



## CARMA<sup>SM</sup> Adds to the Cooperative Driving Automation (CDA) Message Set to Improve Intelligent Transportation Systems (ITS) Communications

The CARMA Ecosystem has created six new message types to enable vehicle-to-everything (V2X) communication between vehicles and other entities for various CDA cooperation classes, as defined in Society of Automotive Engineers (SAE) J3216,<sup>1</sup> which enables true cooperative behavior.

### WHAT IS CARMA?

The CARMA<sup>SM</sup> Program is the Federal Highway Administration's initiative to enable development and collaboration for CDA research. CARMA's purpose is to transform the surface transportation ecosystem by improving efficiency and safety through automated vehicles working together and with roadway infrastructure.

### BACKGROUND

The SAE J3216 Standard<sup>1</sup> defines the CDA cooperation classes for applications to enable cooperation between vehicles and other entities to improve safety and efficiency. The SAE J2735 Standard<sup>2</sup> defines a message set for V2X communication using the available 5.9 GHz bandwidths for Wireless Access in Vehicular Environments (WAVE) communications systems. WAVE provides an opportunity to expand the message set to support general V2X intent sharing and agreement seeking about future actions and to use it for 5G and other wireless communication technologies. In addition, the technology could support general descriptions of traffic controls.

### THE CARMA SUITE OF TOOLS

The CARMA suite of tools, including CARMA Platform<sup>SM</sup>, CARMA Cloud<sup>SM</sup>, CARMA Streets<sup>SM</sup>, and CARMA Messenger, allows informed and dynamic cooperation among vehicles, infrastructure, and other roadway users. All these tools work together with the open-source software V2X Hub to enhance networked, wireless communications between automated vehicles, infrastructure, and personal devices.

A set of six new message types (described on page 4) that address needs for intent sharing, CDA agreement seeking, traffic control information, and maneuvering recommendations was developed through the CARMA Program. The message structures are flexible to support evolving research needs and are structured in accordance with the Standard J2735 Standard<sup>2</sup> to better facilitate incorporation. These new messages are used for:

- **Intent sharing:** A CARMA Platform vehicle can receive information about where other CARMA vehicles

intend to go and the maneuvers they plan to execute. This information allows the CARMA vehicle to plan a trajectory that safely avoids other vehicles while taking advantage of known gaps in traffic lanes. This capability is enabled by the SAE CDA Class B<sup>3</sup> communication class.

- **Agreement seeking:** A CARMA Platform vehicle can communicate with neighboring entities to seek agreement on a mutually beneficial set of cooperative maneuvers such as smoothly weaving two traffic streams. This capability is enabled by the SAE CDA Class C communication class.<sup>4</sup>
- **Traffic control information:** CARMA Cloud can communicate changes in traffic controls to CARMA Platform vehicles with a high level of detail related to geometry and traffic control timing.
- **Maneuvering recommendations:** CARMA Streets can communicate maneuvering recommendations, such as cooperative passing through a four-way stop, with CARMA Platform vehicles.

1 SAE International. 2021. *Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles*. J3216\_202107. Warrendale, PA: SAE International. [https://www.sae.org/standards/content/j3216\\_202107](https://www.sae.org/standards/content/j3216_202107), last accessed September 17, 2021.

2 SAE International. 2016. *Dedicated Short Range Communications (DSRC) Message Set Dictionary*. J2735\_201603. Warrendale, PA: SAE International. [https://www.sae.org/standards/content/j2735\\_201603/](https://www.sae.org/standards/content/j2735_201603/), last accessed September 17, 2021.

3 SAE International. 2011. *Class B Data Communication Network Messages - Detailed Header Formats and Physical Address Assignments (STABILIZED Apr 2011)*. J2178/1\_201104. Warrendale, PA: SAE International. [https://www.sae.org/standards/content/j2178/1\\_201104/](https://www.sae.org/standards/content/j2178/1_201104/), last accessed September 17, 2021.

4 SAE International. 1993. *Class C Communications Protocol Proposal for Off-Road Vehicles*. 930007. Warrendale, PA: SAE International. <https://www.sae.org/publications/technical-papers/content/930007/>, last accessed September 17, 2021.

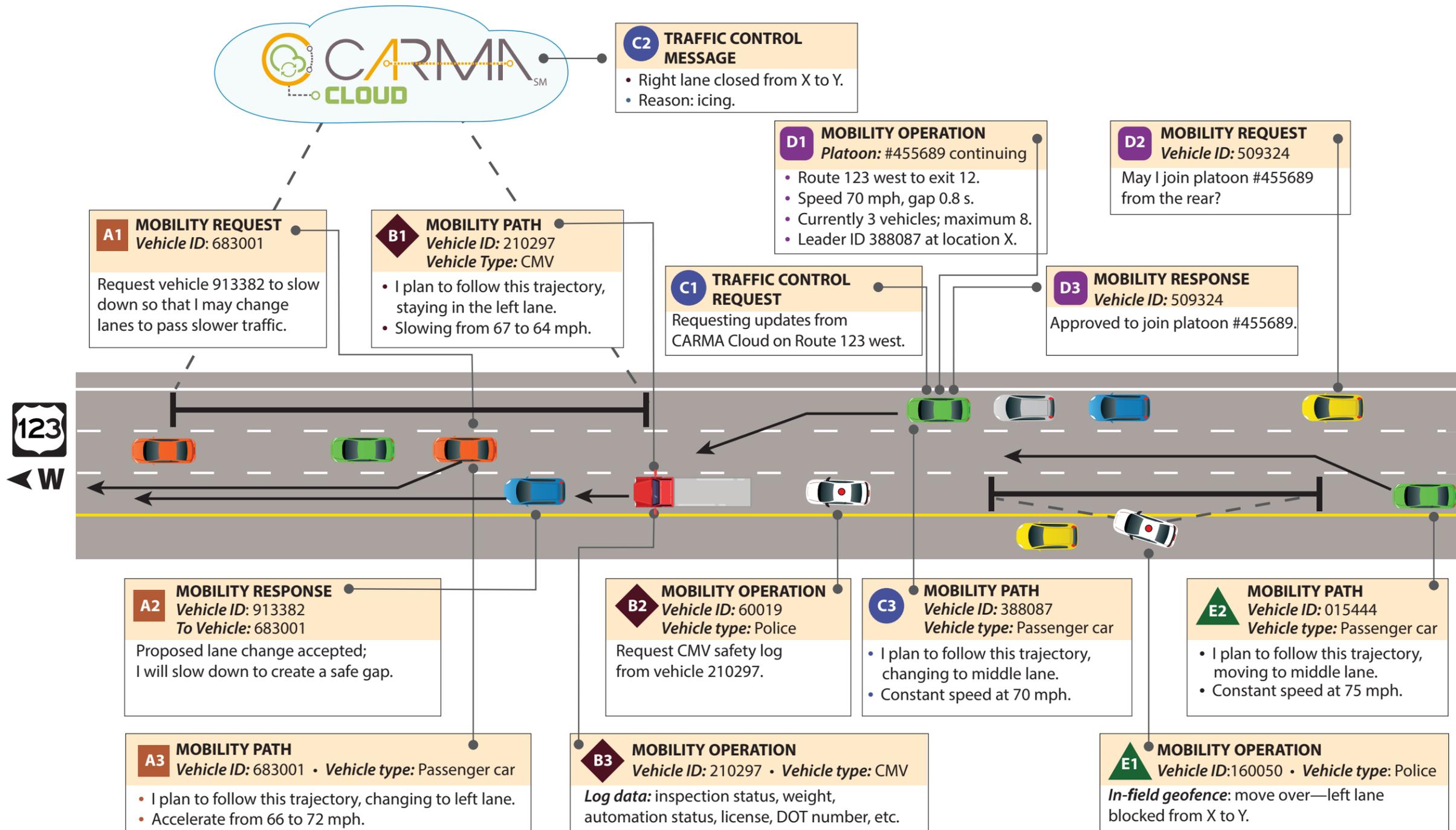


Figure 1 depicts several practical cooperative use cases where the new message set is needed. Each box represents a single message and shows its type (refer to the message type details on page 4). The groupings represent use case events that work together. The number is the sequence in which the message is broadcast within that use case:

- Messages may be repeated periodically as information is updated.
- Message semantics are the focus of the diagram.
- Security provisions operate behind the scenes and may include authentication certificates, message encryption, or other practices.

To learn more about CARMA, visit: [highways.dot.gov/research/research-programs/operations/CARMA](https://highways.dot.gov/research/research-programs/operations/CARMA)

Figure 1. Diagram. CARMA Message Sets.

Source: FHWA

CMV = commercial motor vehicle; DOT = department of transportation; ID = identification.

The six new message types developed by the CARMA program, which fall under either mobility or geofence messages, can be used to enhance capabilities for intent sharing, agreement seeking, traffic control information, and maneuvering recommendations.

- **Mobility messages:** Each message has a common set of information at the beginning that includes fixed identifications for the sender and optional identifications for a targeted recipient (either of which could be a vehicle, infrastructure, pedestrian, or cyclist), as well as temporary basic safety message identifications, plan identifications, and timestamps.

### MOBILITY PATH

Broadcasts a message to inform other vehicles of the message sender's (primary vehicle's) current location and intended path over the next several seconds.

### MOBILITY REQUEST

Proposes a specific relationship with one or more neighboring entities (e.g., cooperative lane merge, pedestrian crossing, or commercial motor vehicle safety check) and indicates the urgency of the plan. This could include a proposed vehicle trajectory. Entities can mean vehicles, road infrastructure, pedestrians, and other road users.

### MOBILITY RESPONSE

Accepts or rejects another entity's proposal.

### MOBILITY OPERATION

Communicates specific relationship parameters, such as platoon operations or emergency vehicle presence (if on shoulder, alerts for the move-over law).

- **Geofence messages:** Each message is applied to part of a single traffic lane and designed to communicate traffic control updates to CARMA vehicles via CARMA Cloud.

### TRAFFIC CONTROL REQUEST

Sent periodically from a vehicle to the roadside infrastructure, specifying the vehicle's desired travel route and current map information, and asking for any available updates to traffic rules (e.g., speed limits and lane closures) along that route.

### TRAFFIC CONTROL MESSAGE

Broadcasts in response to a traffic control request and contains any changes to traffic controls (e.g., lane markings, speed limits, and lane use restrictions) since the requesting entity's last update. The message is customized for the requesting entity.

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