CAT Coalition
Infrastructure-Industry Working Group Quarterly Meeting

July 31, 2019
3:00-4:30 pm (Eastern)
Agenda

- Welcome and Introductions
- Co-Chairs’ Remarks
- Overview of Phase 2 – Year 2 Work plan
- FHWA Updates
- Guest Presentations
  - **Smart Bases CPI AV Pilot**
  - CAT/CAV Capacity & Funding Approaches in the States
  - Impacts of AVs on Highway Infrastructure
- Action Items and Next Steps
Co-Chairs’ Remarks
Tracy Larkin Thomason, Nevada DOT
Steve Gehring, Global Automakers
Infrastructure-Industry Working Group

• Welcome to new Co-Chair: Steve Gehring
• Role of this Working Group is to:
  ▪ Lead adoption of pre-competitive industry research in driving infrastructure development and maintenance
  ▪ Connect IOOs with industry
  ▪ Pursue natural evolution of infrastructure to accelerate CAVs
  ▪ Clarify terms, definitions and target audiences
Overview of Phase 2 – Year 2 Work Plan

Dean Deeter, Athey Creek
Tracy Larkin Thomason, Nevada DOT
Venkat Nallamothu, AASHTO
CAT Coalition Status & Work Plan

• New Coalition Co-Chairs
  ▪ Roger Millar, WSDOT
  ▪ Jennifer Cohan, DelDOT
• Coalition is 8 months into Year 2 (Nov 2018 – Nov 2019)
• Current Organization Chart on the Next Slide
Current Org Chart – Aug 2019

Co-Chairs
Roger Millar, WSDOT & Jennifer Cohan, Del DOT

Focus Area:
Programmatic & Strategic Activities

Focus is on documenting needs and best practices for programmatic, strategic, and technical activities to encourage CAT deployment & operation through initiatives such as the SPaT Challenge & Connected Fleet Challenge

Policy, Legislative and Regulatory Working Group
J. Toth
P. Ajegba

Strategic Initiatives Working Group
B. Leonard
J. Averkamp

Technical Resources Working Group
F. Saleem
N. Katta

Planning / Scenarios Working Group
S. Rosenberg
J. Sydello

Focus Area:
Planning, Scenarios, & Resources

Supports the CAT industry in understanding automated transportation planning & scenario development, available resources, and documenting resource needs

Focus Area:
Infrastructure & Industry

Supports the CAT industry in defining the digital & physical CAT infrastructure, and establishing secure, verified connections between vehicles & infrastructure

IOO/OEM Forum
C. Castle
F. Saleem
M. Shulman

Infrastructure Industry Working Group
T. Larkin-Thomason, S. Gehring

Peer Exchange & Outreach Working Group (E. Seymour) – Supports all focus areas

USDOT/FHWA
Year 2 Work Plan – General

Summary of Year 2 Work Plan:

There is a need to evolve the focus from solely V2I deployment details to include higher level topic areas that surfaced in the National Dialogue, that were documented in the AV 3.0 document, and that will be the focus of the National Strategy on Highway Automation developed over the coming years.
# Year 2 Work Plan – Coalition Wide

## 6 Recommendations & Related Focus Areas

<table>
<thead>
<tr>
<th>#</th>
<th>Recommended Year 2 Work Plan Activities</th>
<th>Infrastructure &amp; Industry</th>
<th>Proj &amp; Strategic Activities</th>
<th>Planning Scenarios &amp; Research</th>
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<tbody>
<tr>
<td>1</td>
<td>Harmonization with the National Dialogue on Highway Automation</td>
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<td>✓</td>
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<td>✓</td>
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<tr>
<td>5</td>
<td>Support members in understanding and benefitting from USDOT activities and deliverables</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>6</td>
<td>Re-examine working group activities and continue key activities</td>
<td>✓</td>
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## Year 2 Work Plan – Infrastructure-Industry WG

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<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6</td>
<td>Re-examine working group activities and continue key activities; I-I WG specific recommendations:</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>• Discuss options for expanding membership in quarterly webinars</td>
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<td></td>
<td>• Introduce MaaS/MOD &amp; discuss relation to this WG</td>
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Infrastructure-Industry WG Activities

- Communications 101
- Primer of Terms
- Exercise about bigger picture for CAT infrastructure
- Expand membership
Infrastructure-Industry WG Activities

- Communications 101
  - A priority effort for this working group
  - Audience: IOO staff making investments and new to this realm
  - What: A brief YouTube video or Primer
  - Content will answer:
    - What are the telecommunications methods?
    - What do the terms mean?
    - How does DSRC work?
    - What is the 5.9 GHz spectrum?
    - What are the V2X benefits of the 5.9 GHz spectrum?
    - May discuss how OEMs communicate now, e.g. cellular systems like Sirius XM/OnStar
Infrastructure-Industry WG Activities

• Primer of Terms
  ▪ Previously a focus of this working group
  ▪ Modify scope to leverage nomenclature and follow the lead of the more mature, data-driven organizations to minimize duplication
    ❖ Similar efforts by other CAT Coalition groups, National Safety Council, IIHS, AAA, Consumer Reports, and NHTSA

• Exercise about bigger picture for CAT infrastructure
  ▪ Discussion with both OEMs and IOOs
  ▪ Understand priorities for planning and implementing IOO infrastructure investments

• Expand membership
  ▪ Increase perspective and better understand issues
FHWA Update
Smart Bases CPI AV Pilot
Col. James Allen, U.S. Army Engineer Research and Development Center (ERDC)
Smart Base CPI
Autonomous Vehicles Pilot

Prepared by Jim P. Allen, PE, Researcher

U.S. Army Engineer Research and Development Center (ERDC)
Construction Engineering Research Laboratory (ERDC-CERL)

Prepared for AASHTO and Northern Virginia Regional Commission

July 2019
Outline

▪ Project Overview
▪ Research Approach
▪ Fort Carson Overview
▪ Timeline and Phases of JBMHH Project
▪ Outstanding Issues
▪ Questions and Discussions
Objective: Explore the use of connected and autonomous vehicles (CAV) at military installations integrated with regional communities to lower costs, improve Soldier and family quality of life, and enhance mission readiness. This project will deploy and research CAV’s at Joint Base Myer-Henderson Hall (JBMHH), VA and Fort Carson, CO.

Project Sponsor: ASA(ALT) and ASA (IE&E)
Partners: US Ignite, Local Motors

PRODUCTS / OUTCOMES
- Plan, develop, demonstrate, and employ CAV technologies at two installations and within the surrounding communities to evaluate commercially-available CAV’s and the potential to reduce base operating costs, improve safety and quality of life, and deliver services more efficiently and effectively
- Pilot at Fort Carson, CO with autonomous delivery and a public safety program
- Pilot at JBMHH, VA with autonomous shuttle and base-to-Pentagon service
- Formation of strategic partnerships with a wide range of stakeholders and industry leaders in smart transportation and cyber security
- Identify and assess emerging transportation technologies focused on infrastructure, data analytics, policy, public safety, and optimization

NEXT STEPS
- Research approach
  - PMP approved
  - Six research LOE’s with designated area leads in PDT and integration component
  - 2 x AV deployments for comparative case study: JBMHH and Ft Carson
- Admin and acquisition actions
  - MOA between ERDC-CERL, JBMHH, and MCICOM
  - Sole source contract with Local Motors as AV operator at JBMHH; for $150K
  - US Ignite BAA proposal for Ft Carson at $4 million

Technical POC: James (Jim) Allen
Project Overview

- **Title:** Smart Bases: Autonomous Vehicles Pilot

- **FY19 $5 million Congressional Program Increase in NDAA to ERDC**

- **Objective:** Explore the use of connected and autonomous vehicles (CAVs) at military installations integrated with regional communities to lower costs, improve Soldier and family quality of life, and enhance mission readiness

- **Locations of pilots:**
  - Fort Carson and Colorado Springs, Colorado
  - Joint Base Myer-Henderson Hall and Arlington, Virginia
Autonomous Vehicle Pilot Research Approach

**Vision**

Military installations leverage connected and autonomous vehicle technologies

**Research Lines of Effort**

- Infrastructure
- Energy and Economy
- Data Architecture and Cyber Security
- Data Analytics
- Human Factors
- Planning and Policy
- Program Integration

**Outcomes**

- Mission Readiness & Mission Assurance
- Transportation Services & Costs
- Safety & Quality of Life

**Measures of Effectiveness/Performance (MOE/MOPs) and Smart Installation Guidance**

**Vision Outcomes**

- Measures of Effectiveness/Performance (MOE/MOPs)
- Smart Installation Guidance

**US Army Corps of Engineers • Engineer Research and Development Center**
Anticipated Products

- Enhanced knowledge and capability to conduct CAV research

- Installation guidelines for deploying CAVs
  - Assessment frameworks, regulation and policy changes
  - Infrastructure, security, and planning requirements
  - Data sharing/analytics standards
  - Cost and energy savings
  - Human interface and education
  - Integration with regional communities

- Technology transfer through publications and policy

- Scenario analysis using the digital infrastructure and digital twin capability within the VTIME platform to further conceptualize and develop Installations of the Future
Fort Carson / Colorado Springs AV Pilot

- Deliberate and incremental approach to deploy AVs that support garrison commander use cases: personal, material, and responder mobility services

- Key contractor tasks:
  - Accelerate the launch of a smart technology testbed that will include an autonomous vehicle (AV) pilot program, an autonomous delivery pilot and a public safety program
  - Form and manage strategic partnerships with the wide range of stakeholders and industry leaders in smart transportation and digital security
  - Identify and assess the right emerging transportation technologies on-base, focused on those that will help reduce costs, improve public safety, and deliver faster services
  - Evaluate smart solutions on- and off-base for use in other vital sectors, such as public safety, sustainability and resilience.

- BAA final proposal from US Ignite at EASB for July 23 review

- Refine research assessment templates for LOEs used at JBMHH
JBMHH / Arlington AV Pilot

- **Target of Opportunity:** Greater Washington Olli Fleet Challenge
  - Joint application of MCICOM, ERDC, JBMHH, and NVRC
  - Selected on March 15, 2019

- **Sole source contract with Local Motors to deliver data and reports relevant to research LOEs**
  - Contract method selected as most expedient to meet pilot timetables
  - Robotic Research key contractor partner with 15 years DoD experience in robotics

- **Key contractor tasks: Data capture and process reporting**
  - Deployment planning and site survey
  - Infrastructure set up and operational test
  - Vehicle and route set up and operational test
  - Invitational events and fixed route mobility service

- **Mobility service set up, operation, and maintenance (late May / early June start)**
  - Phase 1 service: internal JBMHH route => 90 days
  - Phase 2 service: addition of route from JBMHH to Pentagon => day 91 to 180
  - Phase 3 service: additional route to 2 Metros => day 181 to 365
Autonomous Vehicle Timeline and Milestones

- Phases: Acquisition: Sole Source solicitation
  - Phase 1a: Event and invitation mobility service at JBMHH
  - Phase 1b: Fixed route and event mobility service at JBMHH
  - Phase 2: Fixed route mobility service from JBMHH to Pentagon
  - Phase 3: Fixed route mobility service between JBMHH, Pentagon, and Pentagon City/Rosslyn metro stations

- Milestones:
  - Data push being received into Azure gov cloud blob storage
  - Identify indicators for success to proceed into Phase 2 by end of July
POLICY - Why JBM-HH?

- **JBM-HH – History of Innovation**
  - Previous Pilots have been conducted
  - AV technology has far reaching implications across DOD Community
  - Home to Senior Command and Staff Officers
  - Population of ready customers

- **Ideal Testing Environment for Olli – meets roadway attributes:**
  - Secure Campus with a separate governing structure from State
  - All roadways with a maximum speed of 15 - 25 mph
  - 2-lane roadways, or one-way streets
  - No stop light controlled intersections
  - All intersections are governed by stop signs
Stakeholders

- NVRC
- Joint Base Myer-Henderson Hall, Fort Belvoir, and Quantico
- Arlington County
- Virginia Department of Transportation
- Virginia Department of Rail and Public Transit
- Office of the Secretary Veterans and Defense Affairs for the Commonwealth of Virginia
- Virginia Tech
- Barbaricum
- Booz Allen Hamilton
- Amazon
- JBG (Developers for Amazon HQ2)
- Compass Transportation and Technology
JBMHH Route
Olli Launch Event on June 19, 2019 in Arlington, VA
Olli Launch Event on June 19, 2019 in Arlington, VA
Outstanding Issues

- Clarity on milestones for stakeholders to move into Phase 2
- Funding for Phase 2 and 3
- Test to duplicate Route 29 traffic signal and left turn required to Pentagon route from JBMHH
- NHTSA Waiver / DMV authorize for Olli to operate on VDOT/Arlington County roads
- State police involvement during initial deployment on public roads
- Data sharing agreement between DOD and state/local stakeholders
- Additional Research Issues
Questions / Discussion

- Other ???

- Jim P. Allen, PE, PhD candidate
  - James.p.allen@usace.army.mil
  - Ph: 217-373-3497; mobile 217-377-5008
CAT Coalition PLR WG Survey: CAT/CAV Capacity & Funding Approaches in the States

Daniela Bremmer, WSDOT
SURVEY ON CAT/CAV CAPACITY & FUNDING APPROACHES IN THE STATES

Survey conducted by the CAT Coalition
Working Group on Policy, Legislation, and Regulation (PLR)
Survey Administered: April 2019

Daniela Bremmer, CAT Development Manager, WSDOT
CAT Coalition AV Infrastructure-Industry Working Group Meeting. 07/31/2019
CAT Coalition PLR WG Survey on Funding, Financing, and Organizational Structure

• A key goal of PLR WG’s work plan activity #2 was to understand how state and local DOTs are funding their respective CAT activities and the general scale of funding they are investing.

• After examining other, recently conducted surveys (Fall 2018, AASHTO and ITSA), the WG agreed that the questions that members wanted answered had not been asked before. The primary target audience was State DOTs
  • Survey was refined after testing it with a few volunteer states
  • Survey consisted of three, key sections:
    1. Agency Capacity and Organization Section
    2. Agency Funding and Financing Section
    3. Agency Deployment and Partnerships Section
25 State DOTs and 2 Local Agencies responded to the survey (27 total)

1. AKDOT&PF Central Region
2. Arizona Department of Transportation
3. California DMV & DOT
4. City of Vancouver
5. Delaware DOT
6. Florida DOT
7. Georgia DOT
8. Idaho Transportation Department
9. Iowa Department of Transportation
10. Maine DOT
11. Maryland Department of Transportation
12. Maryland DOT-SHA
13. Michigan DOT
14. Minnesota DOT
15. Nevada Department of Transportation
16. NH DOT - TSMO
17. North Dakota Department of Transportation
18. Oregon Department of Transportation
19. PennDOT
20. RI Dept. of Transportation
21. Road Commission For Oakland County
22. Tennessee DOT
23. Texas Department of Transportation
24. Utah DOT
25. Virginia DOT
26. Wisconsin Department of Transportation
27. WSDOT
“Does your agency have dedicated positions supporting/leading CAT/CAV initiative/programs?”

36% Yes
64% No
The number of FTEs dedicated to the agency’s respective CAT/CAV Program ranged from ½ FTE to 7 FTEs.
In most agencies the CAT/CAV program is embedded in TSMO/Operation/ITS types of divisions

"Where is the program located in the organization/reporting structure?

- CAV-X Office Reports to the Operations Division Director
- Central Office / FDOT Head Quarters Traffic Operations
- DMV: Autonomous Vehicle program and Legal DOT: Planning and Modal program
- Office of Innovation in the Director's Office
- Office of Strategic Innovation
- Office of Traffic Operations - Operations Bureau
- Operations
- Planning /Traffic Operations
- Planning Division
- reports directly to the Director of NDDOT
- Reports to the Executive Deputy Secretary
- Secretary's Office
- Strategic planning division
- Traffic Management / Operations
- TSM&O - Systems Technology Group
- TSMO/Region
- under the operations branch of the organization
- Within Traffic Operations
Most CAT/CAV Programs are funded out of existing programs

"If you have a CAT/CAV/AV program, how are you funding deployments, initiatives and or the program today?"

- Existing Operating Program(s)
- State Planning and Research (SPR) Funds (Federal Funds that can be used for Planning and...)
- Relabeled or reorganized existing program(s) funds (e.g. ITS = CAT/CAV, Traffic Operations =...)
- New appropriation/new money
- Other (please specify)
Level of Capital Funds Currently Invested

“Capital Funds: used for field implementation, infrastructure, software development, etc.”

- 5% <$1M Annual
- 40% $1M < $5M Annual
- 55% >$5M Annual
Sustained Funding

“What are your plans to sustain and/or increase either operating or capital funding? “

- Sustain as is: 35%
- Requesting increase/funding changes through Internal Agency Request: 30%
- Other (please specify): 35%
Innovative Financing

“Is your agency using “innovative financing” / “Public Private Partnership - P3” opportunities right now?”

- Yes, currently using: 39%
- No, and we have no plans: 13%
- Not currently using but actively planning to use in 2019/2020: 26%
- Other (please specify): 22%
Current Use of Innovative Financing

“If your agency is currently using “innovative financing” / “Public Private Partnership - P3” opportunities right now, please check all those that apply:

- Volkswagen Mitigation Funds
- Exchange Use of Right of Way by Private Sector in Exchange for Private Sector...
- Telecom Fiber
- 5G Small Cell
- Cellular Towers / exchange for Connected Vehicle Infrastructure
- Transitioning a Legacy System (Traveler Information, Roadway Weather, Data...)
- Outsourcing a Specific Transportation Service (Roadway Safety Rest Area)
- Data Partnerships of any kind (no-cost data exchange, value for both parties)
- Use of Venture Capital
- Advertising
- Other (please specify)

0 1 2 3 4 5 6 43 7
Grant Application Barriers

“In relation to pursuing Federal (or other) Grant Opportunities, what are your top barriers/issues/challenges in being able to develop and submit a competitive proposal?”

- 52% have no barriers/challenges to date
- 31% have significant barriers or challenges
- 17% have some barriers or challenges, but we can manage around it
Grant Application Barriers: “Please list your top barriers, if any. Check all that apply”.

- Grant announcements don’t allow sufficient time to develop a competitive proposal
- Grant criteria/requirement is too complex; requires consultant support to develop a competitive proposal
- Awareness of suitable grant opportunities
- Complex decision making process to obtain support
- Identifying viable partnership opportunities (private or public)
- Identifying state matching funds
- Staff capability (skill sets) and or capacity (availability)
- Other (please specify)
Current CAT/CAV Deployments (funded):
“What CAT/AI/CAV deployments are currently underway, have been implemented or are funded to be implemented near term?”

- Truck Platooning: SAE Level 1 Driver Assisted, other
- Transit: First mile/last mile connections
- Transit: Low-speed AV shuttles
- Transit: Automated bus braking and pedestrian detection
- Electrification: Expanding/building the electric vehicle charging network
- Worker Safety: Autonomous roadway construction zone safety trucks
- Use of aerial drones for maintenance and asset management functions
- Signing and Striping: Roadway machine readable signing and striping
- AI use for accident prediction and stationing of incident management vehicles. Also AI facilitating incident identification and accelerated (12 min) response time.
- Connecting traffic signal timing information to vehicles -SPAT
- Open data/data sharing applications or projects
- Use of aerial drones for maintenance and asset management functions
- Signing and Striping: Roadway machine readable signing and striping
- Worker Safety: Autonomous roadway construction zone safety trucks
- Electrification: Expanding/building the electric vehicle charging network
- Transit: Automated bus braking and pedestrian detection
- Transit: Low-speed AV shuttles
- Transit: First mile/last mile connections
- Truck Platooning: SAE Level 1 Driver Assisted, other
Future CAT/CAV Deployment priorities: “What are your currently unfunded, near-term CAT/AV/CAV deployment priorities?”

- Truck Platooning: SAE Level 1 Driver Assisted, other
- Transit: First mile/last mile connections
- Transit: Low-speed AV shuttles
- Transit: Automated bus braking and pedestrian detection
- Electrification: Expanding/building the electric vehicle charging network
- Use of aerial drones for maintenance and asset management functions
- Signing and Striping: Roadway machine readable signing and striping
- Worker Safety: Autonomous roadway construction zone safety trucks
- Connecting traffic signal timing information to vehicles - SPAT
- Open data/data sharing applications or projects
- Use of aerial drones for maintenance and asset management functions
- Other (please specify)
Private/Public Partnerships:

“Are private or public (local, state) organizations partnering with you?

- Yes: 82%
- No: 18%
Types of Current Partnership Organizations:
“If other organizations are partnering with you, what type of organizations are these?”

- 1. Transit
- 2. Coalition of High-Tech companies
- 3M and VSI Labs (AV testing firm) several cities for AV testing, and several counties and cities for SPaT and rural CV corridor applications.
- academia, industry, local governments, associations, sister agencies
- academic, business, local government, multi-state organizations
- Data Providers, OEMs, Automotive Suppliers, etc.
- Department of Environmental Protection, Motor Vehicles, Efficiency Maine Trust, City of Portland, UMaine
- Industry, technology companies, universities
- Maricopa County DOT, The University of Arizona
- municipalities, transit authority, state agencies
- OEM, ITS, telecoms, universities, cities
- Private application developers
- Private companies and local governments, MPO's
- Private Consulting
- Private, Counties and MPOs
- RTC, Cities, Counties, Universities
- Transit agency, universities
- Transit, county government
- We frequently work with local jurisdictions and Daimler.
Types of Partnership Contributions:
“If other organizations are partnering with you, how are they partnering?

- "hard" match funding: 11%
- "soft" match contributions: 45%
- Other (please specify): 44%
Other Types of Contributions:
If other organizations are partnering with you, how are they partnering? (if “other”, please specify)

- allowing us to learn from their deployments, supporting better deployments in our partners (like how to deploy correctly)
- Both hard and soft matches
- Both of above
- Cost and equipment sharing
- engagement of staff and partnership in the research
- Policy collaboration
- soft match and in-kind services
- We provide data to them
Distribution: Sharing the Results

CAT Coalition website: to come

Other:

Questions?

Contact

- Daniela Bremmer, WSDOT, bremmed@wsdot.wa.gov
- Pat Zelinski, pzelinski@aashto.org
Impacts of AVs on Highway Infrastructure
Paul Carlson, Road Infrastructure Inc.
Impacts of Automated Vehicles (AVs) on Highway Infrastructure

Overview – CAT Coalition
July 31, 2019
Project Information

- Funded by FHWA Office of Infrastructure R&D
- Information in this presentation is for discussion purposes only
- Final products from research are expected in late 2019
Project Overview

**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.
Session Agenda

- AASHTO Maintenance Mtg, Grand Rapids, MI, July 17, 1 – 4 PM
- TRB AVS Mtg, 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
Session Purpose

- Share what we have learned from AV Industry & AASHTO Maintenance
  - Now – priorities for today
  - Future – thoughts about the near-term future (in the next 10 years)
  - Readiness – assessing infrastructure readiness

- Gather feedback in four functional areas of infrastructure
  - Traffic control devices
  - TSMO/ITS
  - Urban multimodal
  - Physical infrastructure (pavements, bridges, and culverts)

- Obtain your feedback
  - Support
  - Concerns
  - Contributions
  - Questions.
Poll Everywhere

- Using Poll Everywhere Tool throughout the session
- Submit responses on your mobile device at PollEv.com/deepakgopala832 or text DEEPAKGOPALA832 to 22333 once to join.
**AASHTO Committee on Maintenance -- Workshop**

Current run (last updated Jul 18, 2019 10:47am)

- 14 Polls
- 117 Participants
- 60 Average responses
- 34% Average engagement

**AVS Session**

Current run (last updated Jul 19, 2019 11:11am)

- 16 Polls
- 50 Participants
- 25 Average responses
- 41% Average engagement
<table>
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<tr>
<th>Industry</th>
<th>Count</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Road Industry: Agency</td>
<td>16</td>
<td>34%</td>
</tr>
<tr>
<td>Road Industry: Consultant/Contractor</td>
<td>8</td>
<td>17%</td>
</tr>
<tr>
<td>Road Industry: Supplier/Manufacturer</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td>Road Industry: Other</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>Auto Industry: OEM</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td>Auto Industry: Supplier Manufacturer</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td>Auto Industry: Other</td>
<td>5</td>
<td>11%</td>
</tr>
<tr>
<td>None of the Above</td>
<td>7</td>
<td>15%</td>
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Setting the Stage
No Rush...Mixed-Fleet

- There are about 250,000,000 cars in the US
- By 2030, there will be close to 100,000,000 cars in the US with some automation (adaptive cruise control, lane departure warning, lane keep assistance, etc.)
- Level 2 cars are only recently available (Super Cruise in the Cadillac, AutoPilot in the Tesla, etc.)
- Audi has a Level 3 vehicle but not in the US
- Most car companies say they will have a Level 4 vehicle before 2030 (they don’t say if it will be available for the consumer to purchase)
- The average age of a vehicle in the US is almost 12 years
- It will take decades for significant US fleet penetration
Pacing the Industries

- Can the highway infrastructure industry keep up with the pace of technology and vehicle automation?

**Technology pace**
- First iPhone was announced 12 years ago. There is an update every year. How old is your phone?

**Vehicle pace**
- How old is the vehicle you have in your garage?

**Infrastructure pace**
- Generally designed for a life span that ranges over decades!
Research Questions

What are the problems today for AV testing, deployment, operations?

What are the risks and opportunities with widespread AV use in the future?
AV Industry Interviews

- OEM (3)
- ADS Sensors (2)
- ADS Computation (1)
- Tier 1 Auto Supplier (1)
- Heavy truck industry (1)
### AV Industry Interviews: Key Observations

<table>
<thead>
<tr>
<th><strong>Implications of Sensor Evolution</strong></th>
<th>Rapid evolution and regular maintenance needs of sensors favors fleet operations in the near-term and presents challenges to future proofing infrastructure.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quality and Uniformity of Physical Infrastructure</strong></td>
<td>Physical infrastructure should be well-maintained and consistent, especially regarding road markings and signage.</td>
</tr>
<tr>
<td><strong>Digital Information Standards</strong></td>
<td>Digital information relayed to AVs should be standardized, secure, and specific to AV operational challenges (e.g., work zone related issues).</td>
</tr>
<tr>
<td><strong>Urban Fleet Operations</strong></td>
<td>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.</td>
</tr>
</tbody>
</table>
### 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.
Discussion of Infrastructure Impacts
Infrastructure Categories and Definitions

Highway Infrastructure Categories

- **Physical Infrastructure**
  - Pavements, Bridges and Culverts

- **Traffic Control Devices**
  - Pavement Markings, Traffic Signs, Traffic Signals, Temporary Traffic Control, Roadside Hardware

- **TSMO and ITS Infrastructure**
  - ITS Roadside Equipment, TSMO Strategies, TSMO Systems

- **Urban Multimodal Infrastructure**
  - Bicycle, Pedestrian, and Transit Infrastructure, Curb Space
Category 1: Traffic Control Devices (TCDs)

- Pavement Markings
- Traffic Signs
- Traffic Signals
- Temporary Traffic Control
- Roadside Hardware
Do you agree or disagree that IOOs should prioritize changes to pavement marking practices to support AV deployment?

Strongly Agree
Somewhat Agree
Neither Agree or Disagree (Neutral)
Somewhat Disagree
Strongly Disagree
Do you agree or disagree that IOOs should prioritize changes to pavement marking practices to support AV deployment?

<table>
<thead>
<tr>
<th>Response options</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>22</td>
<td>56%</td>
</tr>
<tr>
<td>Somewhat Agree</td>
<td>10</td>
<td>26%</td>
</tr>
<tr>
<td>Neither Agree or Disagree (Neutral)</td>
<td>3</td>
<td>8%</td>
</tr>
<tr>
<td>Somewhat Disagree</td>
<td>2</td>
<td>5%</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>2</td>
<td>5%</td>
</tr>
</tbody>
</table>

39 Responses
### What other near-term changes to the TCD infrastructure would best support AV deployment?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Upvotes</th>
<th>Downvotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform work zone set ups</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>12V communications between signals and approaching vehicles (i.e. SPaT)</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Intelligent traffic control devices</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Ensure that network connectivity (i.e. fiber or cell coverage) is available</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>LED signage read-ability by on-board camera systems</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Digitize WZ and sign location data</td>
<td>7</td>
<td>0</td>
</tr>
</tbody>
</table>

**Engagement**

- **54%**
- **36 Responses**
Category 2: TSMO and ITS

- ITS Roadside Equipment
- TSMO Strategies
- TSMO Systems

Source: USDOT

Source: FHWA
What near-term changes to TSMO/ITS infrastructure would best support AV deployment?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Upvotes</th>
<th>Downvotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>V2V and V2I connectivity</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Connectivity</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Sharing of real-time advisories with AVs using V2I comms</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Ensure reliable work zone data is available... active. Location, etc</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Decommission Legacy equipment to free up funding</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>AV vendors’ ability to share information with public agencies.</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Backhouse IT infrastructure to handle data exchange and data sharing between roadside units, vehicles and interagency.</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Creation of Manual of Uniform Digital TCDs</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>
Category 3: Urban Multimodal Infrastructure

- Bicycle, Pedestrian, and Transit Infrastructure
- Curb Space

Source: www.pedbikeimages.org/Ann McCrane
What near-term changes to urban multimodal infrastructure would best support AV deployment?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Upvotes</th>
<th>Downvotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction of conflict multimodal points</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Mode separation</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Video analytics and MEC (multiaccess edge computing) at Traffic signals to process and communicate near ped/bike misses share with buses, vehicle using DSRC / 4GLTE&amp;5G</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Automated collision avoidance systems on buses</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Grade separated lanes for bikes</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Automated buses operating on dedicated lanes: a rubber-tired light rail system</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>5G</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Uniformity of curbs and crosswalks</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Enhanced pedestrian crossing sections</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>

Engagement: 42%

Responses: 32
Given the constraints and uncertainties regarding AV interactions with infrastructure, what existing practices for pavements, bridges, and culverts do you think should be prioritized?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Upvotes</th>
<th>Downvotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter maintenance</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>pavement markings</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Additional funding</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Pavement marking maintenance will need to be a priority.</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Pavement condition</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>pothole patching</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Use of real time gps data to reduce need for markings, signs, weather, etc</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>funding of infrastructure maintenance given current dependency on gas taxes</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Pot holes</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Asset management</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>pavement marking b/c without adequate marking, the functionality will not operate</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>
Readiness
### How ready are IOOs to support AV deployment?

<table>
<thead>
<tr>
<th>Response options</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Ready</td>
<td>2</td>
<td>6%</td>
</tr>
<tr>
<td>Somewhat Ready</td>
<td>5</td>
<td>16%</td>
</tr>
<tr>
<td>Neither Ready of Unready</td>
<td>3</td>
<td>10%</td>
</tr>
<tr>
<td>Somewhat Unready</td>
<td>11</td>
<td>35%</td>
</tr>
<tr>
<td>Very Unready</td>
<td>10</td>
<td>32%</td>
</tr>
</tbody>
</table>
Please indicate why you believe IOOs are ready or unready to support AV deployment.

<table>
<thead>
<tr>
<th>Responses</th>
<th>Upvotes</th>
<th>Downvotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insufficient resources and agencies lack the organizational structure and culture for innovation.</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>More advanced IOOs tend to have a champion at the senior management level</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Not ready because of Funding and lack of standards</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Deployment can go now without mods to infrastructure. AV tech developers can and will adapt to serve their market and grow their business.</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Legacy culture</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>We don’t know what we don’t know.</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
AASHTO MaC Response to Readiness

▪ How ready is your agency?
  ▪ Very ready 0 0%
  ▪ Somewhat ready 8 15%
  ▪ Neutral 13 24%
  ▪ Unready 10 18%
  ▪ Very Unready 23 43%

▪ Common comments
  ▪ Lack or resources / funding
  ▪ Needs not well defined
  ▪ Striping inadequate
  ▪ Lack of an understanding
Please indicate why you feel your agency is ready or unready to address AV impacts to highway infrastructure.

Responses

- Striping
- Lack of understanding
- Autos will go airborne
- Beginning to train staff
- Technology keep changing
- Revenue increase
- Early stages of preparation
- Pavement markings are not ready
- Current revenue source based on mostly gas tax, which will likely decline with AV adoption.
- Our current pavement conditions are driving the funding priorities toward resurfacing and capacity projects. The ability to dedicate funding to this is not there yet.
- Speed of technology changing
- No proven confidence in AV
- Slowly preparing with signs and stripping
- Pavement condition
- Too much weather
- Striping
- Need to know where to even begin
Next Steps

▪ Review Literature (**completed**)
▪ Engage Stakeholders (**on-going**)
▪ Conduct AV Industry Interviews (**completed**)
▪ Develop Draft Findings (**completed**)
▪ Obtain Feedback (**on-going**)
  ▪ Present, vet, discuss (workshops)
    – AASHTO Maintenance Conference, Grand Rapids, MI
    – TRB Automated Vehicle Symposium, Orlando, FL
▪ Refine Findings (**next step**)
▪ Develop Techbrief (**future task**)
▪ Conduct Webinars (**future task, by EOY**)
Action Items & Next Steps

Future Meetings for Infrastructure-Industry WG

- September 12, 3:00-4:30 (Eastern)
- December 18, 3:00-4:30 (Eastern)