SURFACE VEHICLE RECOMMENDED PRACTICE	J3131™	MAR2022
	Issued 2022-03	

Definitions for Terms Related to Automated Driving Systems Reference Architecture

RATIONALE

This SAE Recommended Practice provides a reference functional architecture and describes the functional components and relationships between them of a typical on-road automated driving system (ADS) software architecture, as well as providing related terms and definitions. This SAE Recommended Practice does not provide specifications, or otherwise impose requirements on, the development of ADSs.

This document has been developed according to the following guiding principles, namely, it should:

- Be descriptive and informative rather than normative.
- Provide functional definitions.
- Be consistent with current industry practice.
- Be consistent with prior art to the extent practicable.

These functional definitions build upon definitions developed by the National Institute of Standards and Technology (NIST) and attempt to reflect the language as it is currently used within the ADS development community.

1. SCOPE

The terms and definitions in this document describe the functions performed within an ADS, as defined in SAE J3016. Where possible we have attempted to capture the language that is already in use within the automated driving development community. Where needed, we have added new terms and definitions, including clarifying notes to avoid ambiguity. SAE J3131 deals primarily with Level 4 and Level 5 ADS 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.

ARP6128 Unmanned Systems Terminology Based on the ALFUS Framework

SAE J670 Vehicle Dynamics Terminology

SAE J3016 Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles

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.

Ulbrich, S., Menzel, T., Reschka, A., Schuldt, F., and Maurer, M., "Defining and Substantiating the Terms Scene, Situation, and Scenario for Automated Driving," 2015 IEEE 18th International Conference on Intelligent Transportation Systems, Las Palmas, 2015, pp. 982-988, doi:10.1109/ITSC.2015.164.

2.1.3 ISO Publications

Copies of these documents are available online at http://webstore.ansi.org/.

ISO/PAS 21448:2019 Road Vehicles - Safety of the Intended Functionality

2.1.4 NASA Publications

NASA Technical Services, NASA STI Program STI Support Services, Mail Stop 148, NASA Langley Research Center, Hampton, VA 23681-2199, 757-864-9658, Fax: 757-864-6500, http://ntrs.nasa.gov/.

NASA-GB-8719.13 NASA Software Safety Guidebook

2.1.5 NIST Publications

Available from NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

NISTSP 1011-I-2.0 Autonomy Levels for Unmanned Systems (ALFUS) Framework Volume I: Terminology

NISTIR 6910 NIST 4D/RCS: A Reference Model Architecture for Unmanned Vehicle Systems Version 2.0

2.1.6 Other Publications

Barbera, A., Horst, J., Schlenoff, C., and Aha, D. (2004). Task Analysis of Autonomous On-Road Driving, Mobile Robots. 2004. 17th Proceedings of SPIE—the International Society for Optical Engineering. SPIE. (Accessed June 21, 2021.)

Berns, K. and von Puttkamer, E. (2009). Autonomous Land Vehicles. Steps Towards Service Robots. Wiesbaden, Vieweg and Teubner. GWV Fachverlage GmbH.

Dorf, R. (2013). Digital Avionics Handbook: Second Edition.

Eskandarian, A. (2012). Handbook of Intelligent Vehicles. London: Springer.

Jelavic, E., Gonzales J., and Borrelli, F. (2017). Autonomous Drift Parking using a Switched Control Strategy with Onboard Sensors, IFAC-PapersOnLine.

Leveson, N. (2012). Engineering a Safer World: Systems Thinking Applied to Safety. Cambridge: MIT Press.

Zhang, F., Gonzales, J., Li, K., and Borrelli, F. (2017). Autonomous Drift Cornering with Mixed Open-Loop and Closed-Loop Control, IFAC-PapersOnLine.

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 J3216 Taxonomy and Definitions for Terms Related to Cooperative Driving Automation for On-Road Motor Vehicles

3. DEFINITIONS

Overview: This document describes terminology related to a reference ADS functional architecture, shown in Figure 1. The terms defined in this document relate to the components, functions, and concepts used in the reference architecture; however, they have been defined in such a way as to be agnostic to the specific implementation of these concepts.

During the development of this document, an extensive literature review was performed. One of the frameworks reviewed—4D-RCS (NISTIR 6910)—was designed as open reference model architecture that provided a robust library of analytical tools. The SAE J3131 task force chose to leverage concepts from 4D-RCS and definitions created by NIST for their autonomy levels for unmanned systems (ALFUS) framework. The 4D-RCS framework focuses on designing automated driving systems that perform complex tasks by decomposing these tasks and the respective systems into hierarchical layers based on time-based planning horizons. This decomposition reduces complexity and simplifies design, verification, and validation. The application of the 4D-RCS to this document was informed by an analysis of available literature and interviews with experts.

SAE J3131 deals primarily with Level 4 and Level 5 ADS features. Some of the terms and concepts may be applicable to lower-level driving automation system features that require a driver for at least part of each trip. This document separates terms into various sections with a definition for a key term being followed by definitions for related terms. Section 4 provides an alphabetically sorted index of these terms.

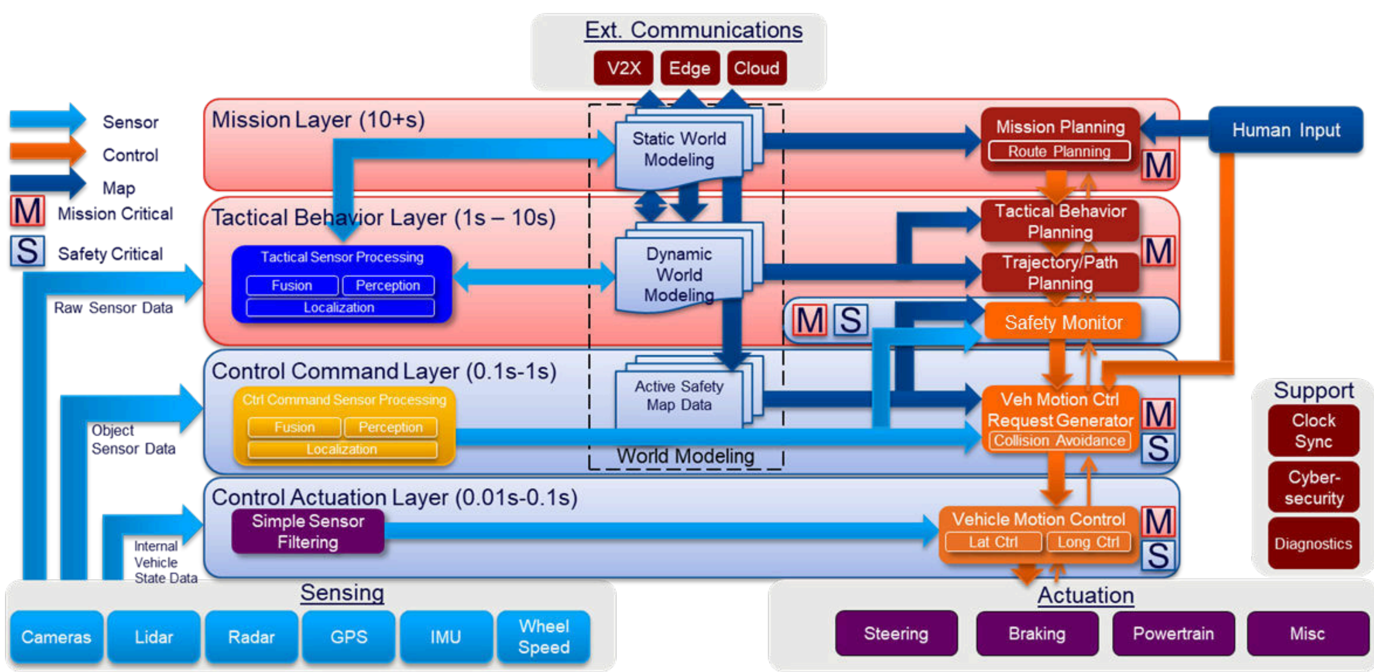

Figure 1 - Overview of the reference ADS functional architecture

3.1 [ADS] SENSING

Use of a device (sensor) to acquire information about an object or a physical phenomenon.

3.1.1 [ADS] SENSOR PROCESSING

A function or set of software and/or hardware processes that operate on sensor signals to compute the characteristics of the vehicle operating environment in order to detect, identify, and classify traffic entities, events, and situations, and to derive other useful information about the operating environment.

NOTE: These processes can be hierarchically structured to produce a series of intermediate outputs with different levels of abstraction and different spatial and temporal resolutions.

3.1.2 [ADS] FUSION

Information processing that manages the filtering, correlation, comparison, association, and combination/integration of data of varying uncertainties from multiple sources to produce the highest confidence estimates of the state of the environment to support ADS perception.

3.1.3 [ADS] PERCEPTION

An ADS's capability to sense and characterize the entities, events, and situations in its environment.

Example perception levels: Varying types of perception data streams could be produced at different levels of aggregation as follows:

- Perception Level P0: Point or pixel. A discrete element that has physical properties which, in turn, can quantitatively be either measured with the system's sensor(s) as singular measurements or computed over time and space.
- Perception Level P1: Line or list. Formed by groupings of sets of points according to certain criteria, such as continuity in position and direction over space and/or time.
- Perception Level P2: Surface or boundary. Formed by groupings of sets of contiguous lines or lists according to certain criteria, such as continuity in orientation or curvature over space and/or time.
- Perception Level P3: Object. Formed by groupings of sets of contiguous surfaces and boundaries according to certain criteria, such as rigid body mechanics, over space and/or time.
- Perception Level P4: Groups of objects. Formed by groupings of sets of objects according to certain criteria, such as density, distribution, and relative positions, motions, and interactions, over space and/or time. (See NOTE 1 below.)

Varying implementations could produce some of these outputs in the world modeling function instead of the perception function.

NOTE 1: Vehicles such as articulated buses and tractor-trailer combinations could be considered a P4: Groups of objects. Another example could be a flock of birds.

NOTE 2: Levels of perception are not to be confused with the levels of automation described in SAE J3016. There is no direct relationship between perception levels and levels of automation.

3.1.4 [ADS PERCEIVED] CIRCUMSTANCE

[Adapted from Ulbrich et al.]

A temporary condition, state, or opportunity that is distinctive and localized.