



SURFACE VEHICLE INFORMATION REPORT

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(R) Taxonomy and Definitions for Terms Related to
Cooperative Driving Automation for On-Road Motor Vehicles

RATIONALE

This revision of SAE J3216 includes:

- Clarification of the scope of Cooperative Driving Automation (CDA) within the broader “Connected and Automated Vehicle (CAV)” context.
- New and revised terms and definitions to reconcile issues identified during J-doc development efforts under the CDA Committee, as well as ongoing revisions to SAE J3016.

1. SCOPE

This document describes machine-to-machine (M2M)¹ communication to enable cooperation between two or more traffic participants or CDA devices hosted or controlled by said traffic participants. The cooperation supports or enables performance of the dynamic driving task (DDT) for a subject vehicle equipped with an engaged driving automation system feature and a CDA device. Other participants may include other vehicles with driving automation feature(s) engaged, shared road users (e.g., drivers of conventional vehicles or pedestrians or cyclists carrying compatible personal devices), or compatible road operator devices (e.g., those used by personnel who maintain or operate traffic signals or work zones).

Cooperative driving automation (CDA) aims to improve the safety and flow of traffic and/or facilitate road operations by supporting the safer and more efficient movement of multiple vehicles in proximity to one another. This is accomplished, for example, by sharing information that can be used to influence (directly or indirectly) DDT performance by one or more nearby road users. Vehicles and infrastructure elements engaged in cooperative automation may share information, such as state (e.g., vehicle position, signal phase), intent (e.g., planned vehicle trajectory, signal timing), or seek agreement on a plan (e.g., coordinated merge). Cooperation among multiple participants and perspectives in traffic can improve safety, mobility, situational awareness, and operations. However, nothing in this document is intended to suggest that driving automation requires such cooperation in order to be performed safely.

Cooperative strategies may be enabled by the sharing of information in a way that meets the needs of a given CDA Feature. The needs may be expressed in terms of performance characteristics, such as latency, information flow, range, privacy and security, and information content and quality. There are several potential technologies for communicating information between a subject vehicle(s) and other traffic participants.

¹ CDA communications are necessarily M2M and are unmediated by human road users so that near real-time safety objectives can be achieved.

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When referring to a CDA Feature, the word “feature” here varies from its common English definition. To emphasize this variance and to avoid confusion, “Feature” is capitalized when modified by the adjective “CDA” or “C-ADS.”

This document focuses on CDA Feature-oriented functionality and does not imply use of any specific communications protocols. This document addresses the performance of functions and actions in conducting the DDT (refer to the current version of ISO/SAE PAS 22736/SAE J3016) by the ADS. This information report is intended to facilitate communication and awareness for the design and anticipated development and validation of CDA Features.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J3016	Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles
SAE J3251	Cooperative Driving Automation (CDA) Feature: Perception Status Sharing for Occluded Pedestrian Collision Avoidance
SAE J3256	Cooperative Driving Automation (CDA) Feature – Infrastructure-Based Prescriptive Cooperative Merge
SAE J3282	Cooperative Infrastructure CDA Feature: Cooperative Permissive Left Turn Across Opposing Traffic with Infrastructure Guidance

2.1.2 IEEE Publications

Available from IEEE Operations Center, 445 and 501 Hoes Lane, Piscataway, NJ 08854-4141, Tel: 732-981-0060, www.ieee.org.

IEEE 1609.2	IEEE Standard for Wireless Access in Vehicular Environments - Security Services for Application and Management Messages
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2.1.3 ISO Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ISO/SAE PAS 22736	Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles
ISO 23374-1	Intelligent transport systems — Automated valet parking systems (AVPS) — Part 1: System framework, requirements for automated driving and for communications interface

2.1.4 Other Publications

5G-PPP. (2017). *5GCAR Scenarios, Use Cases, Requirements and KPIs*. 5GCAR project deliverable D2.1, Tech. Rep.

Albus, J.S., Huang, H.-M., Messina, E.R., Murphy, K., Juberts, M., Lacaze, A., Balakirsky, S.B., Shneier, M.O., Hong, T.H., Scott, H.A., Proctor, F.M., Shackelford, W.P., Michaloski, J.L., Wavering, A.J., Kramer, T., Dagalakakis, N., Rippey, W.G., Stouffer, K.A., and Legowik, S. (2002). *4D/RCS: A reference model architecture for intelligent unmanned vehicle systems, version 2.0* (Report No. NISTIR 6910). Prepared for the Army Research Laboratory Demo III Program. National Institute of Standards and Technology. <https://doi.org/10.6028/NIST.IR.6910>.

Kosseff, J. (2018). Defining cybersecurity law. *Iowa Law Review*, 103(985).

Lochrane, T. (2018, December 18). *Transforming the Transportation Industry with Cooperative Automation Research Mobility Applications (CARMA)* [PowerPoint slides]. Office of Operations Research and Development, Federal Highway Administration. https://transops.s3.amazonaws.com/uploaded_files/NOCoe%20CARMA%20Webinar%20Slides.pdf.

OECD. (2017). *OECD Handbook for Internationally Comparative Education Statistics*, Chapter 6. <https://doi.org/10.1787/9789264279889-en>.

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J2735 V2X Communications Message Set Dictionary

SAE J2945 Dedicated Short Range Communication (DSRC) Systems Engineering Process Guidance for SAE J2945/X Documents and Common Design Concepts™

SAE J2945/1 On-Board System Requirements for V2V Safety Communications

SAE J2945/3 Requirements for Road Weather Applications

SAE J2945/5 Service Specific Permissions and Security Guidelines for Connected Vehicle Applications

SAE J3063 Active Safety Systems Terms and Definitions

2.2.2 Other Publications

5G-PPP. (2015). *Automotive Vertical Sector*. White Paper.

U.S. Department of Transportation. (2015). DSRC Report to Congress, Chapter 2.

U.S. Department of Transportation. (2018). Preparing for the Future of Transportation: Automated Vehicle 3.0 (AV 3.0), Appendix C.

<https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf>.

U.S. Department of Transportation. (2020). Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0 (AV 4.0).

<https://www.transportation.gov/sites/dot.gov/files/2020-02/EnsuringAmericanLeadershipAVTech4.pdf>.

U.S. Department of Transportation. (2014). Traffic Monitoring Guide, Appendix C. VEHICLE TYPES, FHWA publication, last updated 11/7/2014. https://www.fhwa.dot.gov/policyinformation/tmguidetmg_2013/vehicle-types.cfm.

3. ABBREVIATIONS AND ACRONYMS

The terms, abbreviations, and acronyms cited below shall be a part of the terms of this information report unless specifically cited otherwise.

ADS	Automated Driving System
ADS-DV	ADS-Dedicated Vehicle
C-ADS	Cooperative-Automated Driving System
CACC	Cooperative Adaptive Cruise Control
CARMA	Cooperative Automation Research Mobility Applications
CDA	Cooperative Driving Automation
CSP	Communication Service Provider
DDT	Dynamic Driving Task
FHWA	Federal Highway Administration
IOO	Infrastructure Owner/Operator
ITS	Intelligent Transportation System
M2M	Machine-to-Machine
ODD	Operational Design Domain
RSE	Roadside Equipment
SPaT	Signal Phase and Timing
TSMO	Transportation Systems Management and Operations

4. DEFINITIONS

4.1 AUTOMATED DRIVING SYSTEM (ADS)

Refer to the current version of ISO/SAE PAS 22736/SAE J3016.

4.2 COOPERATIVE DRIVING AUTOMATION (CDA)

Driving automation that uses M2M communications to support or enable cooperation among two or more entities with compatible communications technology and is intended to facilitate the safer, more efficient movement of road users, including enhancing performance of the DDT for a vehicle with a driving automation feature(s) engaged. Remote control within protected environments, such as Automated Valet Parking Systems (AVPS) described in ISO 23374-1, are excluded from this definition.

NOTE 1: CDA can be used with SAE Levels 1 to 5 automation. For using CDA with SAE Levels 3 through 5, see [4.3](#). For using CDA with SAE Levels 1 and 2, see [4.4](#). A cooperative driving automation system describes any Level 1 to 5 driving automation system (as described in SAE J3016) that is capable of cooperation.

NOTE 2: CDA communications are distinct from V2X communications, which support a broader set of applications than CDA Features. For example, ADAS applications enabled by V2X (e.g., emergency electronic brake light systems) are intended for human-operated vehicles. By contrast, CDA Features use machine-to-machine (M2M) communications (no human in the loop) specifically to enable two or more proximal traffic participants to automatically cooperate for immediate (possibly prolonged) effect in enhancing safety and/or mobility. As such, defined V2X message content, such as signal phase and timing (SPaT) or basic safety message (BSM) that is broadcast by itself is not a CDA Feature, although they may provide important information for executing a given CDA Feature.

NOTE 3: For cooperative automated driving system-operated vehicles (see [4.3.2](#)) engaged in CDA Feature execution, the M2M communications may enhance the performance of the DDT for the subject vehicle (e.g., object and event detection [OEDR] and response, operational, and tactical maneuvers).

NOTE 4: For road operator CDA devices engaged in CDA Feature execution, the M2M communications may provide situational awareness and influence performance of traffic management (e.g., signal phase and timing [SPaT], dynamic speed limits, and emergency response).

4.3 COOPERATIVE AUTOMATED DRIVING SYSTEM (C-ADS)

An ADS capable of utilizing CDA.

4.3.1 COOPERATIVE AUTOMATED DRIVING SYSTEM (C-ADS)-EQUIPPED VEHICLE

A vehicle equipped with Level 3, 4, or 5 driving automation and capable of utilizing CDA. Note that Level 3 systems require human driver intervention upon ADS request. (Refer to SAE J3016 for additional information about driving automation systems.)

NOTE: CDA vehicle is inclusive of SAE Levels 1 to 5 automation, and C-ADS refers to SAE Levels 3 to 5 automation. See the example in [7.5](#).

4.3.2 COOPERATIVE AUTOMATED DRIVING SYSTEM (C-ADS)-OPERATED VEHICLE

An ADS-operated vehicle that is simultaneously engaging in the execution of a CDA Feature.

NOTE 1: A C-ADS-Operated Vehicle is a C-ADS-Equipped vehicle when its CDA Feature is engaged.

NOTE 2: Additional ADS functions that are not specifically part of executing a CDA Feature may also be actively engaged on a C-ADS-Operated Vehicle.

4.4 CDA DRIVER SUPPORT FEATURE

A Level 1 or 2 driving automation system capable of utilizing CDA. (Refer to SAE J3016 for additional information about driving automation systems.)

4.5 CDA FEATURE

The design-specific functionality supported or enabled by M2M cooperation among CDA devices communicating with one or more CDA vehicles engaging in executing a CDA Feature.

NOTE 1: A given CDA Feature may entail the use of more than one class of CDA cooperation information (see [4.6.1](#) through [4.6.4](#)). For example, a cooperative merge CDA Feature may entail Class C agreement-seeking cooperation among merging C-ADS-Operated Vehicles, as well as Class D prescriptive cooperation between a CDA-I device and merging C-ADS-Operated Vehicles.

NOTE 2: CDA Features may be referred to by generic names (e.g., cooperative merging) or manufacturer-specific names.

4.5.1 SUPPORTING CDA FEATURE

A CDA Feature capable of promoting cooperation among traffic participants intended to augment performance of actions by road users and road operators.

EXAMPLE 1: A C-ADS-Operated Vehicle detects a pedestrian in a crosswalk and shares object classification and path prediction information with a second approaching C-ADS-Operated Vehicle. The approaching vehicle already had detected an object in the crosswalk but had not yet determined classification or path prediction for the object. The CDA communication provides advance information about the pedestrian for the approaching vehicle to proactively adjust vehicle operation for enhanced safety and efficiency by preventing sudden emergency maneuvers.

EXAMPLE 2: A C-ADS-Operated Vehicle receives SPaT information from a CDA-I device, thereby supporting planning and optimization of approach and departure by the vehicle to reduce congestion and travel time and enhance efficiency.

4.5.2 ENABLING CDA FEATURE

A CDA Feature capable of promoting cooperation among traffic participants intended to facilitate the performance of actions by road users and road operators that they would otherwise not be able to perform.

NOTE: The execution of Enabling CDA Features results in a different outcome than could have been achieved without the Enabling CDA Feature (e.g., detect occluded object, achieve target lane position, expand ODD, etc.).

EXAMPLE 1: While approaching a crosswalk, a C-ADS-Operated Vehicle detects a pedestrian in the crosswalk and shares information with a second approaching C-ADS-Operated Vehicle about the location, speed, and heading of the pedestrian, which is occluded by the detecting C-ADS-Operated Vehicle. Without the information provided by the detecting (and occluding) C-ADS-Operated Vehicle, the second C-ADS-Operated Vehicle may not have detected the pedestrian in time to avoid colliding with it. Based on the shared pedestrian information, the second vehicle is able to plan appropriate maneuvers to ensure all participants' safety.

EXAMPLE 2: A CDA Feature enables coordinated intersection departure by means of an infrastructure device providing C-ADS-Operated Vehicles with SPaT information allowing nearby C-ADS-Operated Vehicles to coordinate their departure timing and velocity trajectory for enhanced safety and efficiency.

EXAMPLE 3: A CDA Feature enables closely spaced vehicle platooning movements by exchanging information about desired velocity and headway among vehicles.

EXAMPLE 4: A CDA Feature enables cooperative merging whereby a subject C-ADS-Operated Vehicle uses M2M communication to request a desired lane position and maneuvers from nearby C-ADS-Operated Vehicles, such as slowing down to allow the subject vehicle to move from an on-ramp to a highway. Due to coordinated maneuvers enabled by CDA, merging can be conducted smoothly, without negatively affecting traffic flow.

4.6 CDA COOPERATION CLASSES

Classes of cooperation facilitated by M2M communications among CDA devices that may influence DDT performance and traffic operations, defined as Classes A through D based on the increasing amount of cooperation entailed in each successive class.

NOTE: The use of CDA information to influence DDT performance by one or more C-ADS-Operated Vehicles in any given situation depends upon the type of information provided (see [4.6.1](#) through [4.6.4](#)), as well as other information used by the C-ADS-Operated Vehicle(s).

4.6.1 STATUS-SHARING COOPERATION (CLASS A)

Perception information about the traffic environment and information about the sending entity provided by the sending entity for potential utilization by receiving entities. ("Here I am, and here is what I see.")

NOTE 1: Status-sharing cooperation does not require the ability or consent of transmitting entities to employ the information provided via M2M communication, which may originate from any nearby traffic participant.

NOTE 2: Status-sharing cooperation may be used to confirm or enhance an entity's situational awareness.

EXAMPLE 1: A CDA device carried by a VRU transmits its location, speed, and heading to C-ADS-Operated Vehicles that may be operating in the vicinity.

EXAMPLE 2: A C-ADS-Operated Vehicle shares its current velocity and the velocity of the vehicle immediately in front with nearby vehicles. A C-ADS-Operated Vehicle behind the status-sharing vehicle adjusts its speed to improve traffic flow and safety.

EXAMPLE 3: Cooperative situational awareness whereby a roadside equipment CDA device at a crosswalk communicates to nearby vehicles information that a pedestrian is approaching the crosswalk. A nearby C-ADS-Operated Vehicle receives the information, which it may use, along with information provided by the ADS's sensors, to plan the DDT performance near the crosswalk.

4.6.2 INTENT-SHARING COOPERATION (CLASS B)

Information about planned future actions of the sending entity provided by that entity for potential utilization by receiving entities. ("This is what I plan to do.")

NOTE 1: Intent-sharing cooperation does not require the ability or consent of receiving entities to employ the information provided via M2M communication, which may originate from any nearby traffic participant.

NOTE 2: Receiving entities do not necessarily need to act on the shared intent, and all entities are expected to conduct competent operations regardless of others' actions.

NOTE 3: Intent-sharing cooperation may be used to augment prediction of future states to enhance models of the planned future actions of the sending entity.

EXAMPLE 1: A C-ADS-Operated Vehicle with an engaged Level 3 highway feature transmits its intention to change lanes with proximal traffic participants to facilitate safer and more efficient traffic flow in the immediate vicinity. A proximal C-ADS-Operated Vehicle with an engaged Level 4 highway feature receives the lane change intention information and slows down to maintain a desired longitudinal distance when the Level 3 C-ADS-Operated Vehicle merges into the lane ahead.

EXAMPLE 2: A CDA device located at/near a traffic signal transmits signal phase and timing (SPaT) information to proximal road users to facilitate eco-drive functionality. A C-ADS-Operated Vehicle using a Level 3 feature approaching the traffic signal uses the SPaT information to adjust longitudinal vehicle motion control to reduce braking and acceleration.