Source: FHWA.

CARMA Webinar Series

The CARMA℠ Products Usable in Your Research

June 4, 2020

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?
- How can Cooperative Driving Automation (CDA) help?
- CARMA Feature Groups.
- CARMA Ecosystem Overview:
  - Use cases.
  - Product releases.
  - How CARMA Support Services can help you get started.
- CARMA Roadmap and Release Plan.
- Questions and Answers.

U.S. Department of Transportation
Federal Highway Administration

Webinar Series

Links provided in the chat pod.

- Transforming the Transportation Industry with Cooperative Automation Research Mobility Applications
- CARMA and Transportation Systems Management and Operations (TSMO) Use Cases
- How To Get Started With CARMA And Become a Leader in Cooperative Driving Automation Research
- Creating a ConOps for CAV Freeway Applications

4

Poll Questions #1 — #3

CARMA Overview

What is CARMA℠?

The United States Department of Transportation (USDOT)'s **open source** platform for the research and development of **Cooperative Driving Automation (CDA).**

SAE INTERNATIONAL
J3216
https://www.sae.org/standards/content/j3216/

Cooperative Driving Automation:
CDA enables machine-to-machine (M2M) interactions with each other, other connected roadway users, and infrastructure to increase safety, reduce congestion, and improve mobility.

Source: FHWA.

Where is CARMA SM Going?

CARMA[SM] is growing across modes, applications, and the country.

- Cooperative capabilities features developed under CARMA:
  - Status-sharing.
  - Intent-sharing.
  - Agreement-seeking.
  - Perspective.

- System wide solutions.

USDOT Multimodal Partners:

- Federal Highway Administration.
- Federal Motor Carrier Safety Administration.
- Maritime Administration.
- Intelligent Transportation Systems Joint Program Office.
- Volpe National Transportation Systems Center.

Cooperative Driving Automation (CDA)

Understanding the Problem

The “Why”

Source: Andrei Stanescu, 117493771, iStock Editorial/Getty Images Plus

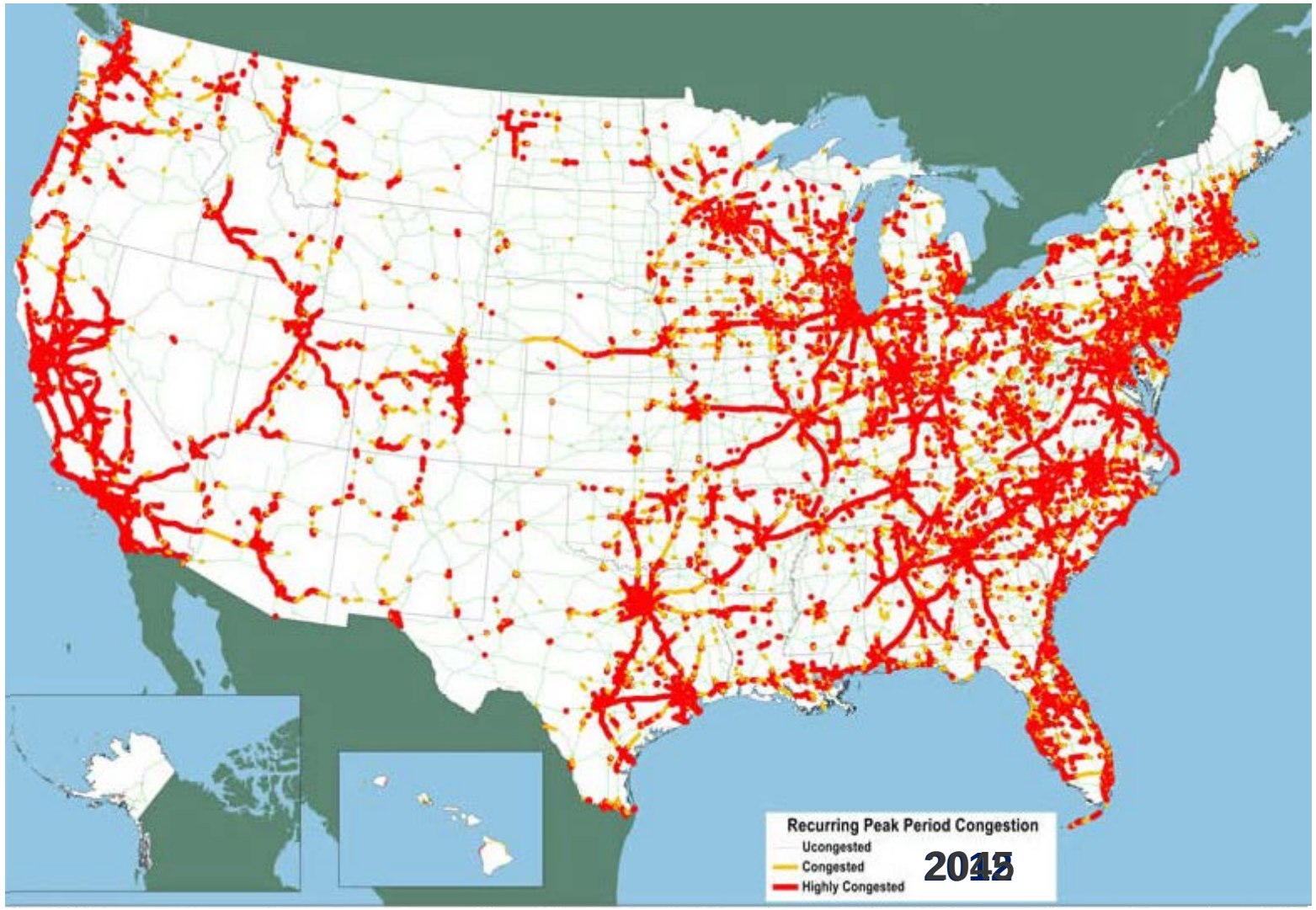
Traffic Congestion Statistics in the United States

2019
Mobility Report

In 2017, the Cost of Congestion increased to **$166 Billion**.

Wasted time increased to **8.8 billion hours** of extra travel time.

Wasted fuel equaled **3.3 billion gallons**.



Peak-Period Congestion on the National Highway System

Source: FHWA.

U.S. Department of Transportation
Federal Highway Administration

2017 Safety Statistics

6 million police-reported vehicle crashes.

Traffic fatalities totaled 37,000 with **2.7 million injuries.**

Loss of life and quality of life factors totaled **$800 billion**.

Source: Andrei Stanescu, 1184303495, iStock Editorial/Getty Images Plus

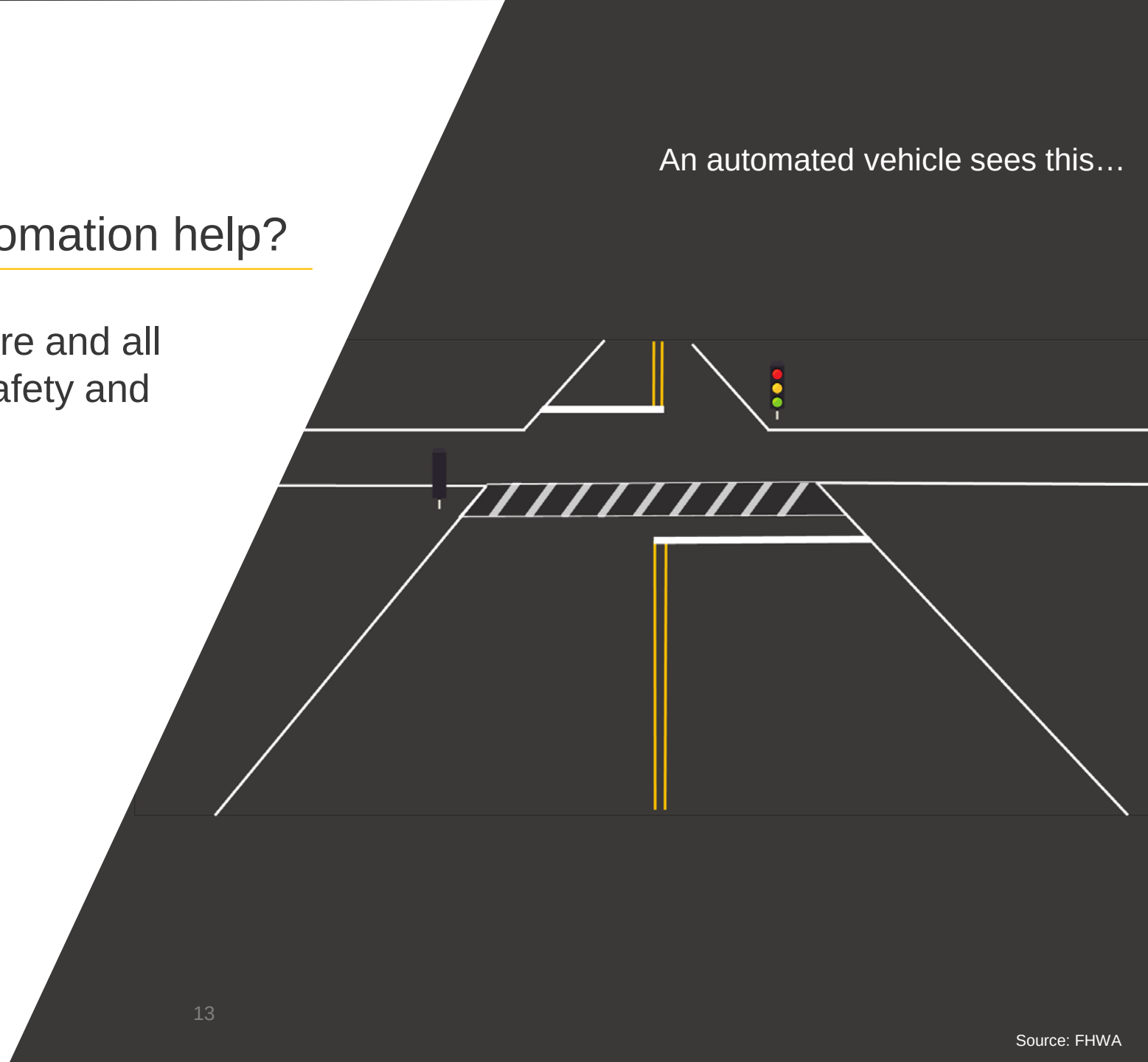
U.S. Department of Transportation
Federal Highway Administration

How can Cooperative Driving Automation help?

Leverages information from infrastructure and all connected roadway users to improve safety and mobility.

For example:

- Enhanced sensing.
- Intersection optimization.
- Congestion mitigation:
  - Work zones.
  - Traffic incidents.
  - Weather.



Source: FHWA

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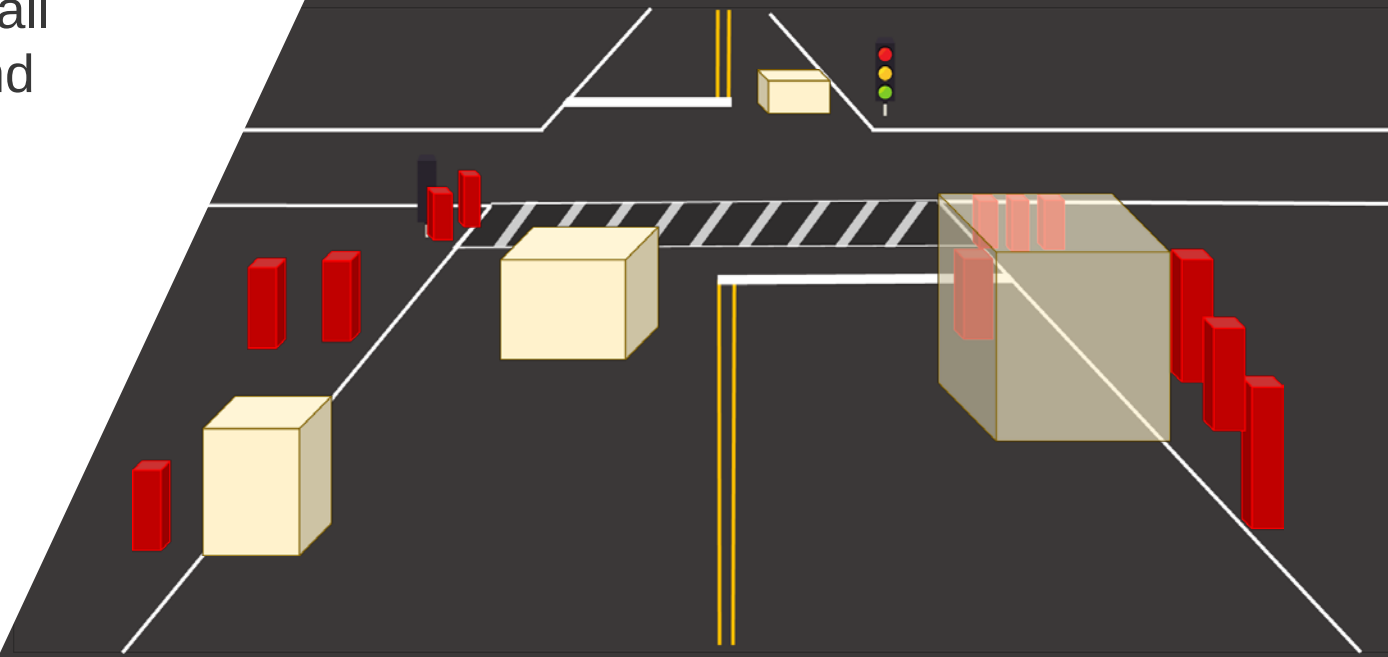

Source: FHWA

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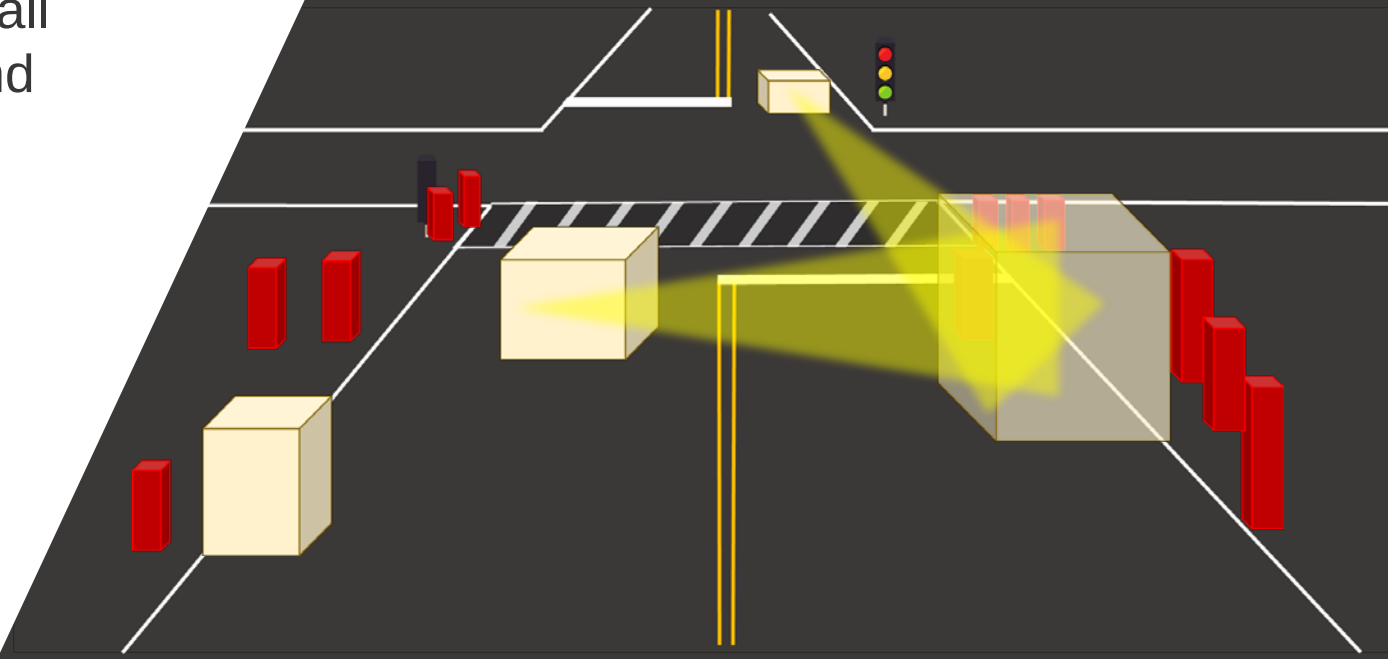

Source: FHWA

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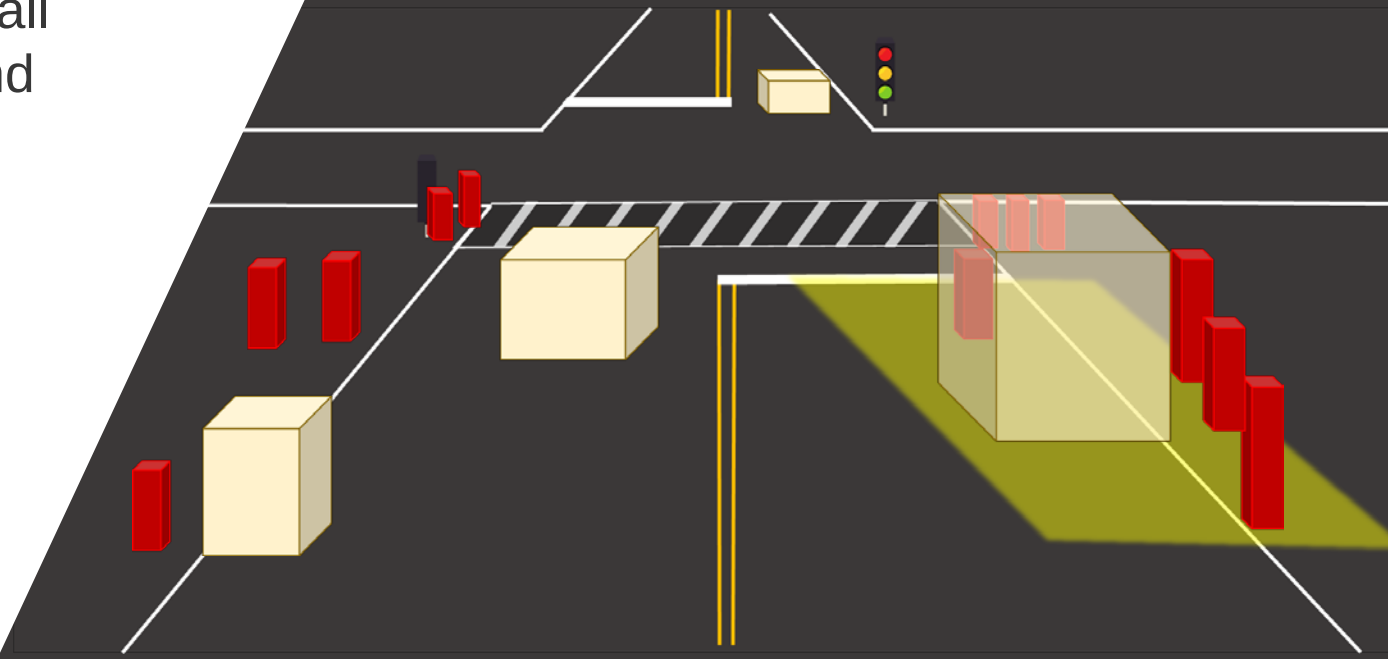
Public transit vehicles could participate in CDA through shared perception.



Source: FHWA

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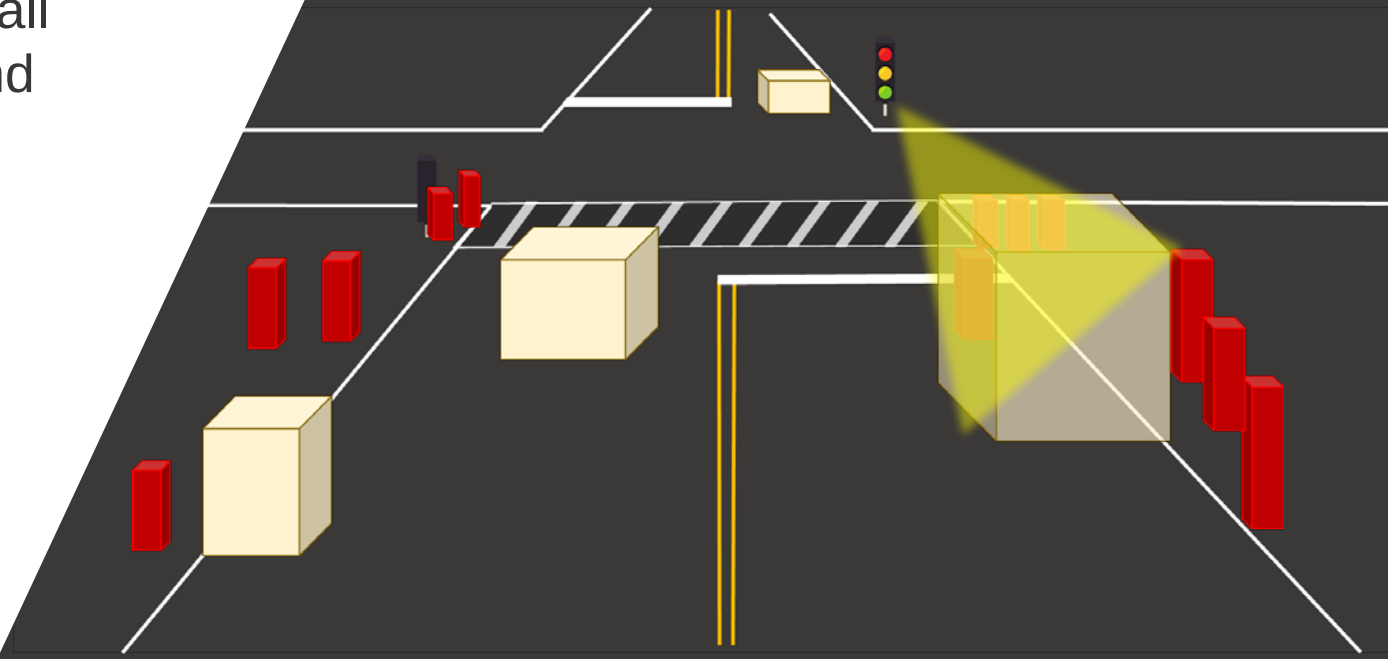
What about infrastructure?



Source: FHWA

Questions?

CARMA SM Feature Groups

CARMA Feature Groups

4 Systems | 20 Feature Groups | 72 Features

PLATFORM

Automated Driving System (ADS):
- 6 Feature Groups
- 22 Features

Cooperative Driving Automation (CDA):
- 8 Feature Groups
- 29 Features

MESSENGER

- 3 Feature Groups
- 9 Features

Coming Soon

CLOUD

- 2 Feature Groups
- 9 Features

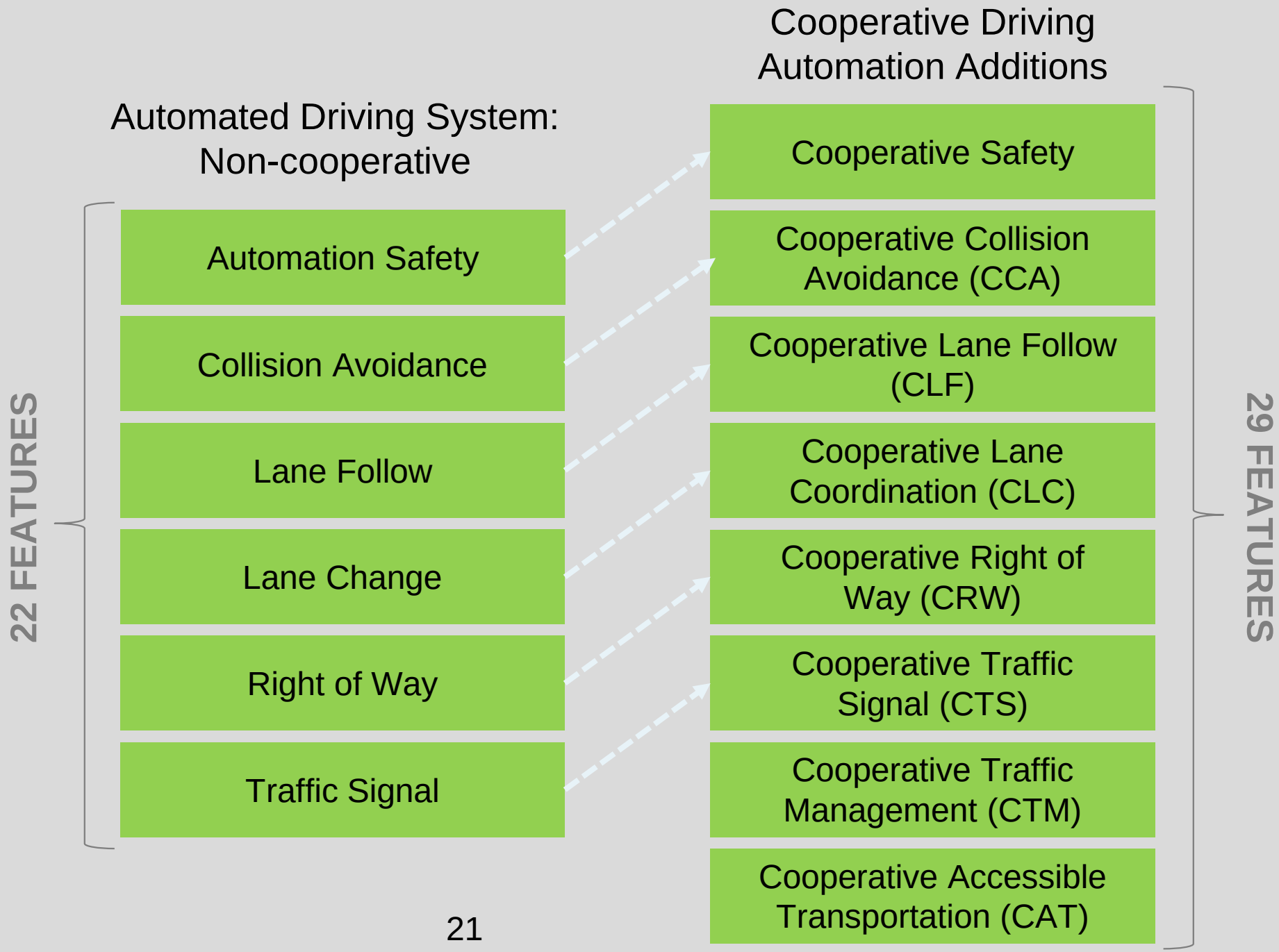
STREETS

- 1 Feature Group
- 3 Features

Coming Soon

HUB

Feature Groups

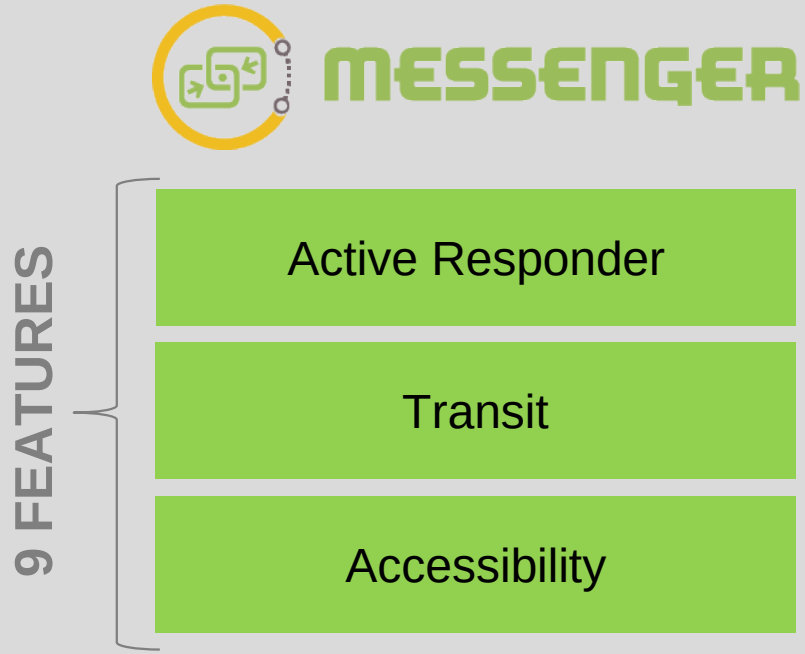


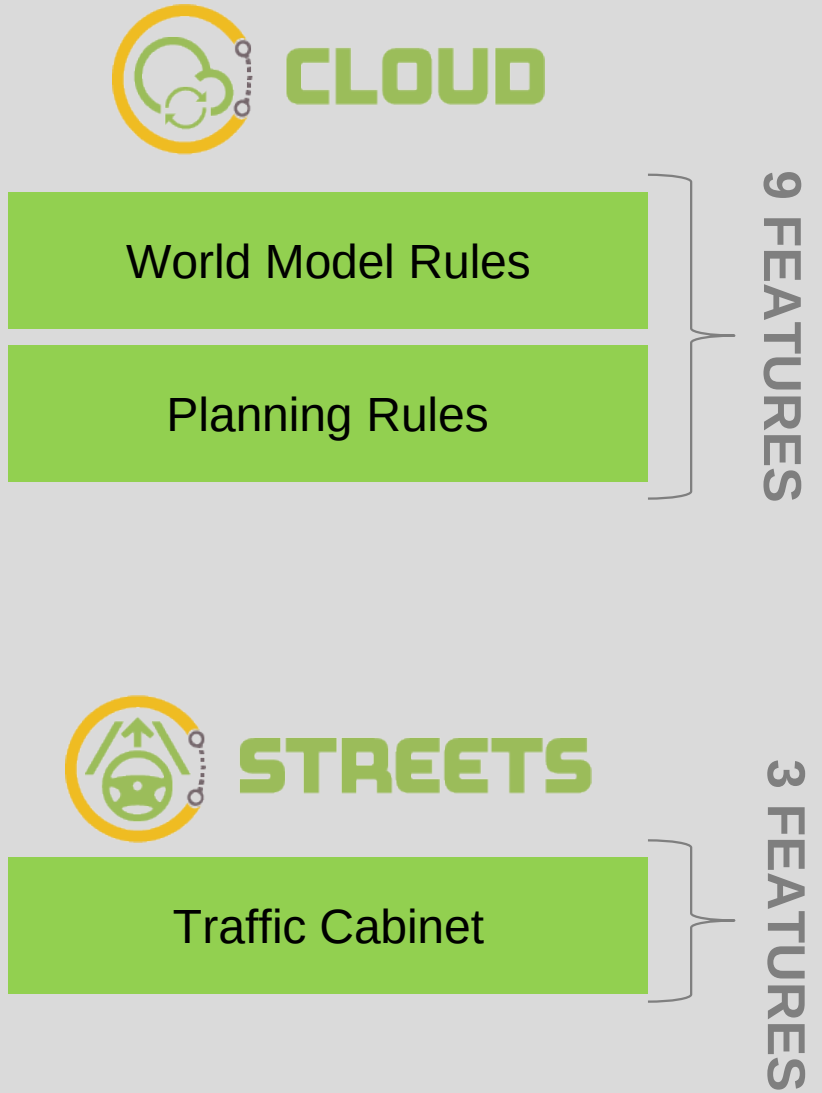
Feature Groups

Example

CARMA Platform Features for IHP2 Project	
Cooperative Lane Follow (CLF)	CACC (Strings)
	Platooning (Groups)
Cooperative Lane Coordination (CLC)	Cooperative Lane Change
	Cooperative Merge
	Cooperative Weave
Cooperative Traffic Management (CTM)	Speed Control
	Gap Control
	Lane Assignment
	Queue Management

Feature Groups

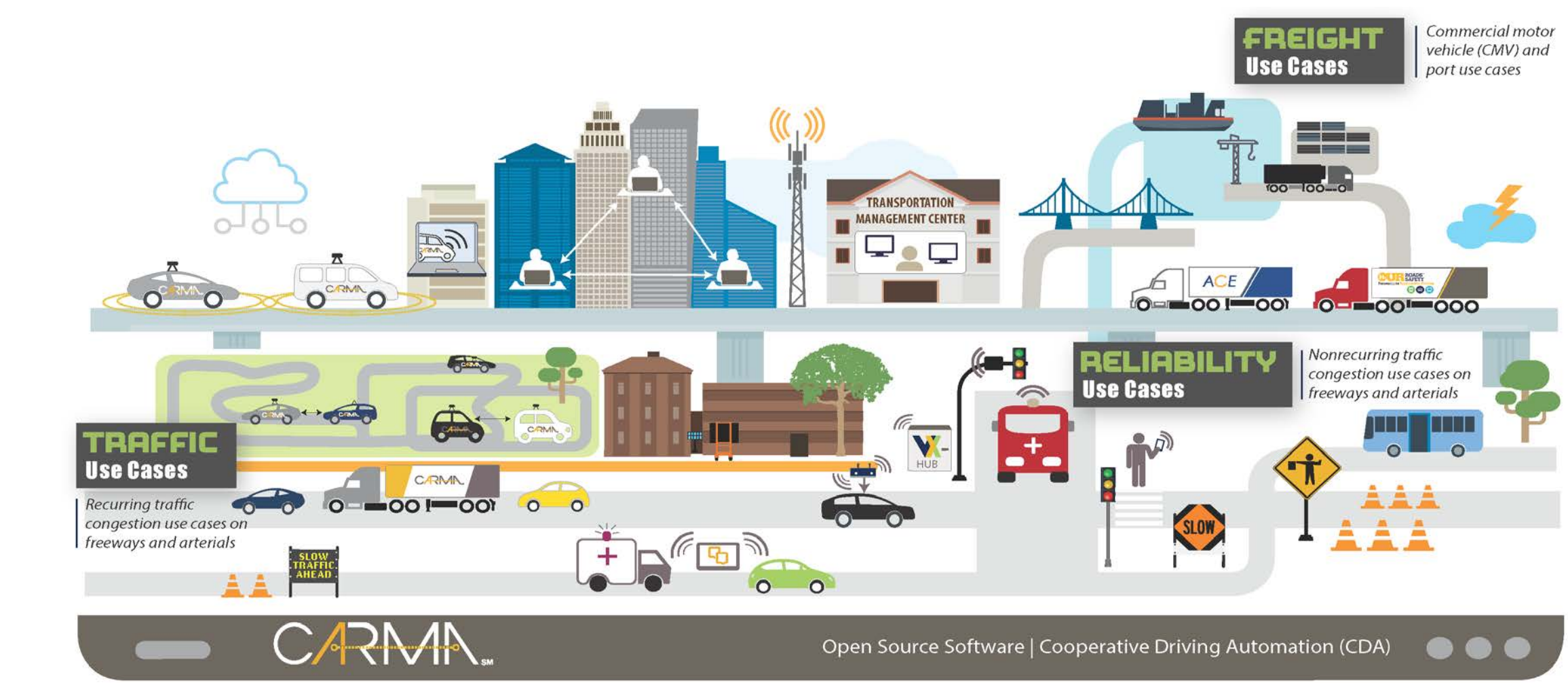




CARMA Ecosystem

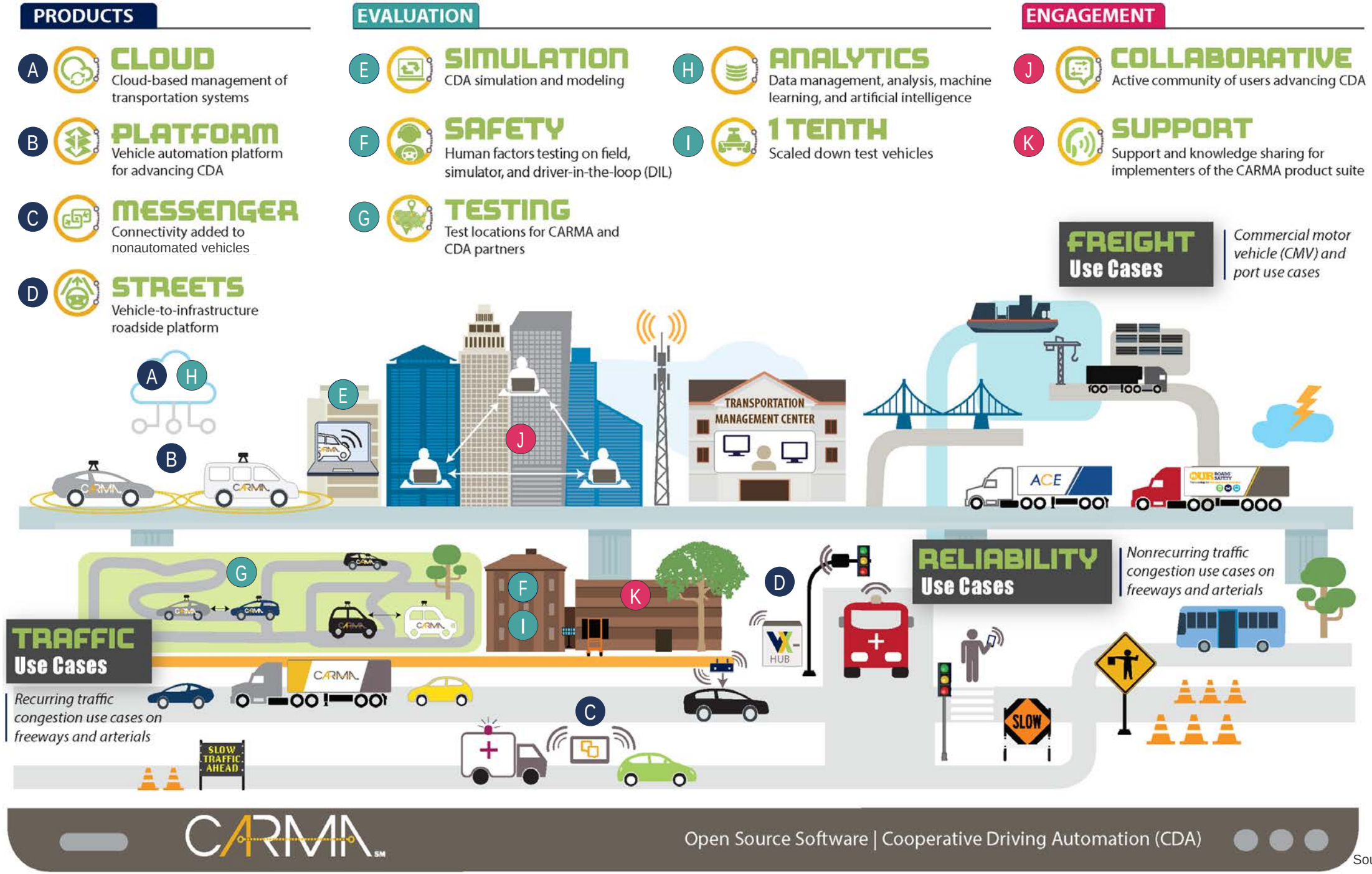
CARMA[SM] Ecosystem

A network of open source software and support services focusing on how infrastructure can move traffic more efficiently by advancing transportation systems management and operations (TSMO) strategies.



Source: FHWA.

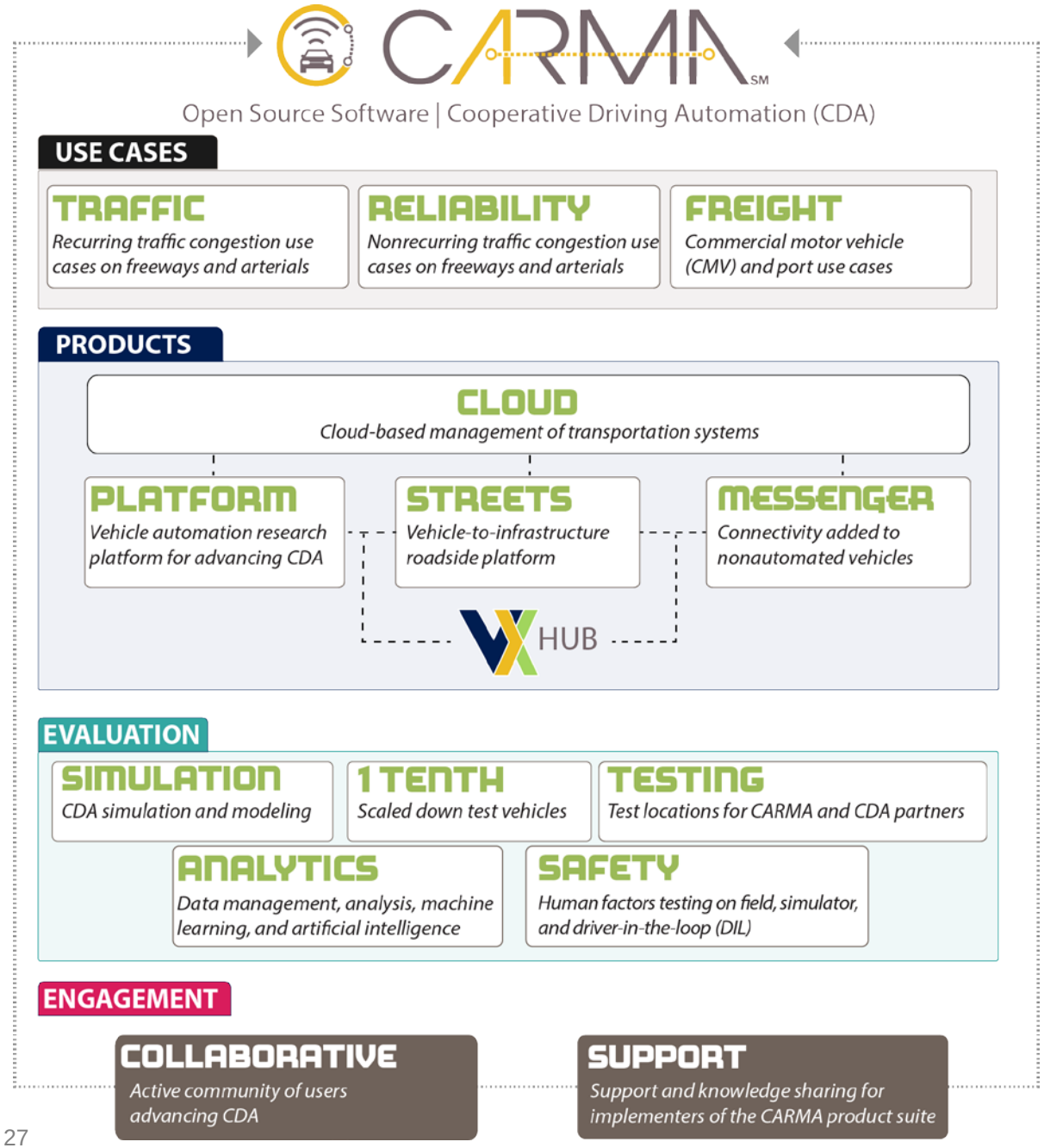
CARMA℠ Ecosystem



Source: FHWA.

Suite of Tools

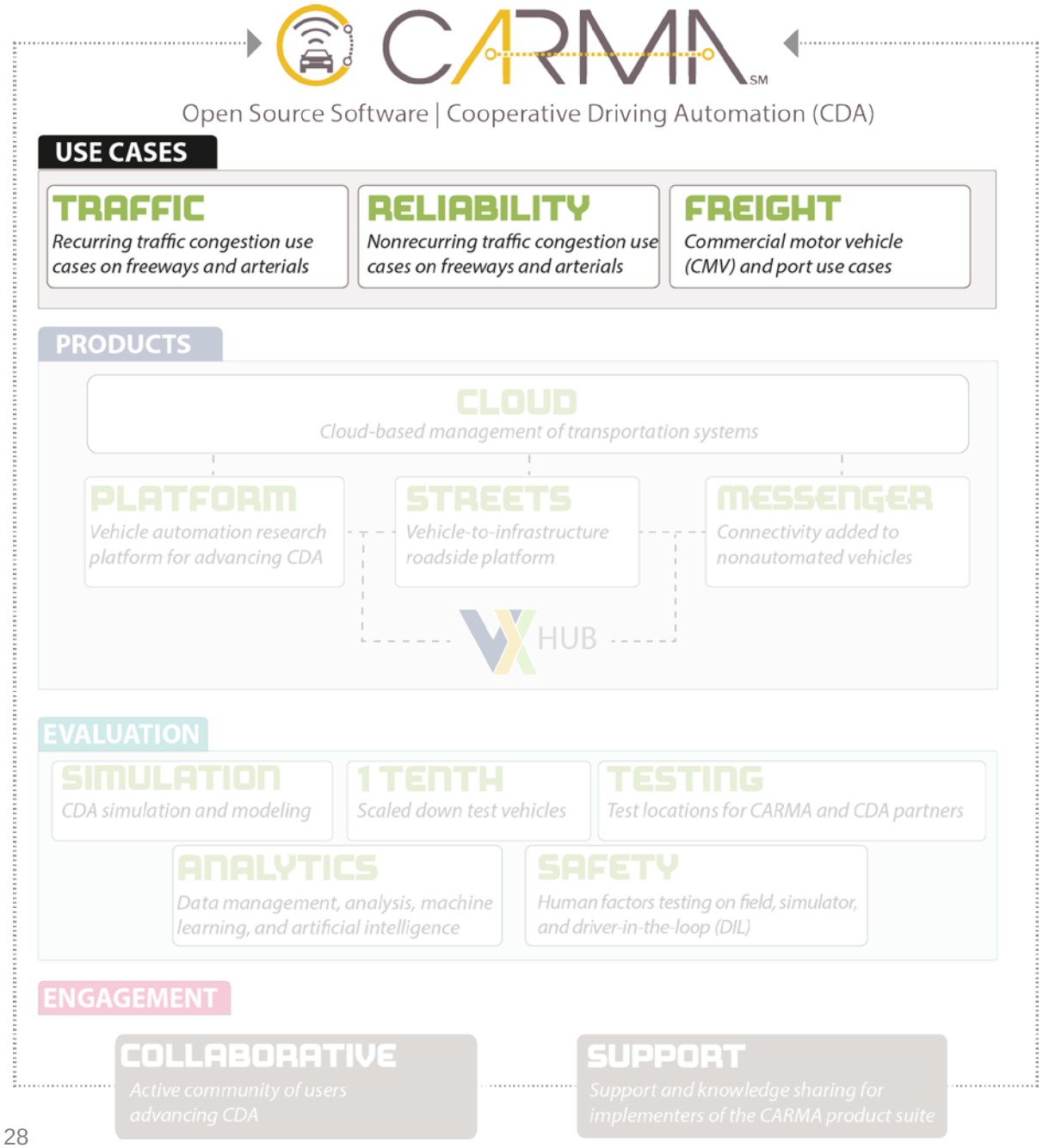
CARMA comprises a full suite of use cases, products, evaluation methods, and engagement strategies supporting the testing and evaluation of CDA concepts.



Source: FHWA.

Use Cases

Aims to encourage stakeholder collaboration and accelerate the deployment of CDA technology. Scenarios will explore traffic, reliability, and freight operations.



Source: FHWA.

CARMA Ecosystem: Use Cases

Recurring traffic congestion use cases on freeways and arterials.

- Congestion
- Transit
- Traffic Signals

Nonrecurring traffic congestion use cases on freeways and arterials.

- Work Zones
- Weather
- Traffic Incident Management (TIM)

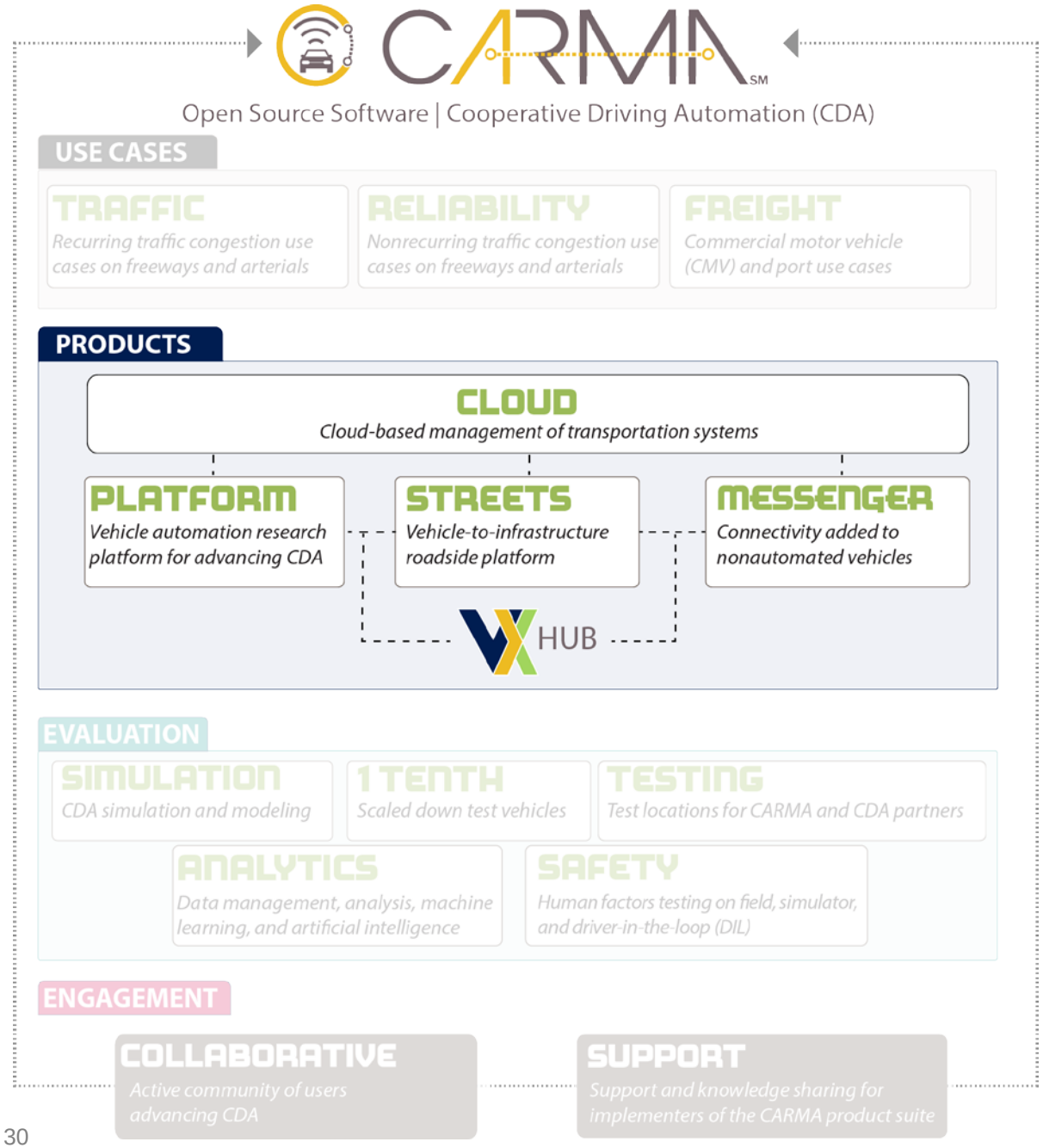
Commercial Motor Vehicle (CMV) and port use cases.

- Port Drayage
- Commercial Motor Vehicles (CMV)
- Truck Platooning

Source: FHWA.

Products

A suite of open source software to enable automated vehicles to improve transportation mobility, efficiency, and safety.

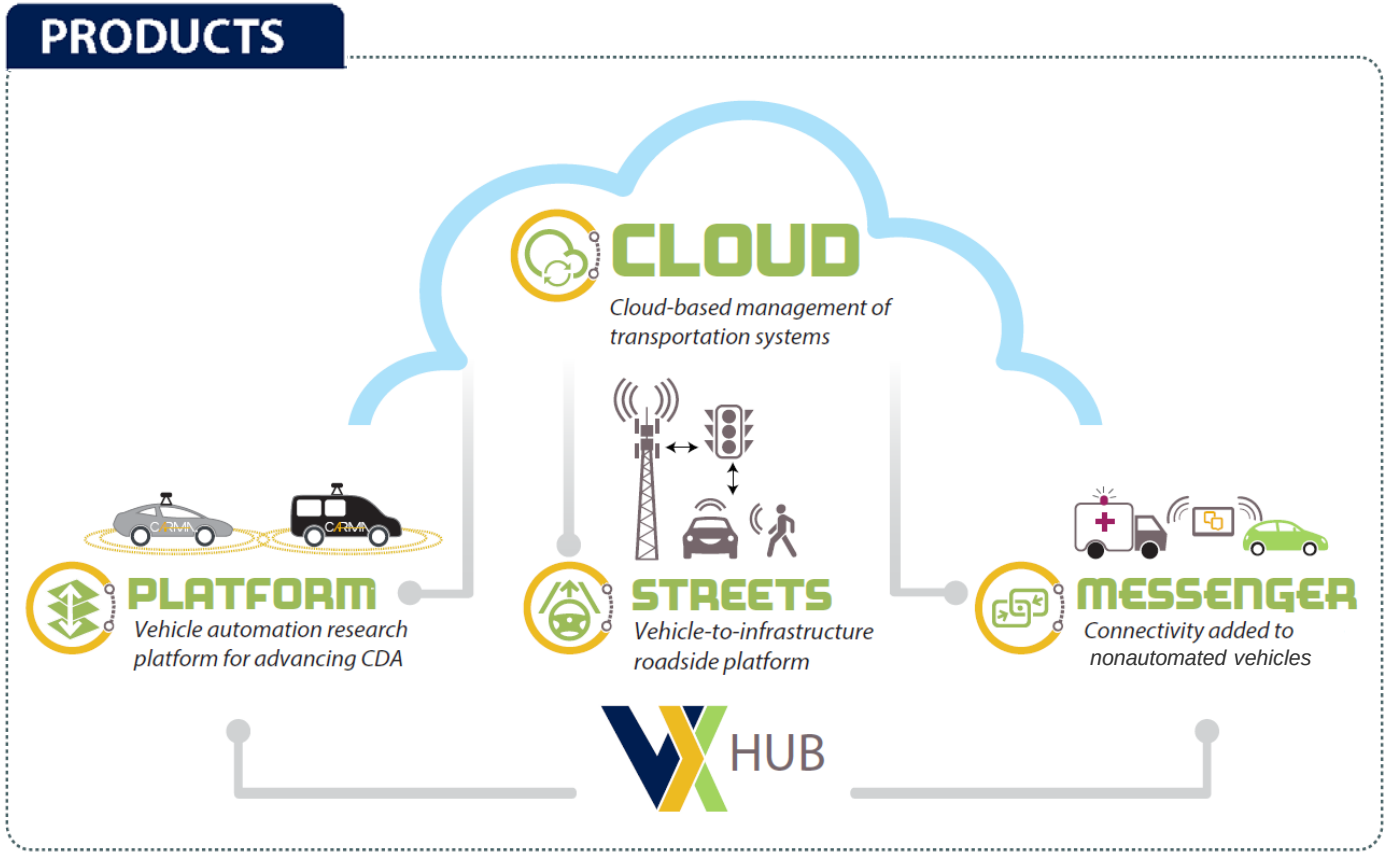


Source: FHWA.

CARMA CLOUD

- Provides cloud-based management of transportation systems and bi-directional communication, data exchange, and management of multiple remote vehicles simultaneously.

  Coming soon to GitHub.



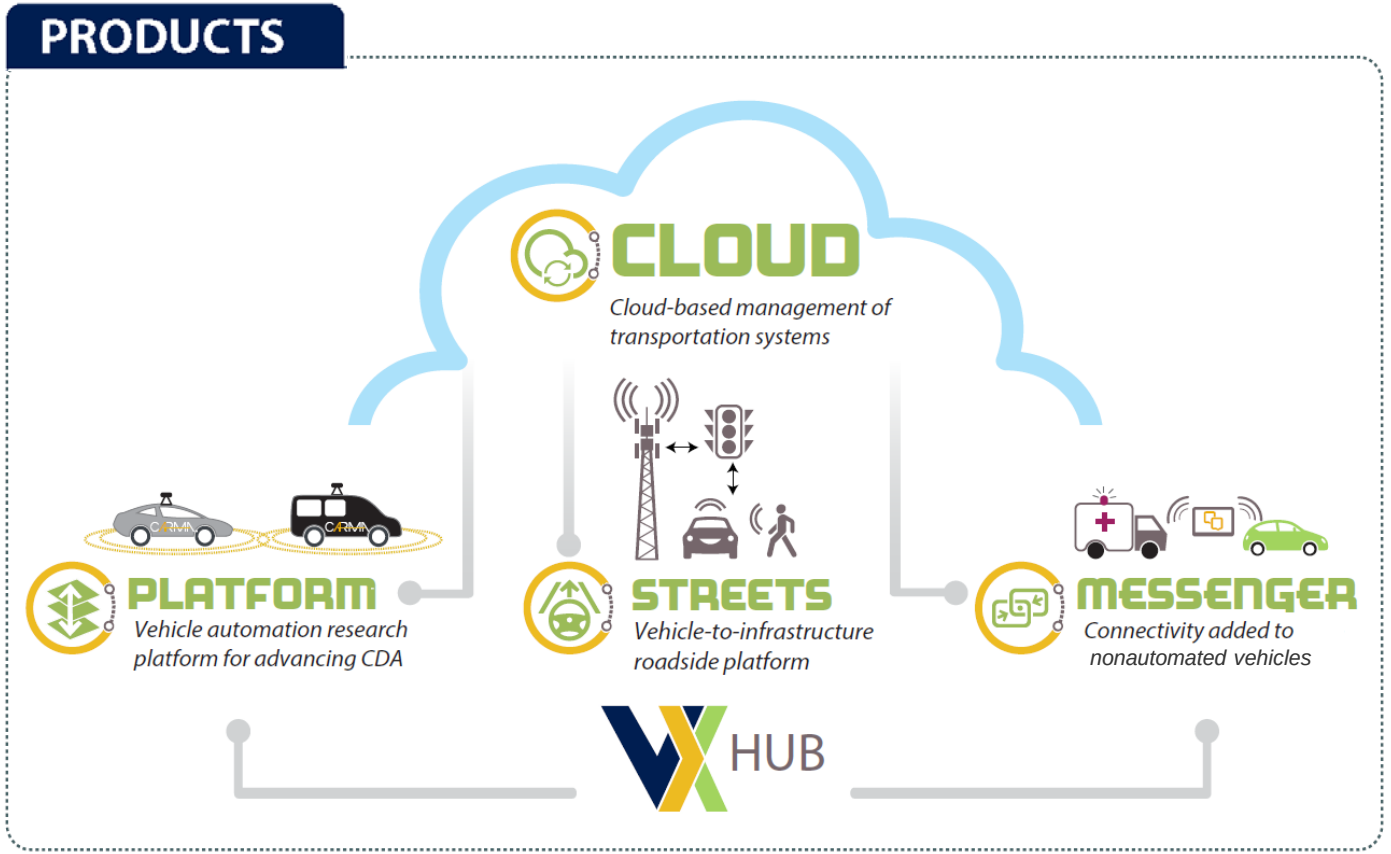
Source: FHWA.

SM

CARMA SM PLATFORM

- A vehicle-based platform for automated vehicles to share information and intent with other vehicles and infrastructure to enable cooperative actions that improve transportation operations and safety.

Available on GitHub now.

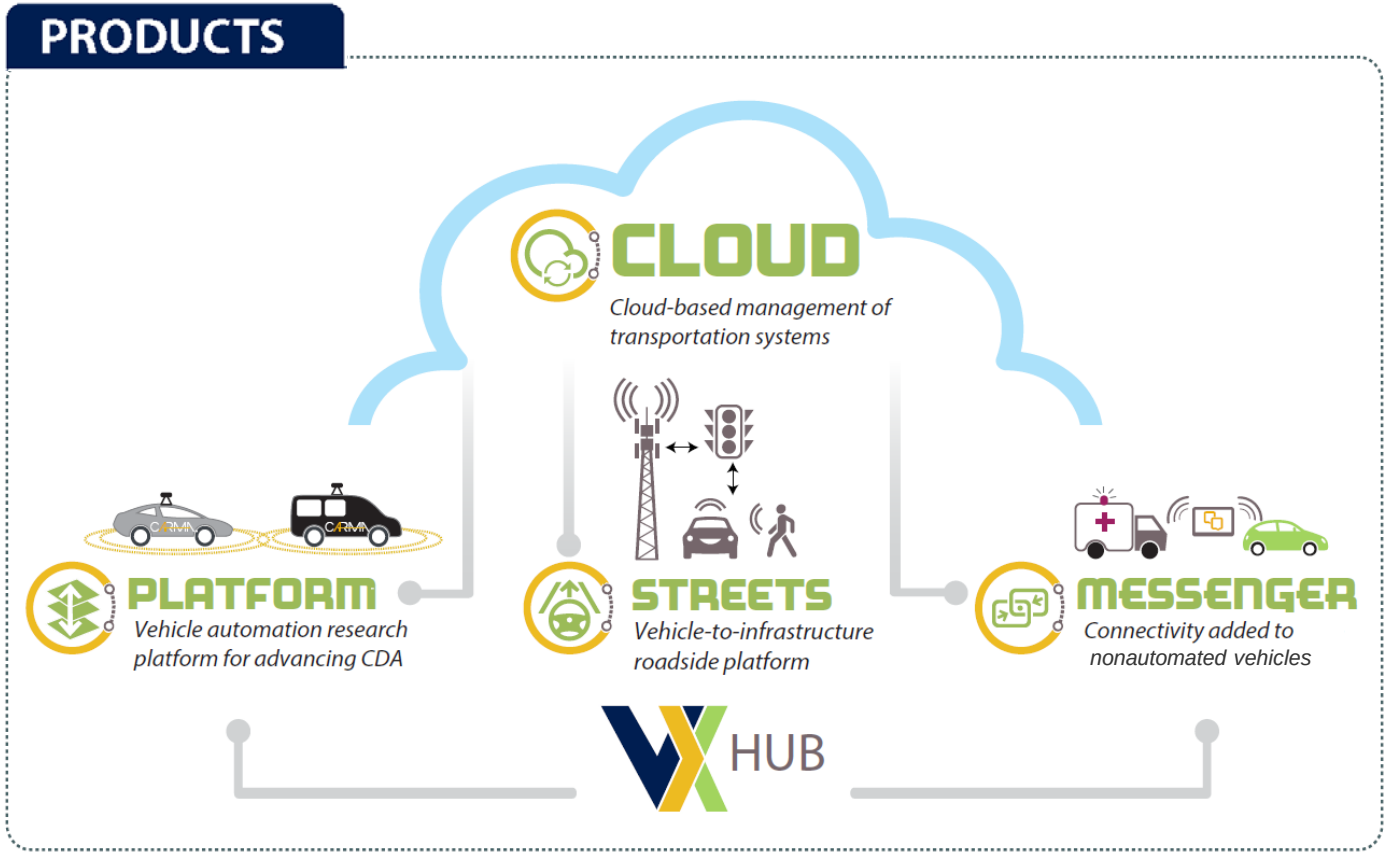


Source: FHWA.

CARMA STREETS SM

- An infrastructure-based platform for cooperative traffic control and edge computing capability to enable cooperative perception that improve transportation operations and safety.

Coming soon to GitHub.

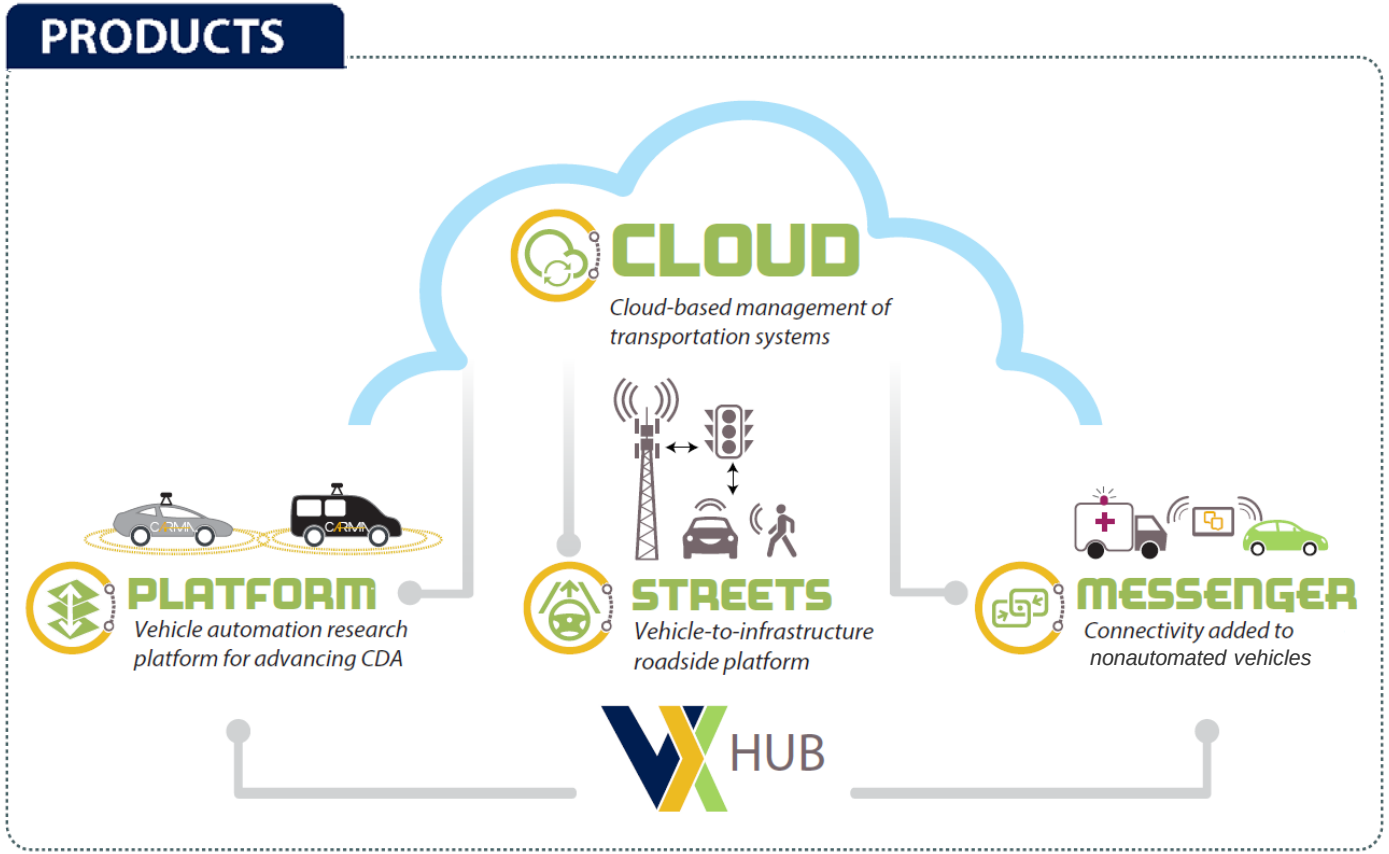


Source: FHWA.

CARMA MESSENGER

- A vehicle-based platform for manual vehicles to enable communication and cooperation with automated vehicles.

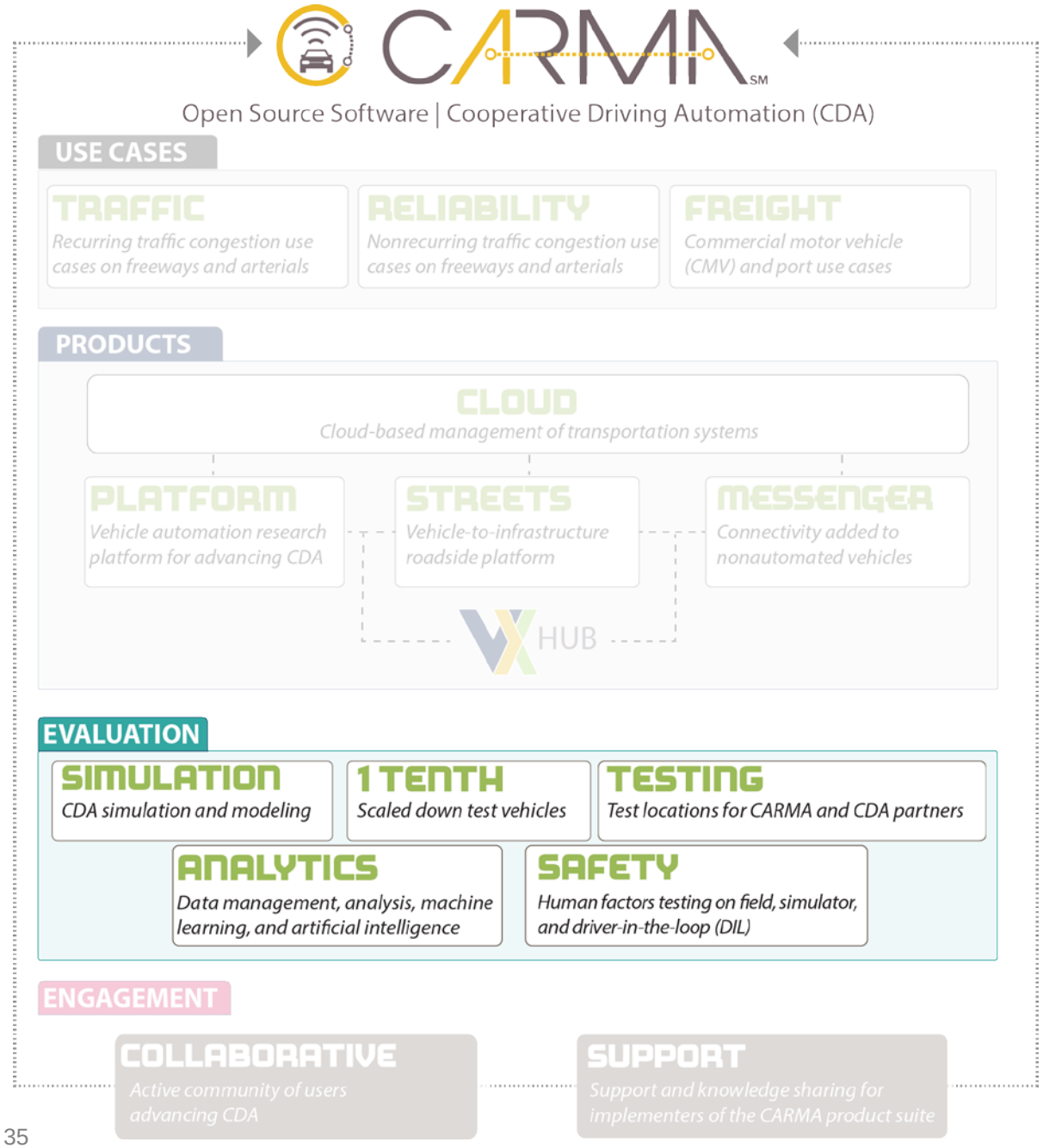
Coming soon to GitHub.



Source: FHWA.

Evaluation

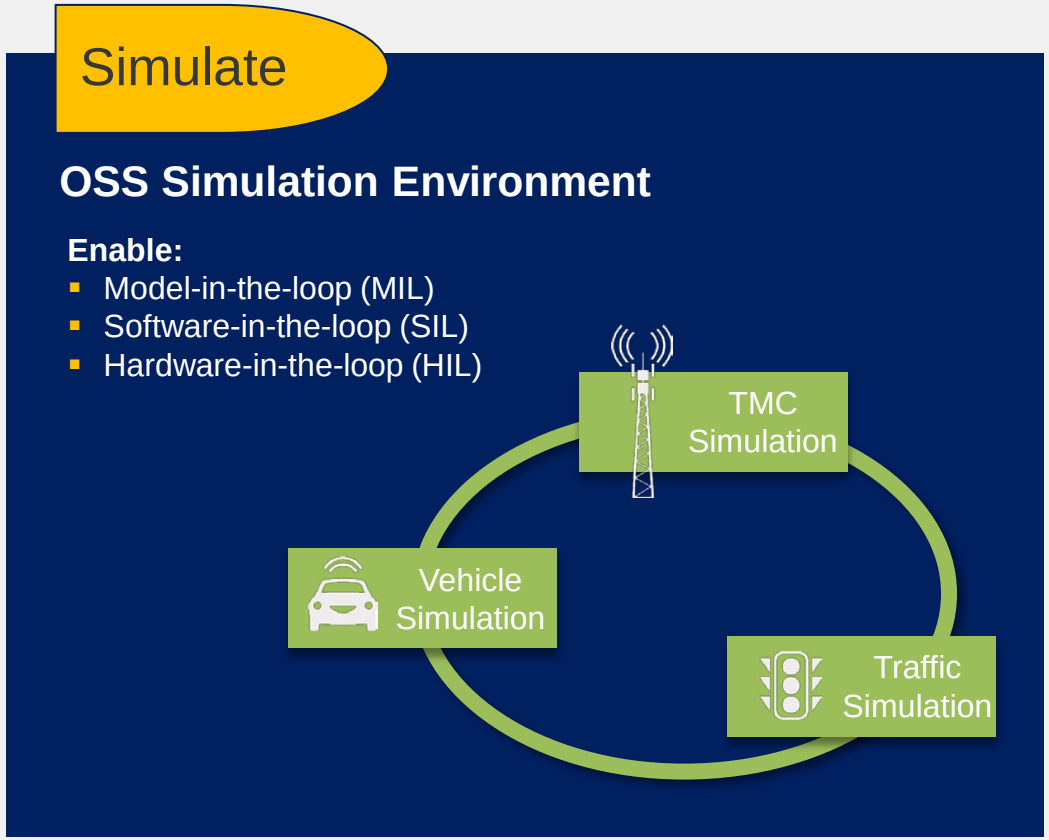
The CARMA Program utilizes several methods for evaluating CDA technology.



Source: FHWA.

CARMA Simulation

- OSS simulation environment being built on CARLA and SUMO.
- CARMA is building MIL, HIL, SIL, capabilities.
- Working with CARMA Cloud, this will enable TMC simulation.
- CARMA and its collaborators are utilizing traffic and vehicle simulation platforms.



CARMA 1tenth

Coming Soon | Ask how you can work with us to develop CARMA 1tenth.

- Scaled down ADS cars with hardware for autonomous driving built by a community of ADS developers.
- Cost efficient ADS research with a customized platform to aid CDA development.
- Capability to engage a larger research community and enable faster learning of CDA research.

Source: FHWA

CARMA Testing

Research Vehicle Fleet

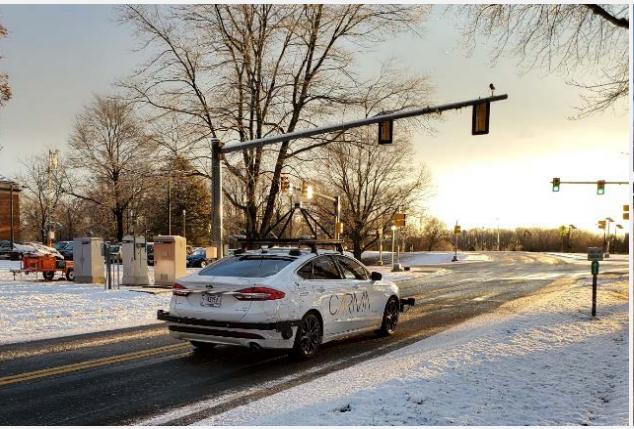
PLATFORM

Source: FHWA

MESSENGER

Testing Locations

- American Center for Mobility (ACM).
  Ypsilanti, MI
- DHS Federal Law Enforcement Training Center (FLETC).
  Cheltenham, MD
- Florida Department of Transportation (FDOT) SunTrax.
  Auburndale, FL
- Summit Point Raceway.
  Summit Point, WV
- Turner-Fairbank Highway Research Center (TFHRC).
  Mclean, VA
- U.S. Army Aberdeen Test Center (ATC).
  Aberdeen Proving Ground, MD




Source: FHWA

CARMA Analytics

- Data management plan and cloud-based platform to support the management, fusion, and analysis of cooperative, automated vehicle, and traditional transportation data.

Coming soon to GitHub.

Source: FHWA.

CARMA Safety

Highway Driving Simulator (HDS) and CARMA systems will be capable of testing:

- Automated Driving Systems (ADS).
- Cooperative ADS.
- Manual vehicles.

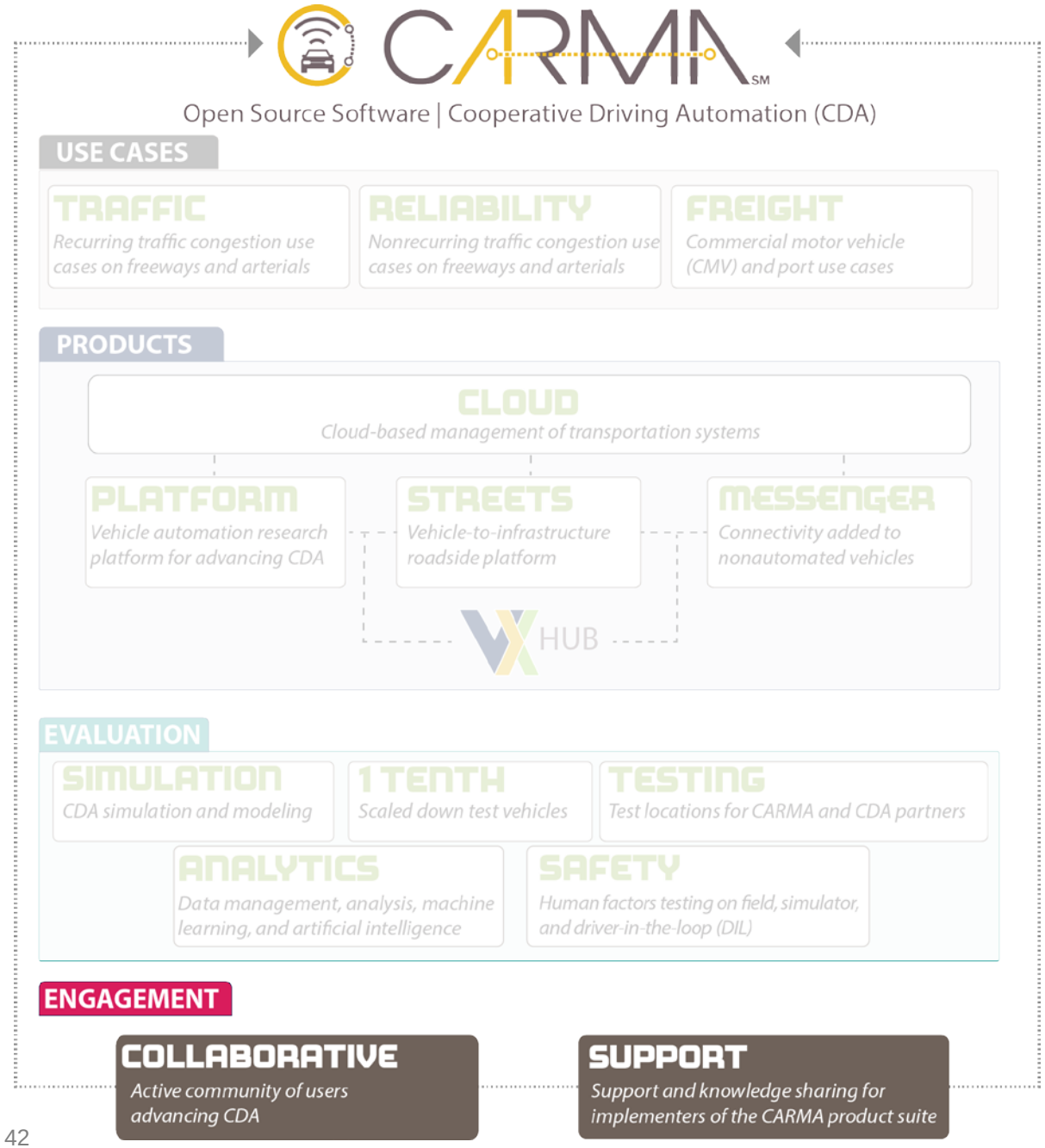
Human factors testing in the field and simulation through driver-in-the-loop.

Source: FHWA

Source: FHWA

Engagement

CARMA stakeholder engagement is encouraged through the Collaborative and Support services.



Source: FHWA.

CARMA COLLABORATIVE

A collaborative environment where the program works with academic institutions to conduct research and testing while providing an active community of users advancing CDA.

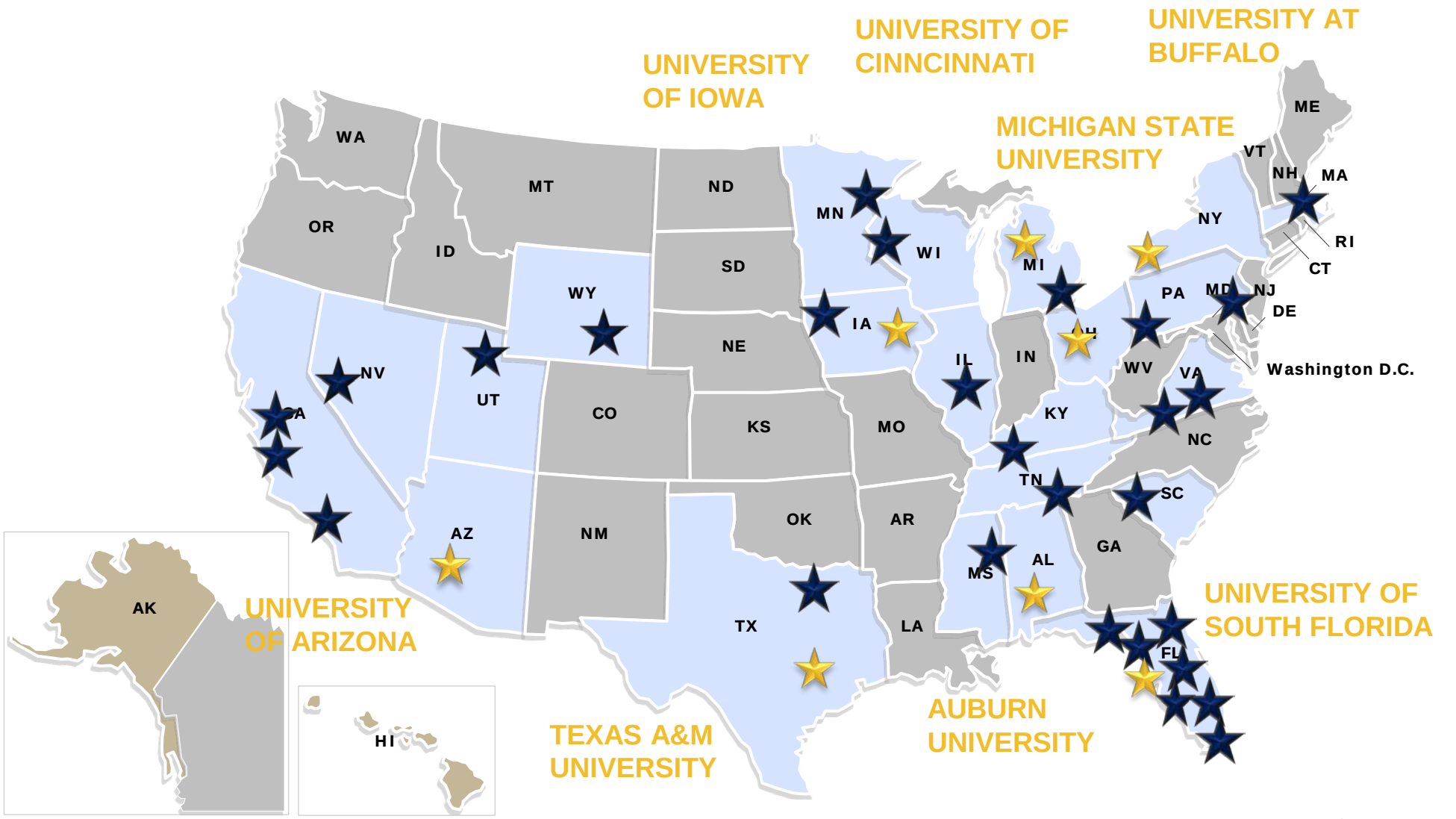
Develop dedicated technical work groups for:

- **Simulation** (CARLA, SUMO, OMNeT++).
- **Architecture** (CARMA Platform, Streets, Messenger, Cloud).
- **Features** (CDA Feature Groups).

Conduct outreach activities including:

- **Virtual engagements** (webinars, virtual conferences, online meetings).
- **Active engagements** (conferences, demonstrations, events, meetups).
- **Content** (website, publications, social media, multimedia).

COMMITTED ACADEMIC PARTNERS



Source: FHWA.

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
- University of Wyoming
- Massachusetts Institute of Technology
- University of Pennsylvania
- Mississippi State
- University of Virginia
- University of North Texas
- University of Utah
- The University of Tennessee at Chattanooga

U.S. Department of Transportation
Federal Highway Administration

Potential: 38 Universities in 22 States

CARMA Support Services

Questions about implementing CARMA into your research?

Source: FHWA

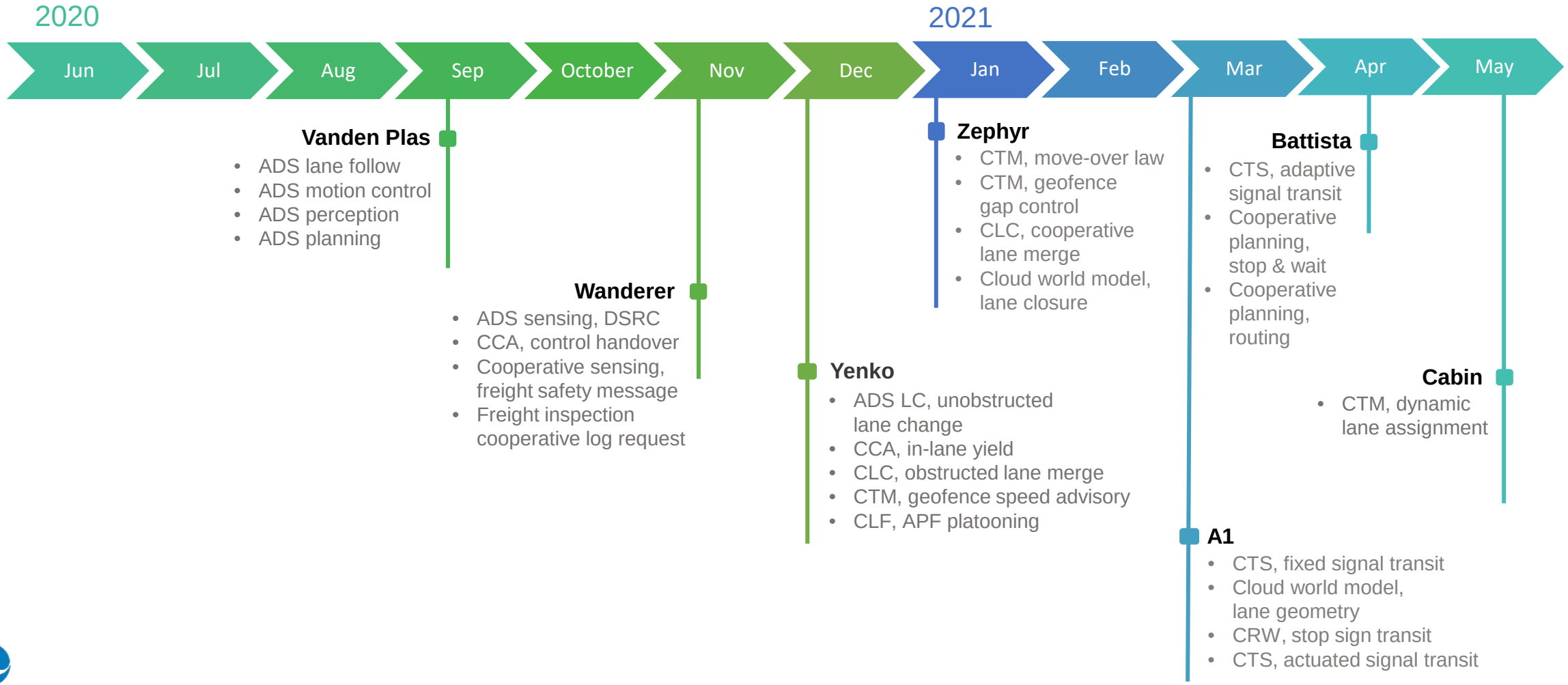
Contact Us

CARMAsupport@dot.gov

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

2020 Release Plan

Latest Update on May 29, 2020



Poll Questions #4 — #6

Questions?

To Learn More About CARMA, Visit:

- **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
- **ROS Discourse –** https://discourse.ros.org/c/carma/59

Icon source: FHWA.

Contact Us!

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CARMA@dot.gov
and
CARMAsupport@dot.gov

Source: FHWA