SAE INTERNATIONAL

SURFACE VEHICLE RECOMMENDED PRACTICE

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Superseding J3016 JAN2014

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

RATIONALE

This Recommended Practice provides a taxonomy describing the full range of levels of *driving automation* in on-road *motor vehicles* and includes functional definitions for advanced levels of *driving automation* and related terms and definitions. This Recommended Practice does not provide specifications, or otherwise impose requirements on, *driving automation systems*. Standardizing levels of *driving automation* and supporting terms serves several purposes, including:

- Clarifying the role of the (human) *driver*, if any, during *driving automation system* engagement.
- Answering questions of scope when it comes to developing laws, policies, regulations, and standards.
- Providing a useful framework for *driving automation* specifications and technical requirements.
- Providing clarity and stability in communications on the topic of *driving automation*, as well as a useful short-hand that saves considerable time and effort.

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.
- Be useful across disciplines, including engineering, law, media, public discourse.
- Be clear and cogent and, as such, it should avoid or define ambiguous terms.

The current revision contains updates that reflect lessons learned from various stakeholder discussions, as well as from research projects conducted in Europe and the United States by the AdaptIVe Consortium and by the Crash Avoidance Metrics Partnership (CAMP) Automated Vehicle Research (AVR) Consortium, respectively.

These revisions, while substantial, preserve the original SAE J3016:JAN2014 level names, numbers, and functional distinctions, as well as the supporting terms. However, this version of J3016:

- Clarifies and rationalizes taxonomical differentiator(s) for lower levels (levels 0-2).
- Clarifies the scope of the J3016 *driving automation* taxonomy (i.e., explains to what it does and does not apply).
- Modifies existing, and adds new, supporting terms and definitions.
- Adds more rationale, examples, and explanatory text throughout.

Italicized terms used in this Recommended Practice are also defined herein.

1. SCOPE

This Recommended Practice provides a taxonomy for motor vehicle *driving automation systems* that perform part or all of the *dynamic driving task* (*DDT*) on a *sustained* basis and that range in level from *no driving automation* (level 0) to *full driving automation* (level 5). It provides detailed definitions for these six levels of *driving automation* in the context of *motor vehicles* (hereafter also referred to as "*vehicle*" or "*vehicles*") and their *operation* on roadways. These level definitions, along with additional supporting terms and definitions provided herein, can be used to describe the full range of *driving automation features* equipped on *motor vehicles* in a functionally consistent and coherent manner. "On-road" refers to publicly accessible roadways (including parking areas and private campuses that permit public access) that collectively serve users of *vehicles* of all classes and *driving automation* levels (including no *driving automation*), as well as motorcyclists, pedal cyclists, and pedestrians.

The levels apply to the *driving automation feature(s)* that are engaged in any given instance of on-road *operation* of an equipped *vehicle*. As such, although a given *vehicle* may be equipped with a *driving automation system* that is capable of delivering multiple *driving automation features* that perform at different levels, the level of *driving automation* exhibited in any given instance is determined by the *feature(s)* that are engaged.

This document also refers to three primary actors in *driving*: the (human) *driver*, the *driving automation system*, and other *vehicle* systems and components. These other *vehicle* systems (or the *vehicle* in general terms) do not include the *driving automation system* in this model, even though as a practical matter a *driving automation system* may actually share hardware and software components with other *vehicle* systems, such as a processing module(s) or operating code.

The levels of *driving automation* are defined by reference to the specific role played by each of the three primary actors in performance of the *DDT*. "Role" in this context refers to the expected role of a given primary actor, based on the design of the *driving automation system* in question and not necessarily to the actual performance of a given primary actor. For example, a *driver* who fails to *monitor* the roadway during engagement of a level 1 adaptive cruise control (ACC) system still has the role of *driver*, even while s/he is neglecting it.

Active safety systems, such as electronic stability control and automated emergency braking, and certain types of driver assistance systems, such as lane keeping assistance, are excluded from the scope of this *driving automation* taxonomy because they do not perform part or all of the *DDT* on a *sustained* basis and, rather, merely provide momentary intervention during potentially hazardous situations. Due to the momentary nature of the actions of *active safety systems*, their intervention does not change or eliminate the role of the *driver* in performing part or all of the *DDT,* and thus are not considered to be *driving automation*.

It should, however, be noted that crash avoidance features, including intervention-type *active safety systems*, may be included in *vehicles* equipped with *driving automation systems* at any level. For *ADS*-equipped *vehicles* (i.e., levels 3-5) that perform the complete *DDT*, crash avoidance capability is part of *ADS* functionality.

2. REFERENCES

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 Applicable Documents

J670 Vehicle Dynamics Terminology (J670:JAN2008).

J3063 Active Safety Systems Terms & Definitions (J3063:NOV2015).

49 U.S.C. § 30102(a)(6) (definition of motor vehicle).

Gasser, Tom et al. “Legal consequences of an increase in vehicle automation”, July 23, 2013, available at http://bast.opus.hbz-nrw.de/volltexte/2013/723/pdf/Legal_consequences_of_an_increase_in_vehicle_automation.pdf.

Michon, J.A., 1985. A CRITICAL VIEW OF DRIVER BEHAVIOR MODELS: WHAT DO WE KNOW, WHAT SHOULD WE DO? In L. Evans & R. C. Schwing (Eds.). Human behavior and traffic safety (pp. 485-520). New York: Plenum Press, 1985.

Crash Avoidance Metrics Partnership – Automated Vehicle Research Consortium, “Automated Vehicle Research for Enhanced Safety – Final Report,” (in publication).

National Highway Traffic Safety Administration. “Preliminary Statement of Policy Concerning Automated Vehicles,”, May 30, 2013, available at http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+Department+of+Transportation+Releases+Policy+on+Automated+Vehicle+Development.

Smith, Bryant Walker. Engineers and Lawyers Should Speak the Same Robot Language, in ROBOT LAW (2015), available at https://newlypossible.org.

3. DEFINITIONS

3.1 ACTIVE SAFETY SYSTEM (SAE J3063:NOV2015)

Active safety systems are vehicle systems that sense and monitor conditions inside and outside the vehicle for the purpose of identifying perceived present and potential dangers to the vehicle, occupants, and/or other road users, and automatically intervene to help avoid or mitigate potential collisions via various methods, including alerts to the driver, vehicle system adjustments, and/or active control of the vehicle subsystems (brakes, throttle, suspension, etc.).

NOTE: For purposes of this report, systems that meet the definition of active safety systems are considered to have a design purpose that is primarily focused on improving safety rather than comfort, convenience or general driver assistance. Active safety systems warn or intervene during a high risk event or maneuver.

3.2 AUTOMATED DRIVING SYSTEM (ADS)

The hardware and software that are collectively capable of performing the entire *DDT* on a *sustained* basis, regardless of whether it is limited to a specific *operational design domain (ODD)*; this term is used specifically to describe a level 3, 4, or 5 *driving automation system*.

NOTE: In contrast to *ADS*, the generic term “*driving automation system*” (see 3.5) refers to any level 1-5 *system* or *feature* that performs part or all of the *DDT* on a *sustained* basis. Given the similarity between the generic term, “*driving automation system,*” and the level 3-5-specific term, “*Automated Driving System*,” the latter term should be capitalized when spelled out and reduced to its acronym, *ADS*, as much as possible, while the former term should not be.

3.3 ADS-DEDICATED VEHICLE (ADS-DV)

A *vehicle* designed to be *operated* exclusively by a level 4 or level 5 *ADS* for all *trips*.

NOTE 1: An *ADS-DV* is a truly “driverless” *vehicle*. However, the term “driverless vehicle” is not used herein because it has been, and continues to be, widely misused to refer to any *vehicle* equipped with a *driving automation system*, even if that *system* is not capable of always performing the entire *DDT* and thus involves a (human) *driver* for part of a given *trip.* This is the only category of *ADS-operated vehicle* that requires neither a *conventional* nor *remote driver* during routine *operation*.

NOTE 2: An *ADS-DV* might be designed without *user* interfaces, such as braking, accelerating, steering, and transmission gear selection input devices designed to be operable by a human *driver*.

NOTE 3: A level 4 *ADS-DV* by design does not *operate* outside of its *ODD* (subject to note 4 below).

NOTE 4: *ADS-DVs* might be *operated* temporarily by a *conventional* or *remote driver*: 1) to manage transient deviations from the *ODD*, 2) to address a *system failure* or 3) while in a marshalling yard before being *dispatched*.

EXAMPLE 1: A level 4 *ADS-DV* designed to *operate* exclusively within a corporate campus where it picks up and discharges *passengers* along a specific route specified by the *ADS-DV dispatcher*.

EXAMPLE 2: A level 4 *ADS-DV* designed to *operate* exclusively within a geographically prescribed central business district where it delivers parts and supplies using roads (but not necessarily routes) specified by the *ADS-DV dispatcher.*

EXAMPLE 3: A level 5 *ADS-DV* capable of *operating* on all roads that are navigable by a human *driver*. The *user* simply inputs a destination, and the *ADS-DV* automatically navigates to that destination.

3.4 DRIVING AUTOMATION

The performance of part or all of the *DDT* on a *sustained* basis.

3.5 DRIVING AUTOMATION SYSTEM or TECHNOLOGY

The hardware and software that are collectively capable of performing part or all of the *DDT* on a *sustained* basis; this term is used generically to describe any system capable of level 1-5 *driving automation*.

NOTE: In contrast to this generic term for any level 1-5 system, the specific term for a level 3-5 system is “*Automated Driving System* (ADS).” Given the similarity between the generic term, “*driving automation system*,” and the level 3-5-specific term, “*Automated Driving System*,” the latter term should be capitalized when spelled out and reduced to its acronym, *ADS*, as much as possible, while the former term should not be. (See 3.2)

3.6 [DRIVING AUTOMATION SYSTEM] FEATURE or APPLICATION

A *driving automation system*’s design-specific functionality at a specific level of *driving automation* within a particular *ODD*.

NOTE 1: A given *driving automation system* may have multiple *features*, each associated with a particular level *of driving automation* and *ODD.*

NOTE 2: Each *feature* satisfies a *usage specification*.

NOTE 3: *Features* may be referred to by generic names (e.g., automated parking) or by proprietary names.

EXAMPLE 1: A level 3 *ADS feature* that performs the *DDT*, excluding *DDT fallback*, in high-volume traffic on fully access-controlled freeways.

EXAMPLE 2: A level 4 *ADS feature* that performs the *DDT*, including *DDT fallback*, in a specified geo-fenced urban center.

3.7 DRIVING MODE

A type of *vehicle operation* with characteristic *DDT r*equirements (e.g., expressway merging, high-speed cruising, low-speed traffic jam, etc.).

NOTE: In the previous version of this document, the term *driving mode* was used more extensively. In this updated version, *operational design domain* is the preferred term for many of these uses.

3.8 DYNAMIC DRIVING TASK (DDT)

All of the real-time operational and tactical functions required to *operate* a *vehicle* in on-road traffic, excluding the strategic functions such as *trip* scheduling and selection of destinations and waypoints, and including without limitation:

1. Lateral vehicle motion control via steering (operational);
2. Longitudinal vehicle motion control via acceleration and deceleration (operational);
3. Monitoring the driving environment via object and event detection, recognition, classification, and response preparation (operational and tactical)
4. Object and event response execution (operational and tactical);
5. Maneuver planning (tactical); and
6. Enhancing conspicuity via lighting, signaling and gesturing, etc. (tactical).

NOTE 1: For simplification and to provide a useful shorthand term, subtasks (3) and (4) are referred to collectively as *object and event detection and response* (*OEDR*) (see 3.15).

NOTE 2: In this document, reference is made to “complete(ing) the *DDT*.” This means fully performing all of the subtasks of the *DDT*, whether by the (human) *driver*, by the *driving automation system*, or by both.

NOTE 3: Figure 1 displays a schematic view of the driving task. For more information on the differences between operational, tactical, and strategic functions of driving, see 8.4.

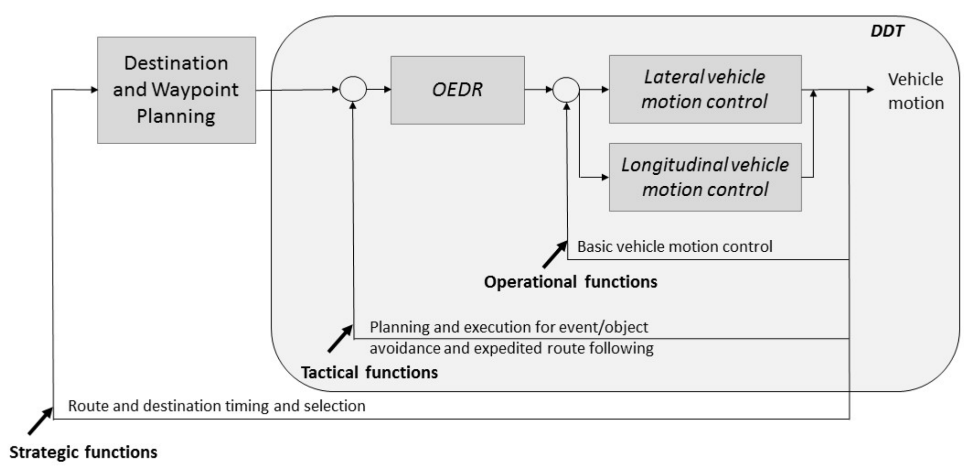


Figure 1 - Schematic view of driving task showing DDT portion

For purposes of *DDT* performance, level 1 encompasses automation of part of the innermost loop (i.e., either *lateral vehicle motion control* functionality or *longitudinal vehicle motion control* functionality and limited OEDR associated with the given axis of *vehicle motion control*); level 2 encompasses automation of the innermost loop (*lateral* and *longitudinal vehicle motion control* and limited OEDR associated with *vehicle motion control*), and levels 3-5 encompass automation of both inner loops (*lateral* and *longitudinal vehicle motion control* and complete *OEDR*). Note that *DDT* performance does not include strategic aspects of driving (e.g., determining whether, when and where to travel).

3.9 [DYNAMIC DRIVING TASK (DDT)] FALLBACK

The response by the *user* or by an *ADS* to either perform the *DDT* or achieve a *minimal risk condition* after occurrence of a *DDT performance-relevant system failure(s)* or upon *ODD* exit.

NOTE 1: The *DDT* and the *DDT fallback* are distinct functions, and the capability to perform one does not necessarily entail the ability to perform the other. Thus, a level 3 *ADS*, which is capable of performing the entire *DDT* within its *operational design domain* (*ODD*), may not be capable of performing the *DDT fallback* in all situations that require it and thus will issue a *request to intervene* to the *DDT fallback-ready user* when necessary.

NOTE 2: At level 3, an *ADS* is capable of continuing to perform the *DDT* for at least several seconds after providing the *fallback-ready user* with a *request to intervene*. The *DDT fallback-ready user* is then expected to achieve a *minimal risk condition* if s/he determines it to be necessary.

NOTE 3: At levels 4 and 5, the *ADS* must be capable of performing the *DDT fallback*, as well as achieving a *minimal risk condition*. Level 4 and 5 *ADS*-equipped *vehicles* that are designed to also accommodate *operation* by a *driver* (whether *conventional* or *remote*) may allow a *user* to perform the *DDT fallback* if s/he chooses to do so. However, a level 4 or 5 *ADS* need not be designed to allow a *user* to perform *DDT fallback* and, indeed, may be designed to disallow it in order to reduce crash risk (see 8.3).

NOTE 4: While a level 4 or 5 *ADS* is performing the *DDT fallback*, it may be limited by design in speed and/or range of *lateral* and/or *longitudinal vehicle motion control* (i.e., it may enter so-called “limp-home mode”).

EXAMPLE 1: A level 1 adaptive cruise control (ACC) *feature* experiences a *system failure* that causes the *feature* to stop performing its intended function. The human *driver* performs the *DDT fallback* by resuming performance of the complete *DDT*.

EXAMPLE 2: A level 3 *ADS feature* that performs the entire *DDT* during traffic jams on freeways is not able to do so when it encounters a crash scene and therefore issues a *request to intervene* to the *DDT fallback-ready user.* S/he responds by taking over performance of the entire *DDT* in order to maneuver around the crash scene. (Note that in this example, a *minimal risk condition* is not needed or achieved.)

EXAMPLE 3: A level 4 *ADS-dedicated vehicle (ADS-DV)* that performs the entire *DDT* within a geo-fenced city center experiences a *DDT performance-relevant system failure*. In response, the *ADS-DV* performs the *DDT fallback* by turning on the hazard flashers, maneuvering the *vehicle* to the road shoulder and parking it, before automatically summoning emergency assistance. (Note that in this example, the *ADS-DV* automatically achieves a *minimal risk condition*.)

The following Figures 2 through 6 illustrate *DDT fallback* at various levels of *driving automation*.

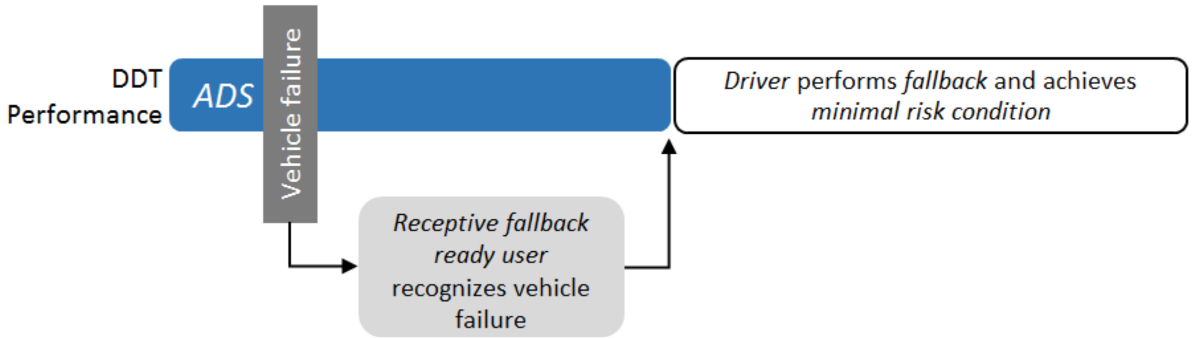


Figure 2 - Use case sequence at Level 3 showing ADS engaged, a vehicle failure and the user resuming control

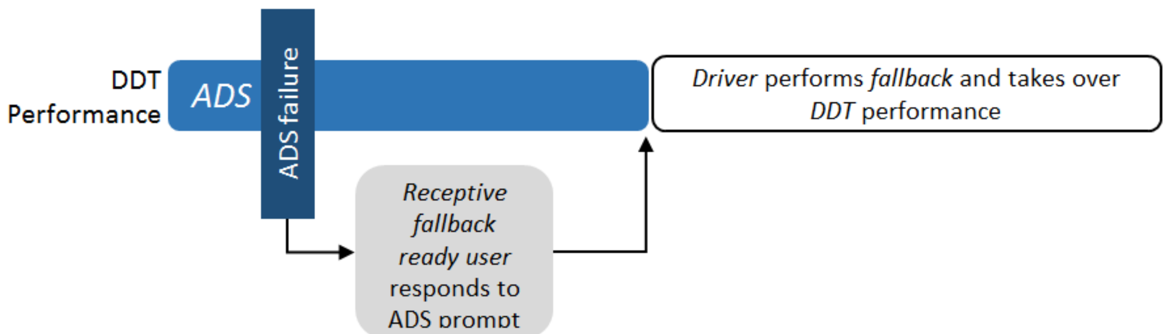


Figure 3 - Use case sequence at Level 3 showing ADS engaged, and ADS failure and the user resuming control

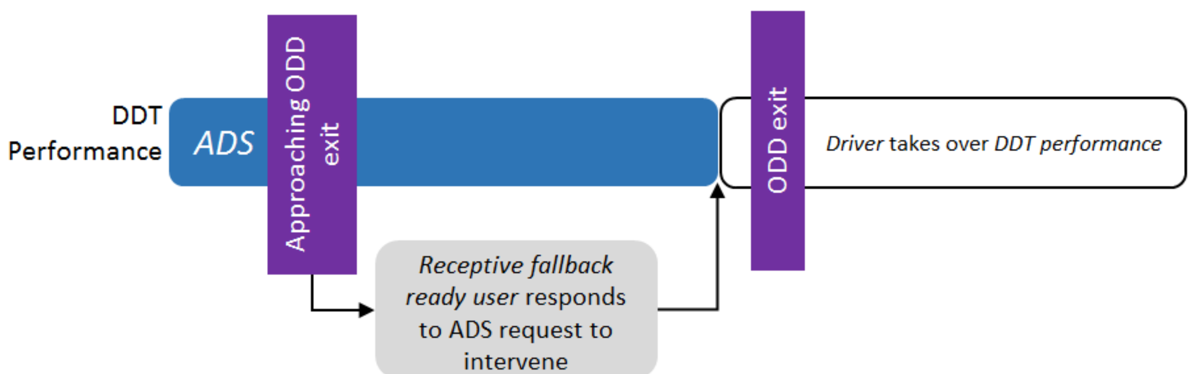


Figure 4 - Use case sequence at Level 3 showing ADS engaged, exiting the ODD and the user resuming control

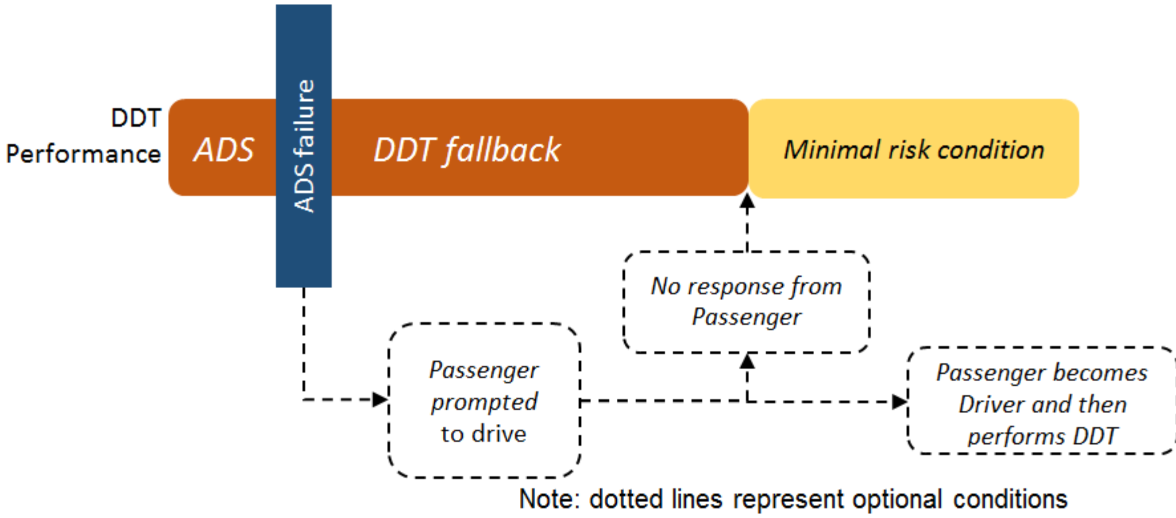


Figure 5 - Use case sequence at Level 4 showing ADS engaged, an ADS failure and the system achieving a minimal risk condition

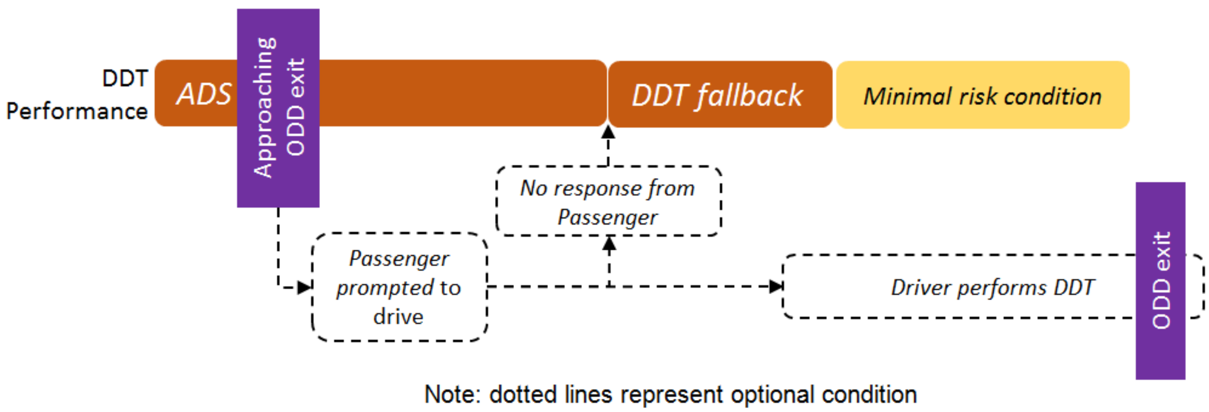


Figure 6 - Use case sequence at Level 4 showing ADS engaged, approaching ODD exit and the system achieving a minimal risk condition

3.10 LATERAL VEHICLE MOTION CONTROL

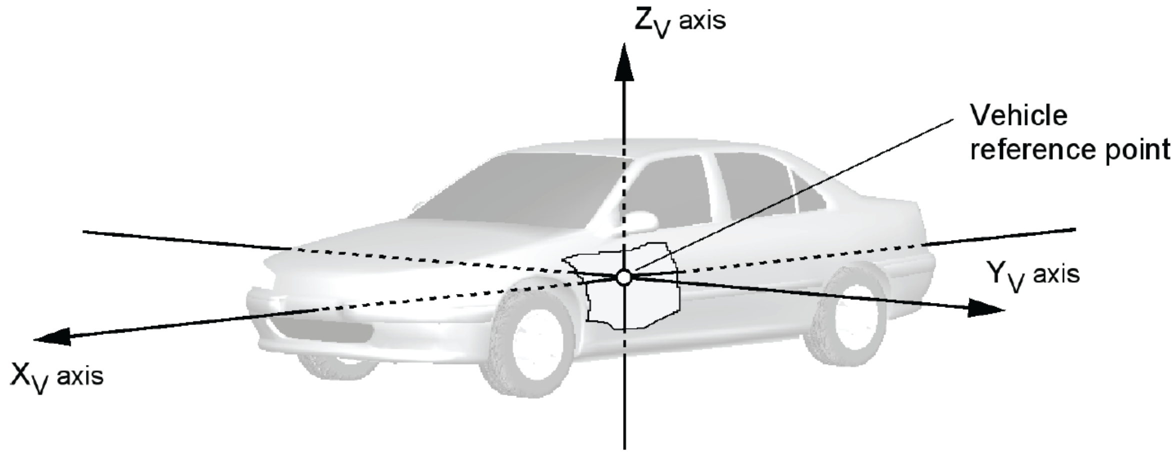
The *DDT* subtask comprising the activities necessary for the real-time, *sustained* regulation of the y-axis component of *vehicle* motion.

NOTE: *Lateral vehicle motion control* includes the detection of the *vehicle* positioning relative to lane boundaries and application of steering and/or differential braking inputs to maintain appropriate lateral positioning.

3.11 LONGITUDINAL VEHICLE MOTION CONTROL

The *DDT* subtask comprising the activities necessary for the real-time, *sustained* regulation of the x-axis component of *vehicle* motion.

NOTE: *Longitudinal vehicle motion control* includes maintaining set speed as well as detecting a preceding *vehicle* in the path of the subject *vehicle*, maintaining an appropriate gap to the preceding *vehicle* and applying propulsion or braking inputs to cause the *vehicle* to maintain that speed or gap.



A. VEHICLE AXIS SYSTEM – Z-UP

Figure 7 - Diagram showing vehicle axes of motion (SAE J670:JAN2008)

3.12 MINIMAL RISK CONDITION

A condition to which a *user* or an *ADS* may bring a *vehicle* after performing the *DDT fallback* in order to reduce the risk of a crash when a given *trip* cannot or should not be completed.

NOTE 1: At levels 1 and 2, the *driver* may or may not achieve a *minimal risk condition* in response to a *vehicle* fault condition or *driving automation system failure*.

NOTE 2: At level 3, given a *DDT performance-relevant system failure* in the *ADS* or *vehicle*, the *DDT fallback-ready user* is expected to achieve a *minimal risk condition* when s/he determines that it is necessary.

NOTE 3: At levels 4 and 5, the *ADS* is capable of automatically achieving a *minimal risk condition* when necessary (i.e., due to *ODD* exit, if applicable, or a *DDT performance-relevant system failure* in the *ADS* or *vehicle*). The characteristics of automated achievement of a *minimal risk condition* at levels 4 and 5 will vary according to the type and extent of the *system failure*, the *ODD* (if any) for the *ADS feature* in question, and the particular *operating* conditions when the *system failure* or *ODD* exit occurs. It may entail automatically bringing the *vehicle* to a stop within its current travel path, or it may entail a more extensive maneuver designed to remove the *vehicle* from an active lane of traffic and/or to automatically return the *vehicle* to a *dispatching* facility.

EXAMPLE 1: A level 2 *driving automation system feature* that allows a *user* to stand outside of the *vehicle* and initiate an automated parking maneuver via wireless device automatically brings the *vehicle* to a stop within its current travel path when it experiences a *DDT performance-relevant system failure*.

EXAMPLE 2: A level 4 *ADS feature* designed to *operate* a *vehicle* at high speeds on freeways experiences a *DDT performance-relevant system failure* and automatically removes the *vehicle* from the active lane of traffic before coming to a stop.

EXAMPLE 3: A level 4 *ADS feature* designed to *operate* a *vehicle* at high speeds on freeways receives a request by a *passenger* to stop and automatically removes the *vehicle* from the active lane of traffic before coming to a stop.

EXAMPLE 4: A vehicle in which a level 4 *ADS* is installed experiences a *DDT performance-relevant system failure* in its primary electrical power system. The *ADS* utilizes a backup power source in order to achieve a *minimal risk condition*.

3.13 (DDT PERFORMANCE-RELEVANT) SYSTEM FAILURE

A malfunction in a *driving automation system* and/or other *vehicle* system that prevents the *driving automation system* from reliably *sustaining DDT* performance (partial or complete).

NOTE 1: This definition applies to *vehicle* fault conditions and *driving automation system failures* that prevent a *driving automation system* from performing at full capability according to design intention.

NOTE 2: This term does not apply to transient lapses in performance by a level 1 or 2 *driving automation system* that are due to inherent design limitations and that do not otherwise prevent the *system* from performing its part of the *DDT* on a *sustained* basis.

EXAMPLE 1: A level 1 *driving automation system* that performs the *lateral vehicle motion control* subtask of the *DDT* experiences a *DDT performance-relevant system failure* in one of its cameras, which prevents it from reliably detecting lane markings. The *feature* causes a malfunction indication message to be displayed in the center console at the same time that the *feature* automatically dis-engages, requiring the *driver* to immediately resume performing the *lateral vehicle motion control* subtask of the *DDT*.

EXAMPLE 2: A level 3 *ADS* experiences a *DDT performance-relevant system failure* in one of its radar sensors, which prevents it from reliably detecting objects in the *vehicle's* pathway. The *ADS* responds by issuing a *request to intervene* to the *DDT fallback-ready user*. The *ADS* continues to perform the *DDT,* while reducing vehicle speed, for several seconds to allow time for the *DDT fallback-ready user* to resume *operation* of the *vehicle* in an orderly manner.

EXAMPLE 3: A vehicle with an engaged level 3 ADS experiences a broken tie rod, which causes the vehicle to handle very poorly giving the fallback-ready user ample kinesthetic feedback indicating a vehicle malfunction necessitating intervention. The fallback-ready user responds by resuming the DDT, turning on the hazard lamps, and pulling the vehicle onto the closest road shoulder, thereby achieving a minimal risk condition.

EXAMPLE 4: A level 4 *ADS* experiences a *DDT performance-relevant* s*ystem failure* in one of its computing modules. The *ADS* transitions to *DDT fallback* by engaging a redundant computing module(s) to achieve a *minimal risk condition*.

3.14 MONITOR

A general term referencing a range of functions involving real-time human or machine sensing and processing of data used to *operate* a *vehicle*, or to support its *operation*.

NOTE 1: The terms below describing types of *monitoring* should be used when the general term "*monitor*" and its derivatives are insufficiently precise.

NOTE 2: The following four terms (1 – *monitor the driver*, 2 – *monitor the driving environment*, 3 – *monitor vehicle performance*, and 4 – *monitor driving automation system performance*) describe categories of *monitoring* (see Scope regarding primary actors).

NOTE 3: The *driver* state or condition of being *receptive* to alerts or other indicators of a *DDT performance-relevant system failure*, as assumed in level 3, is not a form of *monitoring*. The difference between *receptivity* and *monitoring* is best illustrated by example: A person who becomes aware of a fire alarm or a telephone ringing may not necessarily have been *monitoring* the fire alarm or the telephone. Likewise, a *user* who becomes aware of a trailer hitch falling off may not necessarily have been *monitoring* the trailer hitch. By contrast, a *driver* in a vehicle with an active level 1 ACC system is expected to *monitor* the driving environment and the ACC performance and otherwise not to wait for an alert to draw his/her attention to a situation requiring a response. See 3.18 below.

3.14.1 MONITOR THE USER

The activities and/or automated routines designed to assess whether and to what degree the *user* is performing the role specified for him/her.

NOTE 1: *User monitoring* in the context of *driving automation* is most likely to be deployed as a countermeasure for misuse or abuse (including over-reliance due to complacency) of a *driving automation system*, but may also be used for other purposes.

NOTE 2: *User* monitoring is primarily useful for levels 2 and 3, as below these levels evidence from the field has not identified significant incidence of misuse or abuse of driving automation technology, and above these levels the *ADS* is always capable of achieving a *minimal risk condition* automatically, so *user* misuse/abuse is not relevant.

3.14.2 MONITOR THE DRIVING ENVIRONMENT

The activities and/or automated routines that accomplish real-time roadway environmental object and event detection, recognition, classification, and response preparation (excluding actual response), as needed to *operate* a *vehicle*.

NOTE: When *operating* conventional *vehicles* that are not equipped with an engaged *ADS*, *drivers* visually sample the road scene sufficiently to competently perform the *DDT* while also performing secondary tasks that require short periods of eyes-off-road time (e.g., adjusting cabin comfort settings, scanning road signs, tuning a radio, etc.). Thus, *monitoring the driving environment* does not necessarily entail continuous eyes-on-road time by the *driver*.

3.14.3 MONITOR VEHICLE PERFORMANCE (FOR DDT PERFORMANCE-RELEVANT SYSTEM FAILURES)

The activities and/or automated routines that accomplish real-time evaluation of the *vehicle* performance, and response preparation, as needed to *operate* a *vehicle.*

NOTE: While performing the *DDT*, level 4 and 5 *ADSs monitor vehicle performance*. However, for level 3 *ADSs*, as well as for level 1 and 2 *driving automation systems*, the human *driver* is assumed to be *receptive* to *vehicle* conditions that adversely affect performance of the *DDT* (see definition of *receptivity* at 3.18).

EXAMPLE 1: While a level 2 *driving automation system* is engaged in stop-and-go traffic, a malfunctioning brake caliper causes the *vehicle* to pull slightly to the left when the brakes are applied. The human *driver* observes that the *vehicle* is deviating from its lane and either corrects the *vehicle*'s lateral position or disengages the *driving automation system* entirely.

EXAMPLE 2: While a level 4 *ADS* is engaged in stop-and-go traffic, a malfunctioning brake caliper causes the vehicle to pull to the left when the brakes are applied. The *ADS* recognizes this deviation, corrects the *vehicle*'s lateral position and transitions to a limp-home mode until the *vehicle* achieves a minimal risk condition.

3.14.4 MONITOR DRIVING AUTOMATION SYSTEM PERFORMANCE

The activities and/or automated routines for evaluating whether the *driving automation system* is performing part or all of the *DDT* appropriately.

NOTE 1: The term *monitor driving automation system performance* should not be used in lieu of *supervise*, which includes both *monitoring* and responding as needed to perform the *DDT* and is therefore more comprehensive.

NOTE 2: Recognizing *requests to intervene* issued by a *driving automation system* is not a form of *monitoring driving automation system performance*, but rather a form of *receptivity*.

NOTE 3: At levels 1-2, the *driver monitors* the *driving automation system*'s performance .

NOTE 4: At higher levels of *driving automation* (levels 3-5), the ADS *monitors* its own performance of the complete DDT.

EXAMPLE 1: A *conventional driver* verifies that an engaged ACC system is maintaining an appropriate gap while following a preceding *vehicle* in a curve.

EXAMPLE 2: A *remote driver* engaging a level 2 automated parking *feature monitors* the pathway of the *vehicle* to ensure that it is free of pedestrians and obstacles.

3.15 OBJECT AND EVENT DETECTION AND RESPONSE (OEDR)

The subtasks of the *DDT* that include *monitoring the driving environment* (detecting, recognizing, and classifying objects and events and preparing to respond as needed) and executing an appropriate response to such objects and events (i.e., as needed to complete the *DDT* and/or *DDT fallback*).

3.16 OPERATE [A MOTOR VEHICLE]

Collectively, the activities performed by a (human) *driver* (with or without support from one or more level 1 or 2 driving automation features) or by an *ADS* (level 3-5) to perform the entire *DDT* for a given *vehicle* during a *trip*.

NOTE 1: The term “drive” is not used in this document, however, in many cases it could be used correctly in lieu of “*operate*.”

NOTE 2: Although use of the term *operate*/*operating* implies the existence of an “operator,” this term is not defined or used in this document, which otherwise provides very specific terms and definitions for the various types of *ADS*-equipped *vehicle users* (see 3.24).

3.17 OPERATIONAL DESIGN DOMAIN (ODD)

The specific conditions under which a given *driving automation system* or *feature* thereof is designed to function, including, but not limited to, *driving mode*s.

NOTE 1: An *ODD* may include geographic, roadway, environmental, traffic, speed, and/or temporal limitations. A given *ADS* may be designed to *operate*, for example, only within a geographically-defined military base, only under 25 mph, and/or only in daylight.

NOTE 2: An *ODD* may include one or more *driving modes*. For example, a given *ADS* may be designed to *operate* a *vehicle* only on fully access-controlled freeways and in low-speed traffic, high-speed traffic, or in both of these *driving modes*.

NOTE 3: In the previous version of this document, the term *driving mode* was used more extensively. In this updated version, *ODD* is the preferred term for many of these uses.

NOTE 4: Section 6 discusses the significance of *ODD*s in the context of the levels of *driving automation*.

3.18 RECEPTIVITY (OF THE USER)

An aspect of consciousness characterized by a person’s ability to reliably and appropriately focus his/her attention in response to a stimulus.

NOTE 1: In level 0-2 *driving automation*, the *driver* is expected to be *receptive* to evident vehicle *system failures*, such as a broken tie rod.

NOTE 2: In level 3 *driving automation*, a *DDT fallback-ready user* is considered to be *receptive* to a *request to intervene* and/or to an evident *vehicle system failure*, whether or not the *ADS* issues a *request to intervene* as a result of such a vehicle *system failure*.

NOTE 3: *Monitoring* includes *receptivity*.

EXAMPLE 1: While a level 3 *ADS* is performing the *DDT* in stop-and-go traffic, the left-front tie rod breaks. The *DDT fallback-ready user* feels that the *vehicle* has pulled dramatically to the left and intervenes in order to move the *vehicle* onto the road shoulder.

EXAMPLE 2: While a level 3 *ADS* is performing the *DDT* on a free-flowing highway, the left side mirror glass falls out of the housing. The *DDT fallback-ready user*, while *receptive*, does not and is not expected to notice this failure, because it is not apparent.

3.19 REQUEST TO INTERVENE

Notification by an *ADS* to a *driver* indicating that s/he should promptly perform the *DDT fallback*.

3.20 SUPERVISE (DRIVING AUTOMATION SYSTEM PERFORMANCE)

The *driver* activities, performed while *operating* a *vehicle* with an engaged level 1 or 2 *driving automation system*, to *monitor the driving automation system's* performance, respond to inappropriate actions taken by that system, and to otherwise complete the *DDT*.

EXAMPLE: A *driver* notices that an engaged adaptive cruise control (ACC) system is not maintaining headway to a preceding *vehicle* in a curve and brakes accordingly.

3.21 SUSTAINED (OPERATION OF A VEHICLE)

Performance of part or all of the *DDT* both between and across external events, including responding to external events and continuing performance of part or all of the *DDT* in the absence of external events.

NOTE 1: External events are situations in the driving environment that necessitate a response by a *driver* or *driving automation system* (e.g., other *vehicles*, lane markings, traffic signs).

NOTE 2: *Sustained* performance of part or all of the *DDT* by a *driving automation system* changes the *user's* role. (See Scope for discussion of roles.) By contrast, an automated intervention that is not *sustained* according to this definition does not qualify as *driving automation*. Hence, systems that provide momentary intervention in *lateral* and/or *longitudinal vehicle motion control* but do not perform any part of the *DDT* on a *sustained* basis (e.g., anti-lock brake systems, electronic stability control, automated emergency braking) are not classifiable (other than at level 0) under the J3016 taxonomy.

NOTE 3: Conventional cruise control does not provide *sustained operation* because it does not respond to external events. It is therefore also not classifiable (other than at level 0) under the J3016 taxonomy.

3.22 TRIP

The traversal of an entire travel pathway by a *vehicle* from the point of origin to a destination.

NOTE: Performance of the *DDT* during a given *trip* may be accomplished in whole or in part by a *driver*, *driving automation system*, or both.

3.23 USAGE SPECIFICATION

A particular level of *driving automation* within a particular *ODD*.

EXAMPLE 1: Level 3 *driving automation* in high-volume traffic on designated fully access-controlled freeways.

EXAMPLE 2: Level 4 *driving automation* in designated urban centers.

NOTE 1: Each *feature* satisfies a *usage specification*.

3.24 (HUMAN) USER

A general term referencing the human role in *driving automation*.

NOTE 1: The following four terms (1 – *driver*, 2 – *passenger*, 3 – *DDT fallback-ready user*, and 4 - *dispatcher*) describe categories of (human*) users*.

NOTE 2: These human categories define roles that do not overlap and may be performed in varying sequences during a given *trip*.

3.24.1 DRIVER

A *user* who performs in real-time part or all of the *DDT* and/or *DDT fallback* for a particular *vehicle*.

NOTE: In a *vehicle* equipped with a *driving automation system*, a *driver* may assume or resume performance of part or all of the *DDT* from the *driving automation system* during a given *trip*.

3.24.1.1 (CONVENTIONAL) DRIVER

A *driver* who manually exercises in-*vehicle* braking, accelerating, steering, and transmission gear selection input devices in order to *operate* a *vehicle*.

NOTE: A *conventional driver* is assumed to be seated in what is normally referred to as "the *driver*'s seat" in automotive contexts, which is a unique seating position that makes in-*vehicle* input devices (steering wheel, brake and accelerator pedals, gear shift) accessible to a (human) *driver*.

3.24.1.2 REMOTE DRIVER

A *driver* who is not seated in a position to manually exercise in-*vehicle* braking, accelerating, steering, and transmission gear selection input devices (if any) but is able to *operate* the *vehicle*.

NOTE 1: A *remote driver* can include a *user* who is within the *vehicle*, within line of sight of the *vehicle*, or beyond line of sight of the *vehicle*.

NOTE 2: *A remote driver* is not the same as a *dispatcher* (see 3.24.4), although a *dispatcher* may become a *remote driver* if s/he has the means to *operate* the *vehicle* remotely.

NOTE 3: *A remote driver* does not include a person who merely creates driving-relevant conditions that are sensed by, or communicated to, the *ADS* (e.g., a police officer who announces over a loudspeaker that a particular stop sign should be ignored; another *driver* who flashes her head lamps to encourage overtaking, or a pedestrian using a DSRC system to announce her presence).

EXAMPLE 1: A level 2 automated parking *feature* allows the *remote driver* to exit the *vehicle* near an intended parking space and to cause the *vehicle* to move into the parking space automatically by pressing and holding a special button on the key fob, while s/he is *monitoring the driving environment* to ensure that no one and nothing enters the *vehicle* pathway during the parking maneuver. If, during the maneuver, a dog enters the pathway of the *vehicle*, the *remote driver* releases the button on the key fob in order to cause the *vehicle* to stop automatically. (Note that the *remote driver* in this level 2 example completes the *OEDR* subtask of the *DDT* during the parking maneuver.)

EXAMPLE 2: This example is identical to Example 1, except that the *remote driver* is sitting in the back seat, rather than standing outside the *vehicle*.

EXAMPLE 3: A level 4 closed campus delivery *vehicle* that has experienced a *DDT performance-relevant system failure*, which forced it to resort to a *minimal risk condition* by parking on the side of a campus roadway, is returned to its designated marshalling yard by a *remote driver* who is able to *operate* the *vehicle* using wireless means.

3.24.2 PASSENGER

A *user* in a *vehicle* who has no role in the *operation* of that *vehicle*.

NOTE: A *passenger* cannot be remote to the *vehicle* in which s/he is a *passenger*.

EXAMPLE 1: The person seated in the *driver's* seat of a *vehicle* equipped with a level 4 *ADS feature* designed to automate high-speed *vehicle operation* on controlled-access freeways is a *passenger* while this level 4 *feature* is engaged. This same person, however, is a *driver* before engaging this level 4 *ADS feature* and again after disengaging the *feature* in order to exit the controlled access freeway.

EXAMPLE 2: The in-*vehicle users* of a closed-campus shuttle on a university campus equipped with an engaged level 4 *ADS* are *passengers*.

EXAMPLE 3: The in-*vehicle users* of a level 5 *ADS*-equipped *vehicle* are *passengers* whenever the level 5 *ADS* is engaged.

3.24.3 (DDT) FALLBACK-READY USER

The *user* of a *vehicle* equipped with an engaged level 3 *ADS feature* who is able to *operate* the *vehicle* and is *receptive* to *ADS*-issued *requests to intervene* and to evident *DDT performance-relevant system failures* in the *vehicle* compelling him or her to perform the *DDT fallback*.

NOTE 1: *DDT* performance by a level 3 *ADS* assumes that a *DDT fallback-ready user* is available to perform the *DDT* as required. There is no such assumption at levels 4 and 5.

NOTE 2: A *DDT fallback-ready user* who transitions to performing part or all of the *DDT* becomes a *driver.*

NOTE 3: A *DDT fallback-ready user* may be remote to the *ADS*-equipped *vehicle* for which s/he serves as the *DDT fallback-ready user*.

EXAMPLE: A level 3 *ADS* that is performing the *DDT* in congested traffic on a freeway encounters emergency responders who are rerouting traffic to the exit due to a serious crash; the *ADS* issues a *request to intervene* to the *DDT fallback-ready user* instructing him or her to resume performing the *DDT* (i.e., to become a *driver*).

3.24.4 (ADS-EQUIPPED VEHICLE) DISPATCHER

A *user*(s) who verifies the operational readiness of the *vehicle* and *ADS* and engages or disengages the *ADS.*

NOTE 1: Unless the destination(s) is pre-programmed in the *ADS*, a *dispatcher* may also specify the destination(s).

NOTE 2: Only *vehicles* equipped with a level 4 or 5 *ADS* designed to *operate* a *vehicle* throughout a *trip* are potentially subject to being *dispatched*.

NOTE 3: Ensuring operational readiness includes such things as ensuring that conspicuity systems are clean and working, maintaining correct tire pressure and fluid levels, as well as ensuring that on-board diagnostic system checks for the *vehicle* and *ADS* indicate the absence of a *DDT performance-relevant system failure*.

EXAMPLE: A level 4 closed campus delivery *vehicle* that has experienced a *DDT performance-relevant system failure*, which forced it to resort to a *minimal risk condition* by parking on the side of a campus roadway, is returned to its marshalling yard by a *dispatcher* who becomes a *remote driver* and is able to perform the *DDT* using wireless means.

3.25 VEHICLE

A machine designed to provide conveyance on public streets, roads, and highways.

NOTE: As used in this document, *vehicle* refers to motorized *vehicles* and excludes those *operated* only on rail lines. For reference, 49 U.S.C. § 30102(a)(6) defines motor vehicle as follows: “motor vehicle means a vehicle driven or drawn by mechanical power and manufactured primarily for use on public streets, roads, and highways, but does not include a vehicle operated only on a rail line.”

4. TAXONOMY OF DRIVING AUTOMATION

The terms defined above inform a taxonomy of *driving automation* consisting of six discrete and mutually exclusive levels (see section 8.2). Central to this taxonomy are the respective roles of the (human) *user* and the *driving automation system* in relation to each other. Because changes in the functionality of a *driving automation system* change the role of the (human) *user*, they provide a basis for categorizing such systems. For example:

- If the *driving automation system* performs the *sustained longitudinal* and/or *lateral vehicle motion control* subtasks of the *DDT*, the *driver* does not do so, although s/he is expected to complete the *DDT*. This division of roles corresponds to levels 1 and 2.

- If the *driving automation system* performs the entire *DDT*, the *user* does not do so. However, if a *DDT fallback-ready user* is expected to take over the *DDT* when a *DDT performance-relevant system failure* occurs or when the *driving automation system* is about to leave its *operational design domain (ODD)*, then that *user* is expected to be *receptive* and able to resume *DDT* performance when alerted to the need to do so. This division of roles corresponds to level 3.

- Lastly, if a *driving automation system* can perform the entire *DDT* and *DDT fallback* either within a prescribed *ODD* or in all driver-manageable on-road *driving* situations (unlimited ODD), then any *users* present in the *vehicle* while the *ADS* is engaged are *passengers*. This division of roles corresponds to levels 4 and 5.

The *vehicle* also fulfills a role in this *driving automation* taxonomy, but the role of the *vehicle* does not change the role of the *user* in performing the *DDT*.

In this way, *driving automation systems* are categorized into levels based on:

1. Whether the driving automation system performs <u>either</u> the longitudinal <u>or</u> the lateral vehicle motion control subtask of the DDT.

2. Whether the driving automation system performs <u>both</u> the longitudinal <u>and</u> the lateral vehicle motion control subtasks of the DDT simultaneously.

3. Whether the driving automation system also performs the OEDR subtask of the DDT.

4. Whether the driving automation system also performs DDT fallback.

5. Whether the driving automation system is limited by an ODD.

Table 1 (below) summarizes the six levels of *driving automation* in terms of these five elements.

Table 1 - Summary of levels of driving automation

SAE’s levels of driving automation are descriptive and informative, rather than normative, and technical rather than legal. Elements indicate minimum rather than maximum capabilities for each level. In this table, “system" refers to the driving automation system or Automated Driving System (ADS), as appropriate.

Level	**Name**	**Narrative definition**	***DDT***		***DDT fallback***	***ODD***
			Sustained lateral and longitudinal vehicle motion control	***OEDR***		
Driver* performs part or all of the *DDT						
0	**No Driving Automation**	The performance by the *driver* of the entire *DDT*, even when enhanced by *active safety systems*.	*Driver*	*Driver*	*Driver*	n/a
1	**Driver Assistance**	The *sustained* and *ODD*-specific execution by a *driving automation system* of either the *lateral* or the *longitudinal vehicle motion control* subtask of the DDT (but not both simultaneously) with the expectation that the *driver* performs the remainder of the *DDT*.	*Driver* and *System*	*Driver*	*Driver*	Limited
2	**Partial Driving Automation**	The *sustained* and *ODD*-specific execution by a *driving automation system* of both the *lateral* and *longitudinal vehicle motion control* subtasks of the *DDT* with the expectation that the *driver* completes the *OEDR* subtask and *supervises* the *driving automation system*.	***System***	*Driver*	*Driver*	Limited
ADS* (“*System*”) performs the entire *DDT* (while engaged*)						
3	**Conditional Driving Automation**	The *sustained* and *ODD*-specific performance by an *ADS* of the entire DDT with the expectation that the *DDT fallback-ready user* is *receptive* to *ADS*-issued *requests to intervene*, as well as to *DDT performance-relevant system failures* in other *vehicle* systems, and will respond appropriately.	*System*	***System***	*Fallback-ready user (becomes the driver during fallback)*	Limited
4	**High Driving Automation**	The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	***System***	Limited
5	**Full Driving Automation**	The *sustained* and unconditional (i.e., not *ODD*-specific) performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	*System*	**Unlimited**

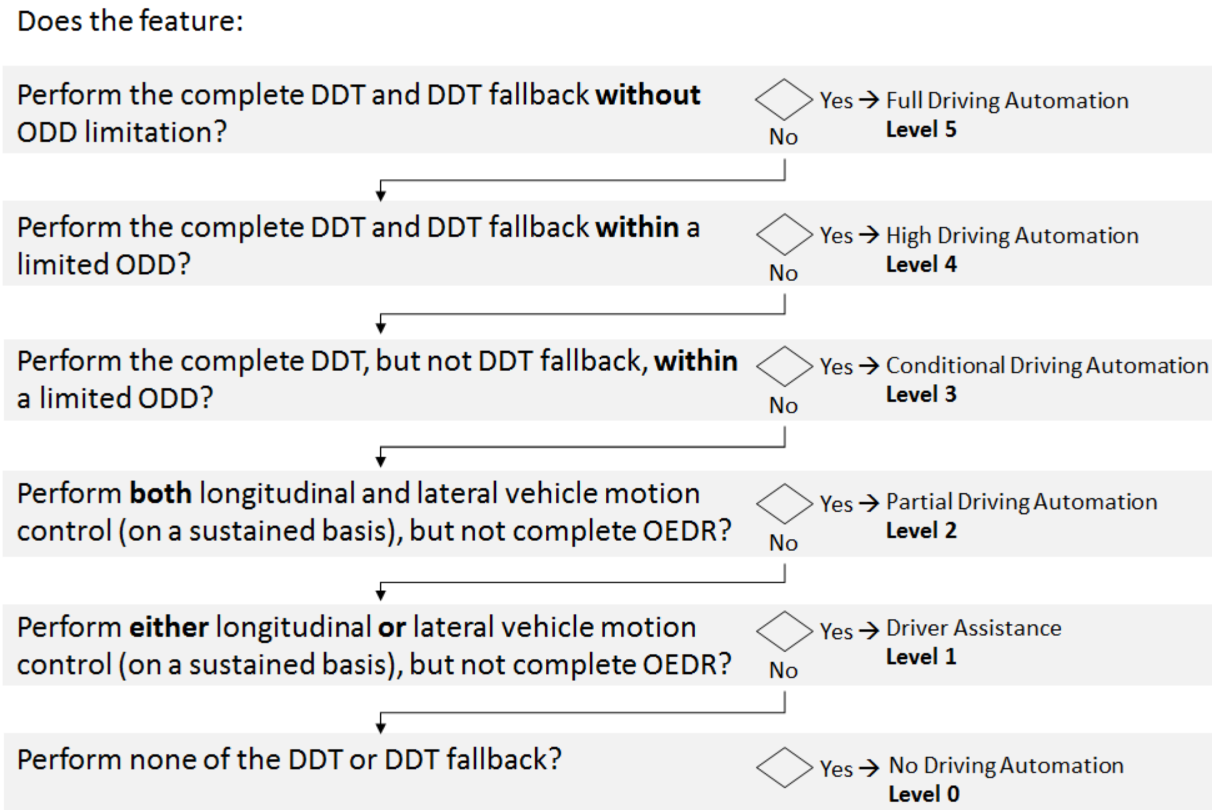


Figure 8 - Simplified logic flow diagram for assigning driving automation level to a feature

Figure 8 shows a simplified logic diagram for classifying *driving automation features*. Note that the information required to answer the questions posed in this figure cannot be empirically derived (see 8.1).

Table 2 (below) details the six levels of *driving automation* with reference to the roles (if any) that the *user* and the *driving automation system* play in performing the *DDT* and the *DDT fallback*. (NOTE: This assignment of roles refers to technical aspects of *vehicle operation* rather than to legal aspects.)

The descriptions provided in column 2 of Table 2 indicate the role (if any) of the *user* in performing part or all of the *DDT* and/or performing the *DDT fallback*, while the descriptions provided in column 3 indicate the role (if any) of the *driving automation system* in performing the same. As in Table 1, "system" refers to the *driving automation system* or *ADS*, as appropriate.

Note that the foregoing roles are determined by the design of the *driving automation system* in combination with the instructions provided to the *user,* regardless of malfunction in a particular *driving automation system* or a user's mis-performance of their role in a given circumstance. (See 8.1.)

Table 2 - Roles of human driver and driving automation system by level of driving automation

Level of *Driving Automation*	**Role of *User***	**Role of *Driving Automation System***
DRIVER* PERFORMS THE *DYNAMIC DRIVING TASK (DDT)		
Level 0 - *No Driving Automation*	*Driver* (at all times): • Performs the entire *DDT*	*Driving Automation System* (if any): • Does not perform any part of the *DDT* on a *sustained* basis (although other *vehicle* systems may provide warnings or support, such as momentary emergency intervention)
Level 1 - *Driver Assistance*	*Driver* (at all times): • Performs the remainder of the *DDT* not performed by the *driving automation system* • *Supervises* the *driving automation system* and intervenes as necessary to maintain safe *operation* of the *vehicle* • Determines whether/when engagement or disengagement of the *driving automation system* is appropriate • Immediately performs the entire *DDT* whenever required or desired	*Driving Automation System* (while engaged): • Performs part of the DDT by executing either the *longitudinal* ***or*** the *lateral vehicle motion control* subtask • Disengages immediately upon *driver* request
Level 2 - *Partial Driving Automation*	*Driver* (at all times): • Performs the remainder of the *DDT* not performed by the *driving automation system* • *Supervises* the *driving automation system* and intervenes as necessary to maintain safe *operation* of the *vehicle* • Determines whether/when engagement and disengagement of the *driving automation system* is appropriate • Immediately performs the entire *DDT* whenever required or desired	*Driving Automation System* (while engaged): • Performs part of the *DDT* by executing both the *lateral* ***and*** the *longitudinal vehicle motion control* subtasks • Disengages immediately upon *driver* request

AUTOMATED DRIVING SYSTEM (ADS) **PERFORMS THE ENTIRE** ***DYNAMIC DRIVING TASK (DDT)***		
Level 3 – Conditional Driving Automation	*Driver* (while the ADS is not engaged)*:* • Verifies operational readiness of the *ADS-equipped vehicle* • Determines when engagement of *ADS* is appropriate • Becomes the *DDT fallback-ready user* when the *ADS* is engaged *DDT fallback-ready user* (while the *ADS* is engaged)*:* • Is *receptive* to a *request to intervene* and responds by performing *DDT fallback* in a timely manner • Is *receptive* to *DDT performance-relevant system failures* in *vehicle* systems and, upon occurrence, performs *DDT fallback* in a timely manner • Determines whether and how to achieve a *minimal risk condition* • Becomes the *driver* upon requesting disengagement of the *ADS*	*ADS (*while not engaged): • Permits engagement only within its *ODD* *ADS* (while engaged): • Performs the entire *DDT* • Determines whether *ODD* limits are about to be exceeded and, if so, issues a timely *request to intervene* to the *DDT fallback-ready user* • Determines whether there is a *DDT performance-relevant system failure* of the *ADS* and, if so, issues a timely *request to intervene* to the *DDT fallback-ready user* • Disengages an appropriate time after issuing a *request to intervene* • Disengages immediately upon *driver* request

Level 4 - High Driving Automation	*Driver/dispatcher* (while the *ADS* is not engaged):
	• Verifies operational readiness of the *ADS-equipped vehicle*
	• Determines whether to engage the *ADS*
	• Becomes a *passenger* when the *ADS* is engaged only if physically present in the *vehicle*
	
	Passenger/dispatcher (while the *ADS* is engaged)*:*
	• Need not perform the *DDT* or *DDT fallback*
	• Need not determine whether and how to achieve a *minimal risk condition*
		ADS (while not engaged):
		• Permits engagement only within its *ODD*
		
		ADS (while engaged):
		• Performs the entire *DDT*
		• May issue a timely *request to intervene*
		• Performs *DDT fallback* and transitions automatically to a *minimal risk condition* when*:*
		  ◦ A *DDT performance-relevant system failure* occurs or
		  ◦ A *user* does not respond to a *request to intervene* or

	• May perform the *DDT fallback* following a *request to intervene* • May request that the *ADS* disengage and may achieve a *minimal risk condition* after it is disengaged • May become the *driver* after a requested disengagement	• A *user* requests that it achieve a *minimal risk condition* • Disengages, if appropriate, only after: • It achieves a *minimal risk condition* or • A *driver* is performing the *DDT* • May delay *user*-requested disengagement
Level 5 - Full Driving Automation	*Driver/dispatcher* (while the *ADS* is not engaged): • Verifies operational readiness of the *ADS*-equipped vehicle • Determines whether to engage the *ADS* • Becomes a *passenger* when the *ADS* is engaged only if physically present in the *vehicle* *Passenger/dispatcher* (while the *ADS* is engaged): • Need not perform the *DDT* or *DDT fallback* • Need not determine whether and how to achieve a *minimal risk condition* • May perform the *DDT fallback* following a *request to intervene* • May request that the ADS disengage and may achieve a *minimal risk condition* after it is disengaged • May become the *driver* after a requested disengagement	*ADS* (while not engaged): • Permits *engagement* of the *ADS* under all driver-manageable on-road conditions *ADS* (while engaged): • Performs the entire *DDT* • Performs *DDT fallback* and transitions automatically to a *minimal risk condition* when: • A *DDT performance-relevant system failure* occurs or • A *user* does not respond to a *request to intervene or* • A *user* requests that it achieve a *minimal risk condition* • Disengages, if appropriate, only after: • It achieves a *minimal risk condition* or • A *driver* is performing the *DDT* • May delay a *user*-requested disengagement

Table 3, below, describes a *user's* role with respect to an engaged *driving automation system* operating at a particular level of *driving automation* at a particular point in time. A *user* occupying a given *vehicle* can have one of three possible roles during a particular *trip*: 1) *driver*, 2) *DDT fallback-ready user* or 3) *passenger*. A *remote user* of a given *vehicle* (i.e., who is not seated in the driver's seat of the *vehicle* during use) can also have one of three possible roles during a particular *trip*: 1) *remote driver*, 2) *DDT fallback-ready user* or 3) *dispatcher*.

Table 3 - User roles while a driving automation system is engaged

	No *Driving Automation*	**Engaged Level of *Driving Automation***				
	0	**1**	**2**	**3**	**4**	**5**
In-*vehicle User*	*Driver*			*DDT fallback-ready user*	*Passenger*	
Remote *User*	*Remote Driver*			*DDT fallback-ready user*	*Dispatcher*	

NOTE: A *vehicle* equipped with a level 4 or 5 *ADS* may also support a *driver* role. For example, in order to complete a given *trip,* a *user* of a *vehicle* equipped with a level 4 *ADS* feature designed to *operate* the *vehicle* during high-speed freeway conditions will generally choose to perform the *DDT* when the freeway ends; otherwise the *ADS* will automatically perform *DDT fallback* and achieve a *minimal risk condition* as needed. However, unlike at level 3, this *user* is not a *DDT fallback-ready user* while the *ADS* is engaged.

5. LEVELS OR CATEGORIES OF DRIVING AUTOMATION

As discussed above, the level of *driving automation* is based on the functionality of the *driving automation system*, as determined by an allocation of roles in *DDT* and *DDT fallback* performance between that *system* and the (*human) user* (if any). The manufacturer of a *driving automation system* determines that *system's* requirements, *operational design domain (ODD)*, and operating characteristics, including the level of *driving automation*, as defined below. The manufacturer also defines the proper use of that *system*.

The lower two levels of *driving automation* (1-2) refer to cases in which the (human) *driver* continues to perform part of the *DDT* while the *driving automation system* is engaged.

The upper three levels of *driving automation* (3-5) refer to cases in which the *Automated Driving System (ADS)* performs the entire the *DDT* on a *sustained* basis while it is engaged.

5.1 LEVEL or CATEGORY 0 - NO DRIVING AUTOMATION

The performance by the *driver* of the entire *DDT*, even when enhanced by *active safety systems.*

5.2 LEVEL or CATEGORY 1 - DRIVER ASSISTANCE

The sustained and ODD-specific execution by a *driving automation system* of either the lateral or the longitudinal vehicle motion control subtask of the DDT (but not both simultaneously) with the expectation that the driver performs the remainder of the DDT.

NOTE: A level 1 *feature* performing either the *lateral* or the *longitudinal vehicle motion control subtask* of the *DDT* is capable of only limited *OEDR* within its dimension (*lateral* or *longitudinal*), meaning that there are some events that the *driving automation system* is not capable of recognizing or responding to. Therefore, the *driver* must *supervise* the *driving automation system* performance by completing the *OEDR* subtask of the *DDT* as well as performing the other dimension of *vehicle motion control*. See Figure 1 (discussing the three primary subtasks of the *DDT*).

5.3 LEVEL or CATEGORY 2 - PARTIAL DRIVING AUTOMATION

The *sustained* and *ODD*-specific execution by a *driving automation system* of both the *lateral and longitudinal vehicle motion control* subtasks of the *DDT* with the expectation that the *driver* completes the *OEDR* subtask and *supervises* the *driving automation system*.

NOTE: A level 2 *driving automation feature* is capable of only limited *OEDR*, meaning that there are some events that the *driving automation system* is not capable of recognizing or responding to. Therefore the *driver supervises* the *driving automation system* performance by completing the *OEDR* subtask of the *DDT*. See Figure 1 (discussing the three primary subtasks of the *DDT*).

5.4 LEVEL or CATEGORY 3 - CONDITIONAL DRIVING AUTOMATION

The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* with the expectation that the *DDT fallback-ready user* is *receptive* to *ADS*-issued requests to intervene, as well as to *DDT performance-relevant system failures* in other vehicle systems, and will respond appropriately.

NOTE 1: The *DDT fallback-ready user* need not *supervise* a level 3 *ADS* while it is engaged but is expected to be prepared to resume the *DDT* when the *ADS* issues a *request to intervene*, such as when a *DDT performance-relevant system failure* occurs.

NOTE 2: A level 3 *ADS's DDT fallback-ready user* is also expected to be *receptive* to evident *DDT performance-relevant system failures* in *vehicle* systems that do not necessarily trigger an *ADS*-issued *request to intervene*, such as a broken body or a suspension component.

NOTE 3: In the event of a *DDT performance-relevant system failure* in a level 3 *ADS* or in the event that the *ADS* will soon exit its *ODD*, the *ADS* will issue a *request to intervene* within sufficient time for a typical person to respond appropriately to the driving situation at hand.

NOTE 4: An “appropriate” response by a *DDT fallback-ready user* to a *request to intervene* may entail bringing the *vehicle* to a *minimal risk condition* or continuing to *operate* the *vehicle* after the *ADS* has disengaged.

EXAMPLE: An *ADS feature* capable of performing the entire *DDT* in low-speed, stop-and-go freeway traffic.

5.5 LEVEL or CATEGORY 4 - HIGH DRIVING AUTOMATION

The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* and *DDT fallback*, without any expectation that a *user* will respond to a *request to intervene*.

NOTE 1: The *user* does not need to *supervise* a level 4 *ADS feature* or be *receptive* to a *request to intervene* while the *ADS* is engaged. A level 4 *ADS* is capable of automatically performing *DDT fallback*, as well as achieving a *minimal risk condition* if a *user* does not resume performance of the *DDT*. This automated *DDT fallback* and *minimal risk condition* achievement capability is the primary difference between level 4 and level 3 *ADS* features. This means that the *user* of an engaged *level 4 ADS feature* is a *passenger* who need not respond to *requests to intervene* or to *DDT performance-relevant system failures*.

NOTE 2: Level 4 *ADS features* may be designed to *operate* the *vehicle* throughout complete *trips* (e.g., a closed campus shuttle *feature*), or they may be designed to *operate* the *vehicle* during only part of a given *trip*, after *ODD* requirements are met (e.g., a high-speed freeway cruising *feature*), For example, in order to complete a given *trip*, a *user* of a *vehicle* equipped with a level 4 *ADS feature* designed to *operate* the *vehicle during* high-speed freeway conditions will generally choose to perform the *DDT* when the freeway ends; otherwise the *ADS* will automatically perform *DDT fallback* and achieve a *minimal risk condition* as needed. However, unlike at level 3, this *user* is not a *DDT fallback-ready user* while the *ADS* is engaged. (see Example 2, below).

EXAMPLE 1: A level 4 *ADS feature* capable of performing the entire *DDT* during valet parking (i.e., curb-to-door or vice versa) without any *driver supervision*.

EXAMPLE 2: A level 4 *ADS feature* capable of performing the entire *DDT* during *sustained operation* on a motorway or freeway (i.e., within its *ODD*). (Note: The presence of a *user* in the driver's seat who is capable of performing the *DDT* is envisioned in this example, as *driver* performance of the *DDT* would have been necessary before entering, and would again be necessary after leaving, the motorway or freeway. Thus, such a *feature* would alert the *user* that s/he should resume *vehicle operation* shortly before exiting the *ODD*, but if the *user* fails to respond to such an alert, the *ADS* will nevertheless perform the *DDT fallback* and achieve a *minimal risk condition* automatically.)

EXAMPLE 3: A *dispatcher* may engage a level 4 *ADS-DV*, which is capable of following a pre-defined route within a confined geographical area (e.g., residential community, military base, university campus).

5.6 LEVEL [CATEGORY] 5 - FULL DRIVING AUTOMATION

The *sustained* and unconditional (i.e., not *ODD*-specific) performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene.*

NOTE 1: "Unconditional/not *ODD*-specific" means that the *ADS* can *operate* the *vehicle* under all *driver*-manageable on-road conditions. This means, for example, that there are no design-based weather, time-of-day, or geographical restrictions on where and when the *ADS* can *operate* the *vehicle*. However, there may be conditions not manageable by a *driver* in which the *ADS* would be unable to complete a given *trip* (i.e., white-out snow storm, flooded roads, glare ice, etc.) until or unless the adverse conditions clear. At the onset of such unmanageable conditions the *ADS* would perform the *DDT fallback* to achieve a *minimal risk condition* (e.g., by pulling over to the side of the road and waiting for the conditions to change).

NOTE 2: In the event of a *DDT performance-relevant system failure* (of an *ADS* or the *vehicle*), a level 5 *ADS* automatically performs the *DDT fallback* and achieves a *minimal risk condition*

NOTE 3: The *user* does not need to *supervise* a level 5 *ADS*, nor be *receptive* to a *request to intervene* while it is engaged.

EXAMPLE: A *vehicle* with an *ADS* that, once programmed with a destination, is capable of *operating* the *vehicle* throughout complete *trips* on public roadways, regardless of the starting and end points or intervening road, traffic, and weather conditions.

6. SIGNIFICANCE OF OPERATIONAL DESIGN DOMAIN (ODD)

Conceptually, the role of a *driving automation system* vis-à-vis a *user* in performance of part or all of the *DDT* is orthogonal to the specific conditions under which it performs that role: A specific implementation of adaptive cruise control, for example, may be intended to operate only at high speeds, only at low speeds, or at all speeds.

For simplicity, however, J3016's taxonomy collapses these two axes into a single set of levels of *driving automation*. Levels 1 through 4 expressly contemplate *ODD* limitations. In contrast, level 5 expressly disavows any such limitations.

Accordingly, accurately describing a *feature* (other than at level 5) requires identifying both its level of *driving automation* and its *operational design domain* (*ODD*). As provided in the definitions above, this combination of level of *driving automation* and *ODD* is called a *usage specification*, and a given *feature* satisfies a given *usage specification*.

Because of the wide range of possible *ODD*s, a wide range of possible *features* may exist in each level (e.g., level 4 includes parking, high-speed, low-speed, geo-fenced, etc.). For this reason, SAE J3016 provides less detail about the ODD attributes that may define a given *feature* than about the respective roles of a *driving automation system* and its *user*.

ODD is especially important to understanding why an *ADS* is not level 5 merely because it *operates* an *ADS-dedicated vehicle*. Unlike a level 5 *ADS*, a level 4 *ADS* has a limited *ODD*. Geographic or environmental restrictions on an *ADS-DV* may reflect the *ODD* limitations of its *ADS* (or they may reflect *vehicle* design limitations).

Figure 9 illustrates the orthogonality of *ODD* relative to levels of *driving automation*.

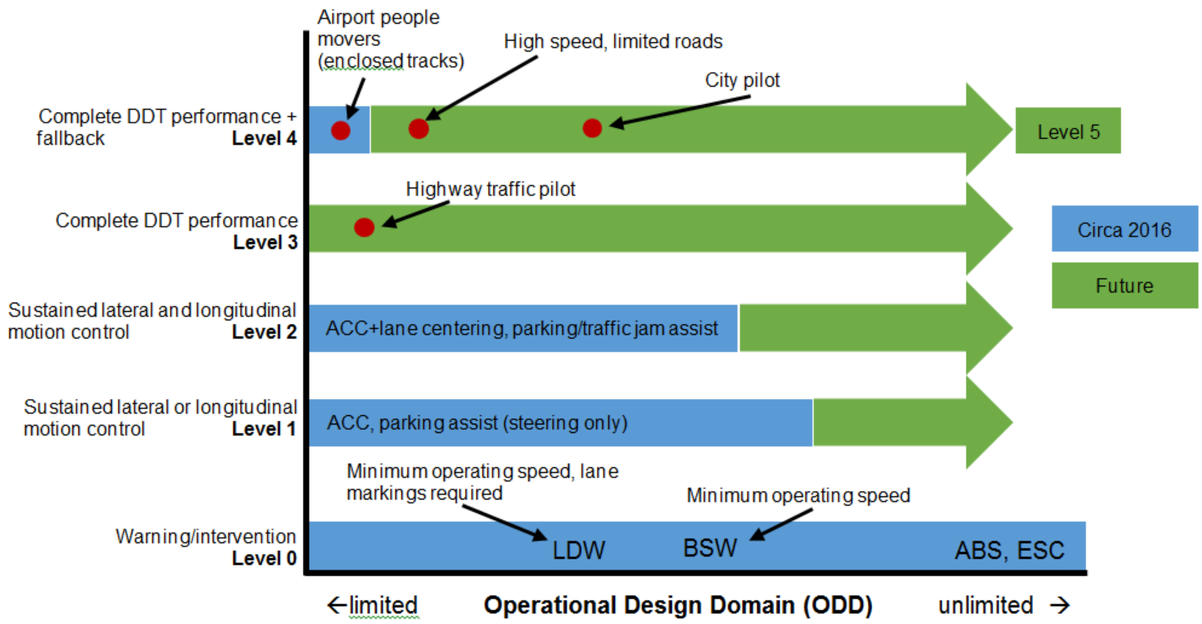


Figure 10 - Illustrates the significance of ODD relative to the levels.

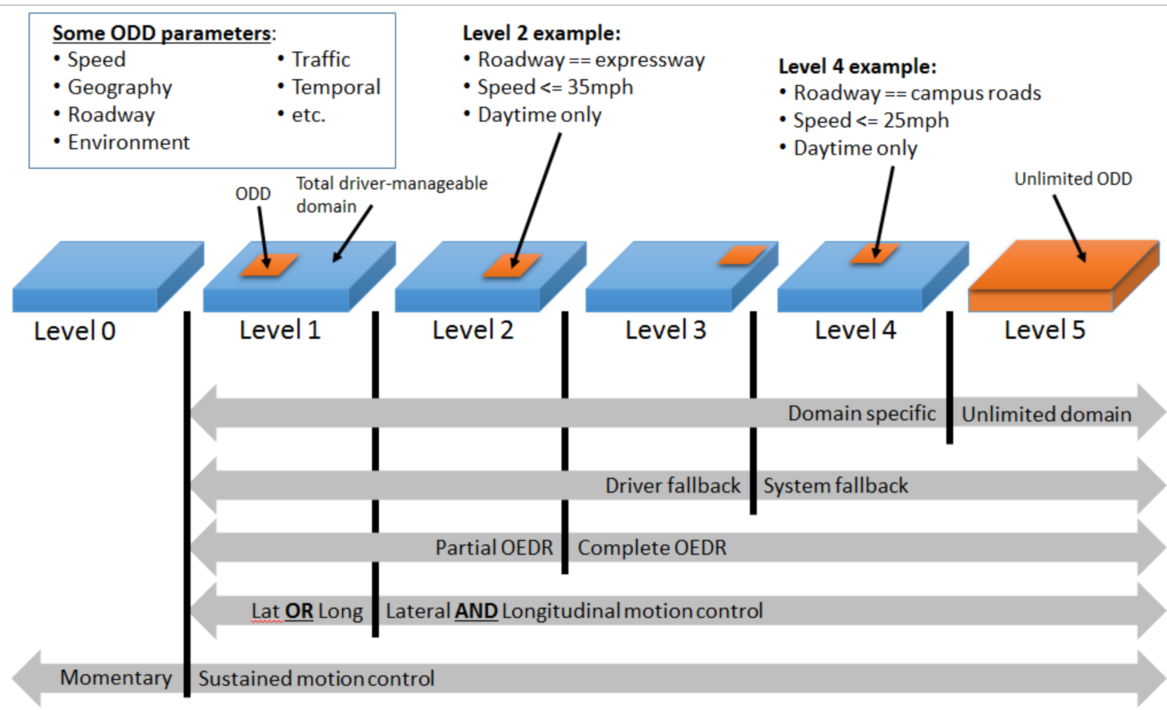


Figure 11 - ODD relative to levels

7. DEPRECATED TERMS

For the sake of clarity, this section identifies certain deprecated terms that are not used in this Recommended Practice either because they are functionally imprecise (and therefore misleading) and/or because they are frequently misused by application to lower levels of *driving automation* (i.e., levels 1 and 2) in which the *driving automation system* does not perform the entire *DDT*.

7.1 Autonomous, Self-Driving, Driverless, Unmanned, Robotic

Vernacular terms such as those above are sometimes used—inconsistently and confusingly—to characterize *driving automation systems* and/or *vehicles* equipped with them. Because automation is the use of electronic or mechanical devices to replace human labor, based on the Oxford English Dictionary, automation (modified by "driving" to provide context) is the appropriate term for systems that perform part or all of the *DDT*. The use of other terms can lead to confusion, misunderstanding, and diminished credibility.

7.1.1 Autonomous

This term has been used for a long time in the robotics and artificial intelligence research communities to signify systems that have the ability and authority to make decisions independently and self-sufficiently. Over time, this usage was casually broadened to not only encompass decision making, but to represent the entire system functionality, thereby becoming synonymous with automated. This usage obscures the question of whether a so-called "autonomous vehicle" depends on communication and/or cooperation with outside entities for important functionality (such as data acquisition and collection). Some *driving automation systems* may indeed be autonomous if they perform all of their functions independently and self-sufficiently, but if they depend on communication and/or cooperation with outside entities, they should be considered cooperative rather than autonomous. Some vernacular usages associate autonomous specifically with *full driving automation* (level 5), while other usages apply it to all levels of *driving automation*, and some state legislation has defined it to correspond approximately to any *ADS* at or above level 3 (or to any vehicle equipped with such an *ADS*).

Additionally, in jurisprudence, autonomy refers to the capacity for self-governance. In this sense, also, "autonomous" is a misnomer as applied to *automated driving technology*, because even the most advanced *ADSs* are not "self-governing." Rather, *ADSs* operate based on algorithms and otherwise obey the commands of *users*.

For these reasons, this document does not use the popular term "autonomous" to describe *driving automation*.

7.1.2 Self-driving

The meaning of this term can vary based on unstated assumptions about the meaning of *driving* and *driver*. It is variously used to refer to situations in which no *driver* is present, to situations in which no *user* is performing the *DDT*, and to situations in which a *driving automation system* is performing any part of the *DDT*.

7.1.3 Driverless and Unmanned

These terms are frequently misused to describe any *vehicle* equipped with a level 2 or higher *driving automation system*. Because "driver" can have many meanings, "driverless" can confuse rather than clarify. (Under J3016's definitions, an engaged level 3, 4, or 5 *ADS* displaces a (human) *driver*.) The term "unmanned" suggests the absence of a person in a vehicle, which can also be misleading because it does not distinguish between a *vehicle* remotely *operated* by a *human driver* and an ADS-*operated vehicle* in which there are no occupants that have the ability to *operate* the *vehicle.*

7.1.4 Robotic

This term is sometimes used to connote level 4 or 5 *driving automation*, such as a closed-campus *ADS-DV* or a "robotic taxi," but it is technically vague because any automation technology could be considered to be "robotic," and as such it conveys no useful information about the *ADS* or *vehicle* in question.

7.2 Automated or Autonomous Vehicle

This Recommended Practice recommends against using terms that make *vehicles*, rather than *driving*, the object of automation, because doing so tends to lead to confusion between *vehicles* that can be *operated* by a (human) *driver* or by an *ADS* and *ADS-DVs*, which are designed to be *operated* exclusively by an *ADS*. It also fails to distinguish other forms of vehicular automation that do not involve automating part or all of the *DDT*.

Moreover, a given *vehicle* may be equipped with a *driving automation system* that is capable of delivering multiple *driving automation features* that *operate* at different levels; thus, the level of *driving automation* exhibited in any given instance is determined by the *feature(s)* engaged.

As such, the recommended usage for describing a *vehicle* with *driving automation capability* is "level [1 or 2] *driving automation system*-equipped *vehicle*" or "level [3, 4, or 5] *ADS*-equipped *vehicle.*" The recommended usage for describing a *vehicle* with an engaged *system* (vs. one that is merely available) is "level [1 or 2] *driving automation system*-engaged *vehicle*" or "level [3, 4, or 5] *ADS-operated vehicle.*"

7.3 Control

In colloquial discourse, the term "control" is sometimes used to describe the respective roles of a (human) *driver* or a *driving automation system* (e.g., "the driver has control"). The authors of this Recommended Practice strongly discourage, and have therefore deliberately avoided, this potentially problematic colloquial usage. Because the term "control" has numerous technical, legal, and popular meanings, using it without careful qualification can confuse rather than clarify. In law, for example, "control," "actual physical control," and "ability to control" can have distinct meanings that bear little relation to engineering control loops. Similarly, the statement that the (human) *driver* "does not have control" may unintentionally and erroneously suggest the loss of all human authority.

The preferred terms "*DDT* performance" (as explained in the definition of *DDT* above) and "*operate*" (also a defined term, above) reduce potential confusion by specifically describing what the (human) *driver* or *driving automation system* actually does in terms of performing part or all of the *DDT*. This Recommended Practice does use the terms *lateral vehicle motion control* and *longitudinal vehicle motion control*, both of which are explicitly defined in terms of specific engineering functions.

If "control" is to be used in a particular *driving automation* context, it should be carefully qualified. To this end, the one using the term "should first describe the control system they actually intend: the goals, inputs, processes, and outputs to the extent they are determined by a human designer and the authority of the human or computer agents to the extent they are not." See Bryant Walker Smith, Engineers and Lawyers Should Speak the Same Robot Language, in Robot Law (2015), available at newlypossible.org.

8. ADDITIONAL DISCUSSION

8.1 Level are assigned, rather than measured

It is not possible to describe or specify a complete test or set of tests which can be applied to a given *ADS feature* to conclusively identify or verify its level of *driving automation*. The level assignment rather expresses the design intention for the *feature* and as such tells potential *users* or other interested parties that the *feature* can be expected to function such that the roles of the *user* vs. the *driving automation system* while the *feature* is engaged are consistent with the assigned level, as defined in this document. The level assignment is typically based on the manufacturer's knowledge of the *feature's*/*system's* design, development, and testing, which inform the level assignment. An *ADS feature's* capabilities and limitations are communicated to prospective *users* through various means, such as in an owner's manual, which explains the *feature* in detail, including how it should and should not be used, what limitations exist (if any), and what to do (if anything) in the event of a *DDT performance-relevant system failure* in the *driving automation system* or *vehicle*.

As such, the manifestation of one or more performance deficiencies in either the *driving automation system* or in the *user's* use of it does not automatically change the level assignment. For example:

- An *ADS feature* designed by its manufacturer to be level 5 would not automatically be demoted to level 4 simply by virtue of encountering a particular road on which it is unable to *operate* the *vehicle*.

- The *user* of an engaged level 3 *ADS feature* who is seated in the driver's seat of an equipped *vehicle* is the *DDT fallback-ready user* even if s/he is no longer *receptive* to a *request to intervene* because s/he has improperly fallen asleep.

8.2 Levels are Mutually Exclusive

The levels in this taxonomy are intentionally discrete and mutually exclusive. As such, it is not logically possible for a given *feature* to be assigned more than a single level. For example, a low-speed driving automation *feature* described by the manufacturer as being capable of performing the complete *DDT* in dense traffic on fully access-controlled freeways cannot be both level 3 and level 4, because either it is capable of automatically performing the *DDT fallback* and achieving a *minimal risk condition* whenever needed, or it relies (at least sometimes) on the *driver* to respond to a *request to intervene* and either perform the *DDT* or achieve a *minimal risk condition* on his or her own.

It is, however, quite possible for a *driving automation system* to deliver multiple *features* at different levels, depending on the *usage specification* and/or *user* preferences. For example, a *vehicle* may be equipped with a *driving automation system* capable of delivering, under varying conditions, a level 1 ACC *feature*, a level 2 highway assistance *feature*, a level 3 freeway traffic jam feature, and a level 4 automated valet parking *feature* – in addition to allowing the *user* to *operate* the *vehicle* at level 0 with no *driving automation features* engaged. From the standpoint of the *user*, these various *features* engage sequentially, rather than simultaneously, even if the *driving automation system* makes use of much of the same underlying hardware and software technology to deliver all four *driving automation features*.

8.3 User request to perform the DDT when a level 3, 4 or 5 ADS is engaged

Vehicles equipped with an engaged level 3 *ADS feature* are expected to relinquish the *DDT* upon request by a *DDT fallback-ready user*. This expectation is a logical consequence of the *DDT fallback-ready user's* need to be able to perform the *DDT fallback* whenever required, including in cases when a *DDT performance-relevant vehicle system failure* has occurred that the *ADS* may not be *monitoring* (such as a broken suspension component).

Some *vehicles* equipped with level 4 or 5 *driving automation features* may not be designed to allow for *driver operation* (i.e. *ADS-DV*). In these types of *vehicles, passengers* may be able to demand a *vehicle* stop by, for example, pulling an emergency stop lever, and in response, the *ADS* would achieve a *minimal risk condition*.

However, other *vehicles* equipped with level 4 or 5 *driving automation features* may also be designed for *driver operation* (i.e., at any lower level, including level 0). A *user* may request to *operate* these *vehicles* while the *ADS* is engaged without having been issued a *request to intervene* by the *ADS*. In these cases, the *ADS* may delay relinquishing of the *DDT* to ensure a smooth transition to the *driver's* performance of the *DDT*, or to prevent a hazardous condition.

For example:

- A *vehicle* being *operated* by a level 4 *ADS* highway pilot *feature* that is negotiating a tight curve may not immediately disengage upon the *user's* request, but may instead do so gradually as the *user* indicates through steering input that s/he is fully re-engaged in the *DDT*.

- A level 4 *ADS feature* designed to *operate* a *vehicle* in a high-speed convoy with small gaps between *vehicles* may delay relinquishing performance of the *DDT* to a *user* upon his or her request to resume driving until after the *ADS* has safely maneuvered the *vehicle* out of the convoy, since (human) *drivers* may not be capable of safely operating a *vehicle* in a close-coupled convoy.

8.4 Driving vs. DDT

Driving entails a variety of decisions and actions, which may or may not involve a *vehicle* being in motion, or even being in an active lane of traffic. The overall act of driving can be divided into three types of *driver* effort: Strategic, Tactical, and Operational (Michon, 1985). Strategic effort involves *trip* planning, such as deciding whether, when and where to go, how to travel, best routes to take, etc. Tactical effort involves maneuvering the *vehicle* in traffic during a *trip*, including deciding whether and when to overtake another *vehicle* or change lanes, selecting an appropriate speed, checking mirrors, etc. Operational effort involves split-second reactions that can be considered pre-cognitive or innate, such as making micro-corrections to steering, braking and accelerating to maintain lane position in traffic or to avoid a sudden obstacle or hazardous event in the *vehicle's* pathway.

The definition of *DDT* provided above (3.4) includes tactical and operational effort but excludes strategic effort. It is that portion of driving that specifically entails *operating* a *vehicle* in an active lane of traffic when the *vehicle* is either in motion or imminently so. (It should be noted that these terms—strategic, tactical and operational—may have different meanings in other contexts but are defined as above for the purposes of this document.) Indeed, this Recommended Practice defines "*operate*" to include both operational and tactical efforts.

Object and event detection, recognition, classification, and response (aka, *OEDR*) form a continuum of activities often cited in the driver workload literature. In the case of *driving automation systems*, *OEDR* also includes *driving* events associated with *system* actions or outcomes, such as undiagnosed *driving automation system* errors or state changes.

8.5 Comparison of J3016 *driving automation* levels with BASt and NHTSA levels

Prior to the initial publication of J3016 in January 2014, there were two published documents that described levels of *driving automation* with respect to motor *vehicles* and/or *driving*: The US National Highway Traffic Safety Administration (NHTSA)'s "Preliminary Statement of Policy Concerning Automated Vehicles" (May 30, 2013) and the German Federal Highway Research Institute's (Bundesanstalt für Strassenwesen, a.k.a. BASt) "Legal consequences of an increase in vehicle automation" Tom M. Gasser et al. (July 23, 2013). After thorough review of both documents, including discussions with both authoring organizations, SAE Task Force members were persuaded that the BASt levels were more in line with the Task Force's operating principles, namely, that SAE J3016 should be:

- Descriptive rather than normative, which is to say it should provide functional definitions.
- Consistent with current industry practice.
- Consistent with prior art – we should start with what has already been done and change only what is necessary.
- Useful across disciplines, including engineering, law, media, public discourse.
- Clear and cogent, which is to say we should avoid or define ambiguous terms.

In keeping with these guiding principles, SAE largely adopted the BASt levels, but with several adjustments:

- Added a sixth level (namely, level 5 – *full driving automation*) not described in the BASt levels.
- Modified level names accordingly.
- Added supporting terms and definitions, such as *DDT*, *minimal risk condition*, etc.
- Described categorical distinctions that provide for a step-wise progression through the levels.
- Provided explanatory text and examples to aid the reader in understanding the levels, definitions, and their derivation.

After SAE J3016 was published in January, 2014, the International Organization of Motor Vehicle Manufacturers (Organisation Internationale des Constructeurs d'Automobiles, a.k.a., OICA) adopted the BASt levels and aligned them (in English) with SAE J3016, including adding a sixth level to represent "*full driving automation*."

However, BASt/SAE/OICA levels differ more fundamentally from the levels described by the National Highway Traffic Safety Administration (NHTSA) in its "Preliminary Statement of Policy Concerning Automated Vehicles" (May 30, 2013). NHTSA's levels were intended to provide preliminary policy guidance to U.S. state and local governments contemplating legislation and/or regulation related to "automated/autonomous vehicles." As such, NHTSA's level descriptions are written in loosely descriptive terms using normative language and therefore do not provide the degree of definitional and functional clarity that are ultimately required to support the technical and policy discussions that lead to standards, norms and/or legal requirements.

Moreover, NHTSA's levels purport to apply to *vehicles*, rather than to *driving automation,* which, as explained above, leads to confusion. The NHTSA levels also include *features* and functions that do not serve to automate part or all of the *DDT* on a *sustained* basis, such as anti-lock brake systems (ABS), electronic stability control (ESC), and lane keeping assistance systems (LKAS). These intervention-type *active safety systems* are not *driving automation system features*, because, *DDT* performance (partial or complete) is not *sustained* between and across external events during driving. Rather, these *active safety systems* are momentarily activated during a specific driving safety hazard scenario and then quickly cut out again, and activation of such systems also does not change the *driver*'s role in terms of performing the *DDT*. (See Scope above.)

Finally, it should be noted that crash avoidance features, including intervention-type *active safety systems*, may be included in *vehicles* equipped with *driving automation systems* at any level. For *ADS*-equipped *vehicles* (i.e., levels 3-5) that perform the complete *DDT*, crash avoidance capability is part of *ADS* functionality.

9. NOTES

9.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE ON-ROAD AUTOMATED VEHICLE STANDARDS COMMITTEE