Prepared by the expert from the UK

Document ADS-08-04/Rev.1
8th ADS IWG session
14-18 April 2025

**Consolidated Draft of Common Provisions on ADS Safety**
(Version 1.4: 28 March 2025)

*This document consolidates the ADS IWG work up to and including the 7th meeting in Petten in March 2025. This consolidated document will act as the base document going forward until separated into a draft GTR and a draft UNR (currently foreseen for the July ADS IWG meeting). It does not contain comments or open items which can be viewed in the open items table.*

Contents



Annexes

- In-Service Reporting Templates
- Critical Occurrences threshold definition
- ODD-based Behavioural competences and Scenario Identification approach

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# 1.Purpose

1.1. (*GTR)* This Global Technical Regulation (GTR) provides worldwide harmonised procedures to set and verify compliance with minimum requirements for the safety of Automated Driving Systems (ADS) and vehicles equipped with ADS.

(*UNR)* This Regulation establishes uniform provisions concerning the approval of motor vehicles with regard to their Automated Driving Systems (ADS).

# 2.Scope

2.1. *(GTR)* This GTR applies to the Automated Driving Systems of vehicles of categories 1 and 2.

*(UNR)* This Regulation applies to the approval of vehicles of categories M and N with regard to their Automated Driving Systems.

# 3.Definitions[1]

Terms not found in the draft text have been omitted.

3.1. "*Automated Driving System (ADS)"* means the vehicle hardware and software that are collectively capable of performing the entire Dynamic Driving Task (DDT) on a sustained basis. [2]

3.2. *"ADS fallback response"* means a system-initiated deactivation of the ADS or an ADS-controlled procedure to place the vehicle in a minimal risk condition.

3.3. *"ADS feature"* means an application of an ADS designed specifically for use within an Operational Design Domain (ODD).

3.3.1. "ADS feature of type 1 (ADSF-1)" means an ADS feature which includes an ADS fallback response requiring a fallback user.

3.3.2. "ADS feature of type 2 (ADSF-2)" means an ADS feature which does not include an ADS fallback response requiring a fallback user.

3.4. *"ADS function"* means an ADS hardware and software capability designed to perform a specific portion of the DDT.

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1 Definitions for terms used in the document.

2 This definition is based on SAE J3016 and ISO/PAS 22736 (Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles). These standards define levels of driving automation based on the functionality of the driving automation system feature as determined by an allocation of roles in DDT and DDT fallback performance between that feature and the (human) user (if any). The term "Automated Driving System" is used specifically to describe a Level 3, 4, or 5 driving automation system.

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3.4.1. *"Strategic function"* means a capability to issue commands, instructions, or guidance for execution by an ADS.[3]

3.4.2. *"Tactical function"* means a capability to perceive the vehicle environment and control real-time planning, decision, and execution of manoeuvres, including conspicuity of the vehicle and its motion.[4]

3.4.3. *"Operational function"* means a capability to control the real-time motion of the vehicle.[5]

3.5. "*ADS user"* means a human user of an ADS vehicle.[6]

3.5.1. *"Driver"* means a human user who performs in real time part or all of the DDT and/or DDT fallback for a particular vehicle.

3.5.2. *"Fallback user"* means a user designated to perform the DDT pursuant to an ADS fallback response.

3.6. *"ADS vehicle"* means a vehicle equipped with an ADS.

3.7. *"Behavioural competency"* means an expected and verifiable capability of an ADS feature to operate a vehicle within the ODD of the feature.

3.8. *"Dynamic Driving Task (DDT)"* means the real-time operational and tactical functions required to operate the vehicle.

When the ADS is in operation, the DDT is always performed in its entirety by the ADS which means the whole of the tactical and operational functions necessary to operate the vehicle (i.e., the ADS performs "the entire DDT" as stated in the definition of an "Automated Driving System" under para. 3.2.). These functions can be grouped into three interdependent categories: sensing and perception, planning and decision, and control.

3.8.1. Sensing and perception include:

(a) Monitoring the driving environment via object and event detection, recognition, and classification.

(b) Perceiving other vehicles and road users, the roadway and its fixtures, objects in the vehicle's driving environment and relevant environmental conditions.

(c) Sensing the ODD boundaries, if any, of the ADS feature.

(d) Positional awareness.

3.8.2. Planning and decision include:

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[3] Examples include setting the starting point, destination, route, and way points to be used by an ADS during a trip.

[4] Examples include deciding whether to overtake a vehicle or change lanes, signalling intended manoeuvres, deciding when to initiate the manoeuvre, choosing the proper speed, and executing the manoeuvre.

[5] Operational functions involve executing micro-changes in steering, braking, and accelerating to maintain lane position or proper vehicle separation and immediate responsive actions to avoid crashes in critical driving situations.

[6] All the variations on "user" roles have been group under the "ADS user" definition. This might prove beneficial in the future development of ADS requirements (i.e., introduction of new "user" definitions).

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(a) Predicting actions of other road users.

(b) Response preparation.

(c) Manoeuvre planning.

3.8.3. Control includes:

(a) Object and event response execution.

(b) Lateral vehicle motion control.

(c) Longitudinal vehicle motion control.

(d) Enhancing conspicuity via lighting and signalling.

3.8.4. The DDT excludes strategic functions.

3.9. *"Edge Case"* means a low-probability occurrence that might arise within the ODD of an ADS and that warrants specific design attention due to the potential severity of outcomes that might result from encountering such a situation or condition.

3.11. *"Failure"* means the termination of an intended behaviour of an element or an item.

3.12. *"Fault"* means an abnormal condition that can cause an element (system, component, software) or an item (system or combination of systems that implement a function of a vehicles) to fail.

3.13. *"Functional safety"* means the absence of unreasonable risks under the occurrence of hazards caused by a malfunctioning behaviour of electric/electronic systems (safety hazards resulting from system faults).

3.14. *"Minimal Risk Condition (MRC)"* means a stable and stopped state of the vehicle that reduces the risk of a crash.

3.15. *"Model*" means a description or representation of a system, entity, phenomenon, or process.

3.16. [*"Occurrence"* means a safety-relevant event during which at least one of the following criteria is fulfilled:

a) Collision involving the ADS vehicle

b) ADS vehicle system/component failure

c) ADS vehicle produces a noncompliance with respect to the requirements of this regulation

d) Injury/fatality as a result of being in the ADS vehicle or being involved in the event

e) Normal operations which are relevant to argument specific ADS design choices and/or the safety case.]

3.16.1. *"Significant Occurrence"* means occurrences which are not "Critical Occurrences", but require to be reported on short term basis due to their relevance on safety

3.16.2. *"Critical Occurrence"* means an occurrence during which at least one of the following criteria is fulfilled:

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(a) At least one person suffers an injury that requires medical attention or dies as a result of being in the vehicle or being involved in the event.

(b) The ADS vehicle, other vehicles or stationary objects sustain physical damage that exceeds a certain threshold.

(c) Any vehicle involved in the event experiences a deployment of any non-reversible *occupant* restraint system, vulnerable road user secondary safety system or the delta-V thresholds to be met, whichever occurs first.

3.17. "*Operational Design Domain (ODD)*" means the operating conditions under which an ADS feature is specifically designed to function.

3.17.1. *"ODD exit"* means:

(a) the presence of one or more ODD conditions outside the limits defined for use of the ADS feature, and/or

(b) the absence of one or more conditions required to fulfil the ODD conditions of the ADS feature.

3.18. *"Other road user (ORU)"* means any entity making use of publicly accessible road infrastructure.

3.19. *"(Model) parameter"* means a numerical value inferred from real-world data and used to represent a system characteristic.

3.20. *"Post-production phase"* means the period in which an ADS vehicle is no longer produced until the end-of-life of all ADS vehicles of the same type. The phase ends when there are no longer any operational ADS vehicles of a specific ADS type.

3.21. *"Priority vehicle"* means a vehicle [operated while making use of] [subject to] exemptions, authorizations, and/or right-of-way under traffic laws [while performing a specified function].

3.22. *"Proving ground"* and "*Test track*" mean a facility closed to public traffic and designed to enable physical assessment of an ADS and/or ADS vehicle performance, e.g., via sensor stimulation and/or the use of dummy devices.

3.23. *"Real time"* means the actual time during which a process or event occurs.

3.24. *"Remote termination"* means the act of remotely disabling one or more ADS features of one or more vehicles.

3.25. *"Road-safety agent"* means a human being engaged in directing traffic, enforcing traffic laws, maintaining/constructing roadways, and/or responding to traffic incidents.

3.26. "*Safety case"* means a structured argument supported by a body of evidence that provides a compelling, comprehensible, and valid case that the ADS is or will be free from unreasonable risk for a given application in a given environment.

[3.26.1. *"Argument"* means a written explanation within a safety case that captures the logical connections between a claim and the evidence for achievement of that claim.

[3.26.2. *"Claim"* means a high-level assertion that the behaviour competencies of an ADS will satisfy the DDT performance requirements applicable to one or more scenarios.]

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[3.26.3. *"Evidence"* means a set of results of analyses, simulations, and physical testing pertinent to demonstrating the validity of an argument within a safety case.]

3.27. *"Safety concept"* means a description of the measures designed into the ADS so that it operates in such a way that it is free of unreasonable safety risks to the ADS vehicle user(s) and other road users in every operating condition relevant to the ODD.

3.28. "*Safety Management System (SMS)"* means a systematic approach to managing safety that encompasses and integrates organisational, human, and technical factors.

(a) Human component ensuring the ADS lifecycle is monitored by personnel with appropriate skills, training, and understanding to identify risks and appropriate mitigation measures to identify risks and appropriate mitigation measures while accounting for the possibility of human errors.

(b) Organisational component procedures and methods that help to manage the identified risks, understand their relationships and interactions with other risks and mitigation measures, and help to ensure that there are no unforeseen consequences.

(c) Technical component using appropriate tools and equipment.

3.29. *"(Traffic) Scenario"* means a description of a sequence of driving situations that may occur during a given trip.[7]

3.29.1. *"Nominal scenario"* means [any scenario that is not a critical or failure scenario].

3.29.2. *"Critical scenario"* means a traffic scenario [where the operating conditions or behaviour of other road users requires a prompt action of the ADS to avoid or mitigate a collision with adverse consequences on human health or property damage].

3.29.3. *"Failure scenario"* means a traffic scenario representing a system failure that compromises the capability of the ADS to perform the entire DDT.

3.29.4. *"Logical scenario"* means a traffic scenario elaborated at a lower level of abstraction to include value ranges or probability distributions for each element of the corresponding functional scenario.[8]

3.29.5. *"Concrete scenario*" means a traffic scenario at a level of abstraction in which specific values have been selected for each element from the continuous ranges as may be defined in the corresponding logical scenario.

3.29.6. *"Complex scenario"* means a traffic scenario containing one or more situations that involve [partly dependent parameters that must be taken into account by the ADS to execute the DDT of the ADS (]e.g., a large number of other road users, unlikely road infrastructure, or abnormal geographic/environmental conditions[)].

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[7] Scenarios include a driving manoeuvre or sequence of driving manoeuvres. Scenarios can also involve a wide range of elements, such as some or all portions of the DDT, different roadway layouts, different types of road users and objects exhibiting static or diverse dynamic behaviours, and diverse environmental conditions (among many other factors).

[8] For example, elaborating the lane element to cover possible lane widths.

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3.30. *"Sensor Stimulation*" means a technique whereby artificially generated signals are provided to trigger the element under testing in order to produce the result required for evaluation of the element.

3.31. *"Simulation"* means the imitation of the operation of a real-world process or system over time utilizing a software implementation for some (or all) of the models, tools or test environment.

3.32. *"Simulation toolchain"* means a simulation tool or a combination of simulation tools that are used to generate evidence for the manufacturer's safety case.

3.33. *"Stochastic model*" means a model involving or containing a random variable or variables pertaining to chance or probability.

3.34. *"System-initiated deactivation of the ADS"* means a procedure by which the ADS initiates the transfer of performance of the DDT from the ADS to a vehicle fallback user.

3.35. *"Test method*" means a structured approach to consistently derive knowledge about the performance of an ADS by means of executing tests.[9]

3.36. *"Useful life (of an ADS vehicle)"* means the duration during which an ADS vehicle is in an operational state under which it may be driven on public roads regardless of the operational state of the ADS.

3.37. *"User-initiated deactivation of the ADS"* means a procedure by which the user initiates the transfer of performance of the DDT from the ADS to the vehicle user.

3.38. *"Validation (of a simulation model)"* means the process of determining the degree to which a simulation model is an accurate representation of the real world from the perspective of its intended uses.

3.39. *"Verification (of a simulation model)"* means the process of determining the extent to which a simulation model or a virtual testing tool is compliant with its requirements and specifications as detailed in its conceptual models, mathematical models, or other constructs.

3.40. *"Virtual testing"* means a type of testing that uses a simulation toolchain(s) to generate evidence for the manufacturer's safety case.

# 4.General Requirements

4.1. ADS Requirements

4.1.1. This regulation establishes performance requirements for the evaluation of ADS driving behaviours:

(a) Under nominal scenarios

(b) Under critical scenarios

(c) Under failure scenarios

[9] For example, virtual testing in simulated environments, physical, structured testing in controlled test-facility environments, and real-world on-road conditions.

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(d) At ODD boundaries

(e) In fallbacks to an MRC.

4.1.2. As a general concept, the safety level of ADS shall be at least to the level at which a competent and careful human driver could minimize the unreasonable safety risks to the ADS vehicle user(s) and other road users.

4.2. Manufacturer Documentation

4.2.1. Manufacturer's Safety Management System

4.2.1.1. This Regulation requires the manufacturer to document its processes for ensuring that the ADS is free of unreasonable safety risks.[10]

4.2.1.2. The Regulation establishes requirements for managing safety throughout the useful life of the ADS vehicle, including the following stages:

(a) Development

(b) Production

(c) Operation

(d) Decommissioning.

4.2.1.3. The Regulation requiresthese processes, collectively known as the Safety Management System (SMS), to address safety risks associated with organisational, human, and technical factors.[11]

(a) Organisational factors concern procedures and methods to manage identified risks, understand their relationships and interactions with other risks and mitigation measures, and reduce the risk of unforeseen consequences.[12]

(b) Human factors concern the roles of personnel, their skills, training, and understanding to identify risks and mitigation measures, and processes to control for the possibility of human error. [13]

[10] Paras. 4.2.1. is based on ADS-05-13: "In respect of ADS, the manufacture shall establish a SMS with robust processes to manage safety risks and to ensure safety throughout the ADS lifecycle (development, production, operation and decommissioning) including in the event of discontinued production, support, or maintenance." The stages have been merged with para. 4.5.1. of the ISMR OPI proposal in para. 4.2.1.4 below.

[11] Based on ADS-05-13: "The SMS shall manage and improve safety by considering organizational, human and technical risk factors."

[12] ADS-05-13: "Organisational component procedures and methods that help to manage the identified risks, understand their relationships and interactions with other risks and mitigation measures, and help to ensure that there are no unforeseen consequences"

[13] ADS-05-13: "Human component ensuring the ADS lifecycle is monitored by personnel with appropriate skills, training, and understanding to identify risks and appropriate mitigation measures while accounting for the possibility of human errors"

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(c) Technical factors concern the tools and equipment used to identify risks and evaluate mitigation measures.[14]

4.2.1.4. The Regulation requires the manufacturer's documentation to cover the following aspects:[15]

(a) Safety policy (para. 6.1.1.)

(b) Risk management (para. 6.1.2.)

(c) Design and development (para. 6.1.3.)

(d) Production (para. 6.1.4.)

(e) Post-deployment (para. 6.1.5)

(f) Safety assurance (para. 6.1.6.)

(g) Safety promotion (para. 6.1.7.).

4.2.2. Testing Environment

4.2.2.1. The manufacturer shall demonstrate that the approach to testing is suitable for the demonstration of the safety case and the compliance with performance/functional requirements.

4.2.2.2. The manufacturer shall demonstrate that the physical testing (proving ground and/or public road) facilities and environment are suitable for the tests that are being conducted.

4.2.2.3. The manufacturer shall demonstrate that the simulation toolchain(s) is suitable for conducting virtual tests. The requirements for the simulation toolchain(s) are listed in 6.2.1.

4.2.3. Safety Case for the ADS

4.2.3.1. The Regulation requires the manufacturer to produce a safety case for the ADS and its feature(s) in a manner that demonstrates the application of the SMS to the ADS under assessment, including the following aspects:

a) The safety concept, which describes the hazard identification and mitigation measures designed into the ADS to meet the requirements of this regulation and achieve the goal of avoidance of unreasonable risk with regard to functional and operational safety,

b) Information and documentation necessary to describe the ADS and its features covered by the safety case, including the intended use, the operating environment, the interactions with humans, sub-systems and components, control strategies,

c) Structured claims, argumentation, and evidence (including validation tests) that affirm and demonstrate that the ADS meets the requirements in Section 5 and is free from unreasonable risks to the ADS vehicle user(s) and other road users,

[14] ADS-05-13: "Technical component using appropriate tools and equipment."

[15] These are the section headings in ADS-05-13. The word "process" has been dropped as unnecessary (and possibly misleading since these management aspects can involve many processes, not just one). Cross-references are added to guide the reader to the corresponding sections.

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d) Demonstration of credibility and suitability of test tools used in generating evidence, and

e) Explanation of the processes for reinforcing ADS safety throughout the life of the ADS.

4.2.4. Post-deployment Safety

4.2.4.1. The In-Service Monitoring and Reporting (ISMR) of the Manufacturers shall ensure the ADS's safety throughout the lifetime of the ADS.

4.2.4.2. The Regulation requires the manufacturer to put in place a monitoring mechanism to collect information from the ADS vehicle in accordance with the requirements listed in the 6.1:

(a) GTR: to confirm the safety case and confirm the validation carried out by the manufacturer before market introduction.

UNR: to confirm the safety case and confirm the validation carried out by the manufacturer before the granting of the approval

(b) to enable the identification of unreasonable risks related to the use of the ADS on public roads and the evaluation of its safety performance during real-world operation.

(c) to enable the identification of unanticipated situations, hazards, and risks that lead to unexpected behaviour of the ADS. This information shall be assessed by the manufacturer and where appropriate be used to develop new or revise existing scenarios derived from ISMR activities.

4.2.4.3. The Regulation requires the manufacturer to have mechanisms for receiving and analysing safety-relevant feedback and reports from other sources, in accordance with the requirement listed in 6.1, to complement the data collected from ADS vehicles.

4.2.4.4. The manufacturer shall put in place a reporting mechanism in accordance with the requirement listed in the 6.4:

(a) To collect, analyze the safety-relevant information related to its in-service ADS' operation that identifies situations which fall into the cases specified for short term and periodic reporting.
(b) To allow information from the ISMR and recommendations from its analysis to be shared with the relevant authority.

4.3. Compliance Assessment

4.3.1. Audit of the Safety Management System

4.3.2. Assessment of the Testing Environment

4.3.3. Assessment of the Safety Case for the ADS

4.3.4. Post-Deployment Safety Assessment

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# 5.ADS Requirements[16]

5.1. ADS Performance of the DDT

5.1.1. The ADS shall be capable of performing the entire Dynamic Driving Task (DDT) within the ODD of its feature(s).

The manufacturer shall use a process to derive behavioural competencies and scenarios that are ODD-relevant. The methodology used in Annex [x] can be used or alternative methods providing they are equally comprehensive.

5.1.2. ADS Performance of the DDT under Nominal Traffic Scenarios

5.1.2.1. The driving behaviour of the ADS shall not cause a collision.

5.1.2.2. The ADS shall adapt its speed in line with safety risks.

5.1.2.3. The ADS shall maintain appropriate distances from other road users by controlling the longitudinal and lateral motion of the vehicle.

5.1.2.4. The ADS shall avoid unreasonable disruption to the flow of traffic in line with safety risks.

5.1.2.5. The ADS shall adapt its driving behaviour in line with safety risks.

5.1.2.5.1. This shall include the anticipation of risks in the driving environment to reduce the likelihood of encountering a critical scenario.

5.1.2.6. The ADS shall detect and respond to objects and events relevant to its performance of the DDT.

5.1.2.7. The ADS shall detect and respond to priority vehicles in accordance with the applicable traffic law(s).

5.1.2.8. The ADS shall not force other road users to take evasive action to avoid a collision with the ADS vehicle.

5.1.2.9. The ADS shall comply with traffic rules in accordance with application of relevant law within the area of operation.

5.1.2.10. The ADS shall interact safely with other road users.

5.1.2.11. The ADS shall avoid collisions with safety-relevant objects.

5.1.2.12. The ADS shall signal its operational status if required by applicable laws.

5.1.2.13. Pursuant to a passenger request under para. 5.2.4.1 the ADS shall bring the vehicle to a safe stop.

5.1.2.14. The ADS shall have strategies in place to appropriately detect and respond to instructions from road safety agents.

5.1.3. ADS Performance of the DDT under Critical Traffic Scenarios

[16] Anything setting functional or performance requirements for an ADS and/or ADS vehicle. This section is based on agreements from the 7th ADS IWG meeting

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5.1.3.1. The requirements for DDT performance under nominal scenarios shall continue to apply during critical scenarios as far as is reasonably practicable under the specific circumstances with the aim of minimising overall safety risks.

5.1.3.2. In the event of a collision involving the ADS vehicle, if required to stop by applicable law, the ADS shall stop or fall back to an MRC as appropriate. During this process the user may initiate deactivation of the ADS if the design of the ADS allows.

5.1.3.2.1. The ADS shall not resume travel unless:

(a) The safe operational state of the ADS vehicle has been verified, and

(b) It is permissible under the applicable law.

5.1.3.2.2. Notwithstanding 5.1.3.2.1., if possible, the ADS [may move the vehicle if this is required/ shall move the vehicle, if technically possible and safe] in order to appropriately respond to a road safety agent.

5.1.4. ADS Performance of the DDT under Failure Scenarios

5.1.4.1. The requirements for DDT performance under nominal scenarios shall continue to apply during failure scenarios as far as is reasonably practicable under the specific circumstances with the aim of minimising overall safety risks.

5.1.4.2. The ADS shall detect faults, malfunctions, and abnormalities that compromise its capability to perform the DDT within the ODD.

5.1.4.3. In response to a fault, the ADS shall either:

a) Execute a fallback response and prohibit activation of the impacted feature(s) if the fault prevents the ADS from performing the DDT in accordance with the requirements of 5.1., or

b) Adapt its performance of the DDT in accordance with the severity of the fault provided the resulting performance complies with the requirements of section 5.1.

5.1.4.4. The ADS shall be capable of remote termination

5.1.4.4.1. Remote termination for an ADS performing the DDT shall be capable of triggering an ADS fallback response.

5.1.4.4.2. Remote termination of an ADS or ADS feature(s) shall render it unable to be activated by a user until such time as the remote termination is rescinded.

5.1.5. ADS Performance of the DDT at ODD Boundaries

5.1.5.1. The ADS shall recognise the conditions and boundaries of the ODD of its feature(s).

5.1.5.2. The ADS shall be able to determine when the conditions are met for activation of each feature.

5.1.5.3. The ADS shall prevent activation of a feature unless the ODD conditions of the feature are met.

5.1.5.4. The ADS shall execute a fallback response when one or more ODD conditions of the feature in use are no longer met.

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5.1.5.5. The ADS shall be able to anticipate and safely respond to foreseeable exits from the ODD of each feature.

5.1.6. Minimal Risk Condition Requirements

5.1.6.2. In the absence of a fallback user, the ADS fallback response shall be to place the vehicle in an MRC.

5.1.6.3. If the ADS feature is designed to request and enable intervention by a fallback user, the ADS shall execute a fallback to an MRC in the event of a failure in the [transition of control] to the user.

5.1.6.4. Upon completion of an ADS fallback to an MRC, a user may be permitted to assume control of the vehicle.

5.2. Safety of ADS User Interactions with the ADS

5.2.1. General requirements

5.2.1.1. The ADS shall signal its intention to place the vehicle in an MRC to the ADS user(s).

5.2.1.2. An ADS that controls the operation of doors shall provide an emergency override to the user.

5.2.1.3. The ADS HMI shall provide safety relevant information and signals clearly noticeable to the target user(s) under all operating conditions, multimodal (e.g., optical, acoustic, haptic) if needed, simply and unambiguously.

5.2.2. ADS features that allow a user to take over manual-control of the DDT.

5.2.2.1. The ADS shall be designed to prevent misuse and errors in operation by the user.

5.2.2.2. When an ADS feature is active, the vehicle driving controls, direct vision, devices for indirect vision, indicators, tell-tales, and DDT-related warnings may be disabled, suppressed, de-activated, inhibited or by other means made unavailable.

5.2.2.3. The vehicle controls dedicated to the ADS shall be clearly identified and distinguishable to accommodate only the appropriate interactions.[17]

5.2.2.4. While an ADS feature is active, it shall inform the user of:

(a) ADS status information.

(b) The role of the fallback user, if applicable.

(c) Adapted performance of the DDT consequent to some failure of the ADS.

5.2.2.5. The ADS shall indicate the availability of a feature for activation.

5.2.2.6. While active, features that have a system-initiated deactivation of the ADS to a fallback user shall:

(a) Continuously assess whether the fallback user is available to assume the role of driver at the end of the deactivation procedure.

[17] Through size, form, location, colour, type, action, spacing and/or control shape. The provision aims to promote correct use and is not intended to prohibit multifunction controls.

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(b) Provide effective procedures for re-engaging the fallback user who has been detected not to be available.

(c) Trigger a fallback to an MRC where it has not been possible, feasible and/or safe to re-engage the fallback user.

5.2.2.7. ADS feature activation

5.2.2.7.1. The ADS shall ensure a safe ADS feature activation.

5.2.2.7.2. The ADS shall provide immediate feedback to indicate success or failure when the user attempts to enable an ADS feature.

5.2.2.7.3. The feature activation process (e.g., sequence of actions and states) shall take into account relevant recommendations or standards.

5.2.2.7.4. An ADS feature activation resulting in a user becoming a fallback user shall immediately and explicitly inform the fallback user of the consequent expectations on them to be ready to respond to a request to resume the DDT.

5.2.3. ADS feature deactivation to manual driving

5.2.3.1. In a nominal scenario, the beginning of a system-initiated deactivation process shall be indicated in a timely manner to support the fallback user re-engaging to the driving task.

5.2.3.2. Following the user requesting deactivation of the ADS feature, the ADS shall follow a deactivation process to safely transfer control of the DDT to the user.

5.2.3.3. The ADS feature shall only respond to the user request to initiate a system deactivation process, if the ADS verifies that the user is in a position to assume the role of the driver.

5.2.3.4. ADS feature deactivation may be delayed if it is assessed by the ADS that the situation is unsuitable or unsafe for the subsequent mode of vehicle operation. In this case, the user shall be informed of this circumstance.

5.2.3.5. The ADS feature shall remain active until the system deactivation process has been completed or the ADS vehicle reaches a minimal risk condition.

5.2.3.6. The deactivation process (e.g., sequence of actions and states) shall take into account relevant recommendations or standards.

5.2.3.7. The ADS shall assess if the user is suitably engaged to resume the DDT before completion of the deactivation process.

5.2.3.8. The ADS shall provide a specific indication of the completion of the deactivation of the ADS.

5.2.3.9. At the completion of the deactivation process, control shall be returned to the driver without any continuous lateral or longitudinal control assistance active.

5.2.3.10. If applicable, during the deactivation procedure, the vehicle controls, direct vision, devices for indirect vision, indicators, warnings, and tell-tales shall be set to an appropriate state for manual driving.

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5.2.3.11. If applicable, ADS features operating control of closures shall no longer influence closures or the controls associated with closures.

5.2.4. ADS features that do not allow a user to take manual control of the DDT

5.2.4.1. The ADS shall provide the passenger(s) with means to request to stop the vehicle.

5.2.4.2. The ADS vehicle shall provide safety-related information to the passengers.

5.2.4.3. The ADS shall not initiate motion unless the safety risks to the passenger(s) have been mitigated.

5.2.4.4. Controls provided for manual driving (e.g., steering, service brake, parking brake, accelerator, lighting) shall be designed to prevent any effect on the DDT whilst the ADS is performing the DDT, or reasonable safeguards shall be put in place to prevent access to controls.

5.2.5. Information Provision to Users (as appropriate: owners, users, operators, etc.)

5.2.5.1. For the ADS users, means shall be provided that facilitates user understanding of the functionality and operation of the system covering at least:

(a) An operational description of the ADS features, capabilities, and limitations (the information should also refer to specific use cases and/or ODD)

(b) The correct use of the ADS and its feature(s)

(c) Instructions for the activation and deactivation of the ADS, with clear explanations of the distinctions between user-initiated deactivation and system-initiated deactivation where applicable

[(d) A description of the responsibilities of the user and ADS when an ADS (feature) is active

(e) Information on ADS responses to ADS vehicle user interventions in the dynamic control of the vehicle

(f) A description of the permitted transitions of roles and the procedure for those transitions

(g) A general overview of non-driving-related activities (NDRA) allowed when an ADS feature is active where applicable

(h) Safety precautions and safety-relevant information for the user

(i) Information related to the HMI of the ADS feature(s) e.g.:

(i) Visual tell-tales, icons

(ii) Auditory signals

(iii) Haptic signals

[(j) Instructions on safety and non-safety measures to be taken when there is a malfunction of the ADS]

(k) Extent, timing and frequency of maintenance operations where applicable

(l) Data protection and data security functionalities.

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5.3. Other Requirements

5.3.1. [Cyber Security provisions]

5.3.2. The manufacturer shall include a robust process in the SMS to ensure that post-deployment software updates are properly validated and distributed and downloading is confirmed.

5.3.3. [DSSAD provisions]

5.3.4. The ADS shall be designed to protect against unauthorized access to and modification of the ADS features and functions. The measures ensuring protection from unauthorized access shall be provided in alignment with engineering best practices.

5.3.5 The ADS shall provide an interface for the purposes of maintenance and repair by authorized persons.

5.3.6 The ADS shall receive and appropriately manage all signals received from other vehicle systems. A list of these signals and how they are managed shall be included in the manufacturer's safety case

5.3.7 [While a Type 2 feature is active], the ADS shall manage relevant non-DDT-related tasks (which would otherwise be performed by a driver) in accordance with the manufacturer's safety case. Alternatively, where the ADS does not perform such necessary tasks, the safety case shall describe how these tasks are performed.

# 6.Manufacturer Requirements[18]

Other requirements (need decisions on how to integrate into the regulations)

The manufacturer shall provide the specific documentation to facilitate the audit and safety assessment.[19]

The manufacturer shall make additional confidential material and analysis data available for on-site inspection (e.g., at a manufacturer facility) as needed for the process audit and/or safety assessment.[20]

The manufacturer shall ensure that this material and analysis data remains available for a period of 10 years counted from the time when production of the ADS is discontinued.

Any changes to ADS safety design shall be communicated as required to the relevant authority.

6.1. Safety Management System[21]

6.1.1. Safety Policy

[18] Anything requiring documentation by the manufacturer.
[19] ADS-05-14
[20] ADS-05-14: If required by the auditor, the manufacture shall made additional confidential material and analysis data (e.g. intellectual property) open for inspection (e.g. on-site in the engineering facilities of the manufacturer) at the time of the product assessment/process audit.
[21] ADS-05-13/Rev.1.

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6.1.1.1. The safety policy shall outline the aims and objectives that the manufacturer uses to achieve the desired safety outcomes with regard to any and all ADSs it manufactures and may apply to other products of the manufacturer as well.

6.1.1.2. The manufacturer shall provide evidence that its safety policy implements the following aspects:[22]

(a) Safety policies and principles (e.g., ISO 21434, para. 5.4.1 and ISO 9001 Automotive 5.2.).

(b) Organization safety objectives and the process for creating safety performance indicators used in the safety case.

(c) Appropriate structure for SMS, taking into account regulation, standards, best practice guidance and the use-case of the vehicle and mapping its organization structure, processes, and work products onto the SMS.

(d) Safety culture (e.g., ISO 26262-2, para. 5.4.2).

(e) Safety Governance elements including management commitment (e.g., ISO 21434, para. 5.4.1 and ISO 9001 Automotive 5.1) and roles and responsibilities (e.g., ISO 26262-2, para. 6.4.2, this relates to the organizational and project dependent activities).

(f) Effective communications within the organization on safety issues (e.g., ISO 26262-2, para. 5.4.2.3).

(g) Information sharing outside of the organization (e.g., ISO 21434, para. 5.4.5 and ISO 9001, but from a safety perspective.

(h) Quality Management System (e.g., IATF 16949 or ISO 9001 to support safety engineering, including change management, configuration management, requirement management, tool management etc.

6.1.2. Risk Management

6.1.2.1. The SMS shall include a management process to identify, assess, and mitigate organisational, human, and technical risks.[23]

6.1.2.1.1. The ADS manufacturer shall then be able to show the link between the overall risk management process, the mitigations, and the resulting operational risks.

6.1.2.2. The manufacturer shall document its risk-management processes and activities with consideration of relevant standards and best practices, including:

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[22] The manufacturer shall provide evidence it has implemented the following as part of its SMS:

[23] ADS-05-13: “The manufacturer shall include in the SMS a Safety risk management process to identify and assess the risks associated to the three SMS factors (i.e., human, organizational, and technical). Any operational risk identified in the product shall, where appropriate, have mitigations implemented. The ADS manufacturer shall then be able to show the link between the overall risk management process, the mitigations, and the resulting operational risks.” The first two sentences can be combined for brevity as “identify, assess, and mitigate”. The risk management process applies to the ADS under assessment, so the specific risks identified and their mitigations would be provided under the safety case [6.2.7.].

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(a) Risk identification (e.g., ISO 31000 para. 6.2).

(b) Risk analysis (e.g., ISO 31000 para. 6.3).

(c) Risk evaluation (e.g., ISO 31000 para. 6.4).

(d) Risk treatment (e.g., ISO 31000 para. 6.5).

(e) Processes for keeping the risk assessments up to date.

(f) Review of safety performance of the organisation and effectiveness of safety risk controls.

6.1.2.3. This process shall include Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA), System-Theoretic Process Analysis (STPA) or any similar process appropriate to system functional and operational safety.[24]

6.1.2.4. The manufacturer shall demonstrate its use of a top down (from possible hazard to design) and a bottom-up approach (from design to possible hazards) in its identification of hazards.[25]

6.1.3. ADS Design and Development

6.1.3.1. This documentation shall include risk management, requirements management, requirements' implementation, testing, failure tracking, remedial actions, and release management [including the following aspects:

(a) Roles and responsibilities of the people involved during the design and development phase.

(b) Qualifications and experience of persons responsible for making decisions that affect safety.

(c) Coordination of roles, responsibilities and information transfer between design and production activities.]

6.1.3.2. The manufacturer shall document its processes and activities to ensure the robustness of the design and development phase, including the following aspects:

(a) A general description of how the organization performs all the design and development activities

(b) Vehicle/system development, integration, and implementation:

(i) Requirements management (e.g. Requirement capture and validation)

(ii) Validation strategies, including but not limited to:

a. Assessment of the physical testing environment

b. Credibility assessment for virtual tool chain

c. System integration

[24] ADS-05-06-Rev.2: "This shall be based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) and a System-Theoretic Process Analysis (STPA) or any similar process appropriate to system functional and operational safety."

[25] ADS-05-06-Rev.2: "The manufacturer shall demonstrate how it has taken both a top down (from possible hazard to design) and bottom-up approach (from design to possible hazards) in its identification of hazards."

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d. Software

e. Hardware.

(iii) Management of functional safety and safety of the intended functionality (e.g., ISO 13407), including the ongoing evaluation and update of risk assessments and interactions.

(iv) Management of human factors, including human-centred design processes.

(c) Design and change management, including but not limited to:

(i) The major design decisions.

(ii) The relevant design modifications to the ADS.

(iii) Changes to key persons responsible for making decisions that affect safety.

(iv) The tools and thresholds adopted for the ADS safety verification.

6.1.3.3. The manufacturer shall institute and maintain effective communication channels between the departments and third-party organizations responsible for functional/operational safety, cybersecurity, and any other relevant disciplines related to the achievement of vehicle safety. These processes and activities shall be documented considering relevant standards and best practice.

6.1.4. Production management

6.1.4.1. The manufacturer shall establish and document the production process in the SMS. The manufacturer shall document its processes and activities to ensure the robustness of the production phase. This documentation shall cover, at least, the following aspects:

(a) Quality Management System accreditation (e.g., IATF 16949 or ISO 9001);

(b) A description of the way in which the manufacture performs all the production functions including management of working conditions, working environment, equipment and tools.

6.1.4.2. The manufacturer shall establish and document their distributed production processes and activities in the SMS. The processes and activities shall include:

(a) Liaison between the vehicle and/or ADS manufacturer and all other manufacturers (partners or subcontractors) involved.

(b) Criteria for the acceptability of "subsystem/components" manufactured by other partners or subcontractors. (i.e., deployment of production assurance requirements to supply chain).

6.1.5. Post-deployment safety

6.1.5.1. The requirements listed in the 6.1.5 are without prejudice to applicable laws governing access to data, availability, and privacy and data protection

6.1.5.2. The manufacturer shall establish processes to demonstrate its capabilities to execute an effective ISMR and to take the corrective remedial action when necessary.

6.1.5.3. The processes for ISMR shall demonstrate the capabilities:

(a) To monitor ADS operations

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(b) To confirm the compliance with the defined safety case and compliance to the performance requirements

(c) To identify safety risks related to ADS performance that need to be addressed in the frame of the SMS activities, including instances of non-compliance with ADS safety requirements

(d) To manage potential safety-relevant gaps during the in-service operation and to provide the information that allows the ADS to be updated according to the appropriate manufacturer processes

(e) To support the development of new or revise existing scenarios

(f) To perform event investigation

(g) To report occurrences to the relevant authority when they occur

(h) To share learnings derived from occurrence analysis

(i) To contribute to the continuous improvement of automotive safety.

6.1.5.4. The process for ISMR shall demonstrate the capabilities for handling the reports received from other sources, including distinguishing false reports from actual events and conducting thorough investigations when necessary.

6.1.5.5. The manufacturer shall demonstrate the capabilities to monitor the performance of all its in-service ADS vehicles.

6.1.5.6. The manufacturer shall demonstrate the capabilities collect and analyse vehicle data, and data from other sources to achieve the ISMR objectives.

6.1.5.6.1. The manufacturer shall have a data acquisition strategy, data retention strategy, data access, and security and protection policy.

6.1.5.6.2. The data acquisition strategy shall ensure a representative collection of data to monitor the ADS in service performance.

6.1.5.6.3. The retention strategy shall ensure that:

(a) Data related to a detected safety issue is retained until any necessary corrective action and review processes are complete, and

(b) The retention of the data for longer-term trend analysis (i.e. subset of the collected data).

6.1.5.6.4. The data access, security and protection policies shall ensure that information access is allowed only to authorized persons and contains safeguards to ensure the security and protection of the data in accordance with the data-protection laws of the relevant jurisdiction.

6.1.5.6.5. The manufacturer shall achieve the following objectives from the monitoring activity:

(a) Verify the safety performance (i.e., Safety Performance Indicators) and confirm the in-service safety level of the system (i.e. metrics and thresholds)

(b) Identify areas of operational risk

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(c) Identify when the ADS prevents incidents/accidents (e.g., MRC fallbacks, collision avoidance, emergency manoeuvres)

(d) Characterize and analyse occurrences

(e) Discover trends that suggest the emergence of unacceptable risks

(f) Ensure that remedial actions are put in place when an unacceptable risk is discovered or predicted by trends

(g) Confirm the effectiveness of any remedial action.

(h) Enable the development of new or the revision existing scenarios derived from ISMR activities.

6.1.5.6.6. The manufacturer shall perform a data analysis with sufficient frequency so that remedial action can be taken promptly and in line with reporting requirements listed in 6.4.

6.1.5.6.7. The analysis techniques shall include at least the following:

(a) Routine measurements: a selection of parameters shall be collected to characterize the performance of ADS and to allow a comparative analysis. These measurements shall aim at identifying and monitoring emerging trends and tendencies before the trigger levels associated with exceedances are reached.

(b) Exceedance detection: a set of "core values" shall be selected to cover the main areas of interest for the ADS operation with aim at searching for deviations from safety performance and limits. They shall be continuously reviewed to reflect the current operations.

(c) Occurrence analysis: It shall be possible to characterize and investigate all the occurrences listed in the 6.4.9 using the recorded data.

(d) Statistics: Data series shall be collected to support the analysis process with additional information. These data shall provide information to generate rates and trends.

6.1.5.7. The manufacturer shall have a mechanisms in place for receiving and analysing safety-relevant feedback and reports from other sources to extract safety-relevant information and to review the safety monitoring data.

6.1.5.7.1. The feedback and reports from other sources shall include at least:

(a) ADS related maintenance and inspection feedback

(b) Enforcers (including the police) and other authorities' reports

(c) Service operator, customer, public and dealer feedback.

6.1.5.8. The manufacturer shall evaluate the results from the monitoring activity to assess:

(a) In-service safety performance

(b) The adequacy of the metrics and thresholds

(c) The outcome of remedial actions.

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6.1.5.9. The manufacturer shall include a robust process in the SMS to ensure that post-deployment software updates are properly validated and distributed and downloading is confirmed.

6.1.6. Safety Assurance

6.1.6.1. The manufacturer shall demonstrate that periodic independent internal audits and external audits are carried out to ensure that the processes established for the Safety Management System are implemented consistently.

6.1.6.2. The manufacturer shall put in place suitable arrangements (e.g., contractual arrangements, clear interfaces, quality management system) with any organization involved in the development, manufacturing, or in-use deployment of its vehicles (e.g., contracted suppliers, service providers, or manufacturers' sub-organizations) The manufacturer shall document its processes and activities, including the following aspects:

(a) Organizational policy for supply chain

(b) Incorporation of risks originating from supply chain

(c) Evaluation of supplier SMS capability and corresponding audits

(d) Processes to establish contracts, agreements for ensuring safety across the phases of development, production, and post-production

(e) Processes for distributed safety activities.

6.1.6.3. SMS documentation shall be regularly updated in line with any relevant changes to the SMS processes. It is required that gap analysis shall be used when auditing and updating the SMS, examining the current safety culture before formulating new and more appropriate SMS processes to ensure issues are adequately resolved.

6.1.6.4. The manufacturer shall have processes for:

(a) Assuring that all practices and activities documented as part of the SMS are followed;

(b) Assuring that an independent check of compliance with the applicable requirements is performed. (i.e., not from person creating the compliance data);

(c) Assuring the continued evaluation of the Safety Management System so that it remains effective.

6.1.6.5. The manufacturer shall define appropriate Key Performance Indicators (KPI) to measure the effectiveness of the Safety Management System throughout the ADS lifecycle (development, production, operation and decommissioning).

6.1.7. Safety Promotion

6.1.7.1. The SMS shall be subject to a process of continual improvement (e.g. "Plan, Do, Check, Act" as described in ISO 9001). Any changes to SMS documentation should be communicated as required to the relevant authority.

6.2. Testing Environment

6.2.1. Virtual Testing and Simulation Toolchain Credibility Requirements

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6.2.1.1. The manufacturer shall describe the intended use(s) of virtual testing and its role in the overall testing strategy.

6.2.1.2. The manufacturer shall demonstrate that the simulation toolchain(s) is suitable to use for virtual testing by:

a) performing a criticality analysis that evaluates the potential risk and consequences of using the simulation toolchain(s) for the assessment of the ADS safety case and functional/user requirements.

b) demonstrating that the simulation toolchain(s) fulfils the credibility requirements corresponding to the identified criticality as per the requirements listed in this section.

6.2.1.3. Simulation Toolchain Data Management

6.2.1.3.1. The manufacturer shall manage the data used to develop, verify, validate and update the simulation toolchain(s) throughout its lifetime. The manufacturer shall consider the completeness, accuracy and consistency of this data.

6.2.1.3.2. The manufacturer shall maintain a record of the data used in the validation of the toolchain(s).

6.2.1.3.3. If the simulation toolchain(s) incorporates or relies upon data/tools from other organizations which are not under the control of the manufacturer, the manufacturer shall demonstrate the measures taken to manage the quality and integrity of that data/tools.

6.2.1.3.4. With regards to input data management and parameters associated with the simulation toolchain(s), the manufacturer shall:

a) document the data used to develop, verify and validate the simulation toolchain(s) and note important quality characteristics

b) provide documentation showing that the data used to develop, verify and validate the simulation toolchain(s) covers the intended functionalities that the virtual testing aims to assess

c) document the data and the calibration procedures employed to fit any parameters associated with the simulation toolchain(s)

d) explain the reasons for data or parameters changing between releases.

6.2.1.3.5. The manufacturer shall quantify the uncertainty in the simulation toolchain(s) and its outputs that occur because of the quality of the data (e.g. data coverage, signal to noise ratio, and sensors' uncertainty/bias/sampling rate).

6.2.1.3.6. With regards to the data that is produced by the simulation toolchain(s) and its components, the manufacturer shall:

a) maintain a record of the output from the simulation toolchain(s) during its validation and ensure that they are traceable to the input data that produced them.

b) document the output data and note any important quality characteristics that can be deduced from analysis of the data, e.g. applying statistical methodologies.

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6.2.1.3.7. With regards to the quality of the data that is produced by the simulation toolchain(s) and its components, the manufacturer shall:

a) ensure it is sufficient to undertake any validation activity

b) ensure it is sufficient to allow consistency/sanity check of the simulation toolchain(s), possibly by exploiting redundant information

c) ensure it is sufficient to justify manufacturer's claims about their safety case.

6.2.1.3.8. With regards to the management of stochastic models, the manufacturer shall:

a) characterize the variance in the simulation toolchain(s)'s output

b) ensure the possibility of a deterministic re-execution of the simulation toolchain(s).

6.2.1.4. Competency of Personnel

6.2.1.4.1. The manufacturer shall document and provide the rationale for their confidence in the competency of:

a) the personnel that developed the simulation toolchain(s) and its components

b) the personnel that assessed the simulation toolchain(s) and its components

c) the personnel that used the simulation toolchain(s) to perform the testing with the purpose of validating the system.

6.2.1.4.2. The manufacturer shall have processes and procedures that identify and maintain the skills, knowledge, and experience needed to perform the various activities. The following processes shall be established, maintained and documented:

a) process to identify and evaluate the necessary competencies that are required to perform the modelling and simulation activities

b) process for training personnel to be competent to perform the modelling and simulation activities.

6.2.1.4.3. The manufacturer shall maintain records of the personnel in the various teams showing they have received the necessary training and have been deemed competent to perform the modelling and simulation activities assigned to those personnel.

6.2.1.4.4. The manufacturer shall set up suitable arrangements with third-party organisations to ensure that the competency of their personnel is adequate to demonstrate the credibility of the simulation toolchain(s).

6.2.1.5. Simulation Toolchain Release Management

6.2.1.5.1. The manufacturer shall manage and support the simulation toolchain(s) used for virtual testing throughout the lifecycle of the simulation toolchain(s).

6.2.1.5.1.1. This management and support shall also continue until the end of the post-production phase of the ADS.

6.2.1.5.2. The manufacturer shall manage and document the simulation toolchain(s) release management process. The simulation toolchain(s) release management activity shall include:

a) a description of the modifications associated with each toolchain(s) release

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b) a record of any associated software (e.g., specific software product, designations and version) and hardware arrangements (e.g., XiL configuration)

c) a record of the internal review activities that supported the toolchain(s) acceptance and release.

6.2.1.6. Description of the Simulation Toolchain

6.2.1.6.1. The manufacturer shall describe the simulation toolchain(s) and identify its scope of applicability, its limitations, assumptions and the sources of uncertainty that can affect results.

6.2.1.6.2. The manufacturer shall provide a description of the simulation toolchain(s) and its components.

6.2.1.6.3. The manufacturer shall provide a description of the approach adopted in the simulation toolchain(s) validation.

6.2.1.6.4. The manufacturer shall provide a description of the acceptance tests and criteria that will be used to determine if a simulation toolchain is considered credible based on the credibility framework.

6.2.1.7. Simulation Toolchain Assumptions, Known Limitations, and Uncertainty Quantification

6.2.1.7.1. The manufacturer shall describe the modelling assumptions and considerations that guided the design of the toolchain(s).

6.2.1.7.2. The manufacturer shall provide information on:

a) Assumptions made during the development of each simulation toolchain and its components and the limitations that these place on its scope and applicability

b) The rationale for choices made about the level of fidelity of each simulation toolchain and its components.

6.2.1.7.3. The manufacturer shall provide justification that the tolerances associated with the simulation toolchain(s) are appropriate and meet the acceptance tests and criteria.

6.2.1.7.4. The manufacturer shall provide details of the sources of uncertainty in each simulation toolchain and its components and the assessment of their impact on the results.

6.2.1.8. Simulation Toolchain Scope

6.2.1.8.1. The manufacturer shall document the scope of each simulation toolchain and identify its limitations.

6.2.1.8.1.1. The scope shall refer to the ODD and identify any limitations about its applicability to the ODD.

6.2.1.8.2. The manufacturer shall demonstrate how each simulation toolchain imitates the relevant physical phenomena and meets the necessary level of accuracy.

6.2.1.8.3. The manufacturer shall demonstrate that the test selection is sufficient to justify the claim that the simulation toolchain(s) can be used within the defined scope.

6.2.1.8.4. The manufacturer shall provide a list of tests used for validation and the corresponding parameters and any known limitations.

6.2.1.9. Simulation Toolchain Criticality Analysis

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6.2.1.9.1. The manufacturer shall review the error estimates of the simulation toolchain(s) to assess their criticality and the effect these would have on the manufacturer's claims about their safety case.

6.2.1.10. Simulation Toolchain Verification

6.2.1.10.1. The manufacturer shall demonstrate that the simulation toolchain(s) will not exhibit unrealistic behaviour for valid inputs which have not been explicitly tested.

6.2.1.11. Simulation Toolchain Code Verification

6.2.1.11.1. The manufacturer shall document the execution of proper code verification techniques used in evaluating each simulation toolchain and its components (e.g., static/dynamic code verification, convergence analysis and comparison with exact solutions if applicable).

6.2.1.11.2. The manufacturer shall provide evidence that the input parameter space was sufficiently explored to identify if there are any parameter combinations for which the simulation toolchain(s) shows unstable or unrealistic behaviour.

6.2.1.11.3. The manufacturer shall provide information on any sanity/consistency checking procedures that are used.

6.2.1.12. Simulation Toolchain Calculation Verification

6.2.1.12.1. The manufacturer shall document numerical error estimates (e.g., discretization error, rounding error, iterative procedures, and convergence).

6.2.1.12.2 The manufacturer shall review the analysis and demonstrate that the numerical errors are understood and sufficiently bounded to allow the simulation toolchain(s) to be used for virtual testing.

6.2.1.13. Simulation Toolchain Sensitivity Analysis

6.2.1.13.1. The manufacturer shall provide documentation demonstrating that the input data and parameters that most critically influence the toolchain outputs have been identified by means of appropriate sensitivity analysis techniques.

6.2.1.13.2. The manufacturer shall demonstrate that robust calibration procedures have been adopted for assigning appropriate value(s) to all the simulation parameters while ensuring that special attention is taken for the most critical parameters. This is to ensure that the simulation toolchain can be used to emulate the relevant real-world system.

6.2.1.13.3. The manufacturer shall demonstrate that sensitivity analysis has been used to identify the critical input data and parameters that need particular attention in order to characterize the uncertainty of the overall simulation toolchain outputs.

6.2.1.14. Simulation Toolchain Validation

6.2.1.14.1. The manufacturer shall perform a validation analysis, based on quantitative metrics, to determine the degree to which each simulation toolchain is an accurate representation of the real-world system.

6.2.1.14.2. The manufacturer shall provide evidence that the simulation toolchain(s) results are consistent and correlated with the results of the physical tests.

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6.2.1.14.3. The validation shall be performed on a sufficiently representative set of tests in order to substantiate the claims that the simulation toolchain(s) is suitable and can be used within its scope.

6.2.1.14.4. The manufacturer shall define the measures of performance (metrics) that will be used when comparing between the results of physical tests and the output of the simulation toolchain(s).

6.2.1.14.5. The manufacturer shall use appropriate statistical techniques when comparing the results of physical tests and the corresponding output of the simulation toolchain and its components.

6.2.1.14.6. The manufacturer shall specify acceptance tests and criteria during the development of each simulation toolchain and its components and demonstrate that they have been achieved.

6.2.1.14.7. The manufacturer shall define the methodology and tests used for each simulation toolchain validation.

6.2.1.14.7.1. It should be clear whether the full ODD is within scope of the toolchain(s) or only part of it.

6.2.1.14.7.2. The validation strategy may consist of one or more of the following:

a) subsystem model validation e.g. environment models, sensor models, and vehicle models;

b) vehicle system model validation (vehicle dynamics model together with the environment model);

c) sensor system validation (sensor model together with the environment model);

d) integrated system validation (sensor model together with the environment model with influences form vehicle model).

6.2.1.14.8. The manufacturer shall demonstrate that the accuracy criteria defined during each simulation toolchain development have been met.

6.2.1.14.9. The manufacturer shall provide evidence that the processes related to the validation activity have been followed.

6.2.1.14.10. The manufacturer shall document their uncertainty characterisation analysis and provide information about how the simulation toolchain(s) should be used and any safety margins that should be applied when it is used for virtual testing.

6.2.1.14.11. The manufacturer shall demonstrate it has techniques to estimate each simulation toolchain's critical inputs.

6.2.1.14.12. The manufacturer shall demonstrate that they have characterised the critical parameters used in each simulation toolchain and its components and where appropriate have identified these as distributions with confidence intervals.

6.2.1.14.13. The manufacturer shall provide evidence that a proper characterization of the uncertainty of the results of each simulation toolchain and its components, because of any assumptions therein, has been made.

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6.2.1.14.14. The manufacturer shall demonstrate that they have differentiated between the aleatory and epistemic[26] uncertainties associated with each simulation toolchain.

6.2.2. Physical testing facilities and environment

6.2.2.1. The manufacturer shall demonstrate that the physical testing facilities (proving ground and/or public roads) and environments are suitable to conduct testing and gather evidence to support the safety case . In particular the manufacturer shall demonstrate that:

6.2.2.1.1. the physical testing facilities includes static and dynamic elements representative of the ODD and the expected operating conditions and as relevant to the tests being performed;

6.2.2.1..2. the facilities and capabilities are suitable to assess the aspects of the safety case under test;

6.2.2.1.3. the facilities have all the relevant equipment and accreditations;

6.2.2.1.4. the equipment undergoes periodic calibrations to ensure that the measurements are characterized by sufficient accuracy and precision.

6.3. Safety Case for the ADS

6.3.1. Safety Concept

6.3.1.1. The safety case shall describe each component of the ADS and any other vehicle systems that are relevant to meeting the requirements of this regulation.

6.3.1.1.1. The description shall include an outline schematic of the ADS illustrating the equipment distribution and the interconnections among the components and systems.

6.3.1.1.2. The outline shall include how the following elements are addressed:

(a) Perception and objects detection including mapping and positioning

(b) Characterisation of decision – making

(c) Remote supervision and remote monitoring by a remote supervision centre (if applicable).

(d) Information display/user interface

(e) The data storage system (e.g., DSSAD)

(f) Redundancies of components and/or connections

6.3.1.2. The safety case shall outline the function of each component of the ADS.

6.3.1.2.1. The outline shall show the signals linking each function with other components or with other vehicle systems. This may be provided by a labelled block diagram or other schematic, or by a description aided by such a diagram.

[26] "Aleatory Uncertainty" means the portion of uncertainty deriving from a random process that cannot be reduced, while "Epistemic Uncertainty" means the portion of uncertainty deriving from a lack of knowledge about a process that can be reduced via observations.

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6.3.1.2.2. Interconnections within the ADS shall be shown by a circuit diagram for the electric transmission links, by a piping diagram for pneumatic or hydraulic transmission equipment and by a simplified diagrammatic layout for mechanical linkages.

6.3.1.2.3. The transmission links both to and from other systems shall be shown.

6.3.1.2.4. There shall be a clear correspondence between transmission links and the signals carried between components and systems.

6.3.1.2.5. Priorities of signals on multiplexed data paths shall be stated wherever priority may be an issue affecting performance or safety.

6.3.1.3. Each component shall be clearly and unambiguously identifiable (e.g. by marking for hardware, and by marking or software identification for software content).

6.3.1.3.1. This will provide a clear method for identifying the hardware and software in the associated documentation.

6.3.1.3.2. Where the software version can be changed without requiring replacement of the marking or component, the software identification must be updated by means of the newly released software.

6.3.1.3.3. Where functions are combined within a single control unit or within a single computer, but shown in multiple blocks in the diagram, then for clarity and ease of explanation, only a single hardware identification marking shall be used.

6.3.1.3.3.1. The identification defines the hardware and software version and, where the software changes and alters the function of the unit, the identifier associated with that software shall also be changed.

6.3.1.4. The manufacturer shall provide information regarding the installation options that will be employed for the individual components that comprise the sensing system.

6.3.1.4.1. These options shall include, but are not limited to, the location of the component in/on the vehicle, the material(s) surrounding the component, the dimensioning and geometry of the material surrounding the component, and the surface finish of the materials surrounding the component, once installed in the vehicle.

6.3.1.4.2. The information shall also include installation specifications that are critical to the ADS's performance such as tolerances on installation angle.

6.3.1.4.3. Any changes to the individual components of the sensing system, or the installation options, shall be updated in the documentation.

6.3.1.5. A list of all input and sensed variables shall be provided and the working range of these defined, along with a description of how each variable is linked to the control functions of the ADS and potential impacts on system behaviour. This shall include the nominal range, and coverage area of each sensor.

6.3.1.6. A list of all of the ADS output variables shall be provided and an explanation given, in each case, of whether the output directly controls the vehicle or is processed via another vehicle system. The range of control exercised on each variable shall be defined as well as the nominal capabilities of control actuators.

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6.3.1.7. The manufacturer shall demonstrate how their SMS processes for functional and operational safety with regards to risk identification, risk analysis, risk evaluation, risk treatment (including acceptance) and keeping the risk assessments up to date have been applied to the ADS according to [section 6.1.2 Risk Management and section 6.1.3 ADS Design and Development].

6.3.1.7.1 Any operational risk identified in the ADS shall, where appropriate, have mitigations implemented. The ADS manufacturer shall then be able to show the link between the overall risk management process, the mitigations, and the resulting operational risks.

6.3.1.8. The manufacturer shall describe how the ADS features detect, identify, and respond to hazards, including the following:

(a) Detection and identification of hazards,

(b) Design provisions for functional and operational safety (e.g. redundancies),

(c) An analysis which shows how the ADS will behave (e.g. control strategies) to mitigate or avoid hazards which can have a bearing on the safety of the ADS vehicle user(s) and other road users, and

(d) An analysis that shows how unknown hazardous scenarios will be managed.

6.3.1.9. The manufacturer shall describe measures taken to assure the cybersecurity of the ADS and the analysis performed to identify and disposition likely security threats. Where UN R 155 applies, the manufacturer shall describe how the ADS meets the requirements of that regulation.

6.3.1.10. The manufacturer shall document measures it has implemented to prevent or deter abuse or misuse of the ADS or its occupants which may normally be performed by a driver. (e.g. unauthorised persons attempting to access a vehicle with occupants, occupant attempting to access driving controls, objects placed on vehicles during operation, attempts to damage a vehicle).

6.3.1.11. [Software updates & Safety Case updates as per 6.1.5.2]

6.3.1.12. The manufacturer shall demonstrate that software updates are validated and confirmed in accordance with SMS section [6.1.5.7] [UNR156].

6.3.1.13. The manufacturer shall describe the following aspects of the data storage system:

(a) Storage location and crash survivability,

(b) Data recorded during vehicle operation and occurrences,

(c) Data security and protection against unauthorized access or use, and

(d) Means and tools to carry out authorized access to data.

6.3.1.14. The safety case provided by the ADS manufacturer shall include a description of each ADS feature configuration including ADS functions applicable to that specific feature, the intended uses and limitations on the use of the feature which gives a simple explanation of its operational characteristics.

6.3.1.15. The manufacturer shall document how it has defined the Operational Design Domain for the ADS feature and the boundaries within which it is designed to operate. The manufacturer shall document how

the ADS determines the presence/absence of the conditions and any linked/dependent conditions (e.g. reduced speed in icy weather). This shall include at least the following characteristics:

(a) Intended area of operation (i.e. Jurisdictions, geographic limitations, etc.)
(b) Roadway characteristics (i.e. road type, road conditions, speed limit, etc.)
(c) Environmental conditions (i.e. Weather, illumination, etc.)
(d) Dynamic elements (i.e. kinds of other road users, etc.)

6.3.1.16. The manufacturer shall describe the conditions that the driving automation system is reasonably likely to encounter on its trip(s), including, but not limited to, environmental and geographical conditions, and/or the presence or absence of certain traffic or roadway characteristics, and explain how those expected conditions compare to the ODD of the ADS.

6.3.1.17. The manufacturer will explain the type of use(s) for which the ADS is intended, such as personal car ownership, urban taxi fleet, goods transportation, highway use, etc.

6.3.1.18. The manufacturer shall document:

(a) The conditions that must be present to permit activation of the feature,

(b) The conditions that trigger a fallback response,

(c) The conditions that must be present to permit deactivation of the feature, and

(d) The conditions which may prompt the user to voluntarily take back control, if applicable

6.3.1.19. The manufacturer shall identify the other road users with whom it is designed to interact.

6.3.1.20. The manufacturer shall identify the ADS users, including remote users with whom it is designed to interact and describe the nature of their interaction with the ADS, distinguishing those who provide remote assistance from those, if any, who perform remote driving.

6.3.1.21. The manufacturer shall describe the methods of activating, overriding, or deactivating the ADS feature by any or all of: the ADS user (where relevant), the remote assistant or operator (where relevant), passengers (where relevant) or other road users (where relevant).

6.3.1.22. The manufacturer shall describe the range of end states constituting a minimal risk condition that can be achieved by the ADS feature. This shall include:

a) The conditions which may trigger an attempt to reach a minimal risk condition,

b) The processes by which the ADS feature attempts to reach a minimal risk condition, and

c) The evaluation of risk related to minimal risk condition end states.

6.3.1.23. The manufacturer shall describe how the ADS detects and responds to approaching and crossing of ODD boundaries. This shall include strategies to limit sudden ODD exits and frequent activation/deactivation situations.

6.3.1.24. The manufacturer shall describe how the ADS feature responds to failure situations, including:

(a) Fallback (or fail safe) operation using a partial system,

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(b) Redundancy using separate systems,

(c) A list of the potential faults identifiable by the diagnostic system(s) of the ADS feature,

(d) Removal of some or all automated driving function(s),

(e) Failure of a vehicle system or component other than the ADS that precludes the ADS from performing the DDT.

6.3.1.25. If a partial performance mode of operation is used under certain fault conditions (e.g. in case of severe failures), The manufacture shall describe:

(a) the conditions for activation of that mode (e.g. type of failure),

(b) the resulting ADS feature behaviour and capabilities (e.g. achievement of a minimal risk condition immediately), and

(c) the warning strategy to the driver/remote supervision centre (if applicable).

6.3.1.26. If a second (backup) means to realize the performance of the dynamic driving task is used, the manufacturer shall describe:

(a) the principles of the change-over mechanism,

(b) the logic and level of redundancy and any built-in backup checking features,

(c) the resulting limits of backup effectiveness.

6.3.1.27. If the chosen provision selects the removal of an ADS function, it shall be done in compliance with the relevant provisions of this regulation. In this case, all the corresponding output control signals associated with this function shall also be inhibited.

6.3.1.28. The safety case shall demonstrate that suitable and documented processes have been used to derive behavioral competencies and scenarios that are ODD-relevant and relevant to the ADS safety concept.

6.3.1.28.1. The methodology in the Annex [X] is a suitable process to derive behavioural competencies

6.3.1.29. The safety case shall demonstrate that processes to identify and generate scenarios:

(a) covers the appropriate nominal, critical and failure scenarios

(b) takes into account data driven, knowledge driven and stochastic approaches to systematically identify hazardous events and other occurrences used to develop scenarios

(c) consider ODD restrictions that are consistent with real world operations OR properly consider scenario elements (especially dynamic elements) that are representative of existing traffic conditions consistent with the ODD

(e) properly maps and characterizes the behaviours of all the elements included in the scenarios

6.3.1.29.1. The safety case shall demonstrate that the set of scenarios resulting from the scenario generation and identification process is suitable for demonstrating ADS safety and to cover the space of reasonably foreseeable situations and conditions that the ADS will encounter during its real-world operations. In particular the set of scenarios selected as evidence to support the ADS safety case includes at least:

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(a) a sufficient number of scenarios reaching ODD limits

(b) reasonably foreseeable scenarios that are not deemed to be preventable by the ADS (e.g. related to unsafe behaviours by other road users or to inappropriate infrastructural elements)

6.3.1.29.2. The methodology in the Annex [XX] is a suitable process to generate scenarios that cover reasonably foreseeable situations and conditions.

6.3.1.29.3. The safety case shall demonstrate that appropriate sampling techniques to select the parameters for the logical and concrete scenarios have been used.

6.3.1.30. The manufacturer shall provide the following information as part of its safety case:

(a) Validation/verification plans including appropriate acceptance criteria,

(b) Analysis of coverage of the different tests and setting minimal ODD coverage thresholds for various metrics and includes ODD boundaries [reference to DDT Annex],

(c) Validation/verification results including evidence that the Validation targets (i.e., validation acceptance criteria) are met,

(d) Evidence that the scenarios tested provide reasonable coverage of the ODD,

(e) How it assesses that the validation methods are robustas per 6.2,

(f) SScenario selection process is reasonably designed to provide reasonable coverage of the ODD and its boundaries, and

(g) Any comparisons drawn between the performance of an ADS feature and that of a manually driven vehicle reflect comparable vehicle categories (e.g. category M1 or category 1-1) and situations.

6.3.1.31. The manufacturer shall state how it has determined that the acceptance criteria it has used in its safety case is deemed to be sufficient, including

(a) Identification of metrics used in evaluating the safety case,

(b) Justification of the chosen acceptance criteria for those metrics, and

(c) The scoring/evaluation of the evidence in generating metrics.

6.3.2. Claims, Arguments and Evidence of the Safety case

6.3.2.1. The safety case shall be composed of a series of claims for each of which there must be at least one supporting argument.

6.3.2.1.1. Each argument shall be supported by at least one piece of evidence.

6.3.2.1.2. Each claim, argument and evidence shall be uniquely labelled but may be used more than once (i.e. a piece of evidence may support more than one argument).

6.3.2.2. The safety case shall include claims, arguments and evidence that are understandable, logical, correct and robust and that demonstrate that:

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(a) the ADS is free of unreasonable risk to ADS user(s) and other road users and

(b) the ADS meets applicable requirements of this regulation in each of following areas:

(i) DDT requirements (5.1)

(ii) User Interactions (5.2)

(iii) Other Requirements (5.3)

6.3.2.3. The manufacturer shall provide the following summary information with regards to its safety case:

(a) A summary identifying the relationships between claims and their supporting argument and evidence, and

(b) A summary identifying each regulatory requirement noted above and the claims that demonstrate the requirement is met.

6.3.2.4. The manufacturer shall demonstrate through the safety case that the application of the SMS is suitable for managing ADS safety throughout the lifecycle of the system in accordance with 6.1

6.3.2.5. The manufacturer shall demonstrate through the safety case its ability to monitor the ADS over its lifetime in accordance with the requirement listed in 6.1.5.1-6.1.5.8

6.3.2.6. The manufacturer shall state relevant assumptions it has made in relation to claims, arguments and evidence.

6.3.2.7. The manufacturer shall demonstrate that the credibility of the simulation toolchain in accordance with 6.2 and that the credibility of physical testing used for the generation of evidence with regards to safety have been assessed.

6.3.2.7.1. The manufacturer shall demonstrate that the approach to testing is suitable for the demonstration of the safety case and the compliance with performance/functional requirements.

6.3.2.8. There shall be at least one claim for each goal or regulatory requirement.

6.3.2.8.1. The manufacturer may create multiple sub-claims for a claim, where a broader claim may not be sufficient or where additional justification is warranted as long as said sub-claims are sequenced logically and their relationships are included in the summary documents.

6.3.2.9. Each argument supporting a claim shall provide contextual information and supporting information that explains how a claim is met based on an appropriate set of evidence.

6.3.2.10. Evidence supporting argumentation shall consist of test results or analysis (e.g. source code, engineering drawings, photographs, required documentation etc.) as appropriate.

6.3.2.10.1. Testing results may be provided individually or on aggregate and shall include appropriate acceptance criteria.

6.3.2.10.2. Each test shall include enough information or be recorded in such a way that it may be reproduced upon request (e.g. same software/hardware versions, same tool versions, same scenario, same parameters etc.).

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6.3.2.10.3. The manufacturer shall facilitate access and execution of the necessary tools and analysis software upon request by the authority for the purpose of reproducing this evidence as part of the approval process or during compliance verification.

6.3.2.11. As part of the manufacturer's demonstration of compliance to [6.1.6.8 b)], the manufacturer shall review its safety case prior to certification/approval and is encouraged do so during the development process.

6.3.2.11.1. The reviewer(s) shall be independent, meaning that they are free from conditions that would threaten their ability to review the Safety Case without bias.

6.3.2.11.2. The reviewer(s) may be internal or external to the manufacturer.

6.3.2.11.3. The review shall be documented, available for inspection and include:

(a) Qualifications of the reviewer/ review team

(b) Date/period of review, version of: the safety case, tools and ADS reviewed

(c) Methods used to review the Safety Case

(d) Listing of any evidence repeated/reproduced

(e) Identified gaps, questions or areas of lower confidence or unknowns

6.3.2.11.4. Following each review, and after a time of the manufacturer's choice but before assessment of compliance, the manufacturer shall include in their review documentation the steps taken to remediate or improve upon any findings (e.g. release notes).

## 6.4. Post-deployment Safety

6.4.1. The requirements of this section are without prejudice to applicable laws governing access to data, availability, and privacy and data protection

6.4.2. The requirements of this section are without prejudice to applicable laws on provision of info to other authorities

6.4.3. The manufacturer shall report, as required by the relevant Authority, on the in-service safety performance of the ADS vehicle and provide confirmatory evidence of the audit results of the Safety Management System.

6.4.4. The reporting shall be carried out according to the laws applicable in each contracting party and according to the information available to the manufacturers.

6.4.5. The reporting shall include:

(a) Initial notifications

(b) Short-term reports

(c) Periodic reports.

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6.4.6. The manufacturer shall provide the short term and periodic reports to the relevant Authority in a report (according to reporting templates in the Annex X), that contains a summary and the information relevant to the requirements for reporting.

6.4.7. The manufacturer shall provide, upon request of the relevant authority, the supporting data underpinning the report by means of an agreed data exchange mechanism.

6.4.8. The manufacturer shall provide the relevant Authority with a description of the data processing (for example: filtering and conditioning) procedure and agree on the steps undertaken to deliver the data supporting the report.

6.4.9. The following table provides the list of occurrences to be reported by the manufacturer. For each occurrence and its relevance to the notification/short-term and/or periodic reporting has been flagged.

| Occurrences | Reporting Type | | |
|---|---|---|---|
| | Notification | Short-term | Periodic |
| 1. **Critical occurrences known to the manufacturer**[1] | X | X | X |
| 2. **Significant occurrences** | | | |
| Occurrences related to ADS operation outside its ODD | | X | X |
| ADS failure to achieve a minimal risk condition when necessary | | X | X |
| Other Indications of failure to meet safety requirements | | X | X |
| Occurrences related to safety-relevant performance issues constituting an unreasonable risk to safety. | | X | X |
| 3. **Other occurrences** | | | |
| Occurrences related to Transfer of Control failure | | | X |
| Occurrences related to communication-related occurrences issues | | | X |
| Occurrences related to cybersecurity-related occurrences issues | | | X |
| Occurrences related to failure scenarios | | | X |
| Maintenance and repair problems to ADS and its components[2] | | | X |
| Occurrences related to unauthorized modifications | | | X |
| [~~Unknown scenarios encountered by the ADS~~ Unexpected behaviours of the ADS, including unexpected triggering of the fall back strategy] | | | X |
| Events where an activated ADS feature required interaction with a remote assistant to navigate a driving situation (if applicable)[3] | | | X |
| Fallback user unavailability (where applicable) [4] | | | X |
| Prevention of takeover under unsafe conditions (where applicable)[5] | | | X |

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| Occurrences | Reporting Type | | |
|---|---|---|---|
| | Notification | Short-term | Periodic |
| [Manoeuvres performed to reach an MRC and manoeuvres linked to a prompt action of the ADS to avoid or mitigate a collision] | | | |

[1] If such an occurrence also belongs to one of the remaining sub-categories listed in the occurrence table, the following provisions apply:

- Short term report: there is no need to double-report such occurrence also as part of one of the remaining categories listed in the table.
- Periodic reporting: the occurrence should be double reported both as part of critical occurrence and as occurrence belonging to one of the remaining categories listed in the table. However, the report shall specifically note this aspect.

2 This occurrence captures systematic problems due to a maintenance/repair/service action discovered during the ADS operations

3 This event does not cover remote driving, but rather events in which the ADS will require remote assistance to cope with very specific situations.

4 At aggregate level, this information can provide useful information on the validity of the HMI concept and on the need to provide more effective procedures for keeping the fall-back user available.

5 It is acknowledged that there is no obligation to implement such design solution. However, such information can provide useful information to evaluate the safety benefit of implementing such solution.

6.4.10. The manufacturer shall report on occurrences when at least one of the following is fulfilled:

(a) The ADS feature was active when the ADS vehicle was involved in the occurrence, or

(b) The ADS feature was active up to 30 seconds prior to the ADS vehicle experiencing the occurrence.

6.4.11. [Initial notifications]

6.4.11.1. The manufacturer shall notify the relevant Authority of a critical occurrence without unreasonable delay in accordance with the applicable laws after becoming aware of it.

6.4.11.2. The initial notification may be limited to high-level data (e.g., location, time, type of accident).

6.4.12. Short-term reporting

6.4.12.1. The manufacturer shall report on short term basis for the following occurrences:

(a) Significant Occurrences

(b) Critical occurrences known to the manufacturer where the ADS was involved

6.4.12.2. The manufacturer shall issue a short-term report within 30 days from the knowledge of the matter.

6.4.12.3. The manufacturer shall report in accordance to the short term template in Annex [X], as required by the relevant Authority, following the occurrences flagged under the “Short term reporting” in [6.4.9]

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6.4.13. Periodic reporting

6.4.13.1. The manufacturer shall undertake periodic reporting of occurrences to the relevant authority.

6.4.13.2. The periodic report shall provide evidence of the in-service ADS safety performance. In particular, it shall demonstrate that:

(a) The ADS fulfils the performance requirements as evaluated in the test methods and/or declared in the safety case.

(b) No inconsistencies have been detected compared to the ADS safety performance declared prior to market introduction.

(c) Any newly discovered significant ADS safety performance issues that pose an unreasonable risk to safety have been adequately addressed and how this was achieved, including how they were addressed.

6.4.13.3. The manufacturer shall submit periodic reporting regularly, at least every year, in the form of aggregated data (e.g., per hour of operation and distance driven) for ADS-vehicle type and related to ADS operation.

6.4.13.4. The manufacturer shall report occurrences in accordance with to the periodic reporting template in Annex X, as required by the relevant Authority, for the occurrences flagged under "Periodic reporting" in [6.4.9]

# 7.Compliance Assessment[27]

7.1. SMS Audit[28]

7.1.1. Objectives of the SMS audit

7.1.1.1. The documentation of the manufacturer's safety management system shall be audited for compliance with the provisions under section 6.2.[29]

7.1.1.2. The audit of the manufacturer's safety management system shall provide confirmatory evidence on the robustness of the manufacturer's processes to manage safety risks and to ensure safety throughout the ADS lifecycle (development, production, operation and decommissioning).

7.1.1.3. The auditor shall evaluate the robustness of the manufacturer's processes to monitor the safety management system activities (KPIs) and to take appropriate (corrective or preventive) action to address any issue.

[27] Anything regarding procedures for the independent assessment of the manufacturer's documentation.
[28] Uniform procedures for verifying compliance of the manufacturer's SMS with the requirements for documentation of the SMS.
[29] ADS-05-14: The auditor shall audit the manufacturer's safety management system in respect to the requirements in the section 6.1. of this regulation.

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7.1.1.4. The audit of the safety management system shall only be conducted by auditors with the technical and administrative knowledge necessary for such purposes. This competence shall be demonstrated by appropriate qualifications or other equivalent training records.

7.1.2. The auditor shall verify that the manufacturer has used suitable and documented processes to derive behavioural competencies and scenarios that are ODD-relevant and are relevant to the ADS safety case.[30]

7.1.2.1. The auditor may refer to the methodology outlined in the Annex [ODD framework annex] as a suitable approach against which to review the approach adopted by the manufacturer.[31]

7.1.2.2. The auditor shall verify that the manufacturer's approach and processes to identify and generate scenarios:[32]

(a) covers the necessary nominal, critical and failure scenarios

(b) takes into account data driven, knowledge driven and stochastic approaches to systematically identify hazardous events and other occurrences used to develop scenarios

(c) properly maps and characterises the behaviour of all the elements included in the scenarios.

7.1.2.3. The auditor shall verify that the manufacturer has used sampling techniques when selecting parameters to be used in creating logical and concrete scenarios used as evidence supporting the ADS safety case to avoid the ADS being optimized for a set of known test cases.[33]

7.1.3. The auditor shall verify that the manufacturer has suitable processes, resources and competent personnel in place for the testing that has been undertaken to demonstrate the ADS safety case.

7.1.3.1. The auditor shall verify that the manufacturer has suitable processes and competent personnel to assess the behavioural competencies demonstrated by the ADS under each scenario against requirements for performance of the Dynamic Driving Task (DDT).[34]

7.1.3.2. The auditor verify that the manufacturer has suitable processes and competent personnel to assess the capability of the ADS to ensure the safety of users and their use of ADS vehicles.[35]

7.1.3.3. The auditor shall verify that the manufacturer has suitable processes in place to identify the set of scenarios to be tested via track-testing.[36]

7.1.3.4. The auditor shall verify that the manufacturer has suitable processes in place to identify test routes that capture predictable aspects of the ODD (e.g., road types and geometries), elements found in the related nominal scenarios (e.g., other road users, signs, and signals), and typical dynamic conditions (e.g., high/low traffic densities). The test routes shall also enable verification of nominal requirements for the

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safety of user interactions, including prior to, at the time of, and after entering and exiting the ODD of an ADS feature.[37]

7.1.4. Pre-Deployment Assessment of In-service monitoring and reporting

7.1.4.1. [UNR] The Type Approval Authority or its Technical Service shall review the manufacturer's documentation to ensure the suitability of ISMR practices for the ADS.

[GTR] The Assessor shall review the manufacture's documentation to ensure the suitability of ISMR practices for the ADS.

7.1.4.2. The documentation review shall provide evidence that:

(a) the processes for ISMR are suitable for the ADS

(b) the tools used for ISMR are suitable for the ADS

(c) the personnel for ISMR have an adequate level of competence.

7.1.4.3. (UNR) The Type Approval Authority or its Technical Service shall evaluate the manufacturer's capability to monitor the ADS as per the requirement listed in the [6.1.5.1.-6.1.5.8.]-

(GTR) The Assessor shall evaluate the manufacturer's capability to monitor the ADS as per the requirement listed in the [6.1.5.1.-6.1.5.8].

7.1.4.4. (UNR) The Type Approval Authority or its Technical Service shall evaluate the manufacturer's approach/methods:

(a) To verify the safety performance of the ADS during the operation and

(b) To ensure the effectiveness of their safety risk controls.

(GTR) The Assessor shall evaluate the manufacturer's approach/methods:

(a) to verify the safety performance of the ADS during the operation and
(b) to ensure the effectiveness of their safety risk controls.

7.1.4.5. (UNR) The Type Approval Authority or its Technical Service shall verify and evaluate that the Manufacturer has a mechanism in place:

(a) To collect data from the vehicle and to receive data other sources

(b) To utilize all relevant data feeding sources in order to assess the ADS safety risks, evaluate its safety performance, and, in time, take appropriate actions and check their effectiveness.

(GTR) The Assessor shall verify and evaluate that the Manufacturer has a mechanism in place:

(a) To collect data from the vehicle and to receive data other sources

(b) To utilize all relevant data feeding sources in order to assess the ADS safety risks, evaluate its safety performance, and, in time, take appropriate actions and check their effectiveness.

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7.1.4.6. The documentation review shall provide evidence that, at least:

(a) Responsibilities and timelines are defined to ensure that the monitoring is applied and effective

(b) Methods for data collection and analysis are adequate to ensure monitoring objectives are fulfilled

(c) ADS safety performance will be verified in reference to the safety performance indicators and safety performance targets as indicated in the Safety Case.

(d) [the risk assessment, including residual risks, will be evaluated regularly through the information coming from the monitoring activities.]

(e) the monitoring takes into account feedback and information received from sources other than the ADS vehicle data

(f) the effectiveness of the monitoring activity will be regularly reviewed.

7.1.4.7. (UNR) The Type Approval Authority or its Technical Service shall evaluate the manufacturer's capability to report the occurrences during the ADS operation as per the requirement listed in the [6.4].

(GTR) The Assessor shall evaluate the manufacturer's capability to report the occurrences during the ADS operation as per the requirement listed in the [6.4].

7.1.4.8. (UNR) The Type Approval Authority or its Technical Service shall evaluate the manufacturer approach/methods for reporting the occurrences experienced by the ADS during the operation and for assessing the cause of such events.

(GTR) The assessor shall evaluate the manufacturer approach/methods for reporting the occurrences experienced by the ADS during the operation and for assessing the cause of such events.

7.1.4.9. (UNR) The Type Approval Authority or its Technical Service shall verify that the manufacturer utilizes the templates in the Annex X. (Note: Not all the data elements included in the template are mandatory. However, the assessor shall evaluate the rationale provided by the manufacturer when:

(a) not mandatory data are not included,

(b) not mandatory data will be included, but in a later stage

(GTR) The Assessor shall verify that the manufacturer utilizes the templates in the Annex X. (Note: Not all the data elements included in the template are mandatory. However, the assessor shall evaluate the rationale provided by the manufacturer when:

(a) not mandatory data are not included,

(b) not mandatory data will be included, but in a later stage.

7.1.4.10. (UNR) The Type Approval Authority or its Technical Service shall evaluate the adequacy of the information that the manufacturer intends to use for the characterisation of the occurrences (e.g. data elements and metrics).

(GTR) The Assessor shall evaluate the adequacy of the information that the manufacturer intends to use for the characterisation of the occurrences (e.g. data elements and metrics).

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7.2. Assessment of the Testing Environment

7.2.1. Appraisal of the physical testing facilities and environment

7.2.1.1. The assessor shall appraise the physical testing (proving ground and/or public road) facilities and environment for their suitability to conduct the testing and gather evidence to support the safety case. In particular the assessor shall verify that:[38]

7.2.1.1.1. the physical testing facilities used by the manufacturer includes static and dynamic elements representative of the ODD and the expected operating conditions and as relevant to the tests being performed;

7.2.1.1.2. the facilities and capabilities are suitable to assess the aspects of the safety case under test;

7.2.1.1.3. the facilities have all the relevant equipment and accreditations;

7.2.1.1.4. the equipment undergoes periodic calibrations to ensure that the measurements are characterized by sufficient accuracy and precision.

7.2.1.2. The assessor may request to witness the execution of some of the physical tests performed by the manufacturer to verify their suitability to conduct the testing and gather evidence to support the safety case as well as to verify that the manufacturer is following the agreed processes for doing the physical testing.7.2.2. Appraisal of the credibility framework developed by the manufacturer for virtual testing

7.2.2.1. The assessor shall verify that the simulation toolchain(s) used by the manufacturer in the assessment of the safety case is suitable for conducting virtual tests and in compliance with requirements listed in 6.2.1. and sub-paragraphs[39]

7.2.2.2. The assessor shall review the manufacturer's credibility framework to determine whether the simulation toolchain(s) is suitable to undertake virtual testing.[40]

7.2.2.3. The assessor shall review the documentation and evidence supporting the manufacturer's claims about the capability of the simulation toolchain(s), including its scope, to confirm that it can be used to perform virtual testing as part of the ADS assessment.

7.2.2.4. The assessor shall audit the information provided by the manufacturer and may request or carry out additional physical or virtual tests. The results of these additional tests shall be reviewed and any concerns or discrepancies shall be raised and reviewed with the manufacturer.[41]

7.2.3.4.1. If the results do not sufficiently replicate those of the manufacturer or raise other concerns and the manufacturer cannot provide an explanation for the discrepancies then the assessor shall inform the manufacturer that they need to undertake their own review to identify the reasons.

[38] Duplicated in ADS-05-07 and ADS-05-16.
[39] ADS-05-16.
[40] Duplicated in ADS-05-07 and ADS-05-16.
[41] Duplicated in ADS-05-07 and ADS-05-16.

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7.2.3.4.2. The manufacturer can resubmit once they have identified and resolved the issue and updated the information. The manufacture shall explain the issue and its extent. The assessor shall conduct a further review that will include an assessment of the additional information supplied by the manufacturer.

7.2.3.5. The assessor may request to witness the generation of some of the virtual testing results to verify the evidence indicated in the previous points.

7.3. Assessment of the Safety Case for the ADS[42]

7.3.1. Assessment of the Safety Case Content

7.3.1.1. The safety case shall be assessed by an assessor, or team of assessors meeting 7.3.6 and 7.3.7 in order to determine if the Safety Case is complete and robust.

7.3.1.2. The assessor may request that the manufacturer provide supporting documentation, assist in repeating/reproducing evidence or subject the ADS to tests the assessor deems necessary for this task.

7.3.1.3. The assessor shall review the manufacturer's safety case for completeness ensuring that at least the following criteria have been met:

(a) the manufacturer's safety concept is consistent and complete,

(b) each requirement in the regulation has been addressed by one or more claims as per 6.3.2.8,

(c) the cumulation of claims would yield a system absent of unreasonable risk as per 6.3.1.30, 6.3.1.31 and 6.3.2.2,

(d) each claim is supported by one or more arguments as per 6.3.2.1,

(e) each argument is supported by a non-zero set of evidence as per 6.3.2.1.1,

(f) the manufacturer has documented metrics and acceptance criteria related to their claims as per 6.3.1.30 and 6.3.1.31.

(g) backwards and forward traceability from requirements to evidence as per 6.3.2.3

7.3.1.4. The assessor shall review the manufacturer's safety case for robustness ensuring that at least the following criteria have been met:

(a) All identified risks in the Safety Concept are either reduced, mitigated or accepted and the sum of risk (quantitative or qualitative) is below the unreasonable risk threshold,

[42] Uniform procedures for assessing the manufacturer's documentation of the safety case for the ADS.

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(b) The integrity level used for development, validation, and verification of the ADS and its features is appropriate to reduce the risk below the unreasonable risk threshold

(c) Testing evidence and the tools by which they are obtained achieve an acceptable level of credibility and demonstrate stability of performance when subjected to variations as per 7.2,

(d) [Acceptable mix of physical, track and virtual testing – as part of credibility? Manufacturer justification?],

(e) The manufacturer has taken steps to limit the potential for unintended functions in the ADS or for unintended functions to be induced in interfacing systems

(f) Evidence provided can be repeated and reproduced with consistency of safety objectives as per 7.3.9,

(g) The evidence demonstrated by the manufacturer provides reasonable coverage of foreseeable operating conditions and events in the intended area of operation, including conditions consistent with the ODD of the ADS and conditions that may involve ODD exit, and

(h) The manufacturer has conducted one or more self-assessments and has taken steps to remediate any findings as per 6.3.2.11.

7.3.1.5. The assessor shall prepare a report of its assessment in such a manner that allows traceability, e.g. versions of documents inspected are coded and listed in the records of the Assessor. The report shall include any identified discrepancies/gaps and remediations undertaken by the manufacturer.

7.3.1.6. The assessment shall be conducted by assessors with the technical and administrative knowledge necessary for such purposes. They shall be competent as assessor for functional safety (e.g. ISO 26262), safety of the intended functionality (e.g. ISO/PAS 21448), human factors considerations and shall be able to make the necessary link with cybersecurity (e.g. UN R155, ISO/SAE 21434). This competence should be demonstrated by appropriate qualifications or other equivalent training records.

7.3.1.7. (UNR) The assessor shall be independent and external in accordance with Schedule 2 part 1.4 of the 1958 agreement

(GTR) The assessors shall be free from conditions that would threaten their ability to assess the Safety Case without bias including:

(a) financial incentives linked to the approval of the Safety Case (excludes incentives for the work undertaken to assess the Safety Case)
(b) participated in the development of the Safety Case via creation of evidence, analyses, test tools or other material
(c) Potential of reprisals for not approving the Safety Case

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7.3.2. Assessment of Safety Case Testing Activities

7.3.2.1. General provisions

7.3.2.1.1. The assessor shall verify that the approach to testing adopted by the manufacturer is suitable for the demonstration of the safety case and the compliance with performance/functional requirements.[43]

7.3.2.1.2. The assessor shall verify that the combined coverage of the testing results from all pillars (virtual, track, real world) is sufficient to support the ADS safety case claims.

7.3.2.2. Assessment of the scenarios and their management

7.3.2.2.1. The assessor shall verify that the manufacturer has used suitable and documented processes to derive behavioural competencies that are relevant to both the ODD and to the ADS safety case[44]

~~7.3.2.2.1.1.~~

7.3.2.2.2. The assessor shall verify that the manufacturer's approach and processes to identify and generate scenarios is appropriate. In particular, the resulting scenarios shall:

7.3.2.2.2.1. cover the appropriate nominal, critical and failure situations;

7.3.2.2.2.2. use data driven, knowledge driven and stochastic approaches to systematically identify hazardous events and other occurrences;

7.3.2.2.2.3. include elements (especially dynamic elements) that are [representative/consistent] of existing traffic conditions in the target operational domain;

7.3.2.2.2.4. incorporate the identified characteristics and behaviours of all the relevant scenario elements.

7.3.2.2.3. The assessor shall verify that the set of scenarios resulting from the manufacturer's scenario generation and identification process is suitable for demonstrating the ADS safety case. This includes covering reasonably foreseeable situations and conditions that the ADS will encounter during its real-world operations[45]. In particular the assessor shall verify that the set of scenarios selected as evidence to support the ADS safety case includes:

7.3.2.2.3.1. a sufficient number of situations in which the ADS needs to initiate a fall-back response (e.g. approaching the ODD limits).

7.3.2.2.3.2. reasonably foreseeable scenarios that are not deemed to be preventable by the ADS (e.g. related to unsafe behaviour by other road users or by infrastructural failures)

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[43] Duplicated in ADS-05-07 and ADS-05-16. Corresponds with para. 6.2.1.

[44] The methodology in the Annex [X] is one suitable process against which to review the process adopted by the manufacturer.

[45] The methodology in the Annex [XX], including the provided scenario template, is one suitable approach against which to review the approach adopted by the manufacturer.

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7.3.2.2.4. The assessor shall verify that the manufacturer has adopted appropriate techniques to explore the parameter space when choosing concrete scenarios. ~~The assessor shall verify that the manufacturer has properly sampled used appropriate sampling techniques to select the parameters for the logical and concrete scenarios.~~

7.3.2.3. Assessment of the processes in place for testing

7.3.2.3.1. The assessor shall verify that the manufacturer has suitable processes, resources and competent personnel to undertake the testing that produces the evidence supporting the ADS safety case.

7.3.2.3.1.1. The assessor shall verify that the manufacturer has suitable processes, resources and competent personnel to assess the behavioural competencies demonstrated by the ADS for each scenario, against the performance requirements of the Dynamic Driving Task (DDT).

7.3.2.3.1.2. The assessor shall verify that the manufacturer has suitable processes, resources and competent personnel who can assess the capability of the ADS to ensure the safety of users and the safe use of the ADS.

7.3.2.3.2. The assessor shall verify that the manufacture has not optimised the ADS for a set of known test cases.

7.3.2.4. Assessment of testing evidence

7.3.2.4.1. The assessor shall review the evidence produced by the manufacturer in demonstrating the ADS safety case.

7.3.2.4.1.1. The assessor shall review the evidence produced by the manufacturer in demonstrating the capability of the ADS to perform its Dynamic Driving Tasks (DDT).

7.3.2.4.1.2. The assessor shall review the evidence produced by the manufacturer in demonstrating the capability of the ADS to interact safelywith users.

7.3.2.4.1.3. The assessor shall review the manufacturer's use of the different testing methods:
1. Virtual testing
2. Track testing
3. Real world testing

7.3.2.4.1.4. The assessor shall verify that the procedures and data collection associated with ~~[user]~~ testing are in line with ~~best~~ established scientific and engineering practice.

7.3.2.4.1.5. For the specific case of ADS user testing, the assessor shall:

7.3.2.4.1.5.1. verify that the people involved ~~in user testing~~ are representative of the general population of ADS users and other road users where applicable;

7.3.2.4.1.5.2~~The assessor shall~~ verify that the results achieved can be considered statistically significant.

7.3.2.4.1.7. The assessor shall verify the suitability of the set of tests carried out as evidence to support the safety case, in particular in terms of coverage and relevance.

7.3.2.4.1.8. The assessor shall assess the results of the tests carried out for meaningfulness and consistency.

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7.3.2.4.1.9. The assessor shall verify that the results of the tests are able to demonstrate the behavioural competencies of the ADS when performing the DDT. In particular the assessor shall verify that the test results confirm the claims and arguments in the ADS safety case:

7.3.2.4.1.9.1. in nominal, critical and failure scenarios;

7.3.2.4.1.9.2. while approaching and crossing the ODD boundaries;

7.3.2.4.1.9.3. in the case that collisions with other road users are not deemed to be preventable.

7.3.2.4.1.10. The assessor shall verify that the manufacturer has suitable processes in place to identify the set of scenarios to be tested using the different testing methods.

7.3.2.4.1.11. The assessor shall verify that the manufacturer has suitable processes in place to verify the consistency of the test results across the different testing methods adopted. [46]

7.3.2.4.2. Assessment of virtual tests.

7.3.2.4.2.1. The assessor shall verify that the manufacturer's virtual testing has been carried out incorporating proper consideration of the assumptions, accuracy and uncertainty in the simulation toolchain(s) in line with the requirements laid down in 6.2.2. The reviewer shall verify that the use of the results from the virtual testing reflects these considerations.

7.3.2.4.2.2. The assessor shall verify that any virtual test using simulation toolchain(s) containing stochastic elements has taken account of the possible uncertainty in the results.

7.3.2.4.2.3. If the manufacturer is using virtual testing to demonstrate scenario coverage the assessor shall verify that they have included critical scenarios and low probability events. The critical scenarios shall include those that could result in a collision. [The assessor will also check how the manufacturer has explored the parameter space and identified the number and type of tests to perform.]

7.3.2.4.3. Assessment of track testing.

7.3.2.4.3.1 The assessor shall review the evidence from track-testing that is provided by the manufacturer to support the ADS' safety case.

7.3.2.4.3.2 The assessor shall verify that at least part of the scenario tested via track-testing includes critical scenarios replicating conditions that could result in a collision.

7.3.2.4.4. Assessment of real-world testing.

7.3.2.4.4.1. The assessor shall review the evidence from real world testing that is provided by the manufacturer to support the ADS safety case.

7.3.2.4.4.2. The assessor shall verify that the manufacturer has suitable processes in place to identify test routes that capture predictable aspects of the ODD (e.g., road types and geometries), elements found in the related nominal scenarios (e.g., other road users, signs, and signals), and typical dynamic conditions (e.g.,

[46] The methodology and models in the Annex [Z] are among the suitable approaches against which to review the approach adopted by the manufacturer to assess the performances of the ADS.

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high/low traffic densities). The test routes shall also enable verification of nominal requirements for the safety of user interactions, including prior to, at the time of, and after entering and exiting the ODD of an ADS feature.

7.3.2.4.4.3. The assessor shall verify that the evidence collected via real world testing by the manufacturer covers a wide variety of situations and conditions that the ADS may encounter during its real-world operations.

7.3.2.4.4.4. To the extent that an ADS encounters critical or failure situations during a real-world test drive, the response of the ADS, including any discrepancies with the nominal performance requirements, shall be considered by the assessor in conjunction with the outcomes of track and virtual testing.

7.3.3. Confirmatory testing by assessor

7.3.3.1. The assessor shall undertake physical testing using the various methods to confirm that the evidence provided by the manufacturer is representative.

7.3.3.1.1. The assessor shall ensure that the physical testing (proving ground and/or public road) facilities and environment are suitable to conduct the testing and confirm the evidence provided by the manufacturer to support the safety case in line with the provisions laid down in 7.2.1. and sub-paragraphs.

7.3.3.1.2. The assessor shall compare the information generated by the confirmatory testing with the evidence produced by the manufacturer to check that there is an appropriate level of correlation between them.

7.3.3.1.2.1. If the assessor is unable to confirm that there is an appropriate level of correlation, then the manufacturer should be informed that the results do not correlate. The manufacturer should review the alleged discrepancies and take appropriate action to resolve them. ~~If the assessor does not acknowledge the presence of an appropriate level of correlation, then the manufacturer should be informed and should review the alleged discrepancies and take appropriate action to resolve them~~.

7.3.3.2. Track testing by assessor.

7.3.3.2.1. The assessor [shall/may] use track testing to confirm the performance of the ADS in a number of selected relevant nominal, critical, and failure scenarios.

7.3.3.2.1.1. The assessor shall explain and document their choices for the scenarios used to test the ADS.

7.3.3.2.2. Any track testing shall be conducted on a testing ground that is part of, or suitably represents, the ODD of the ADS. Tests may be conducted to verify that the ADS responds safely to situations including, crossing ODD boundaries and activation behaviour outside of the ODD, where applicable.

7.3.3.2.2.1. The assessor may use the testing ground used by the manufacturer to carry out confirmatory track testing.

7.3.3.2.3. The assessor shall consider how to manage real world variations. Where appropriate such variations should be allowed rather than restricting all tests to standardised parameters, test objects and test environments. The ADS should continue to perform if the tests remain within the ODD or react appropriately if not.

7.3.3.2.4. The test track, the test environment and the test objects may also be virtual elements as part of a simulation toolchain, provided that the assessor is able to guarantee their credibility in line with the

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requirements laid down in 6.2.2. The ADS or the component being tested shall not be virtual elements or part of a simulation toolchain.

7.3.3.2.5. The assessor shall ensure an appropriate protocol is used for recording the track testing. It will contain at least minimum requirements on test relevant data collection and analysis, e.g., how the data is recorded, how measurements are derived from the recorded data, and how the measurements are analysed.

7.3.3.2.6. The assessor shall ensure that the track testing carried out is recorded with sufficient details to allow the tests to be reproduced to a sufficient level of accuracy. The information recorded shall include at least the test equipment, the test set-up, and the test environment, as well as any variations and adjustments

7.3.3.2.7. The assessor shall select scenarios to be conducted on a test track that are appropriate to the ODD.

7.3.3.2.8. The assessor shall select scenarios where the behaviour or position of other road users require the ADS to react to their movement or presence.

7.3.3.2.9. The assessor shall [verify/confirm] the human factor evidence from the confirmatory tests are correlated with those provided by the manufacturer

7.3.3.2.10. The assessor shall ensure the executin of any track tests in line with the approach set out in Appendix 1 to this Annex.

7.3.3.3. Real world testing by assessor

7.3.3.3.1. The assessor [shall/may] conduct real world testing of the ADS in nominal scenarios. It is acknowledged that critical and/or failure scenarios may occur during real world testing, but generally should not be tested on purpose. If such scenarios occur, they shall not be excluded from the assessment.

7.3.3.3.2. The assessor shall ensure that real world testing is conducted safely and therefore can end a test at any point if it becomes unsafe. ~~. The assessor shall ensure that real world testing is conducted safely. Therefore if it's applicable to the use case, the test assessor can end the test at any point. In addition, the assessor shall review any inappropriate ADS behaviour that is observed and/or the reason if the test is forced to end prematurely.~~

7.3.3.3.3. The assessor shall ensure that real world testing only be conducted if an appropriate level of safety for the other road users and for users in the vehicle can be demonstrated. [This may be provided by considering the audit, virtual testing, and track testing as well as the manufacturer's prior real world testing of the ADS.]

7.3.3.3.4. The assessor shall ensure that real world testing confirms the claimed ADS performance in real traffic conditions.

7.3.3.3.5. The assessor shall ensure that real-world testing confirms the claimed ADS performance when approaching and crossing ODD boundaries, where appropriate. This testing shall include nominal and complex scenarios. The testing shall be used to confirm the claimed ADS performance related to the interaction with users under these conditions

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7.3.3.3.6. The assessor shall ensure that real world testing confirms the claimed ADS performance relating to issues that may not be well captured by track tests and simulation, such as perception quality limitation (e.g. due to light and environmental conditions, etc.)

7.3.3.3.7. The assessor shall ensure that real world testing confirms the claimed ADS performance for aspects relating to human factors, such as user-initiated deactivation, system-initiated deactivation (not leading to a minimal risk condition), audibility of messages in real world conditions, if applicable to the ADS.

7.3.3.3.8. The assessor shall review the environment and conditions of the selected test routes to ensure they reflect the environment and conditions of the ADS' ODD.

7.3.3.3.9. The assessor shall ensure that the test routes that are selected include complex scenarios that the ADS is expected to encounter.

7.3.3.3.10. The assessor shall ensure that an appropriate protocol is followed when undertaking real world testing. It should contain minimum requirements that standardise how the test relevant data are to be collected and analysed (e.g., how the data is recorded, how measurements are derived from the recorded data, and how the measurements are analysed).

7.3.3.3.11. The assessor shall ensure that real world testing confirms the claimed ADS performance both within its ODD and outside its ODD (e.g. to determine the ADS's appropriate recognition and response when not in its ODD) on public roads.

7.3.3.3.12. The assessor shall attempt to increase the likelihood of encountering specific complex scenarios by selecting an ODD (e.g. highway) and examining when and where specific elements (e.g. high- or low-density traffic) typically occur. It is understood that it may not be possible to encounter all traffic scenarios during a real world test.

7.3.3.3.13. The assessor shall review any infractions identified during real world testing and assess it both directly and by evaluating it against any other relevant and available evidence, e.g. the data gathered during other testing or supplied by the manufacturer.

7.3.3.3.14. The assessor shall compare the information generated during real world testing with the information from track testing to ensure there is the appropriate level of correlation of the results including the ADS' performance.

7.3.3.3.14.1. If there is insufficient correlation then the manufacturer should be informed and should review the alleged discrepancies and take appropriate action to resolve them.

7.3.3.3.15. The assessor shall ensure real world testing is undertaken in line with the approach set out in Appendix 1 to this Annex.

7.4. Post-deployment safety

7.4.1. (UNR) The Type Approval Authority or its Technical Service shall receive and review confirmatory evidence produced by ~~that the information provided by the manufacturer during~~ the ADS during its operations (e.g. Notification, short term and periodic reports) ~~is in compliance with~~ and assess that it is in accordance with capabilities described in the manufacturer's SMS [ref. 7.4.1.7-7.4.1.10].

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(GTR) The Assessor shall receive and review confirmatory evidence produced by ~~that the information provided by the manufacturer during~~ the ADS operations (e.g. Notification, short term and periodic reports) ~~is in compliance with~~ and assess that it is in accordance with capabilities described in the manufacturer's SMS [ref. 7.4.1.7-7.4.1.10].

7.4.2. (UNR) The Type Approval Authority or its Technical Service shall review the information provided by the manufacturer on the ADS operations (e.g. Notification, short term and periodic reports):

(a) to receive confirmatory evidence on the ADS manufacturer's safety case and on the Safety Management System,

(b) to receive information on the ADS safety level and assess whether the ADS continues to be safe when operated on the road,

(c) If applicable, to verify that this information, is used to develop new scenarios or variations of existing scenarios included in the Safety case' evidence.

(d) to ensure the effectiveness of the implemented corrective actions.

(GTR) The Assessor shall review the information provided by the manufacturer on the ADS operations (e.g. Notification, short term and periodic reports):

(a) to receive confirmatory evidence on the ADS manufacturer's safety case and on the Safety Management System,

(b) to receive information on the ADS safety level and assess whether the ADS continues to be safe when operated on the road,

(c) If applicable, to verify that this information, is used to develop new scenarios or variations of existing scenarios included in the Safety case' evidence.

(d) to ensure the effectiveness of the implemented corrective actions.

7.4.3. (UNR) The Type Approval Authority or its Technical Service shall review the manufacturer's data processing (for example: filtering and conditioning) procedure during occurrence investigation and agree on the steps undertaken to deliver the data supporting the report.

(GTR) The Assessor shall review the manufacturer's data processing (for example: filtering and conditioning) procedure during occurrence investigation and agree on the steps undertaken to deliver the data supporting the report.

7.4.4. (UNR) The Type Approval Authority or its Technical Service shall ensure the confidentiality of-sensitive and business confidential reported information in the short-term template.

(GTR) The Assessor ensure the confidentiality of sensitive and business confidential reported information in the short term template.

7.4.5. (UNR) The Type Approval Authority or its Technical Service, where necessary, may verify the information provided and, if needed, the Type Approval Authority or its Technical Service may require further investigations and evidence, including test, before closing the occurrence.

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(GTR) The Assessor, where necessary, may verify the information provided and, if needed, the assessor may require further investigations and evidence, including test, before closing the occurrence.

7.4.6. (UNR) If an ~~serious~~ unreasonable safety risk is identified, the Type Approval Authority may inform the Contracting Party on the need of ~~recommend temporary~~ safety measures, including immediately restricting or suspending the relevant operations via remote termination, and on the need to require actions to restore an acceptable level of safety as per the applicable laws.

Alternative for UNR

If an ~~serious~~ unreasonable safety risk is identified, the Contracting Party may recommend temporary safety measures, including immediately restricting or suspending the relevant operations via remote termination, and may require to take actions to restore an acceptable level of safety as per the applicable laws

(GTR) If a ~~serious~~ unreasonable safety risk is identified, the Contracting Party may recommend temporary safety measures, including immediately restricting or suspending the relevant operations via remote termination, and may require to take actions to restore an acceptable level of safety as per the applicable laws.

Alternative proposal UNR/GTR

[If an unreasonable risk to safety is identified, the Contracting Party may carry out its enforcement authorities to the maximum extent under applicable law. Depending on national law, options could include ordering remedies, suspending relevant operations, and recommending or requiring actions to remedy the safety risk]

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# Annexes[47]

## Annex [] In-Service Reporting Templates

This Annex lists two reporting templates aimed at assuring the harmonization of the information to be reported by the manufacturer to the relevant authority

The data elements marked with an asterisk (*) represent information immediately available to the manufacturers and that shall be reported as part of the mandatory reporting requirements in 6.4.

It is advised that the remaining applicable data elements are made available to the relevant authority via collaboration with third-party stakeholders.

Short-term Reporting

1.1. The following template aims at ensuring that a consistent and comprehensive set of information is delivered to the relevant authority to foster an effective application of the short-term reporting scheme.

1.2 The manufacturer may use the short term template to also report for other occurrences which are not mandated in 6.4.9.

1.3 The data elements potentially containing business confidential or sensitive data shall remain confidential.

| **WHAT** | | |
|---|---|---|
| *Entry name* | *Field to be filled* | *Type/size* |
| Headline* | | Text(200) |
| **OCCURRENCE CLASSIFICATION*** | | |
| Occurrence class[48] | | Text(50) |
| Occurrence type[49] | | Text(200) |
| **OCCURRENCE DETAILS** | | |
| Weather conditions* | | Text(20) |
| Lighting conditions* | | Text(20) |

[47] Extensions of the above where useful to facilitate understanding and use of the regulations.
[48] Those can be: critical occurrence/significant occurrence.
[49] Ref Table X6.4.9

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| | | |
|---|---|---|
| ADS vehicle pre-occurrence speed* | | Number(3) – [km/h] |
| ADS vehicle post-occurrence max deceleration* | | Number(3) – [m/s$^2$] |
| ADS vehicle estimated pre-occurrence mass | | Number(5) – [kg] |
| ADS vehicle telematics provided* | | [Y/N] |
| ADS vehicle EDR data provided* | | [Y/N] |
| ADS vehicle DSSAD data provided* | | [Y/N] |
| ADS vehicle media provided*[50] | | [Y/N] |
| Third-party sources media/telematics provided | | [Y/N] |
| Occurrence reported to the police | | [Y/N] |
| Police report available | | [Y/N] |
| ADS feature type at occurrence | | Text(50) |
| ADS users available at occurrence | | [Y/N] |
| Attempted user-initiated deactivation of the ADS within 30 seconds prior to the occurrence | | [Y/N] |
| **WHEN*** | | |
| UTC date | | [YYYY/MM/DD] |
| UTC time | | [HH:mm] |
| Local date | | [YYYY/MM/DD] |
| Local time | | [HH:mm] |
| **WHERE** | | |
| Country | | Text(50) |
| State/Province | | Text(50) |
| City | | Text(50) |
| ZIP code (if applicable) | | Number(10) |
| Street/Intersection | | Text(50) |

[50] Those can include dash-cam or other recording systems

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| | | |
|---|---|---|
| GNSS coordinates[51]* | | [longitude, latitude] [Decimal degree] |
| Occurrence within ODD* | | [Y/N] |
| Speed limit at location* | | Number(3) – [km/h] |
| Roadway type* | | Text(50) |
| Roadway surface* | | Text(50) |
| Roadway description* | | Text(100) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **KNOWN/ALLEGED DAMAGE[52]** | | | | | | | |
| ~~Highest damage~~ | | | | | | | |
| ADS vehicle damage level | | | | | | Text(20) | |
| ADS vehicle damage area | Front left [Y/N] | | Front centre [Y/N] | | Front right [Y/N] | | Top [Y/N] |
| | Rear left [Y/N] | | Rear centre [Y/N] | | Rear right [Y/N] | | Bottom [Y/N] |
| | Right side [Y/N] | | Left side [Y/N] | | Unknown [Y/N] | | |
| ADS vehicle occupant restraint systems deployed | | | [Y/N] | | | | |
| ADS vehicle towed | | | [Y/N] | | | | |
| Any ADS features no longer safe to operate | | | [Y/N] | | | | |
| Other-road users damaged | | | | | Text(20) | | |
| • Alleged damage | | | Text(200) | | | | |
| Road Infrastructure damaged | | | [Y/N] | | | | |
| • Alleged damage | | | Text(200) | | | | |

[51] GNSS coordinates, if available and applicable, can be used instead of country/state/city/ZIP/street localization.

[52] Collision Deformation Classification (CDC) or the Vehicle Damage Index (VDI) shall be provided if applicable

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| | | |
|---|---|---|
| ~~Private property~~ Other items damaged | | [Y/N] |
| • Alleged damage | | Text(200) |
| | | |
| | | |
| | | |
| | | |

| **KNOWN/ALLEGED INJURY**[53] | | |
|---|---|---|
| Highest Injury level | | Text(50) |
| Total fatalities ADS vehicle | | Number(3) |
| Total fatalities other road user | | Number(3) |
| Injured road user type | | Text(50) |
| Total serious (MAIS 3+) injuries ADS vehicle | | Number(3) |
| Total serious (MAIS 3+) injuries other road user | | Number(3) |
| Road user type | | Text(50) |
| Total minor (MAIS 1/2) injuries ADS vehicle | | Number(3) |
| Total minor (MAIS 1/2) injuries other road user | | Number(3) |
| Road user type | | Text(50) |
| Total unknown injuries ADS vehicle | | Number(3) |
| Total unknown injuries other road user | | Number(3) |
| **VEHICLE** | | |
| Vehicle Identification Number* | | Text(17) |

[53] Supporting information can be derived from CADaS taxonomy (https://road-safety.transport.ec.europa.eu/system/files/2021-07/cadas_glossary_v_3_7.pdf) or from Abbreviated Injury Scale (https://www.aaam.org/abbreviated-injury-scale-ais/)

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| | | |
|---|---|---|
| Serial number | | Text(50) |
| License plate | | Text(10) |
| State/Country/Province of registry | | Text(50) |
| Vehicle category* | | Text(50) |
| Manufacturer* | | Text(50) |
| Model* | | Text(50) |
| Model Year* | | Number(4) |
| Mileage | | Number(9) |
| ADS version* | | Text(50) |
| ADS licensing | | Text(50) |
| Operator (if any) | | Text(50) |
| Other ADS features type | | Text(50) |
| **NARRATIVE*** | | |
| Description of the occurrence and post-collision behaviour[54] | | |
| Post-collision behaviour | | |
| **ANALYSIS*** | | |
| Root cause analysis | | |
| New scenario identified or variation of existing scenario | | [Y/N] |
| Corrective implementing action | | |
| **REPORT MANAGEMENT*** | | |

[54] If possible digital reconstruction files shall be provided (e.g. PC CRASH files, etc.).

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| | | |
|---|---|---|
| Reporting entity | | Text(100) |
| Report ID | | Text(240) |
| Report version | | Number(10) |
| Report status | | Text(100) |
| Report date | | [YYYY/MM/DD] |
| Parties informed | | Text(100) |

Periodic Reporting

The periodic templates provide a list of information with corresponding specifications that should be made available to the authority on a yearly basis.

The following template aims at ensuring that a consistent and comprehensive set of information is delivered to the relevant authority to foster an effective application of the periodic reporting scheme. Further granularity of the information can be considered depending on the ADS use cases.

| **ADS IDENTIFICATION*** | | |
|---|---|---|
| Entry name | Field to be filled | Type/size |
| ADS manufacturer | | Text(50) |
| ADS licensing authority(ies) (if applicable) | | Text(50) |
| ADS version | | Text(50) |
| [ADS feature type] | | Text(50) |
| SMS certificate [handbook] number [ID] applicable to ADS feature | | Text(50) |
| Vehicle model | | Text(50) |
| Model year | | Text(50) |
| **ADS OPERATION INFORMATION** | | |
| Number of vehicles featuring ADS* | | Number(10) |
| Cumulative distance travelled by operational ADS*, segmented by | | Number(10) |
| Country/province of operation | | Text(50) |
| Times of the day | | Text(50) |
| Weather conditions | | Text(50) |

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| | | |
|---|---|---|
| Cumulative time travelled by operational ADS*, segmented by | | Number(10) |
| Country/province of operation | | Text(50) |
| Times of the day | | Text(50) |
| Weather conditions | | Text(50) |
| Average ADS time engagement* | | Number(10) |
| ADS Safety Monitoring manufacturer outcome*, including:<br>• SPIs monitoring analysis<br>• Identified operational risks | | Text(500) |
| **OCCURRENCES *** | | |
| **Cumulative number of occurrences** | | Number(10) |
| **Occurrences covered under the short-term reporting provisions** | | Number(10) |
| • Critical occurrences known to the manufacturer | | Number(10) |
| • Occurrences related to ADS operation outside its ODD | | Number(10) |
| • ADS failure to achieve a minimal risk condition when necessary | | Number(10) |
| • Other Indications of failure to meet safety requirements | | Number(10) |
| • Occurrences related to safety-relevant performance issues constituting an unreasonable risk to safety. | | Number(10) |
| **Occurrences covered under the periodic reporting provisions** | | |
| • Occurrences related to Transfer of Control failure | | Number(10) |
| ○ Occurrences safety analysis | | Text(200) |
| • Occurrences related to communication issues | | Number(10) |
| • Occurrences related to cybersecurity issues | | Number(10) |

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| | | |
|---|---|---|
| ○ Occurrences safety analysis | | Text(200) |
| • Occurrences related to failure scenarios | | Number(10) |
| ○ Occurrences safety analysis | | Text(200) |
| • Maintenance and repair problems to ADS and its components | | Number(10) |
| ○ Occurrences safety analysis | | Text(200) |
| • Occurrences related to unauthorized modifications | | Number(10) |
| ○ Occurrences safety analysis | | Text(200) |
| • [Unexpected behaviours of the ADS, including unexpected triggering of the fall back strategy]<br>• | | Number(10) |
| ○ Occurrences safety analysis | | Text(200) |
| | | |
| • Occurrences where an activated ADS feature required interaction with a remote assistant to navigate a driving situation (if applicable) | | Number(10) |
| ○ Occurrences safety analysis | | Text(200) |
| • Fallback user unavailability (where applicable) | | Number(10) |
| ○ Occurrences safety analysis | | Text(200) |

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| | | |
|---|---|---|
| • Prevention of takeover under unsafe conditions (where applicable) | | Number(10) |
| ○ Occurrences safety analysis | | Text(200) |
| • [Manoeuvres performed to reach an MRC and manoeuvres linked to a prompt action of the ADS to avoid or mitigate a collision] | | Number(10) |
| ○ Occurrences safety analysis | | Text(200) |
| **OCCURRENCES SAFETY OUTCOME*** | | |
| Fatalities | | Number(10) |
| • ADS vehicle occupants | | Number(10) |
| • Other road users | | Number(10) |
| Serious (MAIS 3+) injuries | | Number(10) |
| • ADS vehicle occupants | | Number(10) |
| • Other road users | | Number(10) |
| Minor (MAIS 1/2) injuries | | Number(10) |
| • ADS vehicle occupants | | Number(10) |
| • Other road users | | Number(10) |
| Unknown injuries | | Number(10) |
| • ADS vehicle occupants | | Number(10) |
| • Other road users | | Number(10) |
| Accidents and serious incidents | | Number(10) |
| Minor incidents | | Number(10) |
| **OCCURRENCES AGGREGATE DESCRIPTION*** | | |
| Collision with: | | - |
| • Passenger car | | Number(10) |
| • VAN | | Number(10) |
| • Truck | | Number(10) |

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| | | |
|---|---|---|
| • Bus | | Number(10) |
| • Other: Vehicle | | Number(10) |
| • Motorcycle | | Number(10) |
| • Cyclist | | Number(10) |
| • Pedestrian | | Number(10) |
| • Other: VRU | | Number(10) |
| • Animal | | Number(10) |
| • Fixed object | | Number(10) |
| • Unknown | | Number(10) |
| • ADS vehicle damage level | | - |
| • Destroyed | | Number(10) |
| • Substantial | | Number(10) |
| • Minor | | Number(10) |
| • Unknown | | Number(10) |
| ADS vehicle damaged area | | - |
| • Front | | Number(10) |
| • Front-left | | Number(10) |
| • Front-right | | Number(10) |
| • Rear | | Number(10) |
| • Rear-left | | Number(10) |
| • Rear-right | | Number(10) |
| • Left | | Number(10) |
| • Right | | Number(10) |
| • Top | | Number(10) |
| • Bottom | | Number(10) |
| • Unknown | | Number(10) |
| **ADS SAFETY GAP*** | | |
| ADS discovered safety gaps | | Number(10) |
| Gap #1: | | Text(500) |
| Gap #2: | | Text(500) |

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| | | |
|---|---|---|
| ADS status of addressed safety gaps (if any) | | |
| Gap #1: | | Text(500) |
| Gap #2: | | Text(500) |
| ADS how safety gaps ~~are~~ have been addressed ~~and how~~ | | |
| Gap #1: | | Text(500) |
| Gap #2: | | Text(500) |
| **REPORT MANAGEMENT*** | | |
| Reporting entity | | Text(100) |
| Report ID | | Text(240) |
| Report version | | Number(10) |
| Report status | | Text(100) |
| Report date | | [YYYY/MM/DD] |
| Parties informed | • | Text(100) |

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Annex [] Critical Occurrences threshold definition

# 1. General

1.1. The current Annex defines specific thresholds for critical occurrences reporting.

1.2. The critical occurrence's definition lists three criteria which individually can make an occurrence escalate into a critical one:

(a) at least one person suffering an injury that requires medical attention or dying as a result of being in the vehicle or being involved in the occurrence;

(b) the ADS vehicle, other vehicles ~~road users~~ or stationary objects sustaining physical damage that exceeds a certain threshold;

(c) any vehicle involved in the event experiencing the deployment of any non-reversible occupant deployable restraint system, vulnerable road user secondary safety system or the delta-V thresholds to be met, whichever occurs first.

1.3. The timing for the notification of such occurrences starts from the manufacturer's knowledge that the occurrence exceeded the threshold for critical occurrence.

1.4. The manufacturer shall exert all reasonable efforts to gather the relevant evidence supporting the critical occurrence identification without delays or limitations.

# 2. Injury level threshold

2.1. The injury level threshold for critical occurrence aims at promoting the reporting of collisions resulting in a fatality or any person requiring medical attention due to the injury, regardless of whether the person killed or injured was an occupant of the subject vehicle.

2.2. The threshold is triggered by the attendance in the area of the collision of any ambulance.

2.3. The manufacturer shall classify the occurrence as critical if they reasonably believe that there may be an injury requiring medical attention to any person even if an ambulance has not been detected.

2.4. The manufacturer is expected to fulfil these criteria through one of the following approaches:

(a) ADS strategies in place to appropriately detect such situations provided that the ADS vehicle is still capable of performing audio/visual/other sensing capabilities, following the collision or via remote visual check (if applicable);

(b) Processes to receive and analyse information from other sources;

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(c) Combination of a) and b).

# 3. Physical damage threshold

3.1. The physical damage triggering condition for critical occurrence aims at promoting the reporting of collisions that, despite not causing any significant injury or fatality to people, are deemed critical because of the extent of the damages produced on road users or stationary objects.

3.2. The concept of "physical damage" is here intended as:

(a) Tow-away, e.g., damage that restricts/prevents regular operation of a vehicle involved in the collision as part of the reported occurrence;

(b) Importance-based, e.g., a damage that affects the safe state of the ADS, critical road infrastructure asset and other vehicles/road users;

3.3. The manufacturer is expected to fulfil these criteria through one of the following approaches:

(a) ADS strategies in place to appropriately detect such situations provided that the ADS vehicle is still capable of performing audio/visual/other sensing capabilities, following the collision or via remote visual check (if applicable);

(b) Processes to receive and analyse information from other sources;

(c) Combination of a) and b).

3.4. Tow-away damage threshold

3.4.1. The tow-away threshold is triggered when the damage occurred to a vehicle involved in the collision is such that the same can no longer be operated either manually or in automated mode requiring specialized equipment for traffic restoration.

3.5. Importance-based damage threshold

3.5.1. Importance-based damage thresholds consider the type of the item which was damaged to take into account their relevance and health status.

3.5.2. The importance-based threshold shall be deemed exceeded when one of the following conditions occurs:

(a) Collision with priority vehicles;

(b) Collision rendering traffic lights and/or other safety-relevant road signage no longer operational/visible;

(c) Collision affecting infrastructure communication/connectivity support system;

(d) Collision damaging or rendering a roadway segment impassable;

(e) Collision producing a vehicle or other road user fire;

(f) Any other collision which requires the attendance of road safety agent.

# 4. Restraint system and Delta-V threshold

4.1. The restraint system triggering condition for critical occurrence aims at promoting the reporting of events in case of deployment of any non-reversible deployable occupant restraint systems or vulnerable road user secondary safety system such as airbags, pretensions, and active bonnet systems.

Deployment of such non-reversible restrain systems shall be classified as a critical occurrence.

4.2. In absence of non-reversible restrain systems the Delta-V Thresholds shall be considered for classification of critical occurrence

4.2.1. Change in longitudinal vehicle velocity more than 8 km/h within a 150 ms or less interval.

4.2.2. Change in lateral vehicle velocity more than 8 km/h within a 150 ms or less interval.

Prepared by the expert from the UK

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Annex [] ODD-based Behavioural competences and Scenario Identification approach

1. Introduction

This annex provides an overview on an approach that may be used to derive verifiable performance criteria for the certification or, as relevant, for self-certification of ADS, based on the manufacturer/ ADS developer's description of the Operational Design Domain (ODD) of the ADS. Such criteria would be developed by identifying behavioural competencies that embody and correspond to specific ADS safety requirements and relevant scenarios that may be used to validate the ADS's competencies.

The suggested approach includes a description of how such competencies can be classified into nominal, critical and failure categories and mapped to the relevant scenarios, selected either from existing databases or identified through the application of knowledge and data-based approaches.

Different approaches may exist to perform such an activity; therefore, the approach herein presented should be considered as a guideline for both manufacturers and authorities.

1.1. *Operational Design Domain*

Operational design domain (ODD) refers to:

> Operating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics. (SAE J3016)

Given a specific ODD, it is crucial for the ADS to ensure that:

> it can operate safely within its ODD under conditions reasonably expected in the ODD
>
> it will be used only within its ODD
>
> it can monitor whether it is inside/outside its ODD and respond appropriately.

The conditions constituting the ODD in which the ADS was designed to operate will help determine which ADS competencies are required. For example, if an ADS has an ODD which comprises of roads with non-signalised junctions, one of the required behaviour competencies for the ADS in that ODD could potentially be "unprotected left or right turn". However, the same behaviour competency may not be required if the ODD of an ADS is limited to motorways or highways with signalised junctions.

1.2. *Behavioural competencies*

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The concept of "behavioural competencies" is useful in determining the safety of the performance of the Dynamic Driving Task (DDT) by an Automated Driving System (ADS):

- Behaviour: Specific goal-oriented actions directed by an engaged ADS in the process of completing the DDT or DDT fallback within the ODD (if applicable) at a variety of timescales.
- Behavioural Competency: Expected and verifiable capability of an ADS to operate a vehicle within the ODD of its feature(s).

Behavioural competencies can be described with different abstraction levels, similarly to functional, logical, and concrete scenarios. Refinement of the competencies from a functional to a more concrete level is possible by following the approach proposed in these guidelines.

Such competencies track the three broad categories of driving situations that may be encountered in performance of the DDT: nominal, critical, and failure.

Nominal driving situations are those in which behaviour of other road users and the operating conditions of the given ODD are reasonably foreseeable (e.g., other traffic participants operating in line with traffic regulations) and no failures occur that are relevant to the ADS's performance of the DDT.

Critical driving situations are those in which the behaviour of one or more road users (e.g., violating traffic regulations) and/or a sudden and not reasonably foreseeable change of the operating conditions of the given ODD (e.g., sudden storm, damaged road infrastructure) creates a situation that *requires a prompt action of the ADS to avoid or mitigate a collision*. In this case, as it is recognised that in some cases the ADS may not be able to avoid a collision, the ADS performance are compared with safety model performance to set the threshold between where avoidance is required and where it is not feasible, but mitigation may be possible.

Failure situations involve those in which the ADS or another vehicle system experiences a fault or failure that removes or reduces the ADS's ability to perform the DDT, such as sensor or computer failure or a failed propulsion system.

## 2. Approach Description

The ODD-based behavioural competences and scenario identification approach is based on the interaction of the following elements:

Behavioural Competencies and Scenario Identification
Competencies and Scenarios Mapping
Assumptions
Performance Evaluation

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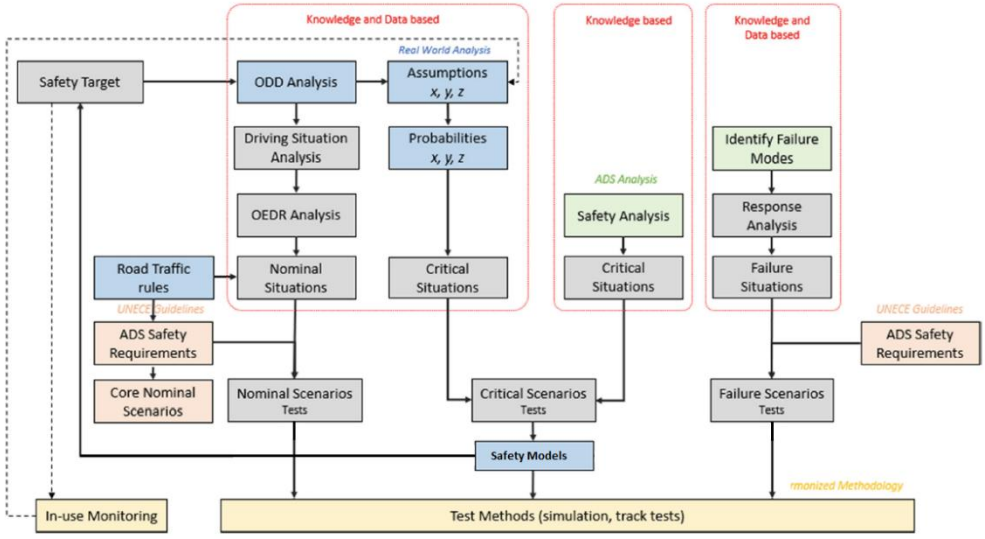
***Figure 1. Approaches to derive verifiable performance criteria***




2.1. Behavioural Competencies Identification

The approach suggests a series of analytical frameworks that could help to derive measurable criteria appropriate for the specific application. These frameworks are divided into:

- ODD Analysis
- Driving Situation Analysis
- OEDR Analysis.

*2.1.1. ODD analysis*

This analysis represents the first step with the aim to identify the characteristics of the ODD. An ODD may consist of stationary physical elements (e.g., physical infrastructure), environmental conditions, dynamic elements (e.g., reasonably expected traffic level and composition, vulnerable road users) and operational

constraints to the specific ADS application. Various sources provide useful guidance for precisely determining the elements of a particular ODD and their format definition.[55,56, 57, 58]

As part of this activity, the level of detail of the ODD definition using the ODD attributes will also need to be established.

2.1.2. *Driving situation analysis*

In the driving situation analysis, the behaviours of other road users that are reasonably expected and the presence of roadway characteristics in the ODD are explored in more detail by mapping actors with appropriate properties and defining interactions between the objects.

An example of this analysis is given in Table 1, where static and dynamic behaviours of other objects (including other road users) that the ADS is reasonably expected to encounter within the ODD are described. In the case of vehicles, this includes behaviours such as "acceleration", "deceleration", "cut-in"; for pedestrians, examples of dynamic behaviours include "crossing road", "walking on sidewalk", etc. Some of these behaviours may involve nominal situations while others may involve critical scenarios(e.g., sudden cut-ins or unpredictable pedestrian or cyclist behaviour, including behaviours that may violate local traffic laws such as crossing a road outside a designated cross walk).

The behaviour of other road users and the condition of physical objects within the ODD may fall at any point along a continuum of likelihood. For example, deceleration by other vehicles may range from what is expected and reasonable in the traffic circumstances, to unreasonable but somewhat likely rapid deceleration, to extremely unlikely (e.g., a sudden cut-in combined with full braking on a clear high-speed road). The analysis of the ODD and reasonably expected driving situations within the ODD should make distinctions that include an estimate of the likelihood of situations to ensure that the ADS's performance is evaluated based on response to reasonably likely occurrences involving nominal, critical and failure situations but not on the expectation that the ADS will avoid or mitigate the most extremely unlikely occurrences.

***Table 1. Static / Dynamic elements and their properties***

| Objects | Events/Interactions |
|---|---|

[55]; E.g., *AVSC Best Practice for Describing an Operational Design Domain: Conceptual Framework and Lexicon*; and *A Framework for Automated Driving System Testable Cases and Scenarios* (NHTSA).

[56] *E.g. BSI PAS 1883:2020 Operational Design Domain (ODD) taxonomy for an automated driving system (ADS) - Specification*

[57] ASAM OpenODD

[58] Road Vehicles — Test scenarios for automated driving systems — Taxonomy for operational design domain

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| | |
|---|---|
| Vehicles (e.g. cars, light trucks, heavy trucks, buses, motorcycles) | Lead vehicle decelerating,<br>Lead vehicle stopped,<br>Lead vehicle accelerating,<br>Changing lanes,<br>Cutting in,<br>Turning,<br>Encroaching opposite vehicle,<br>Encroaching adjacent vehicle,<br>Entering roadway,<br>Cutting out,<br>… |
| Pedestrians | Crossing road -inside crosswalk,<br>Crossing Road – outside crosswalk,<br>Walking on sidewalk / shoulder |
| Cyclists | Riding in lane,<br>Riding in adjacent lane,<br>Riding in dedicated lane,<br>Riding on sidewalk/shoulder,<br>Crossing road – inside/outside crosswalk,<br>… |
| Animals | Static in lane,<br>Moving into/out of lane,<br>Static/Moving in adjacent lane,<br>Static/Moving on shoulder,<br>… |

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| | |
|---|---|
| Debris | Statis in lane |
| Other dynamic objects (e.g. shopping carts) | Static in lane,<br>Moving into/out of lane,<br>… |
| Traffic signs | Stop,<br>Yield,<br>Speed limit,<br>Crosswalk,<br>Railroad crossing<br>School zone,<br>… |
| Vehicle signals | Turn signals |

*2.1.3. Object and Event Detection and Response (OEDR) Analysis: Behavioural competency identification*

Once the objects and their reasonably expected behaviours have been identified, it is possible to map the appropriate ADS response, which can be expressed as a behavioural competency. The detailed response is derived from more general and applicable functional requirements [ref to DDT section. The acceptable ADS response will vary depending on whether the driving situation involves nominal, critical, or failure characteristics.

The outcome of the analysis is a set of behaviour competencies that can be applied to the events characterizing the ODD. Table 2 provides a qualitative example of a matching event – response.

| Event | Response |
|---|---|
| Lead vehicle decelerating | Follow vehicle, decelerate, stop |
| Lead vehicle stopped | Decelerate, stop |
| Lead vehicle accelerating | Accelerate, follow vehicle |
| Lead vehicle turning | Decelerate, stop |

| | |
|---|---|
| Vehicle changing lanes | Yield, decelerate, follow vehicle |
| Vehicle cutting in | Yield, decelerate, stop, follow vehicle |
| Opposite vehicle encroaching | Decelerate, stop, shift within lane, shift outside lane |
| Adjacent vehicle encroaching | Yield, decelerate, stop |
| Lead vehicle cutting out | Accelerate, decelerate, stop |
| Pedestrian crossing road | Yield, decelerate, stop |
| Cyclist riding in lane | Yield, follow |
| Cyclist crossing road | Yield, decelerate, stop |

***Table 2. Example of elementary behavioural competencies for given events.***

The combination of objects, events, and their potential interaction, as a function of the ODD, constitute the set of nominal or critical scenarios pertinent to the ADS under analysis.

2.2. Scenario Identification

To ensure that the behavioural competences identified in the previous paragraphs are ready to be assessed through the application of simulations or physical testing, ODD-relevant scenarios must be developed. Scenario creation involves use of assumptions concerning the actions of road users that incorporate realistic parameters.

This approach suggests two complementary methodologies to derive reasonably expectable situations which might occur for a given ODD:

- Knowledge-based (e.g. goal-based)
- Data-based.

A knowledge-driven scenario generation approach utilizes domain specific (or expert) knowledge to identify hazardous events systematically and create scenarios. A data driven approach utilizes the available data (e.g. accident databases, insurance records) to identify and classify occurring scenarios. Figure 1 illustrates various data-based and knowledge-based scenario generation methods.

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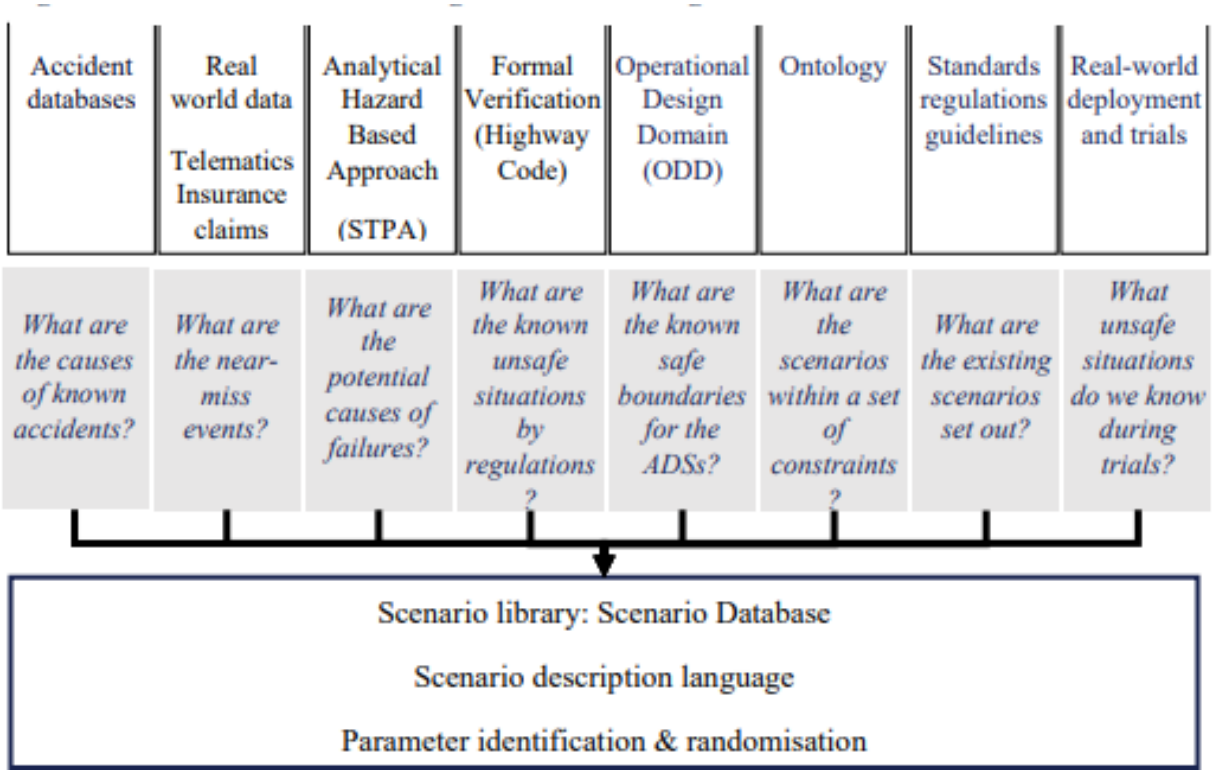


Accident datasets and field data can be analysed to identify accident hotspots and scenario parameters which contribute to causation of accidents carrying high levels of severity.

Knowledge based methods, or other formal techniques can be used to analyse the characteristics of the ADS architecture and identify system failures and hazardous situations [see SAE J3187]. The analysis is then converted into a set of abstract/logical scenarios together with their corresponding pass/fail criteria.

Other knowledge-based methods include the formal analysis approach with the highway code rules for scenario generation. Each of the highway code rules describes a hypothetical driving scenario with the corresponding behaviour and ODD elements. The ODD is a specification set out by the manufacturer of an ADS and it defines the operating conditions within which the ADS can operate safely. Formal models are generated via a model template to create the mathematical representations of those scenarios, collecting the combinations of ODD and behaviour parameters. The analysis reports the manoeuvre parameters that are close of violating the pass criteria and produce scenarios that represent these set of violations. Other knowledge-based methods use formal representation of the ODD and behaviour competencies of the ADS for scenario generation.

Furthermore, the existing scenarios already defined in the standards, regulations or guidelines (Option 6 - KB) can also be utilized for the testing of ADSs, for example the scenarios set out in ISO22737 and NCAP. ISO22737 has been developed for low-speed automated driving systems (LSAD) and the NCAP provides

a set of testing scenarios for the safety assurance of vehicles. Option 7 (DB) includes the scenarios that occur during real world trials and deployments. Such scenarios might have not been considered pre-deployment but are key learnings.

*2.3.* Behavioural competencies and scenarios mapping

Once relevant scenarios and behavioural competencies have been identified, it is necessary to link them. The classification in the three broad categories of driving situations an ADS might encounter such as nominal, critical and failure, serves the purpose.

*2.3.1.* Nominal Situations Competencies

In these situations, ADS competencies can often be derived by applying traffic laws of the country where the ADS is intended to operate, as well as by applying general safe driving principles for situations not addressed adequately by current traffic laws for human drivers. Examples of such competencies may include adherence to legal requirements to maintain a safe distance from vehicles ahead, provide pedestrians the right of way, obey traffic signs and signals, etc. Of course, some nominal competencies (e.g., safe merging, safely proceeding around road hazards) may not be explicitly articulated or mandated by traffic laws. In some instances, traffic laws may provide wide discretion for the driver to determine the safest response to a particular situation (for example, how to respond to adverse weather conditions). As such not all traffic laws are stated with sufficient specificity to provide a clear basis for defining a competency.

Therefore, an approach to codify rules of the road to provide additional specificity was developed (see Appendix 1). Additionally, application of models involving safe driving behaviour may be needed in addition to reference to codified rules of the road in developing behavioural competencies for nominal driving situations.

***Table 3. Example of competencies and scenario mapping in nominal situation***

| ODD Element | Driving Behaviour | Traffic Rule | DDT Requirement | Behaviour Competency | Test Scenario |
|---|---|---|---|---|---|
| Bicycle | Riding in lane | | The ADS shall adapt its driving behaviour to reduce safety risks | The ADS ensures relative velocity during passing manoeuvre does not exceed [30] km/h | The ADS travels between [30–50]km/h on the centre line of its lane |
| | | Drivers will need to use a minimum passing distance for bicycles of 1.5m in urban | The ADS shall comply with traffic rules in accordance with application of relevant law | The ADS shifts in lane to pass by cyclist with 1.5.m lateral distance | A cyclist travels in the same direction as the ADS between [10–20] km/h, [0.2–1] m |

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| | | | | | |
|---|---|---|---|---|---|
| | | areas, and 2m out of town | within the area of operation. | | away from the lane edge |
| | | | The ADS shall avoid unreasonable disruption to the flow of traffic in line with safety risks. | The ADS crosses the centre lane marking to ensure the safe passing distance is not violated | |
| | | | The ADS shall interact safely with other road users | The ADS activates the turn signal if the centre lane marking is crossed | |

*2.3.2.* Critical Situations Competencies

The development of these competencies requires analysis of (1) what constitutes such unreasonable behaviour by ORUs and/or a sudden change of the operating conditions that are not reasonably foreseeable and (2) what constitutes an appropriate ADS response to avoid or mitigate the imminent crash. Additionally, it is also important to identify the occurrence of unplanned emergent behaviour in critical situations.

Analysis of the first type may be based on a variety of methodologies, including e.g. IEEE 2846-2022 (which offers guidance on what behaviours by other road users are reasonably foreseeable) and other models of reasonable driving behaviour. Analysis of the second factor may be based on various models of acceptable human driving behaviour in crash imminent situations.

Hazard identification methods (e.g. STPA as mentioned in SAE J3187) which analyse the system design for functional and operational insufficiencies can help identify the occurrence of emergent behaviour which may lead to critical situations.

Development of behavioural competencies for critical driving situations faces several challenges. No general consensus exists on the appropriate models for the behaviour of ORUs or appropriate responses by the ADS to unreasonable ORU behaviours that make a crash imminent.

**Table 4. Example of competencies and scenario mapping in critical situation**

| Losses | Hazards | Unsafe Control Action | Loss scenario | Causal factors | Test behaviour | Test Scenario |
|---|---|---|---|---|---|---|
| Collision | ADS does not | Braking demand | Object in vehicle trajectory is | Undetected/ misclassified object; | The ADS is following behind a | Lead vehicle decelerated |

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| | | | | | | |
|---|---|---|---|---|---|---|
| with object outside the vehicle | maintain a safe distance from the lead motor vehicle | is not provided | not detected | Obscured object;<br>Incorrect sensor fusion result | lead vehicle, with the headway set by the ADS.<br>The lead vehicle decelerates at the max assumed rate depending on the weather conditions | to turn [right/left] or travel straight on a [mini / large] roundabout |
| | | | Object is not considered to be in the vehicle trajectory | Localisation issues leading to incorrect positioning of ego vehicle or object | | Lead vehicle decelerated whilst shifting lane to avoid a [static object/other road user] |

*2.3.3.* Failure Situations Competencies

The ADS safety requirements include management of various failure modes. As noted above, failure situations scenarios involve those in which the ADS or another vehicle system experiences a fault or failure that removes or reduces the ADS's ability to perform the DDT, such as sensor or computer failure or a failed propulsion system.

In developing the behavioural competencies appropriate for failure situations, the objective is to describe the ability of the ADS to detect and respond safely to specific types of faults and failures. Depending upon the nature and extent of the fault or failure, the responses can include identifying a minor fault for immediate repair after trip completion, responding to a significant fault with restrictions (such as limp-home mode) for the remainder of the trip, or responding to major failures by achieving a minimal risk condition. Communication of the fault or failure condition to vehicle users may also be a desirable ADS behavioural competency.

**Table 5. Example of competencies and scenario mapping in failure situation**

| Failure Type | Failure Mode | Potential Cause | Response | DDT Requirement | Test Scenario | Pass / Fail Criteria |
|---|---|---|---|---|---|---|
| Perception | Fail to identify ODD | Failure to detect ODD | Safely stop in | The ADS shall recognise the conditions and boundaries of the | The ADS operates beyond the | The ADS detects the |

| | | | | | | |
|---|---|---|---|---|---|---|
| | boundary | attribute e.g. heavy rain/fog | lane of travel | ODD of its feature(s) | predicted ODD | ODD conditions are not met and issues a<br>minimal risk manoeuvre |
| | | | | In response to a fault, the ADS shall execute a fallback response and prohibit activation of the impacted feature(s) if the fault prevents the ADS from performing the DDT in accordance with the requirements of 5.2., | | The minimum<br>risk manoeuvre should not cause the vehicle to decelerate greater than [4]m/s2 |

2.4. *Assumptions: Logical to concrete behavioural competencies*

Concrete performance requirements depend on the specific situations the ADS encounters, on a reference behaviour that is deemed appropriate for a human driver or a technical system, and on assumptions (e.g. cut-in speed values, reaction times, …) about the behaviour of the vehicle and other road users. Assumptions concerning the actions of other road users may need to account for cultural differences in driving styles in different geolocations, making it impracticable to harmonise these assumptions across different domains. Therefore, evidence should be provided to support the assumptions made. Existing standards e.g. IEEE 2846-2022 provide a set of assumptions to be considered by ADS safety-related models for an initial set of driving situations. Additionally, several other tools including data collection campaigns performed during the development phase, real-world accident analysis and realistic driving behaviour evaluations, constraint randomisation, Bayesian optimisation besides others can be used to inform values for such assumptions.

2.5. Performance Evaluation - Acceptance Criteria

As previously highlighted, nominal situations are considered reasonably foreseeable and preventable for a given ODD and therefore it is expected that the ADS would be capable of handling them without any resulting collision.

On the other hand, failure situations are performed to assess the ADS ability to recognise faults/failures in the system.

For the purpose of defining performance criteria in critical situations, those where others are at fault, behaving unforeseeably, and the collision might potentially not be prevented have to be analysed further. In these situations, it is proposed that safety models are used to explore and compare the ADS performance with mathematical formulations to derive what is deemed as preventable or where mitigation strategy is needed.

2.5.1. Application of Rules of Road

An approach to define an acceptance criterion related to nominal driving situations is to evaluate the ADS performance against the rules of the road. Furthermore, ADS safety requirements state that *"The ADS shall comply with traffic rules in accordance with application of relevant law within the area of operation."* It is challenging to test against this requirement in the absence of codified rules of the road.

Appendix 1 of this annex provides a framework for codifying the rules of the road that govern the behaviour of ADS. The approach may be used to define "good behaviour" to inform validation and verification processes (including for scenario-based testing) for nominal scenarios.

*Using rules of the road as pass criteria*

Figure 3 illustrates the use of codified rules of the road as a pass criterion for scenario-based testing activities. Every test scenario definition will have ODD and behaviour competency attributes defined. Every rule of the road will also have ODD and behaviour competency attributes as part of its definition. Therefore, it is possible to map every scenario to a corresponding rule(s) of the road using ODD and behaviour tags or labels in a scenario catalogue.

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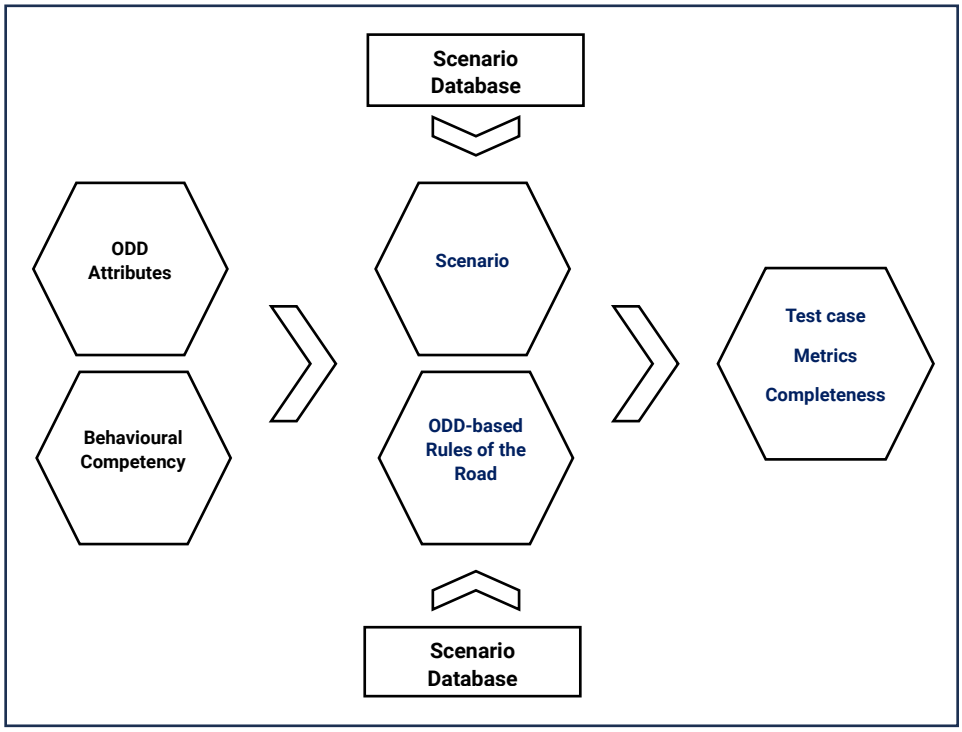


This approach would allow the test engineer to map each scenario to a corresponding rule (or set of rules). These rules can then serve as the pass criteria during the scenario-based testing approach. This approach can thus enable engineers and authorities to show/assess compliance to traffic rules by making the rules of the road verifiable.

2.5.2. Use of Safety Models

A matrix combining suggested reference behaviours / safety models with driving situations.

Even though behavioural competencies will help the automated vehicle to not cause accidents or drive defensively to stay away from conflicts, there are situations where collisions might not be prevented, for example where other traffic participants are at fault or behaving unforeseeably.

It is the task of the automated driving system – like it is the task for human drivers – to perform evasive actions, whether it is possible and reasonable in order to minimize risk.

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For this, simple logic models, the so-called safety models, are introduced. They provide assumptions how traffic rule violations and misbehaviour by other traffic participants could be dealt with and use physical properties and fundamental driving dynamics to further detail conditions for accident avoidance.

The set of safety models described in this document should be regarded as a set of tools, whereas selecting the right tool (the right safety model) depends on the boundary conditions. Hence in this document, there exists no preference for any of the safety models being introduced.

Two important points to consider: safety models are a methodology to support considerations on collisions that have to be avoided and those where only mitigation is required. The aim is NOT to prescribe a specific behaviour of the ADS in any given critical situation.

The safety models can be grouped into models for the performance in accident avoidance and behaviour models for conflict avoidance, see Table 3. The difference between those two is that the accident avoidance models can be used to understand to what extent accident situations – caused by other traffic - are unavoidable, while conflict avoidance models formalize strategies for the behaviour of an ADS to not come into conflict. Conflict avoidance models are better suited being integrated into the document on the dynamic driving task.

*Table 3. Overview of Safety Models**

| *Model* | *Explanation* |
|---|---|
| **Performance Requirements for Accident Avoidance** | |
| Last Point to Steer | Estimate avoidance and mitigation in longitudinal traffic, typically used for driver assistance & active safety |
| Safety Zone | Estimate avoidance and mitigation in cross-traffic accidents with VRU |
| Careful and Competent Human Driver | Estimate avoidance and mitigation in longitudinal traffic cut-in situations, using reaction characteristics of good human driver |
| Fuzzy Surrogate Safety Model | Estimate avoidance and mitigation in longitudinal traffic cut-in situations, taking anticipation of other vehicle behaviour into account |

*Models discussed during guidelines development and not intended as an exhaustive list.

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## Annex I - Use-case for Nominal, Critical and Failure Situations Mapping

**Include final tables**

**[Annex 1—Appendix 1**

Codification methodology for rules of the road

Current rules of the road (for human drivers) have three components:

| | |
|---|---|
| *Rule of road* (for human drivers) | *= Operating condition + Behaviour competency + Assumptions (implicit)* |

Operating conditions include both ODD aspects and vehicle states (e.g., system failures, hardware failures etc.). Every set of traffic laws or behaviour rules (for human drivers) defined in any country are based on an understanding of the expected behaviours of human drivers. As a result, they do not explicitly define all aspects of the expected driving behaviour but can be argued to include "implicit assumptions" based on this understanding.

| | |
|---|---|
| *Codified Rule of road* | *= Operating condition + Behaviour competency + Driving decisions* |

Following the process (illustrated in section 8.1), a "codified" rule of the road for an automated driving system, will also have three components:

The process of codification helps identify where "implicit assumptions" about driving behaviour are present in the rules for human drivers. The codified rules of the road help to turn "undefined" attributes in the rules of the road (for human drivers) to "defined" attributes in the codified "rules of the road".

Taking an example of the UK road rules where behaviour (for human drivers) is governed by the Highway Code (HC), the methodology is further explained. UK's Highway Code Rule 195 states (Zebra crossing):

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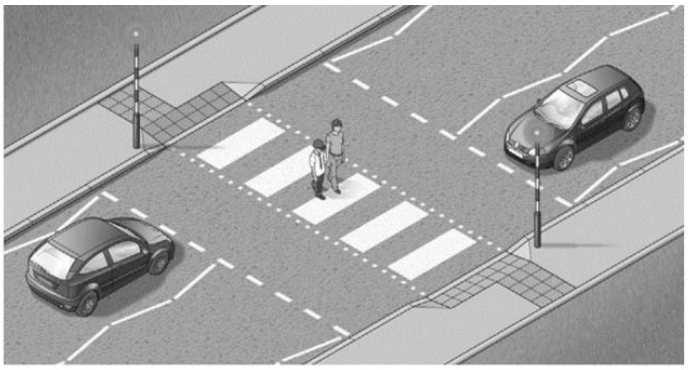
*Rule 195: "As you approach a zebra crossing: look out for pedestrians waiting to cross and be ready to slow down or stop to let them cross; you MUST give way when a pedestrian has moved onto a crossing."*

*Figure 3: Example of zebra crossing from UK's Highway Code:*
*Source: https://www.gov.uk/guidance/the-highway-code/rules-for-pedestrians-1-to-35#rule19*



From this rule, one can extract the "operating condition or ODD" variables, as well as the behaviour competencies. "Zebra crossing" and "pedestrian" define the operating condition; and "slow down or stop" defines the behaviour competency. However, the rule doesn't mention for how long the vehicle should be stopped, or when it is considered safe to proceed again. There is an "implicit assumption" made based on typical human (the driver behaviour), and it is not considered necessary for the rule to define this. However, for an ADS, such assumptions how long the vehicle is stopped for, and when it moves off again will be determined by the automated driving system and its analysis of the relevant parameters specific to that situation and will need to be specified. For every concrete scenario being tested, the driving decisions exhibited by ADS will need to be explainable.

Figure 4 illustrates this process. After following the codification process of defining the "rules of the road", there will be no underlying "assumptions" (see Codification methodology below).

*Table SEQ Table * ARABIC 4. Converting current rules of the road (for human drivers) to codified rules for ADS*

*Current Rules of Road* = *f(Operating condition, Behaviour competency,* ***driving decision****)*

Applying the proposed process

*Codified Rule of the Road* = *f(Operating condition, behaviour competency,* ***driving characteristics****)*

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Furthermore, for all areas or jurisdiction or country, there will be a minimum set of behaviour code rules which will have consistent "driving characteristics" – the base or common set of rules of the road (for ADS).

*Codification methodology*

The codification methodology is a four-step process:

- Step 1: Identify terms and construct a vocabulary: The natural language text of the rule is analysed and words that are associated with the ODD or behaviour of actors in the rule are identified. These terms taken together are used to identify the component of the rule that can be codified.
- Step 2: Identify unspecified terms: Some terms are unclear because they are not unequivocal or absolute and therefore require clarification. In some cases, these terms are codified as is, when a meaning can be inferred, while in others, comments are provided to highlight why the terms are not defined, and how they may be elaborated.
- Step 3: Query / Update/ Add ODD and Behaviour terms: Terms defining predicates (representing facts whose truth may be evaluated) and functions (representing non-Boolean properties – such as ADS attributes, action labels) are identified. The codified rule will consist of these predicates and functions. The outcome of Step 3 is an intermediate rule that is in its minimal form.
- Step 4: Express rule in first order logic: For each rule of the road, a single codified rule, or a set of rules are written. The predicates and functions identified in Step 3, together with the structure of constraints from Step 1 are used to construct the rule(s). The output of Step 2 provides insights concerning the rule and gaps that exist in its codification. Step 4 uses the vocabulary to identify which sub-rules are to be converted to First Order Logic and then perform the conversion.

*Vienna Convention codification example*

The Vienna convention rule is stated below (Chapter 2 – Rules of the Road – Article 11 (Overtaking – 11)).

Vienna Convention Rule Text:

*A vehicle shall not overtake another vehicle which is approaching a pedestrian crossing marked on the carriageway or signposted as such, or which is stopped immediately before the crossing, otherwise than at a speed low enough to enable it to stop immediately if a pedestrian is on the crossing.*

The following sections take this rule through each step, explaining how each component of the codification process works.

Step 1: Identify Terms and Construct a Vocabulary

The rule is re-stated below highlighting important terms:

A vehicle **shall not overtake another vehicle** which is **approaching** a **pedestrian crossing** marked **on** the **carriageway or signposted** as such, **or** which is **stopped immediately before**

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the **crossing**, **otherwise** than at a **speed** **low enough** to **enable** it to stop immediately **if** a **pedestrian** is **on** the **crossing**.

Terms that are ODD and behaviour related are in bold and underline, while other terms that are relevant to giving the rule meaning are in bold.

Step 2: Identify Unspecified Terms

From the example above, the terms that remain underspecified are as follows:

| Term | Specification Required |
|---|---|
| Immediately | How is immediately defined? A *distance* may be used to define this. |
| Low enough | What speed is considered low enough? This could be a function of distance to the pedestrian, or an absolute threshold. |
| **Overtaking is an action that is applicable to vehicles that are ahead of the ego** | This is an assumption that is understood by a human reader. |

Step 3: Identify Predicates and Functions

The non-highlighted terms are removed and only terms that are important to the meaning of the rule are kept.

**Shall not overtake another vehicle**

- **approaching pedestrian crossing on carriageway or signposted,**
- **or stopped immediately before crossing**,

**otherwise speed low enough enable stop immediately if pedestrian on crossing**.

| Predicate | Description |
|---|---|
| isEgo(x) | x is the Ego |
| canOvertake(x,y) | x can overtake y |
| isApproaching(x,y) | x is approaching y |
| isPedestrianCrossing(x) | x is a pedestrian crossing |

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| | |
|---|---|
| isCarriageway(x) | x is a carriageway |
| isSignposted(x) | x is signposted |
| isStopped(x) | x is stopped |
| isAhead(x,y) | x is ahead of y |
| hasSpeed(x,y) | x has speed y |
| isLowEnoughSpeed(x,y) | x is a low enough speed for action y |

The terms identified are converted into predicates. For the VC Rule, we construct the following predicates:

Step 4: Express Rule in First Order Logic

The rule determines overtaking behaviour for a vehicle that is close to a pedestrian crossing. The rule contains conditions that would prevent a vehicle from overtaking another, but simultaneously provides an exception, that of being slow enough to stop. Further, the ability of the vehicle to stop is independent of whether there is an actor (such as a pedestrian) on the crossing. The rule makes references to the vehicle having a slow enough speed to stop immediately, which has been identified as an ambiguous phrase and represented as a predicate in Step 3. To represent the action of stopping immediately, we use the constant "STOP_IMM".

For ease of understanding, the rule may be broken down into four logical statements, that are logically related, with the relationship being stated as the last rule. The predicates that were produced as an outcome of Step 1 are used to construct the logic specification for the rule.

The parameters for the rules: the ego vehicle (x), the other actor (y), the pedestrian crossing (w), the carriageway (c), the speed of the ego (s).

The rules are as follows:

| | | |
|---|---|---|
| Rule (a): | isEgo(x) ⋀ isOtherRoadUser(y) | x is the ego and y is the other vehicle |
| Rule (b): | isPedestrianCrossing(w) ⋀ (isCarriageway(c) V isSignposted(w)) | w is a pedestrian crossing and (c is a carriageway or w is signposted) |

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| | | |
|---|---|---|
| Rule (c): | isApproaching(y,w) V isAhead(w,y) | y is approaching w, or w is ahead of y |
| Rule (d): | hasSpeed(x,s) ⋀ ¬isLowEnoughSpeed(s,STOP_IMM) | x has speed s, and s is not a low enough speed to stop immediately. |
| *The Rule* | *(a) ⋀ (b) ⋀ (c) ⋀ (d) → ¬canOvertake(x,z)* | |

The symbol "¬" when used as a prefix to a predicate indicates the negation of the predicate. In this context, in English, the rule may be read as: If "a" is true, and "b" is true, and "c" is true, and "d" is true, then x cannot overtake z. Note that the exception condition, that of being slow, is used in its negative form to assert that the vehicle cannot overtake, since this is explicit in the rule. It is left to interpretation if a positive rule, specifically allowing the vehicle to overtake is necessary. If so, a new rule that allows a vehicle to overtake must be written. This would depend on the interpretation of the rule. ]

Prepared by the expert from the UK

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