Source: FHWA.

CARMA℠ Webinar Series

How to Get Started with CARMA℠ and Become a Leader in Cooperative Driving Automation Research

U.S. Department of Transportation
Federal Highway Administration

SAXTON LABORATORY

Housekeeping

- Please dial-in to the conference via phone to ask questions and participate in the questions and discussion portion:
  - Dial-in: (800)832-0736
  - Room #990-1296
  - Unmute yourself: *#
- The chat pod is also available for you to ask questions. A moderator will announce your question.

Agenda

- What is CARMA?
- CARMA program.
  - CARMA Platform℠.
  - CARMA Cloud℠.
  - CARMA Collaborative.
- CARMA 3 Software.
- How to implement CARMA 3 in your research.
- Utilizing CARMA resources:
  - CARMA Collaborative.
  - CARMA Support Services.
- What's next in CARMA?
- Questions and discussion.

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What is CARMA℠?

CARMA

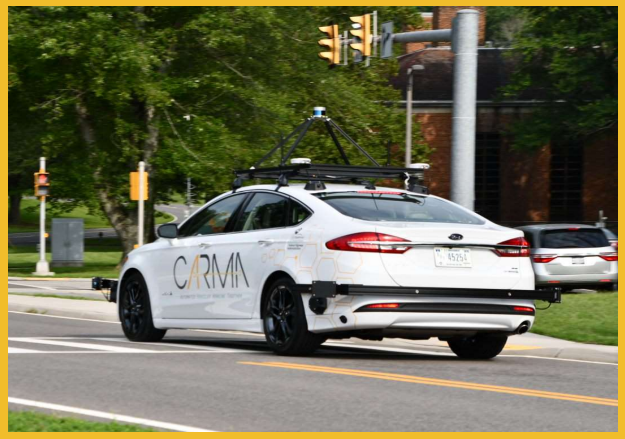
CARMA, an FHWA initiative, to achieve the benefits of cooperative driving automation (CDA) through collaboration using open source tools.

Source: FHWA and © 2019 Creative Commons

Cooperative Automation

Research Program

Research focuses on **automated vehicles working together and with roadway infrastructure** to increase safety and improve operational efficiency.



Source: FHWA.

Reduce fuel consumption at intersections by 20 percent.

Source: FHWA.

Double capacity of existing lanes.

Source: FHWA.

Fuel savings of 10 percent.

CARMA 1

COOPERATIVE ADAPTIVE CRUISE CONTROL

Objectives:

- Develop Automated Vehicle Testing Capability.
- Develop an Algorithm for Proof of Concept Cooperative Adaptive Cruise Control (CACC) Vehicle Platooning.
- Demonstrate CACC Enabled on Five SAE Level 1 Automated Vehicles (AVs).

Source: FHWA.

Source: FHWA.

Icon source: FHWA.

CARMA 2

INTEGRATED HIGHWAY PROTOTYPE (IHP)

Objectives:

- Build new CARMA2 Research Platform *(Open-Source).*
- Develop an algorithm *(Open-Source)* for:
  - Speed Harmonization.
  - Vehicle Platooning.
  - Cooperative Lane Change.
  - Cooperative Ramp Merge.
  - Signalized Intersection Approach and Departure.

5
Cooperative Driving Features

24
Days at Aberdeen Test Center (ATC)

22,000
Miles of closed track testing

42,000
Lines of code

Source: FHWA.

CARMA 3

Source: FHWA and © 2019 Port Houston.

USDOT Multimodal Partnership

Federal Highway Administration
Office of Operations
Office of Operations R&D
Office of Safety R&D

Federal Motor Carrier Safety Administration
Technology Division
Research Division

Maritime Administration
Office of Ports & Waterways Planning

Intelligent Transportation Systems Joint Program Office
Vehicle Safety and Automation
Data Program

Volpe National Transportation Systems Center
Advanced Vehicle Technology Division

TSMO Use Cases

FHWA

4 Automated Cars

6 Use Cases

1 Basic Travel

2 Traffic Incident Management

3 Work Zones

4 Weather

5 Intersections

6 Arterial Management

FMCSA

4 Automated Trucks

4 Use Cases

1 Truck Platooning

2 Roadside Inspection/Enforcement

3 Work Zones

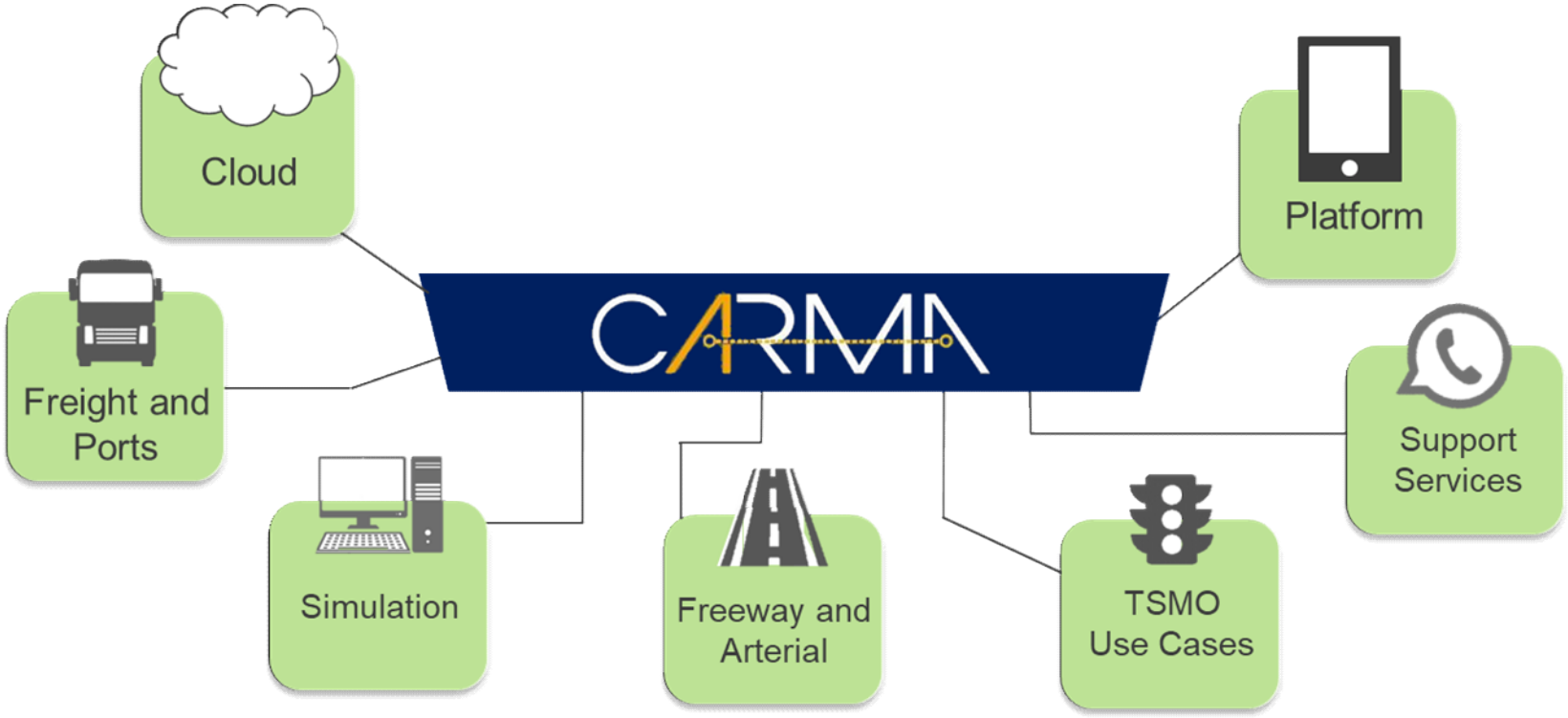
MARAD

1 Port Drayage

Source: FHWA.

CARMA Programs

CARMA Project Structure



Source: FHWA.

CARMA 3

FHWA Automated Research Vehicles

- Utilize industry's automated vehicle (AV) technology.
- Based on existing AV Open Source Software.

CARMA Platform

- Adds vehicle-to-everything (V2X) communications.
- Enables AVs to cooperate.
- Facilitates participation and collaboration.

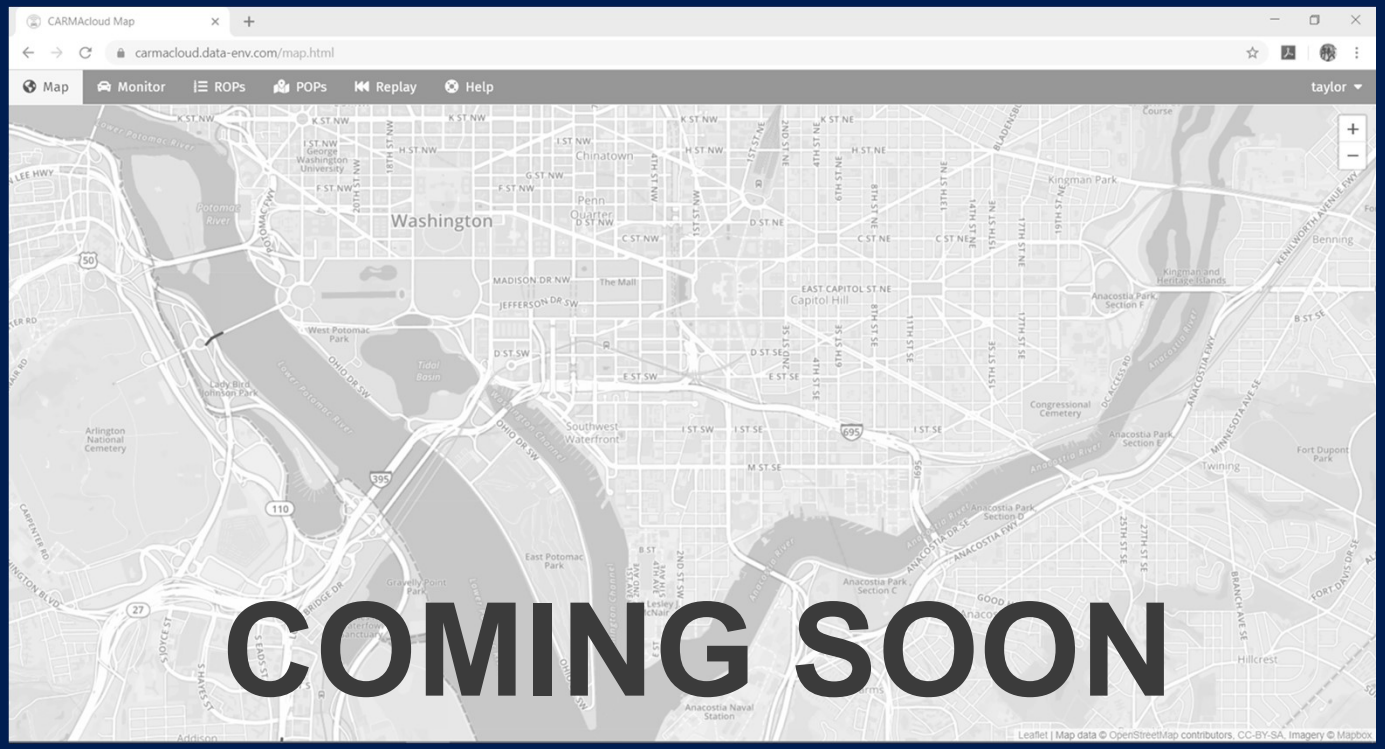
4 Automated Cars

4 Automated Trucks

Source: FHWA.

CARMA Cloud

- Provides interaction between the roadway operators and AVs.
- Enables the management of AVs to improve traffic.
- Builds understanding on how to manage traffic of the future.



Source: FHWA.

CARMA COLLABORATIVE

The CARMA Collaborative community will transform transportation, improving efficiency and safety through automated vehicles working together.

© 2017 Pexel Images Pixabay.

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Approach

- **Introduce** industry to cooperative automation.
- **Create a community** of CARMA users and prospective users.
- **Advance understanding** of cooperative automation and the impacts it can have on mobility.
- **Facilitate active engagement**, interaction, and discussion on the use of CARMA.
- **Accelerate market readiness** of CARMA and adoption of cooperative and automated technologies.

CARMA 3 Software

Software

- Reusable and extensible vehicle platform that can be used with multiple vehicle.
- First open source research platform that implements V2X and cooperative behaviors.
- Behaviors are controlled by plugins that can be contributed by users.

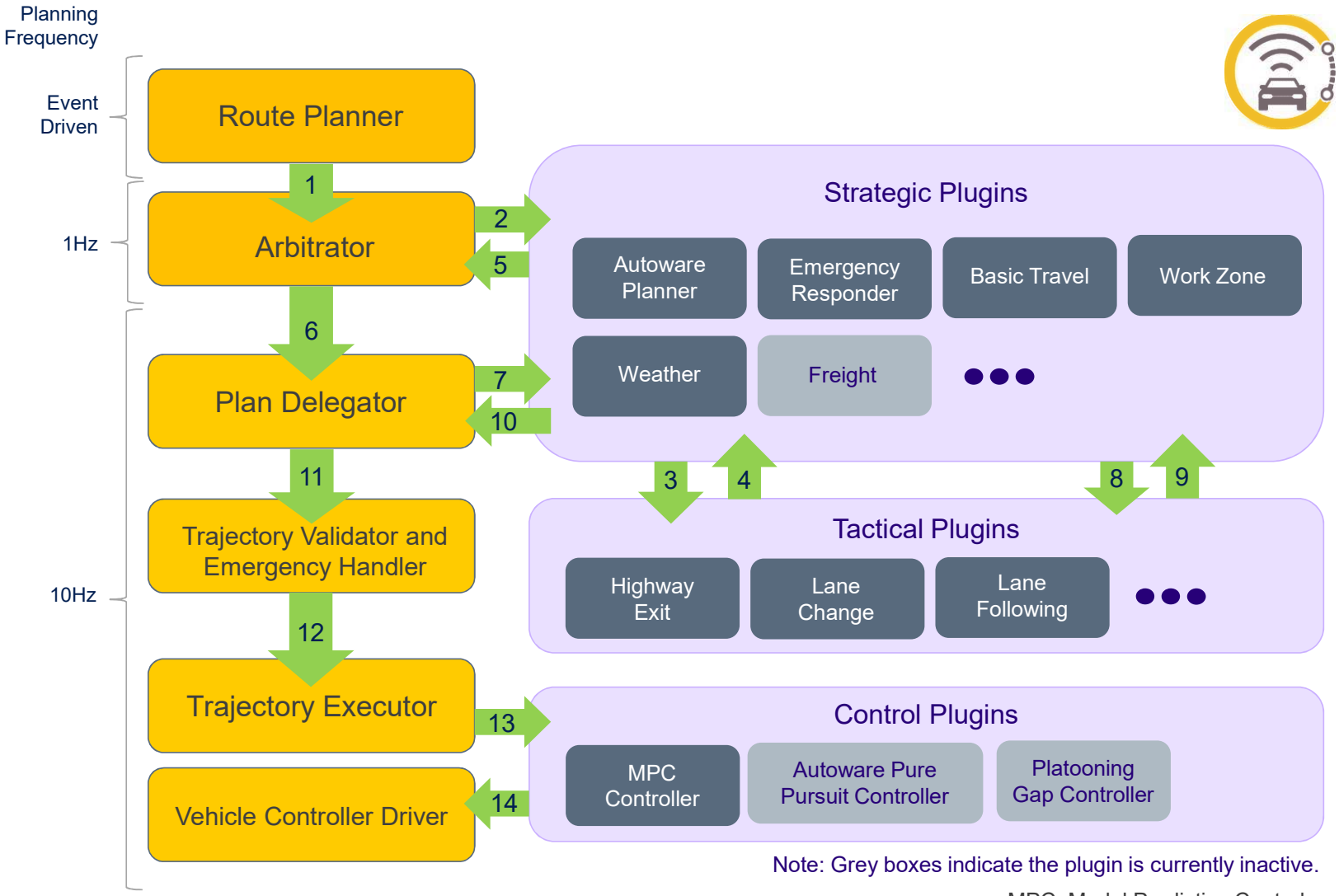
Vehicle Behavior Planning Process

Route	Maneuver	Trajectory	Command
Defines the mission. Ex: A → B	Defines behaviors. Ex: 30 seconds	Defines precise path. Ex: 5 seconds	Defines motion. Ex: 0.1 second

- Negotiation may occur during maneuver planning, if needed.
- Driving mode selection allows user preferences to be specified.

CARMA Planning

- Route.
- Maneuver.
- Trajectory.
- Command.



Note: Grey boxes indicate the plugin is currently inactive.

MPC: Model Predictive Control.

Source: FHWA

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CARMA 3 Implementing Into Research

Implementing Into Research

Vehicle Research: CARMA Platform capabilities are being developed for vehicles modified to support Automated Driving Systems (ADS) needs.

- Obtain a CARMA Kit to modify vehicles.

Simulation Research: Capabilities are being created and will be available in the future.

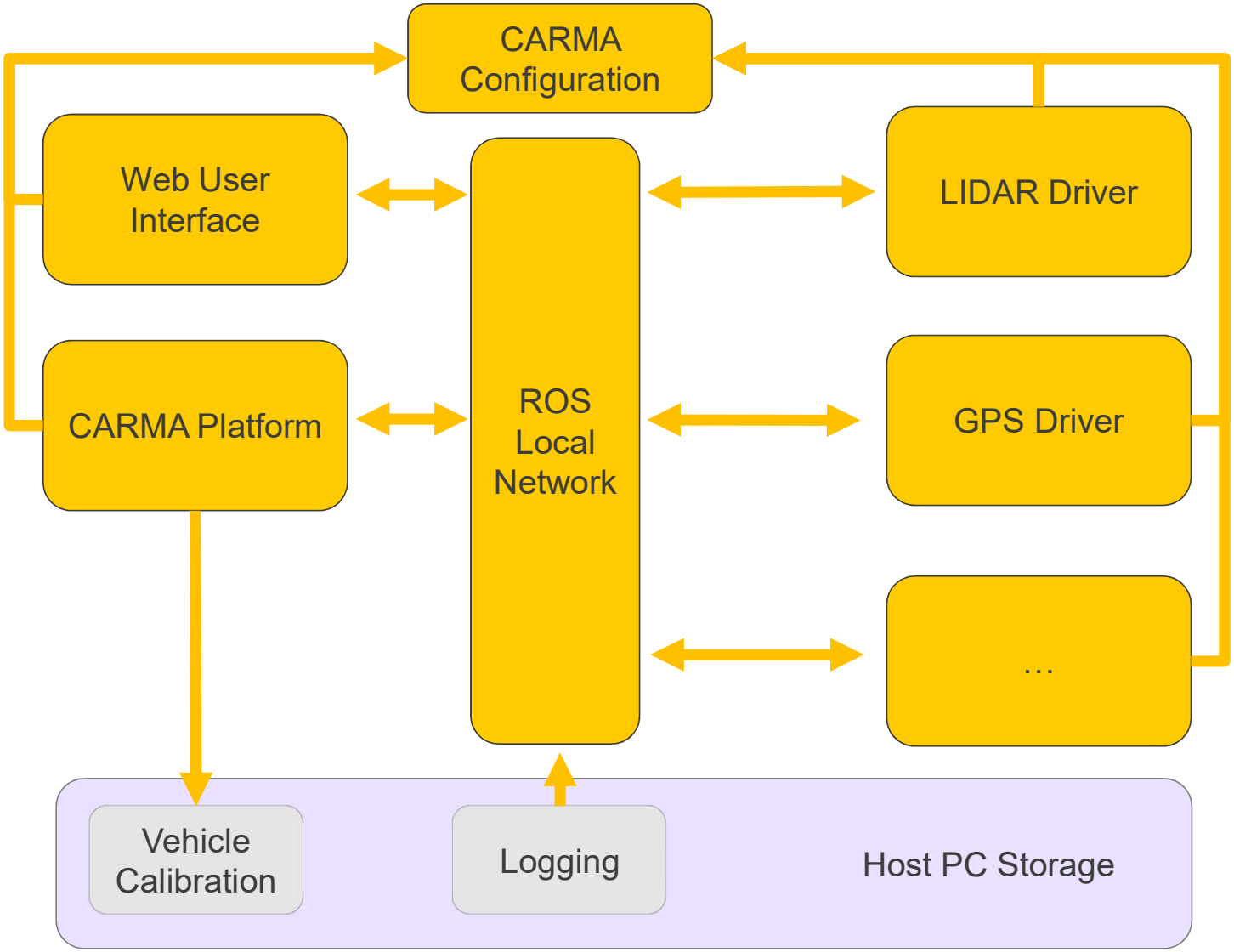
- Download and install complete deployments on your vehicle or simulation platform. Available on Docker Hub.
- Build or find desired plugins to define the behaviors you want to study. Install along with the core components.
- Set up a Transportation Management Center (TMC)-like emulation for interacting with CARMA vehicles on the CARMA Cloud.

Source: FHWA

CARMA Deployment

- Docker
- Vehicle Configurations
- Vehicle Calibrations

- Docker Image
- PC Storage
- Shared Memory (Docker Volume)



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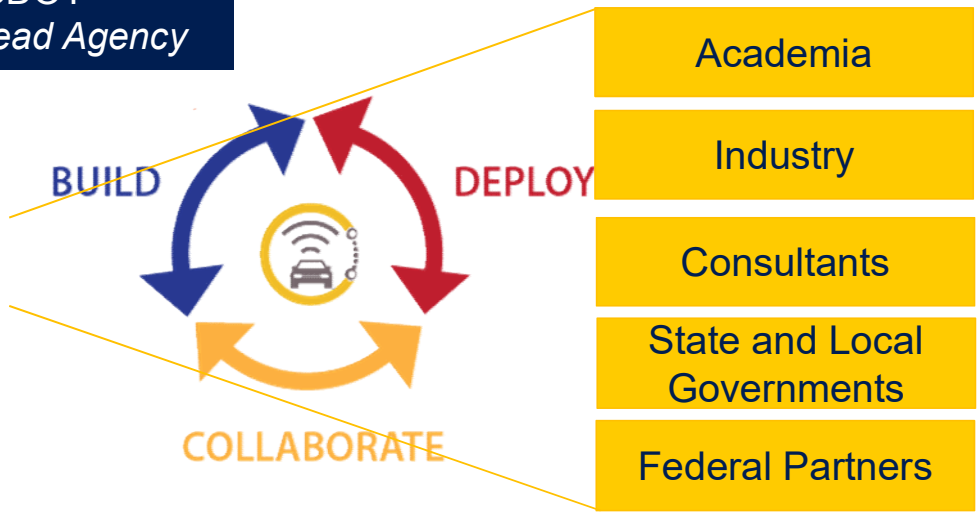
CARMA℠ Resources

Open Source Collaboration Vision

Advance cooperative automation research.

USDOT
FHWA Lead Agency



Approach

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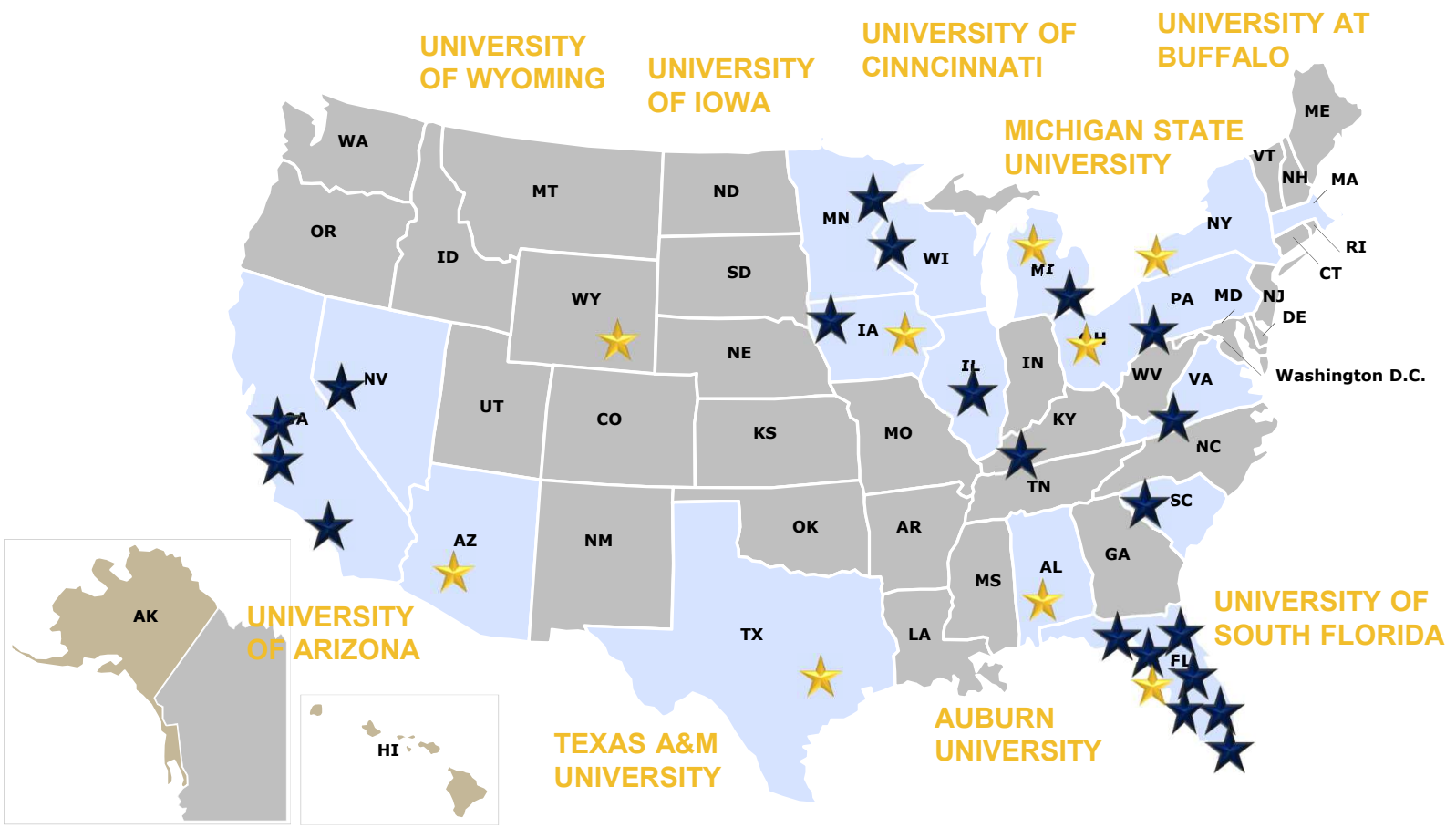
CARMA℠ COMMITTED ACADEMIC PARTNERS



Source: FHWA.

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Potential: 16 States – 27 Universities – 1 Canadian University

ENGAGING PARTNERS

- University of California, Riverside
- Clemson University
- Carnegie Mellon University
- Florida A&M University
- Florida State University
- Florida Atlantic University
- Florida Polytechnic University
- Florida International University
- Iowa State University
- University of Central Florida
- University of Florida
- University of Minnesota
- University of North Florida
- University of Wisconsin-Madison
- Virginia Tech
- Western Kentucky University
- University of Nevada, Reno
- University of Michigan
- Berkeley-University of California
- Stanford University
- Illinois State
- University of Waterloo

CARMA Support Services

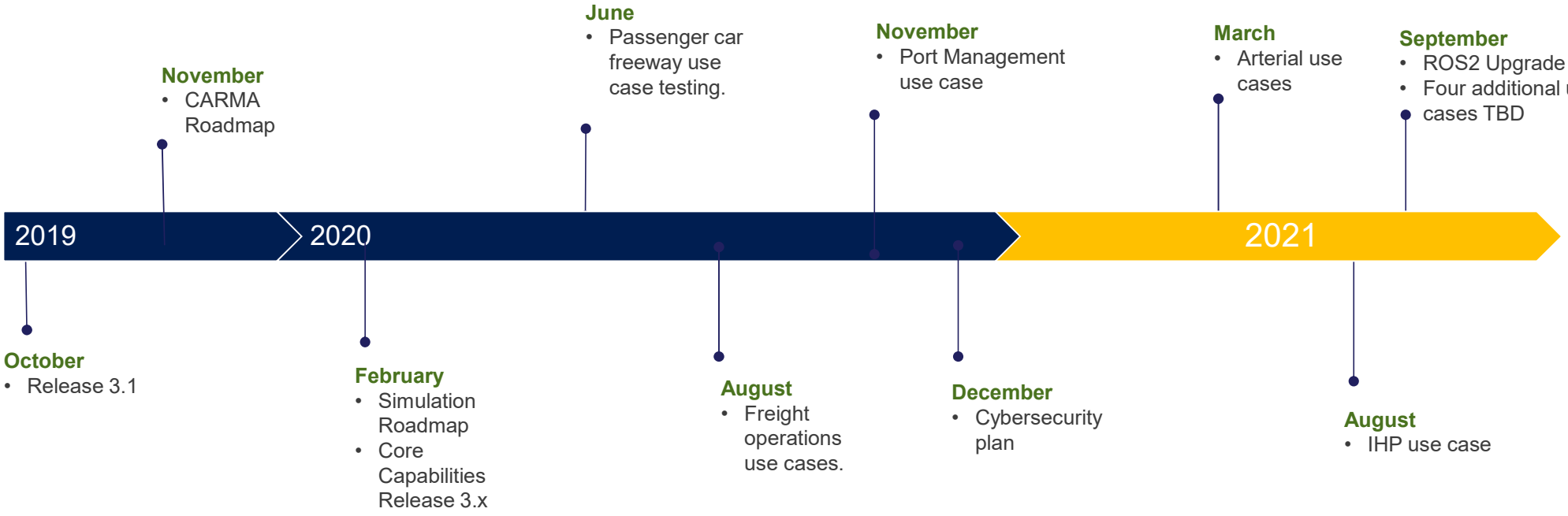
Available to support CARMA researchers implementing CARMA products.

Contact Us

CARMAsupport@dot.gov

Open 8 a.m.–5 p.m. EST
Monday–Friday
(excluding any holidays)

Upcoming Milestones



More Information

- **FHWA Site** – https://highways.dot.gov/research/research-programs/operations/CARMA
- **GitHub Site –** https://github.com/usdot-fhwa-stol
- **Confluence Site –** https://usdot-carma.atlassian.net/wiki/spaces/CAR/overview
- **Jira Site –** https://usdot-carma.atlassian.net/secure/Dashboard.jspa

Icon source: FHWA.

Questions

CARMA℠

Contact us!

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Source: FHWA