

Global Technical Regulation on Automated Driving System (ADS)

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I. Statement of technical rationale and justification

A. Introduction

1. With the rapid development of Automated Driving System (ADS) technology, ADS vehicles hold great potential to improve road safety and enhance mobility options for numerous road users. ADS are poised to significantly change the nature of road transport. They also pose many novel safety risks that must be effectively addressed by manufacturers and the international regulatory community.
2. The introduction of ADS presents many new, unique challenges for the development of vehicle regulation. Governments around the world are facing the problem of how to formulate effective regulatory measures. To ensure ADS safety, the safety regulators require new concepts, tools, and methodologies in addition to those historically used for previous vehicle technologies and systems.¹
3. WP.29 recognizes that for automated vehicles to fulfil their potential, in particular to improve road transport, they must be placed on the market in a way that reassures road users of their safety. If automated vehicles confuse users, disrupt road traffic, or otherwise perform poorly, then they will fail to improve road transport outcomes.² Therefore, there is an urgent need for regulatory measures, to ensure the safety of automated vehicles that are deployed on public roads, and to promote collaboration and communication amongst those involved in their development and oversight.
4. Technical provisions, guidance resolutions and evaluation criteria for automated vehicles will, to the best extent possible, be performance based, technology neutral, and based on state-of-the-art technology, while avoiding restricting future innovation.³ Automated vehicle systems, operating in automated mode in their respective Operational Design Domain (ODD) shall not cause any traffic accidents resulting in injury or death that are reasonably foreseeable and preventable. Based on these principles, this GTR sets out a series of vehicle safety provisions to address the safe deployment of ADS equipped vehicles.⁴
5. It is important to note that the diversity of ADS vehicle configurations and the characteristics and constraints of their ODD present challenges in establishing harmonized requirements for worldwide use. At the same time, the complexity of driving also presents challenges to the assessment of ADS performance across the diversity of ODDs.⁵
6. This GTR aims to provide a harmonized methodology, incorporating high-level requirements that address the unique nature and safety challenges associated with ADS technology as well as a multi-pillar approach to ensure comprehensive, effective and efficient validation of ADS safety.⁶
7. This GTR is based on the collaborative efforts of the Informal Working Group on Automated Driving Systems (IWG ADS) and the Working Party on

¹ ECE/TRANS/WP.29/2024/39.

² ECE/TRANS/WP.29/2019/34/Rev.2.

³ ECE/TRANS/WP.29/2019/34/Rev.2.

⁴ ECE/TRANS/WP.29/2019/34/Rev.2.

⁵ GRVA-18-50.

⁶ GRVA-18-50.

automated and Connected Vehicles (GRVA) workshops on Automated Driving Systems.

B. Procedural background

8. ISA 90% performance required wrto Israeli sign catalogue. In 2015, the World Forum for Harmonization of Vehicle Regulations (WP.29) established a programme under the Intelligent Transport Systems (ITS) informal working group to focus on automated driving (ITS/AD).
 - (a) During its 174th (March 2018) session, WP.29 approved a proposal from the ITS/AD informal group for a “Reference document with definitions of Automated Driving under WP.29 and the General Principles for developing a UN Regulation on automated vehicles”.
 - (b) In March 2018, ITS/AD established a Task Force on Automated Vehicle Testing (TFAV) “to develop a regulatory testing regime that assesses a vehicle’s automated systems so as to realise the potential road safety and associated benefits under real life traffic conditions”.
 - (c) TFAV established subgroups to consider AV assessment methods:
 - (i) Physical certification tests and audit;
 - (ii) Real-world test drive.
9. At the 178th session, WP29 adopted the Framework document on automated vehicles (WP.29/2019/34/Rev.2), herein referred to as the Framework document and the Terms of Reference (ToRs) (WP.29/1147/Annex VI). The Framework Document provides “guidance to WP.29 subsidiary Working Parties (GRs) by identifying key principles for the safety and security of automated vehicles of levels 3 and higher”.⁷ The Framework Document allocated work on these WP.29 priorities across several informal working groups, including Functional Requirements for Automated Vehicles (FRAV) and Validation Methods for Automated Driving (VMAD). The Framework document instructed VMAD and FRAV to develop a ‘new assessment/test method for automated driving’ (NATM) for consideration during the 183rd (March 2021) session of WP.29.
10. VMAD’s mandate under the ToRs was to develop assessment methods, including scenarios, to validate the safety of automated systems based on a multi-pillar approach including audit, simulation/virtual testing, test track, and real-world testing. FRAV developed functional (performance) requirements for automated vehicles. Based on the work of both groups the NATM master document, which outlines a conceptual framework for validating the safety of automated driving systems, was developed. The first version of this document was adopted at the 184th session (June 2021) of WP29 (ECE/TRANS/WP.29/1159). The second version was submitted to the 12th session (January 2022) of GRVA⁸.
11. Building on this conceptual work, VMAD and FRAV were instructed by WP29 to undertake the development of the NATM guidelines. This document

⁷ ECE/TRANS/WP.29/2019/34/Rev.2 and ECE/TRANS/WP.29/1147 Annexes V and VI. ⁴

The Framework Document refers back to the Automated Driving definitions provided in the reference document ECE/TRANS/WP.29/1140 noted in para. 1.2. The reference document cites SAE J3016:2016 as its source for establishing levels of driving automation (1-5).

⁸ ECE-TRANS-WP29-GRVA-2022-02e

- was developed to provide direction to developers and contracting parties of the 1958 and the 1998 UN vehicle regulations agreements on recommended procedures for validating the safety of ADS.⁹
12. WP.29 further directed FRAV and VMAD to collaborate and deliver a consolidated FRAV/VMAD submission (requirements and assessment methods) for its June 2024 session. WP.29 approved the integrated FRAV/VMAD guidelines during the June 2024 session.¹⁰
 13. At the 191st session of the World Forum for Harmonization of Vehicle Regulations and the 68th session of the Executive Committee of the 1998 Agreement in Nov. 2023, WP.29 adopted a proposal for the regulatory approach for Automated Driving Systems (WP.29-191-30/Rev.1). This proposal included the creation of (i) a new Informal Working Group on Automated Driving Systems (IWG ADS) and (ii) Working Party on automated and Connected Vehicles (GRVA) workshops to launch and undertake the work on regulatory activities for such systems. This decision is noted in the report of the WP.29 191st session.¹¹ WP.29's administrative council (AC.3) approved the request for authorization of a new UN GTR on ADS in March 2024 as noted in Annex IV of the report on the 192nd session of WP.29.¹²
 14. At the eighteenth session of the GRVA, the regulatory approach for Automated Driving Systems, as adopted by WP.29, was discussed. GRVA deliberated on the establishment of a bureau composed of representatives from Canada, China, the European Commission, the United Kingdom, Japan, and the United States to lead the activity. GRVA adopted the draft terms of reference for the IWG on ADS and the workshops on ADS, and submitted them to WP.29.¹³
 15. At the 192nd session of the World Forum for Harmonization of Vehicle Regulations and the 69th session of the Executive Committee of the 1998 Agreement in March 2024, WP.29 agreed that the IWG on ADS would be sponsored and led by Canada, China, European Commission, Japan, United Kingdom of Great Britain and Northern Ireland and the United States of America. WP.29 also noted that the secretariat services would be provided by the representatives of AAPC, OICA, JASIC and SAE International. The IWG on ADS was tasked with developing the technical requirements for the ADS regulation for Contracting Parties under the 1958 and 1998 Agreements. The Workshops focused on the development of the administrative requirements for the ADS regulation, as well as an interpretation document to assist in the implementation of these regulations. Two ambassadors (from Australia and the Netherlands) were tasked to align the activities of the IWG on ADS and the Workshops, and evaluate the progress of both activities.¹⁴ During this session, WP.29 adopted an amendment to the Framework Document on automated vehicles to take into account these new activities.¹⁵
 16. During the first session of the IWG on ADS the work plans and a draft structural framework referring to the ADS GTR and UNR content were explained based on specific sections, particularly "General requirements," "Performance requirements/Test specifications," and "Assessment/Test

⁹ ECE/TRANS/WP.29/1159

¹⁰ ECE/TRANS/WP.29/2024/39

¹¹ ECE/TRANS/WP.29/1175

¹² ECE/TRANS/WP.29/1177

¹³ GRVA-18-41/Rev.2 and GRVA-18-42/Rev.2.

¹⁴ ECE/TRANS/WP.29/2024/38 and ECE/TRANS/WP.29/AC.3/62

¹⁵ ECE/TRANS/WP.29/2024/33 based on informal document WP.29-191-31

procedures.”¹⁶ It was agreed to appoint “Officers of Principal Interest” (OPI) for each section, who would act as points of contact and coordinators, receiving assistance from IWG on ADS experts. During the first session of the ADS workshop OPIs were also selected to develop the text for the administrative provisions for the ADS GTR and UN Regulation.

17. The initial objective of the IWG was transposition of the ADS guidelines (1958 and 1998 Agreement) into common regulatory provisions, focusing first on requirements and then on assessment methods/processes.¹⁷ This text is derived from the specific provisions and annexes received from the June 2024 Functional Requirements for Automated Vehicles (FRAV) - Validation Method for Automated Driving (VMAD) Informal Working Group Integrated Document¹⁸ under the Working Party on automated and Connected Vehicles (GRVA) and workshops for the generation of the draft UN Global Technical Regulation on ADS. The second phase involved transposing the common provisions into UN GTR and UN Regulation texts and integrating the GRVA ADS workshop outcomes into the text.
18. The IWG also received reports on the work of other informal groups, including Automated Vehicle Categorisation (AVC), Event Data Recorders and Data Storage Systems for Automated Driving (EDR/DSSAD), Regulation Fitness for Automated Driving Systems (FADS), and the GRVA ADS WS. The IWG noted the need for consistency across all these activities with the ADS regulations.¹⁹
19. The text was further refined from subsequent discussions at multiple IWG on ADS sessions and GRVA workshops. This included consolidation of common provisions of the text based on the work of the IWG OPIs. The consolidated common provisions document provided a baseline document that was then separated into a draft GTR and a draft UNR.

C. Technical background

20. The key subject of this GTR is the ADS). The definition of ADS “means the vehicle hardware and software that are collectively capable of performing the entire Dynamic Driving Task (DDT) on a sustained basis.”²⁰ 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 required to operate the vehicle²¹”.
21. Section C.1 describes what the DDT consists of.
22. Section C.2 describe the need to demonstrate the technical competency of the ADS.

¹⁶ ADS-01-03

¹⁷ WP.29-194-ADS/Add.1

¹⁸ ECE/TRANS/WP.29/2024/39

¹⁹ GRVA-21-44/Add.1

²⁰ ECE/TRANS/WP.29/2024/39 paragraph 3.1.2. 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.

²¹ ECE/TRANS/WP.29/2024/39 paragraph 3.1.11.1.

23. Section C.3 describes the various methods used to validate the safety of the ADS.
- 1. ADS performs all tactical and operational functions of driving**
24. Driving consists of three categories of functions: strategic, functional and operational. The real-time tactical and operational functions required to operate a vehicle in on-road traffic are collectively known as the DDT, which does not include strategic functions. Strategic functions include activities such as determining a trip destination that do not involve vehicle dynamic control.
25. The tactical level involves manoeuvring the vehicle in traffic during a trip, including perceiving and assessing of the driving environment, deciding and planning on a specific manoeuvre.
26. Tactical functions include but are not limited to manoeuvre planning and execution, enhancing conspicuity (lighting, signalling, gesturing, etc.), and managing interactions with other road users. Tactical functions generally occur over a period of seconds.
27. Operational functions include but are not limited to lateral vehicle motion control (steering) and longitudinal vehicle motion control (acceleration and deceleration). This operational effort involves split-second reactions, such as making micro-corrections while driving²².
28. The DDT definition explains that these functions can be grouped into three interdependent categories: sensing and perception, planning and decision, and control²³.
29. 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.
30. Planning and decision include:
- (a) Predicting actions of other road users;
 - (b) Response preparation;
 - (c) Manoeuvre planning.
31. 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.

²² ECE/TRANS/WP.29/2024/39 Annex 1 paragraph 6, 8, 9, 11-15.

²³ ECE/TRANS/WP.29/2024/39 paragraph 3.1.11.1.

- 2. ADS needs to demonstrate the competency of vehicle safety**
32. An ADS must demonstrate the competency to operate the vehicle safely, to respond to external conditions, and to manage internal failures.
33. Moreover, the ADS must be designed to ensure safe use and the safety of its users throughout the useful life of the vehicle.
34. To ensure that the safety competency is demonstrated, an ADS might be expected to be assessed via a framework for the development of traffic scenarios
35. The framework would include nominal, critical and failure scenarios. The requirements of the rule intentionally avoid technical specifications and performance limits for specific scenarios because each traffic situation requires a response appropriate to its combination of elements, risks, and available options.
36. Defining the performance criteria in critical scenarios could be difficult. In these cases, this could be done by using appropriate safety models to enable assessment of ADS performance within the limits of the safety models²⁴.
37. As a general concept, the safety level an ADS should be at least the same or greater than a competent and careful human driver. This concept is important minimizing unreasonable safety risks to the ADS vehicle user(s) and other road users²⁵. The manufacturer's safety case for the ADS and its features will include a description of the design processes used to implement the safety concept, and a structured presentation demonstrating through a body of evidence that the ADS and its features have undergone sufficient safety validation to ensure an absence of unreasonable risk in the ADS's performance.²⁶
- 3. Validating the safety of ADS**
38. Validating the ADS's capabilities is a highly complex task which cannot be done comprehensively nor effectively through one validation methodology alone. As a result, it is necessary to adopt a multi-pillar approach for the validation of ADS.
39. These various methodologies are intended for use in combination(s) to produce an efficient, comprehensive, and coherent assessment of ADS safety performance. Each of the testing methodologies possess their own strengths and limitations, such as differing levels of environmental control, environmental fidelity, scalability, and cost, which should be considered. In some cases, the application of more than one method could be necessary to assess the capability of an ADS to cope with range of situations that can arise in real-world traffic. The use of multiple methods allows for flexibility in the composition, sequencing, and application of testing across the diversity of ADS, while avoiding unnecessary redundancies and overlaps. Figure 1 below illustrates relationships across the ADS safety requirements, ODD analysis and scenario generation, and the validation pillars.²⁷

(a) Simulation/virtual Testing

²⁴ ECE/TRANS/WP.29/2024/39 paragraph 4.2-4.6.

²⁵ ECE/TRANS/WP.29/2024/39 paragraph 4.8.

²⁶ ECE/TRANS/WP.29/2024/39 paragraph 5.3.3.

²⁷ ECE/TRANS/WP.29/2024/39 paragraph 4.18.

It uses different types of simulation toolchains to assess the compliance of an ADS with the safety requirements on a wide range of virtual scenarios including some which would be extremely difficult if not impossible to test in real-world settings. The aspect of credibility of simulation/virtual testing is included in this topic.²⁸

(b) Track testing

It uses a closed-access testing ground with various scenario elements to test the capabilities and functioning of an ADS.²⁹

(c) Real world testing

It uses public roads to test and evaluate the performance of ADS related to its capacity to drive in real traffic conditions.³⁰

(d) Audit/assessment procedures

They establish how manufacturers will be required to demonstrate to safety authorities using documentation, their simulation, test-track, and/or real-world testing of the capabilities of an ADS. The audit will validate that hazards and risks relevant for the system have been identified and that a consistent safety-by-design concept has been put in place. The audit will also verify that robust processes/mechanisms/strategies (i.e., safety management system) that are in place to ensure the ADS meets the relevant safety requirements throughout the vehicle lifecycle. It shall also assess the complementarity between the different pillars of the assessment and the overall scenario coverage.³¹

(e) In-service monitoring and reporting

It addresses the in-service safety of the ADS after its placing on the market. It relies on the collection of fleet data in the field to assess whether the ADS continues to be safe when operated on the road. This data collection can also be used to fuel the common scenario database with new scenarios from the field and to allow the whole ADS community to learn from major ADS accidents/incidents.³²

²⁸ ECE/TRANS/WP.29/2022/57 IV. Paragraph 15.

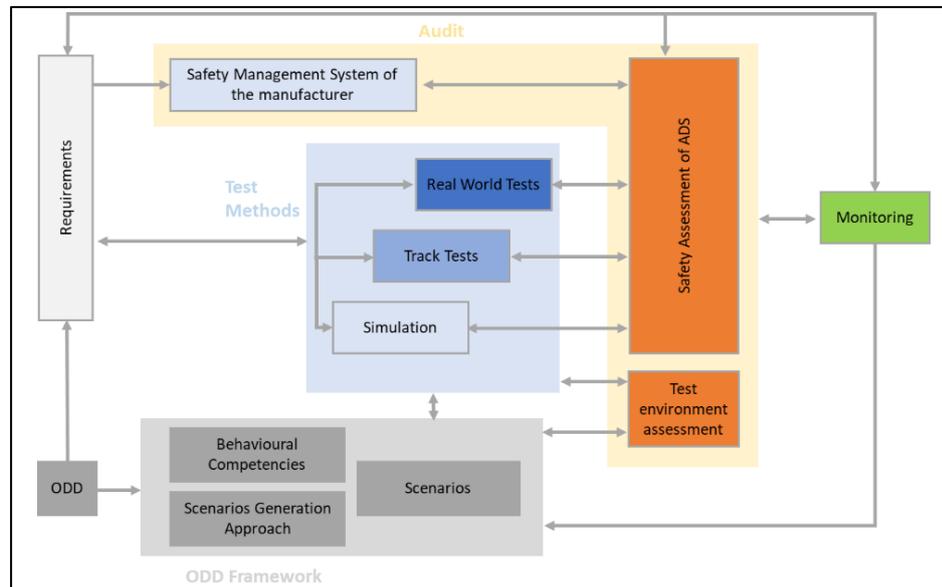
²⁹ ECE/TRANS/WP.29/2022/57 IV. Paragraph 16.

³⁰ ECE/TRANS/WP.29/2022/57 IV. Paragraph 17.

³¹ ECE/TRANS/WP.29/2022/57 IV. Paragraph 18.

³² ECE/TRANS/WP.29/2022/57 IV. Paragraph 19.

Figure 1. Relationships across safety requirements, ODD analysis and scenario generation, and validation pillars



4. Common Issues and Principles

40. The following list of issues and principles guided discussions and activities on automated vehicles within WP.29 and each of its relevant subsidiary Working Parties. The aim was to capture the shared interests and concerns of regulatory authorities, provide the general parameters for work, and to provide common definitions and guidance.

41. The following is a list of common principles with brief descriptions and explanations. It is expected these would form the basis for further development. Except for items n) and o), all these items have been identified in ECE/TRANS/WP.29/2029/34/Rev. 2.

- (a) **System Safety:** When in the automated mode, the automated vehicle should be free of unreasonable safety risks to the driver and other road users and ensure compliance with road traffic regulations;
- (b) **Failsafe Response:** The automated vehicles should be able to detect its failures or when the conditions for the ODD are not met anymore. In such a case the vehicle should be able to transition automatically (minimum risk manoeuvre) to a minimal risk condition;
- (c) **Human Machine Interface (HMI) /Operator information:** Automated vehicle should include driver engagement monitoring in cases where drivers could be involved (e.g. takeover requests) in the driving task to assess driver awareness and readiness to perform the full driving task. The vehicle should request the driver to hand over the driving tasks in case that the driver needs to regain proper control of the vehicle. In addition, automated vehicle should allow interaction with other road users (e.g. by means of external HMI on operational status of the vehicle, etc.);
- (d) **Object Event Detection and Response (OEDR):** The automated vehicles shall be able to detect and respond to object/events that may be reasonably expected in the ODD.

- (e) Operational Design Domain (ODD) (automated mode): Manufacturers should document the ODD available on their vehicles and the functionality of the vehicle within the prescribed ODD. The ODD should describe the specific conditions under which the automated vehicle is intended to drive in the automated mode. The ODD should include the following information at a minimum: roadway types; geographic area; speed range; environmental conditions (weather as well as day/night time); and other domain constraints;
- (f) Validation for System Safety: Manufacturers should demonstrate a robust design and validation process based on a systems-engineering approach with the goal of designing ADS free of unreasonable safety risks and ensuring compliance with road traffic regulations and the principles listed in this document. Design and validation methods should include a hazard analysis and safety risk assessment for the ADS, OEDR, as well as the overall vehicle design into which the ADS is being integrated. When applicable, the broader transport ecosystem should be included in this analysis. Design and validation methods should demonstrate the behavioural competencies an automated vehicle would be expected to perform during a normal operation, the performance during crash avoidance situations, and the performance of fall-back strategies. Test approaches may include a combination of simulation, test track, and on road testing;
- (g) Cybersecurity: The automated vehicle should be protected against cyber-attacks in accordance with established best practices for cyber vehicle physical systems. Manufacturers shall demonstrate how they incorporated vehicle cybersecurity considerations into ADSs, including all actions, changes, design choices, analyses and associated testing, and ensure that data is traceable within a robust document version control environment;
- (h) Software Updates: Manufacturers should ensure system updates occur as needed in a safe and secured way and provide for after-market repairs and modifications as needed;
- (i) Event data recorder (EDR) and Data Storage System for Automated Driving vehicles (DSSAD): The automated vehicles should have an ability to collect and record the necessary data related to the system status, occurrence of malfunctions, degradations or failures in a way that can be used to establish the cause of any crash and to identify the status of the automated driving system and the status of the driver. The identification of differences between EDR and DSSAD are to be determined;
Additional issues not listed in the currently agreed WP.29 priorities
- (j) Vehicle maintenance and inspection: Vehicle safety of in-use vehicles should be ensured through measures such as those related to maintenance and the inspection of automated vehicles etc. Additionally, manufacturers are encouraged to have documentation available that facilitates the maintenance and repair of ADSs after a crash. Such documentation would likely identify the equipment and the processes necessary to ensure safe operation of the automated vehicle after repair;
- (k) Consumer Education and Training: Manufacturers should develop, document and maintain employee, dealer, distributor, and consumer education and training programs to address the anticipated differences

in the use and operation of automated vehicles from those of conventional vehicles;

- (l) Crashworthiness and Compatibility: Given that a mix of automated vehicles and conventional vehicles will be operating on public roadways, automated vehicle occupants should be protected against crashes with other vehicles;
- (m) Post-crash AV behaviour: automated vehicles should be able to return to a safe state immediately after being involved in a crash. Bringing the vehicle to a safe state includes considerations such as shutting off the fuel pump, removing motive power, moving the vehicle to a safe position off the roadway, and disengaging electrical power. It is vital that the ADS have the capability to engage with an operations centre or collision notification centre.
- (n) Artificial Intelligence: vehicle automation is based on a combination of hardware and software. The requirements in this regulation are based on the condition that this software does not include the use of online in-vehicle learning Artificial Intelligence. Artificial Intelligence can be used to analyse and improve ADS software in an engineering environment. By means of a software update (over the air or connected) this update can be installed in the vehicle, again without in-vehicle learning features during operation of this version.
- (o) ADS vehicles shall be in conformity with regional legislation (e.g. data protection, privacy)

D. Principles for developing the global technical regulation

- 42. The GTR provides a necessary first step to the safe deployment of ADS equipped vehicles on public roads as there are no existing global regulations nor regulations established in the Compendium of Regulations of the 1998 Agreement to support ADS deployment.
- 43. Furthermore, industry has repeatedly indicated the need for regulations to be developed to support the deployment of vehicles equipped with ADS. This is necessary to prevent the fragmentation of regulatory approaches and avoid delaying the deployment of new technologies with the potential of improving road safety, promoting cleaner and greener transport, promoting social inclusion, and supporting economic growth.
- 44. This GTR was developed on the principal of being performance based and technology neutral. The regulations have been developed in a manner that can be adapted to accommodate different types of vehicle certification processes.
- 45. There are several GRVA subgroups active in the field of vehicle automation (EDR/DSSAD, TF AVC, TF FADS, CS/OTA). This first GTR is based on the information currently available from these subgroups. It provides worldwide harmonised procedures to set and verify compliance with minimum requirements for the safety of ADS and vehicles equipped with ADS with the notion that future improvements of the GTR are expected as ADS technologies continue to evolve. It takes into consideration existing and new data, research, and standards proposed by the contracting parties and industry.

E. Technical rationale and justification

1. Application/Scope

46. This UN GTR applies to vehicles of Category 1 and Category 2 based on the vehicle classification and definitions outlined in the 1998 Global Agreement Special Resolution No. 1 (S.R.1) with regards to their Automated Driving System.
47. Given that high potential of the improvement for road traffic safety is expected for the vehicles equipped with ADS, this regulation will help to establish the minimum safety requirements for the manufacturers developing ADS and the adequate validation requirements for the approval authorities³³.
48. Considering the diversity of ADS vehicle configurations, use cases and the characteristics of their ODDs (e.g. highway, urban, parking), this regulation will provide generic and high-level requirements to support the harmonization for ADS regulatory development worldwide and to support the introduction of innovations, allowing the industry to use state of the art technologies. At the same time, it will offer approval authorities a way to harmonize the safety level of ADS vehicles in the market.
49. The generic requirements framework of this regulation will also allow further development of additional requirements for specific use cases or ADS features in the future.
50. The safety case also includes requirements that the manufacturer review its safety case and remediate issues prior to certification/approval.

2. Rationale for requirements concerning performance of the dynamic driving task

51. 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.
52. Driving involves real-time risk management under prevailing traffic scenarios which means a description of a sequence of driving situations that may occur during a given trip. Therefore, safe ADS performance of the dynamic driving task (DDT) depends upon the situations presented under each individual scenario and each scenario is associated with one or more behavioural competencies.
53. This UN GTR establishes requirements for ADS driving behaviours under relevant traffic situations (nominal situations, critical situations, failure situations), at ODD boundaries and in fallbacks to an MRC.
54. The broad objectives are that the ADS operates safely in all traffic situations. To do this the ADS must be able to recognize the ODD of its features and prevent activation of its features outside their ODD. While a feature is active, the ADS should not cause traffic accidents or unreasonably disrupt the flow of traffic and should obey traffic rules in nominal situations. Under critical traffic

³³ Throughout this document, the term 'Approval Authority' is used to denote the competent authority of a Contracting Party to the 1958 Agreement that grants approval or refuses approval or withdraws approval or grants extension of approval or refuses extension of approval or suspends approval. The reference to the type approval authority is solely for the purpose of better illustrating the relevant background of the GTR (Global Technical Regulation) development and does not involve any type access requirements.

situations or failure situations, the ADS may need to diverge from its behaviour in nominal situations and prioritise safety over other aspects.

- 3. Rationale for requirements concerning ADS user interactions with the ADS**
55. The requirements for safe interactions between users and ADS vary depending on user role, system design and tasks to be performed by the user during the use of the ADS equipped vehicle, such as:
 - (a) ADS features that permit a user to take over the performance of the DDT;
 - (b) ADS features that do not permit a user to take over the performance of the DDT.
56. There is significant concern that unclear procedures for the safe deactivation of ADS features could lead to mode confusion – where the user does not know if the ADS or the user is in control of the DDT. Several requirements are included for these transitions including the use of a driver monitoring system to verify that fallback users remain able to take control when requested, and that control of the DDT is only given to a user if they are in a position to safely assume the driving task.
57. In addition to the requirements for the ADS, this UN GTR requires the manufacture to provide appropriate means in order to facilitate user understanding of the functionality and operation of the ADS. The means shall cover relevant aspects, such as operational description of the ADS features, capabilities, and limitations, instructions for the activation and deactivation of the ADS, general overview of non-driving-related activities (NDRA) allowed when an ADS feature is active where applicable, etc.
- 4. Rationale for other ADS requirements**
58. Other requirements are necessary to ensure overall safety of the ADS. This includes installation of a DSSAD to monitor the performance of the ADS, cyber security requirements, protection from unauthorised access to the ADS and the ability to conduct necessary maintenance. While not specific to the testing and validation of the ADS these provisions have been deemed as playing an important role to ensure that the manufacturer takes a holistic approach to ensuring the safety of the ADS throughout its lifecycle.
- 5. Rationale for safety management system**
59. The safety management system (SMS) is a systematic approach of the manufacturer to manage safety that encompasses and integrates human, organisational and technical factors:
 - (a) The human component ensures the ADS lifecycle is monitored by personnel with appropriate skills, training, and understanding to identify risks and appropriate mitigation measures;
 - (b) The 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) The technical component using appropriate tools and equipment.

60. An adequate SMS will incorporate all three factors to monitor and improve safety and help to control the identified risks. It should also include taking measures to monitor the vehicle during the in-service operation and to take corrective remedial action when necessary.
61. To facilitate auditing, the manufacturer should provide certain specific documentation to demonstrate that a SMS with robust processes to manage safety risks and to ensure safety throughout the ADS lifecycle (development, production, operational, decommissioning) has been established.
62. This UN GTR requires the manufacturer's documentation to cover relevant aspects, including safety policy, risk management, safety assurance, safety promotion, management of design and development, management of production and management of post-deployment safety.

6. Rationale for Assessment of Test Environments

63. The use of new tools for testing introduces some uncertainty that the tools themselves adequately represent the environments in which the ADS will operate. Manufacturers will need to use a combination of testing methods (virtual testing, track testing, real-world testing) during the development and validation of their ADS. Due to the large number of potential scenarios to replicate, virtual testing will likely be thoroughly used in this process.
64. The manufacturer should demonstrate that the approach to testing (virtual testing, track testing, real-world testing) and the scenario coverage/selection are suitable to validate/verify the safety case and compliance with the associated performance/functional requirements specified in this UN GTR.
65. High confidence in simulation toolchain credibility is needed so that virtual testing can be used by the manufacturer to validate the safety of their ADS on its own and in conjunction with the other testing methods. This requires that simulation tool or a combination of simulation tools provide an accurate representation of the real-world system where the ADS operates. The validity and credibility of the simulation toolchain(s) may vary depending on the environment and operating parameters. It is critical to determine in which scenarios the results of the simulation toolchain(s) can be relied upon. Therefore, it is essential to set up a harmonized credibility framework as part of this UN GTR. The framework includes requirements for the simulation toolchain including information on assumptions, limitations, quantification of uncertainty, scope, criticality analysis, sensitivity analysis, verification and validation.
66. Regarding from the assessment aspect, there are two main parts outlined in this UN GTR. One component is for assessment of the safety case testing activities and the other is for confirmatory testing.

7. Rationale for drafting a safety case

67. A complete safety case for the ADS and its features is required to be documented by the manufacturer. This includes a description of the system, the design processes used to implement the safety concept, and a structured presentation demonstrating through a body of evidence that the ADS and its feature(s) meet the requirements in the regulation and have undergone sufficient safety validation to ensure there are no unreasonable risks in the ADS's performance.
68. The safety case by the manufacturer demonstrates the application of the SMS to the ADS under assessment, including its design and intended uses (safety

concept) and an evidence-based structured argument (safety claim, argument, evidence) that the ADS meets the safety requirements specified in this UN GTR.

69. The safety case allows the relevant authority to determine whether the manufacturer has the capability to manage ADS safety throughout the lifecycle of the system.

70. The safety case also includes requirements that the manufacturer review its safety case and remediate issues prior to certification/approval.

8. Rationale for assessment of the safety case

71. The evaluation (i.e. safety assessment) of the safety case provided by the manufacturer, including the safety of the ADS design is essential to determine the vehicle's ADS is safe by design and that the ADS has been sufficiently validated before market introduction.

9. Rationale for post-deployment safety

72. In addition to the pre-deployment assessment of ADS safety, verification that the processes and capabilities to perform post-deployment assessment of ADS performance is required. The purpose of post-deployment safety is to confirm the manufacturer's safety case and safety during real-world operation. The reporting requirements for post-deployment safety will also help to identify unanticipated situations encountered in the real world which can then be used to develop new or revise existing scenarios.

73. Before the deployment of the ADS, the manufacturer should demonstrate it has processes in place and is capable of performing the post-deployment safety tasks. These processes should be documented as part of the manufacturer's SMS.

74. The monitoring program established by the manufacturer should collect and analyse vehicle data, and data from other sources. Manufacturers are required notify the relevant authority of a critical occurrence without unreasonable delay to allow the relevant authority to take any necessary actions to ensure public safety. Furthermore, two types of reports are required as part of post-deployment safety: short-term reports for specific significant and critical occurrences and periodic reports focus on more general statistics and other occurrences experience by deployed vehicles.

10. Rationale for Other Manufacturer Requirements

75. Besides requirements that are focused on validating the safety of the ADS the manufacturer will be required to provide owners and operators with necessary information on any required maintenance to ensure that the ADS can continue to operate safely once it is deployed.

11. Rationale for audit of SMS

76. The purpose of the SMS audit pillar is to allow the relevant authority to determine that the manufacturer has established robust processes to manage safety risks, manage safety throughout the ADS lifecycle, and that the manufacturer is compliant with the requirements as outlined in this UN GTR.

77. Given that the post-deployment safety is also included in the SMS, the audit of the SMS should review the manufacturer's documentation to ensure the suitability of post-deployment safety practices (processes, tools, personnel) for

the ADS and evaluate the manufacturer's capability to monitor the ADS and to report any occurrences/safety relevant events during the ADS operation. Documentation should also note the manufacturer's approach/methods to verify the safety performance of the ADS and for reporting the occurrences/safety relevant events experienced by the ADS during the operation.

78. This UN GTR specifies the requirements for the audit of SMS, including audit of the manufacturer's post-deployment safety mechanism.

12. Rationale for post-deployment safety assessment

79. The evaluation of the ADS post-deployment is necessary to assess evidence as to whether the safety management system and the safety case are sufficient or if any changes are necessary to ensure the safety of the ADS.

F. Existing regulations, directives, and international voluntary standards

80. The purpose of compiling this list of existing regulations and standards is to provide a comprehensive overview of the current landscape governing automated driving systems. The list categorizes these into three main sections:

- (a) UN guidance used as a basis for the development of the GTR/UNR;
- (b) Standards and regulations referenced in the GTR/UNR;
- (c) Other standards and regulations identified. This compilation aims to facilitate better understanding, comparison, and alignment of ADS regulatory practices globally, reflecting the foundational work accomplished by the groups from UN and highlighting the current regulatory status of contracting parties.

(a) The following documents reflect the technical progress made by WP.29 before starting to draft the ADS regulation, these technical documents come from informal working groups such as FRAV and VMAD, which are not only "existing regulations or technical documents", but also the basis for the preparation of this regulation, which was compiled on the basis of the conversion of the above technical documents.

- (UN) Guidelines and Recommendations concerning Safety Requirements for Automated Driving Systems
- (UN) New Assessment/Test Method for Automated Driving (NATM) Guidelines for Validating Automated Driving System (ADS)
- (UN) Guidelines and recommendations for ADS safety requirements, assessments and test methods to inform regulatory development

(b) The following documents consist of regulations, directives, and international voluntary standards that were already in effect prior to the development of this regulation. These documents were referenced or quoted during the development process of the ADS regulation (GTR/UNR).

United Nations (UN):

- (UN) R157 -Automated lane keeping System

International Organization for Standardization (ISO):

- ISO/SAE 21434:2021 - Road Vehicles - Cybersecurity engineering

- ISO/SAE PAS 22736:2021 Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles
- ISO 26262: 2018 - Road vehicles – Functional safety – From Part1 to Part 10
- ISO 9001 - Quality management systems
- ISO 31000 - Risk management
- ISO 21448: 2022 - Road vehicles — Safety of the intended functionality
- ISO 9241-210:2019 Ergonomics of human-system interaction Part 210: Human-centred design for interactive systems
- ISO PAS 8800 : 2024- Road vehicles — Safety and artificial intelligence
- ISO/TS 5083:2025 Road vehicles — Safety for automated driving systems — Design, verification and validation

International Automotive Task Force (IATF):

- IATF 16949 - Quality management systems (automotive)

(c) Although not explicitly referenced in the ADS regulations, the following documents submitted by contracting parties and relevant organizations (as of September 2025) are recognized as relevant to the development and deployment of automated vehicles.

United Nations (UN):

- (UN) R155 - Cyber security
- (UN) R156 - Software updates

International Organization for Standardization (ISO):

- ISO 34501:2022 Road vehicles - Test scenarios for automated driving systems — Vocabulary
- ISO 34502:2022 Road vehicles - Test scenarios for automated driving systems-Scenario based safety evaluation framework
- ISO 34503:2023 Road Vehicles - Test scenarios for automated driving systems - Specification for operational design domain
- ISO 34504:2024 Road vehicles - Test scenarios for automated driving systems - Scenario categorization
- ISO/TR 21959-1:2020 Road vehicles - Human performance and state in the context of automated driving
- ISO 24089:2023 - Road Vehicles - Software update engineering

Society of Automotive Engineers (SAE):

- SAE J3208-Taxonomy and Definitions of ADS Verification & Validation
- SAE J3237-Operational Safety Metrics for Verification & Validation of Automated Driving Systems (ADS)
- SAE J3279-Best Practices for Applying Simulations in Driving Automation System Development
- SAE 3259-Taxonomy & Definitions for ODD for Driving Automation Systems
- SAE J3016-Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles

Institute of Electrical and Electronics Engineers (IEEE): ...

- IEEE 2846 2022 Assumptions for Models in Safety Related Automated Vehicle Behavior

5G Automotive Association (5GAA) :

- 5GAA TR T-210009 1.0 Safety Treatment in Connected and Automated Driving Functions

Association for Standardization of Automation and Measuring Systems(ASAM):

- ASAM OpenSCENARIO DSL V2.1.0
- ASAM OpenSCENARIO XML V1.3.1
- ASAM OpenDRIVE V1.8.1
- ASAM OpenODD V1.0

European Union:

- (EU) Regulation 2022/1426
- (EU) Regulation 2019/2144
- (EU) ELKS Regulation 2021/646

The United Kingdom:

- (UK) BSI PAS 1884 Safety operators in automated vehicle testing and trialing
- Automated Vehicles Act (2024)

The United States of America:

- (US) NHTSA DOT HS 812 083 Advanced Test Tools for ADAS and ADS
- (US) NASA-STD-7009A - Standard for models and simulations

China :

- (CN) GB/T 40429-2022 Taxonomy of driving automation for vehicles
- (CN) GB/T 41798-2022 Intelligent and connected vehicles—Track testing methods and requirements for automated driving functions
- (CN) GB 44497-2024 Intelligent and connected vehicle—Data storage system for automated driving
- (CN) GB/T 44721-2024 Intelligent and connected vehicle—General technical requirements for automated driving system
- (CN) GB/T 44719-2024 Intelligent and connected vehicle—Methods and requirements of road test for automated driving functions
- (CN) GB/T 45312-2025 Intelligent and connected vehicles—Operational design condition for automated driving system

France:

- (FR) Ordonnance no. 2021-443 of April 14, 2021 on the criminal liability regime applicable in the event of the circulation of a vehicle with driver delegation and its conditions of use.

Japan:

- (JP) JIS D 6805 Testing Method of the Characteristics and

Functions of Automatic Guided Vehicles

Germany :

- (DE) Act on Autonomous Driving (Section 1a - 1l Road Traffic Act, StVG), 2021
- (DE) Ordinance on Approval and Operation of Autonomous Vehicles (AFGBV), 2022

G. Benefits and costs

81. For the time being, ADS will not be mandatory for vehicles. Currently there is only one specific ADS application for which a UN ADS regulation has been developed (ALKS/R157). Consequently, for all other ADS applications except ALKS, there is no clear regulation which helps manufacturers in developing their ADS and authorities in validating the related products and processes. This GTR is an important prerequisite to support the process of harmonization of engineering and validation requirements.
82. For ADS technology, the issue of responsibility attribution is one of the core challenges on its development path. Based on the authoritative platform of WP.29, formulating a comprehensive set of global technical regulations for ADS with international consensus is an important step in improving the relevant legal environment, while also clarifying the current capabilities and limitations of ADS technology. In this way, provisions can be built upon the existing technological conditions through a regulation that establishes a clear and reasonable framework for responsibility attribution. This framework establishes traceable technical parameters and system behavior logging requirements for manufacturers and software developers. In accident scenarios, the documented technical evidence provides an auditable basis for accountability determination processes, while maintaining adaptability for evolving ADS verification methodologies. The standardized technical benchmarks support alignment with legal proceedings without constituting legal judgments.
83. Social trust and acceptance are key to the widespread integration of ADS technology into people's daily lives. The formulation and subsequent use of ADS regulations can play an important role in enhancing public awareness, dispelling misunderstandings, and fostering trust. These processes not only provide the public with a more comprehensive and in-depth understanding of ADS technology but also, through legal commitments and safeguards, might alleviate people's uncertainties and fears about the new technology. In the long run, this could create a positive and open social environment for realizing the grand vision of intelligent transport.
84. At this stage of ADS development, there is no quantitative data to support a thorough cost-benefit analysis. With the accumulation of data from various deployments and testing, the GTR might help quantifying both the costs and benefits of ADS regulation. A globally harmonized regulation may potentially reduce costs and increase efficiencies for manufacturers. Such benefits may stem from streamlined production processes as well as the resources required to adapt to different regulatory regimes. For example, manufacturers may not be required to retool production facilities to comply with different regulations in different countries. With wider application of ADS, more data will become available to improve the cost/benefit analysis.

85. Empirical data from ADS demonstration zones and research institutions worldwide highlight the potential benefits and challenges of ADS technology across diverse traffic environments. Statistical analyses of passenger vehicles indicate that accident rates in ADS modes are consistently lower than in manual driving. [According to the data shared by the GRVA experts, there is an average of 18.5 accidents per million kilometres in manual driving (10.2 at-fault accidents), compared to 7.1 accidents in automated driving (2.8 at-fault accidents). Notably, some leading technology providers have achieved zero at-fault accidents per million kilometres in automated mode.]
86. [However, according to the data shared by the GRVA experts, challenges to traffic efficiency persist, particularly during peak hours or in complex scenarios. Studies suggest automated vehicles may experience a 5%-15% reduction in average speed compared to human drivers, primarily due to conservative following distance decisions, suboptimal route planning, and delayed responses to dynamic environments. For example, pilot projects in multiple urban areas reported peak-hour automated vehicle speeds of 22–28 km/h, 10%-18% lower than manual driving, with travel times increasing by 8%-12% on average.]
87. This regulation's development, while resource-intensive, promises safety improvements. [The GTR could prevent an estimated 250,000 global fatalities and reduce severe injuries through comprehensive implementation of automated driving systems (ADS).] The collaborative process has enhanced knowledge-sharing between automakers, governments, and research bodies, creating transferable insights for future regulatory work—including ADAS standards. Notably, this marks the first simultaneous development of a GTR and corresponding UN Regulation (UNR) for shared safety goals, setting a new benchmark for international regulatory cooperation. Key technical elements from this GTR also demonstrate broader applicability, potentially informing updates to existing driver assistance regulations. The established framework may accelerate future rulemaking processes in evolving automotive technologies.
88. At the same time, qualitative analysis remains equally important. Factors such as user acceptance, public perception, and regulatory adaptability cannot be fully captured through numbers alone. A deeper examination is required to ensure comprehensive regulation. By combining both quantitative and qualitative analyses, decision-making for future regulation development can be optimized. This regulation provides important sources for these analyses, such as In Service Monitoring and Reporting (ISMR). This ISMR element helps to balance supporting innovation with controlling the safety level. Output of ISMR can be used to further improve ADS regulation where needed.

II. Text of Regulation

<Submitted by IWG-ADS>

Annex 1 - Appendix

<Submitted by IWG-ADS>
