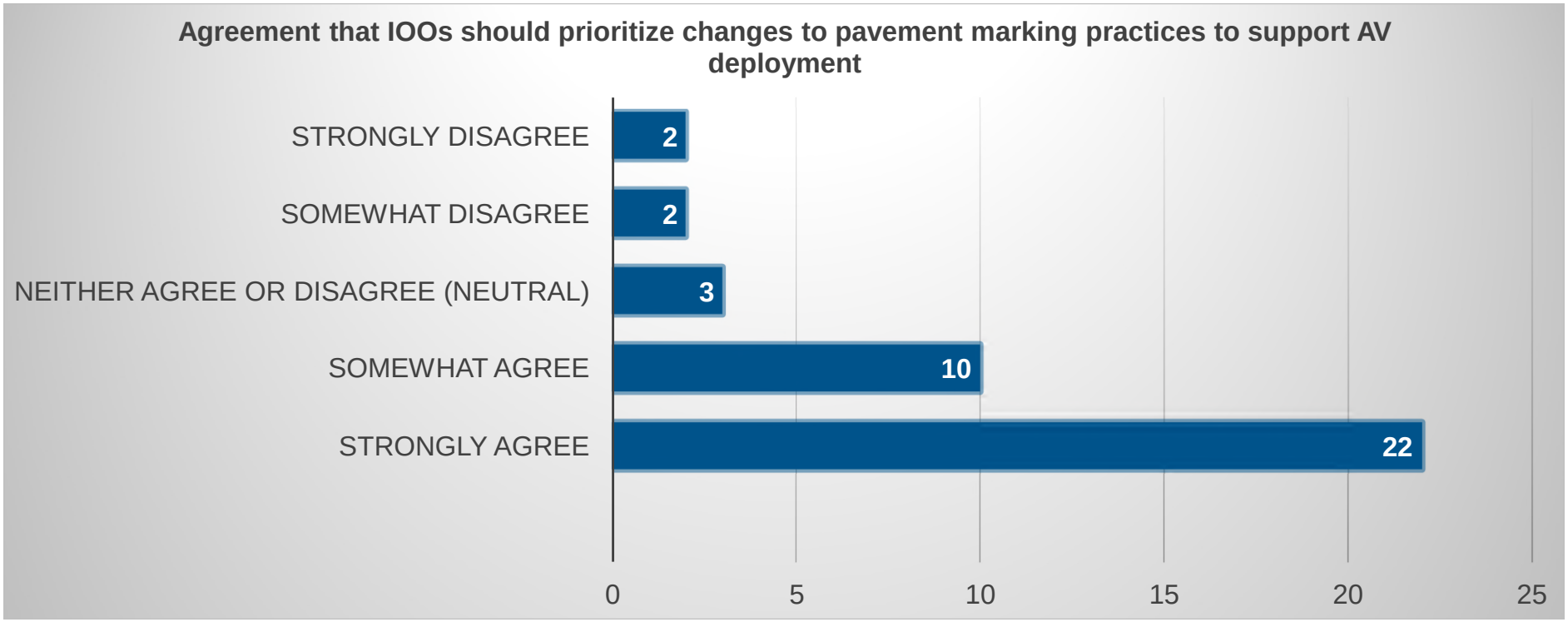
Example of National Workshop Findings



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Readiness Actions Reported by State DOTs

- Upgrading signal equipment
- Changing pavement marking policies
- Dedicating personnel / developing internal teams
- Coordinating with other DOTs
- Engaging with automotive industry
- Conducting research
- Supporting enabling legislation
- Waiting for more clarity

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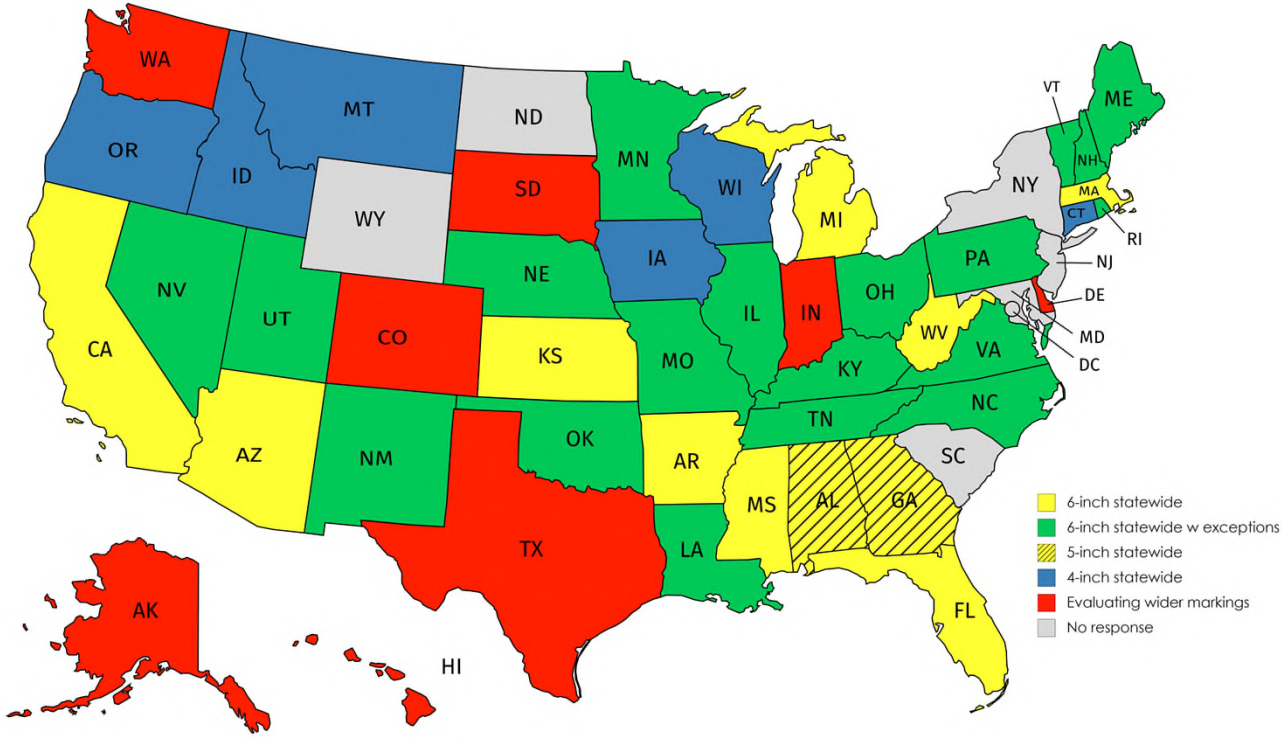
Compliance with MUTCD ≠ Uniformity

- MUTCD is silent on certain issues (such as contrast marking patterns)
- MUTCD allows flexibility in other areas (such as use of dotted lane line extensions along entrance and exit ramps)
- US map shows state DOT policies for pavement marking width



AASHTO Survey Results (January 2019)

Colorado and Iowa transitioned in 2019

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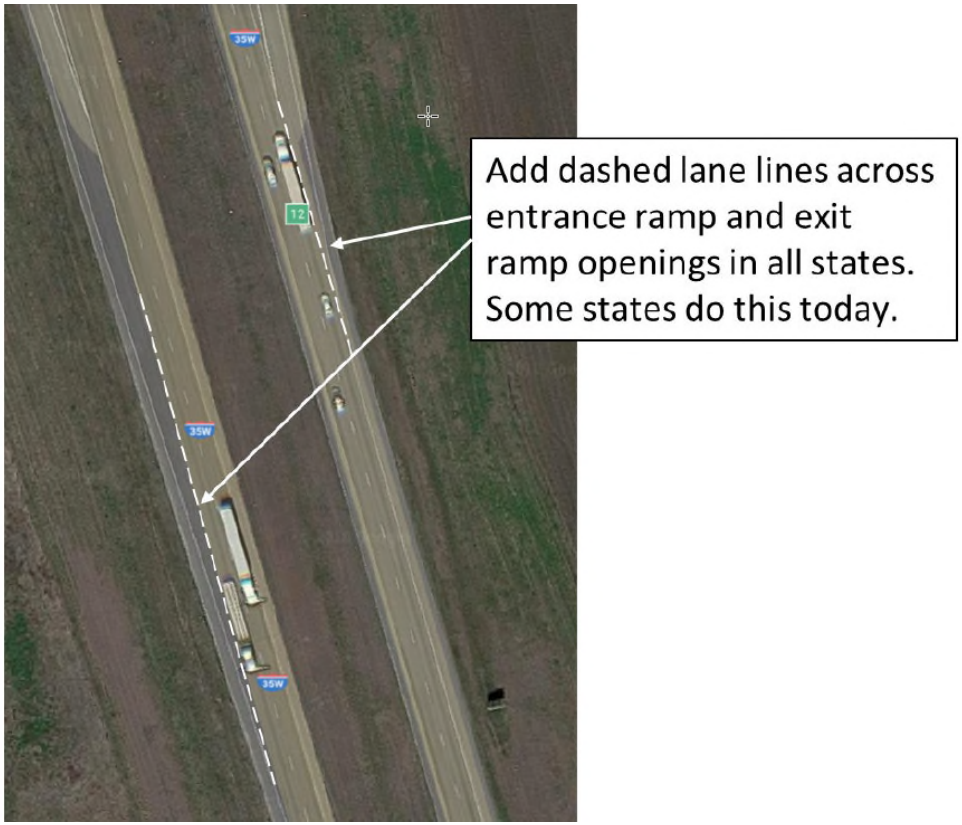
Specifics from Vehicle Industry

- TCD uniformity “interests” identified through various engagements with auto industry representatives, companies, and associations.
- Example shown here where Google Earth image was annotated with “interest”



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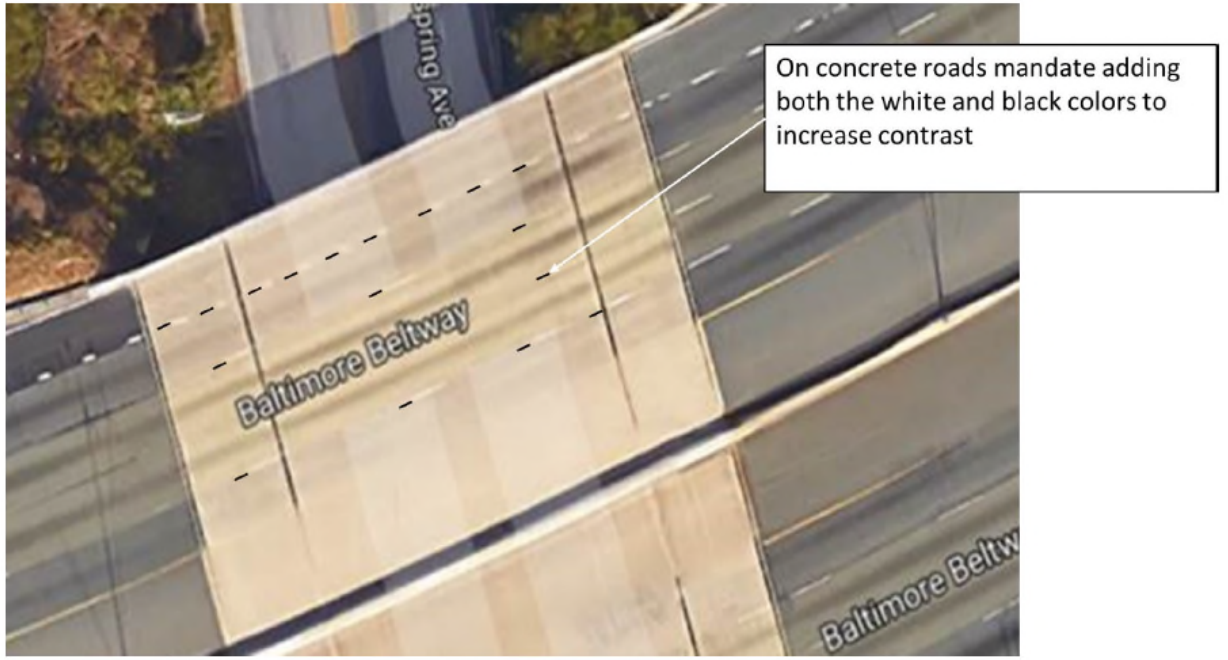
Specifics from Vehicle Industry

- Another Google Earth image annotated showing an “desire” for lead-lag pattern contrast markings on light colored pavements



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Perception of Readiness

How ready are IOOs to support AV deployment?

Response options	Percentage
Very Ready	6%
Somewhat Ready	16%
Neither Ready of Unready	10%
Somewhat Unready	**35%**
Very Unready	32%

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Reasons Driving the Perceptions

- Insufficient resources
- Lack of culture for innovation
- More advanced IOOs have a champion at the CEO level
- Not ready: lack of standards
- AV development should go on with infrastructure as is
- We don’t know what we don’t know

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Next Steps

- Review Literature **(completed)**
- Engage Stakeholders **(on-going)**
- Conduct AV Industry Interviews **(completed)**
- Develop Draft Findings **(completed)**
- Obtain Feedback **(completed)**
  - Present, vet, discuss (workshops)
    - AASHTO Maintenance Conference, Grand Rapids, MI
    - TRB Automated Vehicle Symposium, Orlando, FL
- Refine Findings **(on-going)**
- Develop Techbrief **(2020 Q1)**
- Conduct Webinars **(2020 Q2)**

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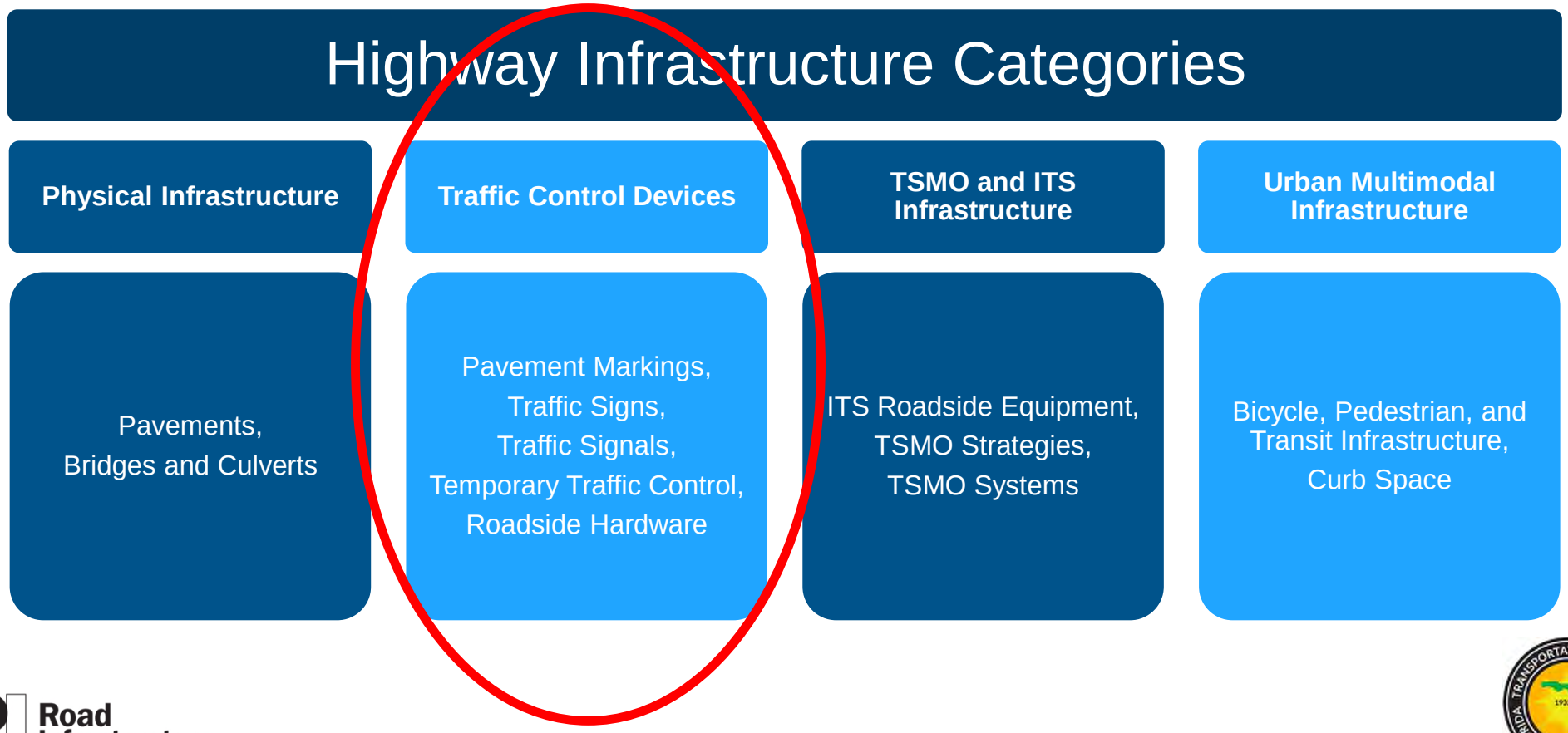
Key Research Findings



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Specifics – Intersections

- **Upgrade to modern ATC cabinet**
- **Consider SAE-J2735 compliant communications for transmitting / receiving data (DSRC, C-V2X, both)**
  - SPaT – Signal Phase and Timing
  - VRU – Vulnerable Road User
  - BSM – Basic Safety Message
  - Map data, etc.
- **Consider security credentials**
- **Sensors for enhanced detection (such as pedestrians)**
- **Use of backplates along East-West facing signals**

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Specifics – Interstates / Freeways

- 6-inch wide markings
- 15 ft lane lines (25 ft gap)
- Dotted edge line extension along exit ramps
- Eliminate Botts Dots as substitute for markings
- Mark lane shifts in work zones with continuous markings
- Use contrast markings on light colored pavements

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Specifics – Other Highways

- 6-inch wide edge line markings
- Eliminate Botts Dots as substitute for markings
- Mark lane shifts in work zones with continuous markings
- Use contrast markings on light colored pavements

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Concluding Thoughts

- **Uncertainty in communication protocol has slowed CV development / deployment**
  - Toyota paused DSRC plans
  - Ford pursuing C-V2X
  - GM remains silent
- **AV continues to move forward**
  - 50 million vehicles in US with forward looking camera
  - Practically all vehicles sold by 2022 will include a camera
  - ADAS will continue to evolve and increase highway safety
  - Auto industry is now reporting that HAV deployment will take longer than expected

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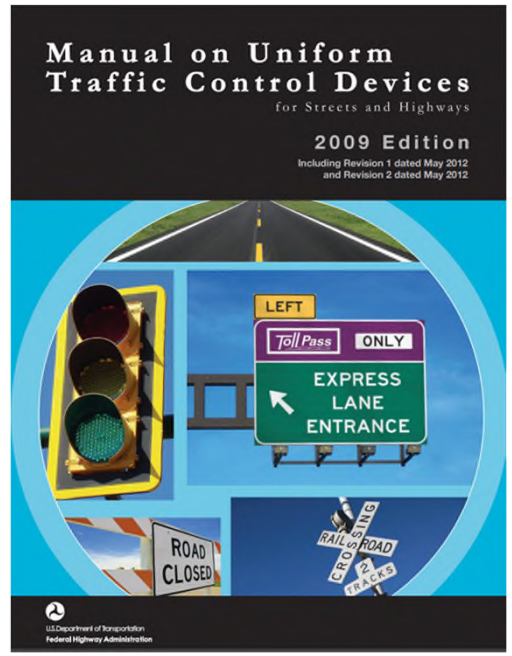
Efforts Underway in the US

- **National Committee on Uniform Traffic Control Devices – Connected-Automated Vehicle Task Force (active since 2017)**
  - Engaged Experts
  - Reviewed Literature
  - Developed Strawman
  - Surveyed and Coordinated with Stakeholders
    - AASHTO
    - Auto Alliance
    - Automotive Safety Council
    - Machine Vision Developers
    - ATSSA
  - Developed draft MUTCD language



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January 2020 – NCUTCD ballot passes

- **Requires** 6-inch wide markings on all freeways
- **Requires** 6-inch wide edge lines on all other highways with posted speed ≥ 55 mph and 6,000 vehicles/day
- **Recommends** all skip lines on freeways be extended to 15 foot in length (currently they are 10 feet)
- **Requires** dotted edge lines extensions along all exit ramps

- **State DOT reactions**
  - Concerned about funding
  - Some – have started updating their policies (TX)
  - Some – will likely adopt 6-inch statewide (IL, NH)
  - Some – not much of an impact (FL, CA, TN …)
  - QnA – June 2020 AASHTO mtg

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Questions

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Activities:

- NCUTCD CAV Task Force Chair
- SAE ORAD Infrastructure Chair
- AASHTO CAT Coalition
- Leading/Member of 4 FHWA/NCHRP research projects associated with preparing the highway infrastructure for CAVs

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