COOPERATIVE AUTOMATION RESEARCH
MOBILITY APPLICATIONS (CARMA)

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Cooperative Automated Driving Systems (CADS) safely improve the operational efficiency of our Nation’s urban and rural roadways.

Research Focused on Arterial & Freeways
Which technology can help DOTs address current and future congestion?
Cooperative Automated Driving Technology

Single vehicle ADS vs Multi-Vehicle CADS: Platoonning (SAE Level 1)

Preliminary Results and Benefits

- 1 Vehicle ADS
- 2 Vehicle CADS
- 3 Vehicle CADS
- 5 Vehicle CADS

Cooperative Automated Driving Technology

Cooperative ADS vs ADS:
- +42.6%
- +54.9%
- +66.3%
- +11.0%

Automated Driving System (ADS)
Cooperative Automated Driving System (CADS)
Connectivity – Why is it important?

Communications enables:
- CADS
- Speed Management
- Traveler information
- Work zone updates
- Road closures
- Incident Management
- Curve Speed Warning
- Signal Phase and Timing

Today – Expensive Infrastructure

Tomorrow
Cooperative Automation Research Mobility Applications (CARMA)

A reusable, extensible platform for studying cooperation and mobility aspects of connected vehicles

- FHWA’s open source code used to test Cooperative Automation Driving Systems (CADS) applications (i.e. platooning, speed harmonization, lane changing, etc.)
- Provides vehicle automation and sensing, communication capability, and API for researcher guidance algorithms
- Developed on ROS (Robot Operating System), a flexible framework for writing software, to develop an innovative approach to collaborate with leading researchers.
  - ROS has become a popular open source robotics framework, and is widely used for automated vehicle development.
  - ROS is a collection of tools, libraries, and conventions that aim to simplify the task of creating complex and robust robot behavior.
- Version 1 of the code will be published on GitHub repository fall 2018 for community to review and participate
Cooperative Automated Driving Technology
CARMA Release 2: Speed Harmonization (SAE Level 1)
Testing at Aberdeen Test Center Dec. 4-7th 2017

Speed Harmonization Plugin
✓ Algorithm sits on Cloud Server (i.e. TMC)
✓ Determines Command Speed based on Location and traffic conditions
✓ Sends speed command via Cellular
Cooperative Automated Driving Technology
CARMA Release 2: Speed Harmonization (SAE Level 1)
Testing at Aberdeen Test Center Dec. 4-7\textsuperscript{th} 2017

• 2 vehicles, ATC professional drivers
• Completed 24 Test Runs
CARMA Software Architecture

**CARMA Platform**

**GUIDANCE**
- PLUG INS (cruise, speed control, platooning, lane change and merge, approach & departure, etc.)
- Generates vehicle trajectory and sends commands to CONTROLLERS

**VEHICLE ENVIRONMENT**
- Message - V2V/V2I traffic, sensor fusion, roadway, route
- Represents information about host vehicle and the environment outside of the vehicle

**DEVICE DRIVERS**
- Controller software, communication, position (GPS), sensor, CAN
- Contains all software drivers. All drivers implement a common API

**Positioning and Communications**

**HMI INTERFACE**

**ROS Operating System**

**User Interface Examples**
Research Collaboration and Partnerships

• Across DOT and DOD
  • Volpe Transportation Center
  • U.S. Army Aberdeen Test Center

• With DOE
  • ARPA-E: NEXT-CAR Program

• With Automotive OEM’s
  • CAMP – Traffic Optimization for Signalized Corridors
  • CAMP – Cooperative Automation Small Scale Test

• With States
  • Connected Vehicle Pooled Fund
  • AASHTO Infrastructure Owner Operators/OEM’s Forum
  • VDOT/Transurban

• With Other Automotive Tech Organizations
  • TBD
Traffic Optimization for Signalized Corridors (TOSCo)

Current project includes simulation of TOSCo system for two corridors:

- Plymouth Road in Ann Arbor, MI (lower speed corridor)
- State Highway 105 in Conroe, TX (higher speed corridor)

Simulations will allow team to refine performance of TOSCo algorithms and to assess benefits.

Planned project next year would include live testing on the two corridors with TOSCo-equipped vehicles.
The things we learn from proof-of-concept testing…

- Early in development, identify/define which data element will be critical to the application performance measures
- Example of what we learned from CACC platooning tests
  - CACC algorithm saturated the platform control subsystem.
  - Application developers likely didn’t know; and as a result, fuel economy and driver acceptance were not optimized.
Partnering for Solutions

Current speed commands provided for platooning in the CARMA platform.

- Better Performance and stability requires the “Controller Output” and “Actual Speed” lines to closely match the green “Desired Speed” line.
National Dialog Overview

One: Launch Webinar: Announcing the Dialogue

One: Launch Workshop: Refining the Topics and Issues Framework

Five: National Workshops: Gathering Input
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<td>May 8</td>
<td>Launch Webinar</td>
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<td>June 7</td>
<td>National Dialogue Launch Workshop</td>
<td>Cobo Center, Detroit, MI</td>
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<td>June 26-27</td>
<td><strong>National Workshop 1</strong>&lt;br&gt;Planning and Policy Considerations for Highway Automation</td>
<td>Science History Institute Philadelphia, PA</td>
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<td>July 12</td>
<td><strong>Automated Vehicle Symposium</strong>&lt;br&gt;FMCSA-FHWA Truck Automation Listening Session</td>
<td>San Francisco, CA</td>
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<td>Week of July 30</td>
<td><strong>National Workshop 2</strong>&lt;br&gt;Digital Infrastructure and Data Considerations for Highway Automation</td>
<td>Seattle, WA</td>
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<td>Week of September 5</td>
<td><strong>National Workshop 3</strong>&lt;br&gt;Multimodal Safety and Infrastructure Design Considerations for Highway Automation</td>
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<td><strong>National Workshop 5</strong>&lt;br&gt;Operations Considerations for Highway Automation</td>
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National Dialogue Overview *Objectives*

1. **LISTEN: Gather input** from a broad group of stakeholders on key issues, challenges, and concerns in highway automation, such as infrastructure readiness, traffic operations, transportation planning, and other topics impacted by automation. Identify the priorities and needs of public sector stakeholders and hear their suggestions for addressing them.

2. **ENGAGE: Facilitate information sharing** among industry, public agencies and others to understand the current state of ADS and roadway capabilities and inform FHWA actions. Facilitate communication among industry, State, and local agencies regarding highway automation.

3. **EVOLVE: Update institutional structures** for working with existing and new stakeholders. Aid in developing new partnerships and strengthening coordination channels among industry, associations, public agencies, and other key groups.

4. **INFORM: Raise awareness** of FHWA and USDOT activities in automation and emerging technologies. Identify opportunities for strategic partnerships among Federal activity and State, local, and industry activity. Provide information to educate stakeholders and serve as a resource.
National Dialogue Overview

Outcomes

1. Understanding of potential impacts of highway automation on national highway infrastructure, safety, policy, operations, and planning.

2. Prioritized actions to inform integration of automation into existing FHWA programs and policies.

3. Models for sustained information sharing between public agencies and the private sector alongside newly developed partnerships among these organizations. Further, a more defined and clear path of communication between FHWA and automation stakeholders.

4. Insights from infrastructure owners and operators and the users of highways into possible technical guidance actions at the Federal level.

5. Validation or direction into highway research priorities and roles among FHWA, national partner organizations, industry, and State and local governments.

6. Development of an engaged national community or coalition on highway automation with inputs and members from States, local governments, industry, and associations, alongside FHWA and other Federal agencies.
Planning and Policy: Explores relevant issues for the planning and policy community, such as travel demand changes from automation, land use implications, infrastructure funding, right of way use, transportation systems management and operations, automation legislation/policy and other topics.

Digital Infrastructure and Data: Centers on the data requirements and needs of automated vehicles (e.g., digital work zone maps, road closures, etc.). It will explore the possibility of developing new partnerships and collaboration between public agencies and industry for data sharing and safety.

Multimodal Safety and Infrastructure Design: Covers infrastructure requirements, standardization, and consistency for automation. It will highlight topics where automation technology developers and public agencies require collaboration to plan for locations where existing roadway infrastructure, road conditions, design features and environments could lead to potential safety hazards.

Operations: Surveys the range of operations challenges from highway automation and initiate a discussion on what further research is necessary to address them. These challenges may include incident management and system inefficiency which may have implications on traffic patterns and roadway capacity.

Freight: Deals with truck platooning applications and automated truck freight delivery issues. It will cover possible implications on traffic patterns and operations, as well as potential infrastructure considerations.
Partner with Us!

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