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Global Technical Regulation on Automated Driving System (ADS)

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I. Statement of technical rationale and justification

A. Introduction

With the rapid development of ADS technology, the global demand for ADS vehicles is continuously increasing, showing a huge market potential. Technological advancements have not only gradually gained recognition for ADS but are also gradually changing the mode of transportation.

However, the introduction of ADS presents new challenges to the safety regulator. Governments around the world are facing the problem of how to formulate effective regulatory measures. To ensure ADS safety, the safety regulator require new concepts, tools, and methodologies in addition to those historically used for previous vehicle technologies and systems. *[ECE/TRANS/WP.29/2024/39- 3. ADS present challenges to the safety regulator that require new concepts, tools, and methodologies in addition to those historically used for previous vehicle technologies and systems.]*

WP.29 recognizes that for automated/autonomous vehicles to fulfil their potential in particular to improve road transport, then they must be placed on the market in a way that reassures road users of their safety. If automated/autonomous vehicles confuse users, disrupt road traffic, or otherwise perform poorly then they will fail. Therefore, there is an urgent need for regulatory obligations to helping to deliver safe and secure road vehicles in a consistent manner, and to promote collaboration and communication amongst those involved in their development and oversight. *[ECE/TRANS/WP.29/2019/34/Rev.2- 6. WP.29 recognizes that for automated/autonomous vehicles to fulfil their potential in particular to improve road transport, then they must be placed on the market in a way that reassures road users of their safety. If automated/autonomous vehicles confuse users, disrupt road traffic, or otherwise perform poorly then they will fail. WP.29 seeks to avoid this outcome by creating the framework to helping to deliver safe and secure road vehicles in a consistent manner, and to promote collaboration and communication amongst those involved in their development and oversight.]*

Technical provisions, guidance resolutions and evaluation criteria for automated vehicles will to the extent possible, be performance based, technology neutral, and based on state of the art technology while avoiding restricting future innovation. Automated/autonomous vehicle systems, under their automated mode ([ODD/OD]), shall not cause any traffic accidents resulting in injury or death that are reasonably foreseeable and preventable. Based on those principle, this GTR sets out a series of vehicle safety topics to be taken into account to ensure safety.*[ECE/TRANS/WP.29/2019/34/Rev.2- 3. Technical provisions, guidance resolutions and evaluation criteria for automated vehicles will to the extent possible, be performance based, technology neutral, and based on state of the art technology while avoiding restricting future innovation.][ECE/TRANS/WP.29/2019/34/Rev.2- 7. The level of safety to be ensured by automated/autonomous vehicles implies that "an automated/autonomous vehicle shall not cause any non-tolerable risk", meaning that automated/autonomous vehicle systems, under their automated mode ([ODD/OD]), shall not cause any traffic accidents resulting in injury or death that are reasonably foreseeable and preventable. Based on this principle, this framework sets out a series of vehicle safety topics to be taken into account to ensure safety.]*

However, 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 possible ODD. *[ECE/TRANS/WP.29/2024/39- 19. The diversity of ADS and ADS vehicle configurations requires attention to the roles, if any, that a vehicle user may* *play in the use of the vehicle. ADS vehicles may, or may not, be designed to carry human occupants. They may, or may not, be designed to be driven by a human being. They may permit or prohibit driver activation of the ADS while the vehicle is moving. 20. Safety requirements must account for the role(s) a user may have in the use of the ADS and/or ADS vehicle such as driver or passenger. These human-user roles may involve vehicle occupants, or they may be external to the vehicle.]*

This GTR therefore aims to provide a harmonized methodology to address these concerns by establishing high-level requirements to cope with the above diversity and by introducing a multi-pillar approach to ensure comprehensive and efficient validation of ADS safety. *[ECE/TRANS/WP.29/2024/39- 19. The diversity of ADS and ADS vehicle configurations requires attention to the roles, if any, that a vehicle user may play in the use of the vehicle. ADS vehicles may, or may not, be designed to carry human occupants. They may, or may not, be designed to be driven by a human being. They may permit or prohibit driver activation of the ADS while the vehicle is moving. 20. Safety requirements must account for the role(s) a user may have in the use of the ADS and/or ADS vehicle such as driver or passenger. These human-user roles may involve vehicle occupants, or they may be external to the vehicle.]*

B. Procedural background

ECE/TRANS/WP.29/2022/58 Guideline for Validating Automated Driving System (ADS)

1. At the 178th session of the United Nations Economic Commission for Europe (UNECE)'s World Forum for Harmonization of Vehicle Regulations (WP.29), Terms of Reference (ToRs) (WP.29/1147/Annex VI) for the Informal Working Group on Validation Methods for Automated Driving (VMAD) were developed. VMAD's mandate under these ToRs is 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. Throughout this document, safety encompasses the safe performance of automated driving systems and System Safety.

2. Also at the 178th session, WP29 adopted the Framework document on automated/autonomous vehicles (WP.29/2019/34/Rev.2) herein referred to as the Framework document. The Framework document instructed VMAD to develop a 'new assessment/test method for automated driving' (NATM) for consideration during the 183rd (March 2021) session of WP.29.

3. To inform this work, VMAD developed an NATM master document which outlines a conceptual framework for validating the safety of automated driving systems. 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 GRVA (ECE-TRANS-WP29-GRVA-2022-02e).

4. Building on this conceptual work, VMAD was instructed by WP29 (ECE/TRANS/WP.29/1159) to undertake the development of NATM guidelines that could 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 automated driving systems (ADS).

ECE/TRANS/WP.29/2024/39 Outcome of the FRAV/VMAD Integration Group

1.1. 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).

1.2. 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".1
1.3 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".2
1.4. TFAV established subgroups to consider AV assessment methods:
(a) Physical certification tests and audit;
(b) Real-world test drive.
1.5. In October 2018, TFAV proposed creating an informal working group on Validation Methods for Automated Driving (VMAD) "to develop methods to assess the safety of driving performance of automated driving systems including safe responses to the environment as well as safe behaviour towards other road users":
(a) In a controlled environment;
(b) Via audit of OEM processes;
(c) Under simulation and virtual testing; and
(d) Under real-world conditions.
1.6. During its 178th (June 2019) session, WP.29 approved a Framework Document on Automated/Autonomous Vehicles.3
1.6.1. The Framework Document provides "guidance to WP.29 subsidiary Working Parties (GRs) by identifying key principles for the safety and security of automated/autonomous vehicles of levels 3 and higher."4

C. Technical background

Description/comments :
The task is to provide a comprehensive overview of the technical aspects relevant to the GTR. It includes detailed information on the technologies, systems, and engineering principles that underpin the regulation

ECE/TRANS/WP.29/2024/39/Annex 1 Background on development of ADS safety requirements
1. This annex provides background information concerning the deliberations on safety requirements for Automated Driving Systems (ADS).
2. The development of these recommendations involved extensive consideration of what an ADS is and how ADS relate to human roles in driving. Accordingly, the definition of ADS is central to these recommendations. Two leading international standards bodies (SAE and ISO) define ADS as: "The hardware and software that are collectively capable of performing the entire DDT (Dynamic Driving Task) on a sustained basis, regardless of whether it is limited to a specific Operational Design Domain (ODD)."1
3. ADS present challenges to the safety regulator that require new concepts, tools, and methodologies in addition to those historically used for previous vehicle technologies and systems.
4. This section explains the considerations behind the recommendations for ensuring ADS safety presented in this document. Driving
5. Driving is a complex activity with traffic laws and codes of behaviour based upon human cognitive strengths and weaknesses.
6. Driving involves three behavioural levels: strategic, tactical, and operational. 7. The strategic level concerns general trip planning such as determination of trip goals, the route to be used, the modal choice, and evaluation costs and risks associated with these decisions.

8. 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 (e.g., on whether and when to overtake another vehicle), and executing the manoeuvre.
9. The operational level concerns vehicle-stabilisation capabilities (e.g., making microcorrections to steering, braking, and accelerating to maintain lane position in traffic).
10. For example, a decision to drive from home to a workplace involves a strategic assessment of the current conditions, the risks involved in driving under those conditions, and the probability for arriving at work on time. While driving, the driver makes tactical decisions based on conditions encountered along the way such as to change lanes or turn onto another street. In changing lanes, the driver makes a tactical assessment that the lane change is feasible, actuates the direction indicators and steers the vehicle while maintaining an appropriate speed, often with continuous adjustments on the operational level.
11. These behavioural levels relate to perception, information processing, and decision making under uncertainty. Driving can be considered an exercise in risk management within the context of achieving strategic goals. Drivers assess and respond in real time to perceived risks (including the behaviours of other road users) in the road environment.
12. The real-time tactical and operational functions required to operate a vehicle in onroad traffic are collectively known as the Dynamic Driving Task (DDT). As noted above, these functions may be performed within the context of strategic goals, but the DDT itself 1 This term is used specifically to describe a Level 3, 4, or 5 driving automation system These aspects of DDT, ODD, and the “hardware and software” capabilities are addressed in these recommendations, including their interplay in defining applications of ADS technologies and assurance of their safe deployment.

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excludes such strategic functions. These functions may overlap or operate in combination such as in a tactical decision in response to road conditions to deviate from the original strategy to follow a particular route. Strategic decisions nonetheless may be made during a trip (for example, a decision to leave the motorway for lesser roads).
13. Although the DDT comprises several subtasks (sensing, cognitive processing, action), the DDT itself refers to performing the whole driving task within its Operational Design Domain (ODD). Within the ODD, the ADS or the driver performs the DDT. A system that cannot perform the entire DDT can only assist the driver’s performance of the DDT.
14. 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.
15. 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 driving.
16. The DDT cannot be apportioned between a driver and a driving system because these functions are interdependent and operate as a whole. Operational and tactical functions are inherent in monitoring the driving environment (object and event detection, recognition, classification, and response preparation) and in object and event response execution. Automated driving
17. While the previous section concerns driving in general, human and automated driving have notable differences.
18. Unlike human drivers broadly licensed to operate a vehicle on all roadways under all conditions, ADS may be designed for specific purposes and to operate under specific conditions.
19. The diversity of ADS and ADS vehicle configurations requires attention to the roles, if any, that a vehicle user may play in the use of the vehicle. ADS vehicles may, or may not, be designed to carry human occupants. They may, or may not, be designed to be driven by a

human being. They may permit or prohibit driver activation of the ADS while the vehicle is moving.
20. Safety requirements must account for the role(s) a user may have in the use of the ADS and/or ADS vehicle such as driver or passenger. These human-user roles may involve vehicle occupants, or they may be external to the vehicle.
21. Roles may change during the course of a trip. For example, in some configurations, a driver may activate the ADS while the vehicle is moving such that the ADS becomes the sole vehicle operator (i.e., performing the DDT within the ODD of the activated feature) and the driver shifts to the role of fallback user. For safety reasons, this fallback-user role might entail an obligation to remain receptive and responsive to ADS requests to assume control over the vehicle (i.e., to return to the role of driver). In other configurations, human occupants might not be expected to play any DDT-relevant role during the course of an entire trip.
22. The requirements recommended in this document address misuse prevention and the safety of user interactions such as transitions of vehicle control.
23. The conditions under which an ADS is designed to operate are known as the Operational Design Domain (ODD), which include but are not limited to aspects such as roadway speed limits, road designs (surface, geometry, infrastructure, etc.), weather conditions, and traffic densities. The ODD may include constraints or limitations on ADS use such as maximum vehicle speed, maximum rate of rainfall, or road type.
24. The ADS requirements must address the diversity of driving conditions that may arise singly and in combination within the ODD. ECE/TRANS/WP.29/2024/39 44
25. In addition, the requirements must address ADS that may be designed to operate in more than one ODD. As long as the ADS safely performs the DDT within each ODD, there is no reason to limit the definition of sets of ADS capabilities designed to operate the vehicle under separate sets of ODD conditions.
26. For an ADS, the operational and tactical functions of the DDT can be logically grouped under three general categories: • Sensing and Perception ADS sensing and perception functions include monitoring the driving environment to achieve object and event detection, recognition, and classification. These functions include perceiving other vehicles and road users, the roadway and its fixtures, objects in the vehicle's driving environment, and relevant environmental conditions, including sensing ODD boundaries, if any, of the ADS feature and positional awareness relative to driving conditions. • Planning and Decision Planning and decision include anticipation and prediction of actions that other road users may take, response preparation, and manoeuvre planning. • Control Control refers to lateral and/or longitudinal motion control and enhancing vehicle conspicuity via lighting and signalling. Automated Driving Systems
27. Based on the above, ADS need to be described in terms that cover the DDT (tactical and operational functions required to operate the vehicle in traffic) and the ODD (conditions under which such ADS capabilities are made available to a user).
28. An ADS consists of hardware and software that are collectively capable of performing the entire DDT on a sustained basis within one or more ODD.
29. Driving automation systems that require human intervention to perform aspects of the DDT fall below the level of an ADS.
30. In order to cover the diversity of ADS configurations, uses, and limitations on use, these recommendations define ADS in terms of functions and features. ADS functions: DDT Performance Capabilities
31. ADS integrate subsets of hardware and software (i.e., functions) designed to perform one or more aspects of the DDT.
32. ADS functions, in general, correspond to system-level capabilities integrated into the ADS design.
33. A function enables the ADS to perform one or more elements of the DDT (e.g., sensing the environment).

34. Functions represent the first level of safety that an ADS must fulfil. These functions correspond to essential capabilities without which an ADS cannot be deemed safe for use in traffic.
35. However, functions that enable performance of the DDT and capabilities that ensure safe use, including the safety of user interactions, have distinctly different objectives and requirements. Safe ADS performance of the DDT
36. Requirements to ensure safe ADS performance of the DDT address the functional and behavioural objectives described by the WP.29 Framework Document on Automated Vehicles: ADS operation shall not cause any traffic accidents resulting in property damage, injury, or death that are reasonably foreseeable and preventable.

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37. The requirements recommended in this document aim to ensure that each ADS is capable of performing the entire DDT to the extent necessary to operate the vehicle within the ODD of the ADS feature(s). Because the performance of tactical and operational functions is dependent on the prevailing traffic conditions, these DDT requirements specify that the ADS must demonstrate behavioural competencies across traffic scenarios covering its ODD. The behavioural competencies inherently require functional capabilities to perform the DDT.
38. These recommendations intentionally omit specifications for individual DDT functions. For example, the recommendations do not in general prescribe technical specifications for lateral or longitudinal control. As noted above, performance of the DDT is dependent on traffic conditions where such functions cannot be limited to representative specifications. For example, it is not possible to specify a particular measure of lateral control that would be appropriate in all circumstances. ADS safety involves real time tactical and operational adaptation to dynamic road conditions in the ODD. Tactical and operational functions are interdependent where the complexity of their interactions needs to be assessed under diverse traffic conditions.
39. By ensuring that an ADS will be subjected to traffic scenarios representative of what the ADS is reasonably likely to encounter in its ODD, the assessment of the behavioural competencies demonstrated by the ADS under those scenarios verifies the capability of the ADS to perform the entire DDT necessary to navigate its ODD. Additional ADS Capabilities: Safe use of ADS and ADS vehicles
40. In addition to DDT-specific functions, an ADS may require capabilities that contribute to ensuring the safe operational state of the ADS and/or preventing use when the ADS is not in a safe operational state.
41. ADS functions might also ensure the correct use of the ADS and safe interactions with a user such as in transitions of control.
42. Ensuring the safety of interactions between ADS and their users demands a humancentred focus on user needs, strengths, and weaknesses.
43. Trust often determines automation usage. Operators may not use a reliable automated system if they believe it to be untrustworthy. Conversely, they may continue to rely on automation even when it malfunctions. ADS should be designed to foster a level of trust that is aligned with their capabilities and limitations to ensure proper use.
44. These recommendations address user understanding of the ADS configuration, intended uses, and limitations on use, simplicity in defining and communicating user roles and responsibilities, clarity and commonality across ADS controls, requests, and feedback, and both misuse prevention as well as safeguards in the event of misuse.
45. The recommendations encourage Safety Management Systems that integrate HumanCentred Design Processes to ensure safe interactions between ADS and their users.
46. These human-centred processes should include analyses by qualified personnel of user needs and risk, setting safety and usability objectives, specifying user requirements and ensuring user understanding and context to produce design solutions that meet the requirements.

47. ADS should be evaluated, particularly under real-world testing on real users (i.e., not the people who are developing the products).
48. ADS performance should be monitored in the field and this information should be used to set future design targets and evaluate designs against these requirements.
49. These recommendations for user safety align with this human-centred approach to identify functions that must be integrated into ADS designs to ensure safe interactions and prevent misuse. **ECE/TRANS/WP.29/2024/39 46 ADS features**
50. An ADS feature refers to an application of ADS capabilities designed for use within a defined ODD. In the case of an ADS designed to operate within a single ODD, the ADS and the ADS feature are synonymous. Examples of ADS features are highway-only driving and automated parking.
51. Although an ADS performs the entire DDT on a sustained basis, an ADS may be designed to operate within more than one ODD.
52. Each set of ODD-specific capabilities has a unique set of constraints defining the conditions under which the ADS may be used.
53. ADS functions enable each ADS feature to operate the vehicle within the ODD of the feature. ADS functions may be used by more than one ADS feature and ADS features may use some or all of the ADS functions.
54. This document recommends a feature-based assessment of ADS. In cases where an ADS has more than one feature (i.e., is designed to operate in more than one ODD), each feature should be assessed to ensure that the ADS provides the functions necessary for performance of the entire DDT within the ODD of each feature.

ECE/TRANS/WP.29/2019/34/Rev.2，Framework document on automated/autonomous vehicles

8. The following list of issues and principles will guide discussions and activities on automated/autonomous vehicles within WP.29 and each of its relevant subsidiary Working Parties. The aim is to capture the shared interests and concerns of regulatory authorities, provide the general parameters for work, and to provide common definitions and guidance.
9. The following is a list of common principles with brief descriptions and explanation. It is expected these would form the basis for further development.
a) System Safety: When in the automated mode, the automated/autonomous 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/autonomous vehicles should be able to detect its failures or when the conditions for the [ODD/OD] 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/autonomous vehicle should include driver engagement monitoring in cases where drivers could be involved (e.g. take over 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 a 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/autonomous vehicles shall be able to detect and respond to object/events that may be reasonably expected in the [ODD/OD];
e) Operational Design Domain (ODD/OD)] (automated mode): For the assessment of the vehicle safety, the vehicle manufacturers should document the OD available on their vehicles and the functionality of the vehicle within the prescribed OD. The OD should describe the specific conditions under which the automated vehicle is intended to drive in the automated mode. The OD 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: Vehicle manufacturers should demonstrate a robust design and validation process based on a systems-engineering approach with the goal of designing automated driving systems 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 Automated Driving System (ADS), for the OEDR, but also for the overall vehicle design into which it is being integrated and when applicable, for the broader transportation ecosystem. Design and validation methods should demonstrate the behavioural competencies an Automated/autonomous 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/autonomous vehicle should be protected against cyber-attacks in accordance with established best practices for cyber vehicle physical systems. Vehicles 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: Vehicle 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/autonomous vehicles should have the function that collects and records 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/autonomous driving system and the status of the driver. The identification of differences between EDR and DSSAD to be determined;

Additional issues not listed in the currently agreed WP29 priorities

j) Vehicle maintenance and inspection: Vehicle safety of in-use vehicles should be ensured through measures such as related to maintenance and the inspection of automated vehicles etc. Additionally, vehicle 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/autonomous vehicle after repair;

k) Consumer Education and Training: Vehicle 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/autonomous vehicles and conventional vehicles will be operating on public roadways, automated/autonomous vehicle occupants should be protected against crashes with other vehicles;

m) Post-crash AV behavior: Automated/autonomous vehicles should be able to return to a safe state immediately after being involved in a crash. Things such as shutting off the fuel pump, removing motive power, moving the vehicle to a safe position off the roadway, disengaging electrical power, and other relevant actions should be considered. A communication with an operations canter, collision notification canter, or vehicle communications technology should be used.

Informal document WP.29-190-08/ Guidelines for Regulatory Requirements and Verifiable Criteria for Automated Driving System Safety Validation

1. Introduction

1.1. This section provides background information concerning the deliberations on safety requirements for Automated Driving Systems (ADS).

1.2. The development of these recommendations involved extensive consideration of what an ADS is and how ADS relate to human roles in driving. Accordingly, the definition of ADS is central to these recommendations. Two leading international standards bodies, SAE and ISO, define ADS as: “The hardware and software that are collectively capable of performing the entire DDT (Dynamic Driving Task) on a sustained basis, regardless of whether it is limited to a specific operational design domain (ODD) [; this term is used specifically to describe a Level 3, 4, or 5 driving automation system].”

1.3. ADS present challenges to the safety regulator that require new concepts, tools, and methodologies in addition to those historically used for previous vehicle technologies and systems.

1.4. This section explains the considerations behind the recommendations for ensuring ADS safety presented in this document.

1.5. Driving.

1.5.1. Driving is a complex activity with traffic laws and codes of behaviour based upon human cognitive strengths and weaknesses.

1.5.2. Driving involves three behavioural levels: strategic, tactical, and operational.

1.5.3. The strategic level concerns general trip planning such as determination of trip goals, the route to be used, the modal choice, and evaluation costs and risks associated with these decisions.

1.5.4. 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 (e.g., on whether and when to overtake another vehicle), and executing the manoeuvre.

1.5.5. The operational level concerns vehicle-stabilisation capabilities (e.g., making micro-corrections to steering, braking, and accelerating to maintain lane position in traffic).

1.5.6. For example, a decision to drive from home to a workplace involves a strategic assessment of the current conditions, the risks involved in driving under those conditions, and the probability for arriving at work on time. While driving, the driver makes tactical decisions based on conditions encountered along the way such as to change lanes or turn onto another street. In changing lanes, the driver makes a tactical assessment that the lane change is feasible, actuates the direction indicators and steers the vehicle while maintaining an appropriate speed, often with continuous adjustments on the operational level.

1.5.7. These behavioural levels relate to perception, information processing, and decision making under uncertainty. Driving can be considered an exercise in risk management within the context of achieving strategic goals. Drivers assess and respond in real time to perceived risks (including the behaviours of other road users) in the road environment.

1.5.8. The real-time tactical and operational functions required to operate a vehicle in on-road traffic are collectively known as the Dynamic Driving Task (DDT). As noted above, these functions may be performed within the context of strategic goals, but the DDT itself excludes such strategic functions. These functions may overlap or operate in combination such as in a tactical decision in response to road conditions to deviate from the original strategy to follow a particular route. Strategic decisions nonetheless may be made during a trip (for example, a decision to leave the motorway for lesser roads).

1.5.9. Although the DDT comprises several subtasks (sensing, cognitive processing, action), the DDT itself refers to performing the whole driving task within its Operational Design Domain (ODD). Within the ODD, the ADS or the driver performs the DDT. A system that cannot perform the entire DDT can only assist the driver’s performance of the DDT.

1.5.10. 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.

1.5.11. 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 driving.

1.5.12. The DDT cannot be apportioned between a driver and a driving system because these functions are interdependent and operate as a whole. Operational and tactical functions are inherent in monitoring the driving environment (object and event detection, recognition, classification, and response preparation) and in object and event response execution.

1.6. Automated driving.

1.6.1. While the previous section concerns driving in general, human and automated driving have notable differences.

1.6.2. [Unlike human drivers broadly licensed to operate a vehicle on all roadways under all conditions, ADS may be designed for specific purposes and to operate under specific conditions.]

1.6.3. The diversity of ADS and ADS vehicle configurations requires attention to the roles, if any, that a vehicle user may play in the use of the vehicle. ADS vehicles may, or may not, be designed to carry human occupants. They may, or may not, be designed to be driven by a human being. They may permit or prohibit driver activation of the ADS while the vehicle is moving.

1.6.4. Safety requirements must account for the role(s) a user may have in the use of the ADS and/or ADS vehicle such as driver or passenger. These human-user roles may involve vehicle occupants, or they may be external to the vehicle.

1.6.5. [Roles may change during the course of a trip. For example, in some configurations, a driver may activate the ADS while the vehicle is moving such that the ADS becomes the sole vehicle operator (i.e., performing the DDT within the ODD of the activated feature) and the driver shifts to the role of fallback user. For safety reasons, this fallback-user role might entail an obligation to remain receptive and responsive to ADS requests to assume control over the vehicle (i.e., to return to the role of driver). In other configurations, human occupants might not be expected to play any DDT-relevant role during the course of an entire trip.]

1.6.6. The requirements recommended in this document address misuse prevention and the safety of user interactions such as transitions of vehicle control.

1.6.7. The conditions under which an ADS is designed to operate are known as the Operational Design Domain (ODD), which include but are not limited to aspects such as roadway speed limits, road designs (surface, geometry, infrastructure, etc.), weather conditions, and traffic densities. The ODD may include constraints or limitations on ADS use such as maximum vehicle speed, maximum rate of rainfall, or road type.

1.6.8. The ADS requirements must address the diversity of driving conditions that may arise singly and in combination within the ODD.

1.6.9. In addition, the requirements must address ADS that may be designed to operate in more than one ODD. As long as the ADS safely performs the DDT within each ODD, there is no reason to limit the definition of sets of ADS capabilities designed to operate the vehicle under separate sets of ODD conditions.

1.6.10. For an ADS, the operational and tactical functions of the DDT can be logically grouped under three general categories:

1.6.10.1. Sensing and Perception

ADS sensing and perception functions include monitoring the driving environment to achieve object and event detection, recognition, and classification. These functions include perceiving other vehicles and road users, the roadway and its fixtures, objects in the vehicle's driving environment, and relevant environmental conditions, including sensing ODD boundaries, if any, of the ADS feature and positional awareness relative to driving conditions.

1.6.10.2. Planning and Decision

Planning and decision include anticipation and prediction of actions that other road users may take, response preparation, and manoeuvre planning.

1.6.10.3. Control

Control refers to lateral and/or longitudinal motion control and enhancing vehicle conspicuity via lighting and signalling.

1.7. Automated Driving Systems

1.7.1. Based on the above, ADS need to be described in terms that cover the DDT (tactical and operational functions required to operate the vehicle in traffic) and the ODD (conditions under which such ADS capabilities are made available to a user).

1.7.2. An ADS consists of hardware and software that are collectively capable of performing the entire DDT on a sustained basis within one or more ODD.

1.7.3. [Driving automation systems that require human intervention to perform aspects of the DDT fall below the level of an ADS.]

1.7.4. In order to cover the diversity of ADS configurations, uses, and limitations on use, these recommendations define ADS in terms of functions and features.

1.8. ADS functions: DDT Performance Capabilities

1.8.1. ADS integrate subsets of hardware and software (i.e., functions) designed to perform one or more aspects of the DDT.

1.8.2. ADS functions, in general, correspond to system-level capabilities integrated into the ADS design.

1.8.3. A function enables the ADS to perform one or more elements of the DDT (e.g., sensing the environment).

1.8.4. Functions represent the first level of safety that an ADS must fulfil. These functions correspond to essential capabilities without which an ADS cannot be deemed safe for use in traffic.

1.8.5. However, functions that enable performance of the DDT and capabilities that ensure safe use, including the safety of user interactions, have distinctly different objectives and requirements.

1.8.6. Safe ADS performance of the DDT

1.8.6.1. Requirements to ensure safe ADS performance of the DDT address the functional and behavioural objectives described by the WP.29 Framework Document on Automated Vehicles: ADS operation shall not cause any traffic accidents resulting in [property damage,] injury or death that are reasonably foreseeable and preventable.

1.8.6.2. [In order to ensure vehicle safety, the safety level of ADS performance shall satisfy the criteria that meet the requirements taking into account of safety level of functions which are already available in the market. The safety level of ADS performance shall be at least equal to or higher than the safety level of careful and competent human driver performance.]

1.8.6.3. The requirements recommended in this document aim to ensure that each ADS is capable of performing the entire DDT to the extent necessary to operate the vehicle within the ODD of the ADS feature(s). Because the performance of tactical and operational functions is dependent on the prevailing traffic conditions, these DDT requirements specify that the ADS must demonstrate behavioural competencies across traffic scenarios covering its ODD. The behavioural competencies inherently require functional capabilities to perform the DDT.

1.8.6.4. These recommendations intentionally omit specifications for individual DDT functions. For example, the recommendations do not in general prescribe technical specifications for lateral or longitudinal control. As noted above, performance of the DDT is dependent on traffic conditions where such functions cannot be limited to representative specifications. For example, it is not possible to specify a particular measure of lateral control that would be appropriate in all circumstances. ADS safety involves real time tactical and operational adaptation to dynamic road conditions in the ODD. Tactical and operational functions are interdependent where the complexity of their interactions needs to be assessed under diverse traffic conditions.

1.8.6.5. By ensuring that an ADS will be subjected to traffic scenarios representative of what the ADS is reasonably likely to encounter in its ODD, the assessment of the behavioural competencies demonstrated by the ADS under those scenarios verifies the capability of the ADS to perform the entire DDT necessary to navigate its ODD.

1.8.7. Additional ADS Capabilities: Safe use of ADS and ADS vehicles

1.8.7.1. In addition to DDT-specific functions, an ADS may require capabilities that contribute to ensuring the safe operational state of the ADS and/or preventing use when the ADS is not in a safe operational state.

1.8.7.2. ADS functions might also ensure the correct use of the ADS and safe interactions with a user such as in transitions of control.

1.8.7.3. [Ensuring the safety of interactions between ADS and their users demands a human-centred focus on user needs, strengths, and weaknesses.]

1.8.7.4. [Trust often determines automation usage. Operators may not use a reliable automated system if they believe it to be untrustworthy. Conversely, they may continue to rely on automation even when it malfunctions. ADS should be designed to foster a level of trust that is aligned with their capabilities and limitations to ensure proper use.]

1.8.7.5. [These recommendations address user understanding of the ADS configuration, intended uses, and limitations on use, simplicity in defining and communicating user roles and responsibilities, clarity and commonality across ADS controls, requests, and feedback, and both misuse prevention as well as safeguards in the event of misuse.]

1.8.7.6. [The recommendations encourage Safety Management Systems that integrate Human-Centred Design Processes to ensure safe interactions between ADS and their users.]

1.8.7.7. [These human-centred processes should include analyses by qualified personnel of user needs and risk, setting safety and usability objectives, specifying user requirements and ensuring user understanding and context to produce design solutions that meet the requirements.]

1.8.7.8. [ADS should be evaluated, particularly under real-world testing on real users (i.e., not the people who are developing the products).]

1.8.7.9. [ADS performance should be monitored in the field and this information should be used to set future design targets and evaluate designs against these requirements.]

1.8.7.10. These recommendations for user safety align with this human-centred approach to identify functions that must be integrated into ADS designs to ensure safe interactions and prevent misuse.

1.9. ADS features

1.9.1. [An ADS feature refers to an application of ADS capabilities designed for use within a defined ODD. In the case of an ADS designed to operate within a single ODD, the ADS and the ADS feature are synonymous. Examples of ADS features are highway-only driving and automated parking.]

1.9.2. [Although an ADS performs the entire DDT on a sustained basis, an ADS may be designed to operate within more than one ODD.]

1.9.3. Each set of ODD-specific capabilities has a unique set of constraints defining the conditions under which the ADS may be used.

1.9.4. ADS functions enable each ADS feature to operate the vehicle within the ODD of the feature. ADS functions may be used by more than one ADS feature and ADS features may use some or all of the ADS functions.

1.9.5. [This document recommends a feature-based assessment of ADS. In cases where an ADS has more than one feature (i.e., is designed to operate in more than one ODD), each feature should be assessed to ensure that the ADS provides the functions necessary for performance of the entire DDT within the ODD of each feature.]

Informal document WP.29-183-05 /New Assessment/Test Method for Automated Driving (NATM) Master Document Proposal

Background

1.1 During the 178th session of the United Nations Economic Commission for Europe (UNECE)'s World Forum for Harmonization of Vehicle Regulations (WP.29), the Framework document on automated/autonomous vehicles (WP.29/2019/34/Rev.2) was adopted and the

Terms of Reference (ToR) (WP.29/1147/Annex VI) for the Informal Working Group on Validation Methods for Automated Driving (VMAD) were developed.

1.2 The Framework document included the action item of a ‘new assessment/test method for automated driving’ (NATM) for consideration during the 183rd (March 2021) session of WP.29.

1.3 Consistent with the Framework document, the ToR outlines that VMAD’s mandate under the Working Party on Automated/Autonomous and Connected Vehicles (GRVA) is to develop assessments 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.

1.4 During the development of this work, the ToR outlines that VMAD should:

(a) Pursue this work in line with the following principles/elements described in the WP.29 Framework Document on Autonomous Vehicles:

(i) Object event detection and response (assessment): The automated/autonomous vehicles shall be able to detect and respond to object/events that may be reasonably expected in the operational design domain (ODD); and (ii) Validation for system safety: vehicle manufacturers should demonstrate a robust design and validation process based on a system-engineering approach with the goal of designing automated driving systems (ADS) free of unreasonable risks and ensuring compliance with road traffic regulation and the principles listed in this document. Design validation methods should include a hazard analysis and safety risk assessment for ADS, for the object event detection and response (OEDR), but also for the overall vehicle design into which it is being integrated and when applicable, for the broader transportation ecosystem. Design and validation methods should demonstrate the behavioural competencies an automated/autonomous 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.

(b) Take account of the developments of other subsidiary Working Parties (GRs) of WP.29 and their IWGs and work in full cooperation with them; and,

(c) Consider existing data, research and technical standards (e.g. SAE, ISO) available during the development of its action items

GRVA-16-39/ECE/TRANS/WP.29/2023/44/Rev.1/ New Assessment/Test Method for Automated Driving (NATM) Guidelines for Validating Automated Driving System (ADS)

Ⅰ. Background

1. At the 178th (June 2019) session of the United Nations Economic Commission for Europe (UNECE)’s World Forum for Harmonization of Vehicle Regulations (WP.29), Terms of Reference (ToRs) (ECE/TRANS/WP.29/1147/Annex VI) for the Informal Working Group on Validation Methods for Automated Driving (VMAD) were developed. VMAD’s mandate under these ToRs is 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. Throughout this document, safety encompasses the safe performance of automated driving systems and System Safety.

2. Also at the 178th session, WP.29 adopted the Framework document on automated/autonomous vehicles (ECE/TRANS/WP.29/2019/34/Rev.2) herein referred to as the Framework document. The Framework document instructed VMAD to develop a ‘new assessment/test method for automated driving’ (NATM) for consideration during the 183rd (March 2021) session of WP.29.

3. To inform this work, VMAD developed the NATM master document which outlines a conceptual framework for validating the safety of automated driving systems. The first version of this document was adopted at the 184th session (June 2021) of WP.29 (ECE/TRANS/WP.29/1159). The second version was submitted to the 12th session (January

2022) of the Working Party on Automated/Autonomous and Connected Vehicles (GRVA) (ECE/TRANS/WP.29/GRVA/2022/2).
4. Building on this conceptual work, VMAD was instructed by WP.29 (ECE/TRANS/WP.29/1159) to undertake the development of NATM guidelines that could 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.

Informal document WP.29-175-21/ Artificial Intelligence and vehicle regulations
I. Introduction
1. In 2015, public figures warned the international community with an Open Letter on Artificial Intelligence about the potential risks related to the use of Artificial Intelligence (AI). In 2017, more than hundred renowned experts wrote a letter to the United Nations stating their position on potential risks related to AI. Also in 2017, an experiment got public attention when it was reported that the experiment had to be abandoned after two artificially intelligent programs involved in the experiment appeared to be chatting to each other in a strange language only they understood, highlighting the risk of a AI systems control loss and recalling some science fictions about the rise of superintelligences that do not act in accordance with human wishes.
2. AI has found some prominent applications in the automotive sector. Some of these applications are related to infotainment and vehicle management (as Human Machine Interface (HMI) enhancement) e.g. infotainment management (incl. destination entry in the navigation systems). Some applications are related to the development of the vehicle self-driving capability.
3. Some AI implications might fall in the remit of the World Forum for the Harmonization of Vehicle Regulations (WP.29), e.g. HMI / distraction as well as the performance of automated vehicles.

Informal document GRVA-13-04/Rev.1/ Outcome of the GRVA workshops on Artificial Intelligence and Vehicle Regulations
1. Introduction
Recent achievements and communications give the impression that the switch from conventional software to Artificial Intelligence (AI) and Machine Learning (ML) in automotive products would happen overnight and that suddenly all the software modules onboard a vehicle would be using AI ML algorithms. This isn't exactly the case.
The introduction of AI and Machine Learning in vehicles is expected to be a slow and steady journey that leads to the introduction of machine learning into an Automated Driving System (ADS) or an Advanced Driver Assistance System (ADAS), starting off with a few software modules.
To date, the use of AI and machine learning is more focused on perception algorithms. But then, as more confidence is attained in these types of algorithms, AI could be used for control algorithms and decision logic. The use of machine learning for control algorithms could be challenging, though, as there are hard sets of requirements for functional limits that ADS need to comply with. Machine learning algorithms make it hard to control compliance to those hard sets of functional boundaries like having a prescribed lateral acceleration limit for a lane keeping system not exceeding three meters per second squared or having a certain deceleration rate for Advanced Emergency Braking System (AEBS). So, this evolution from using conventional software over to using machine leaning is going to be a slow process and something that industry will implement carefully.
The progressive introduction of AI and machine learning into vehicles requires to identify the potential elements that would be missing in the regulatory frameworks applicable to automotive systems. The policy makers defining best practices and horizontal requirements for AI based systems expect that certain aspects are duly taken into account in the various industry regulatory verticals.

The present document describes how safety is assessed for Automated Driving Systems and explores the compatibility of existing technology neutral provisions, drafted so far by the Working Party on Automated/Autonomous and Connected Vehicles (GRVA) for the assessment of ADS with the use AI and machine learning algorithms within their system itself.

Informal document GRVA-18-04/Proposal for amendments to ECE/TRANS/WP.29/2024/34
Proposal for a draft guidance document on Artificial Intelligence in the context of road vehicles

Software update
1. This guidance document applies to certification requirements and Conformity of Production. Industry shall not issue software updates, which will significantly modify already certified functions according to the recommendations on uniform provisions concerning cyber security and software updates without resuming the relevant certification procedure.
2. It is recommended that after having trained an AI-system which is incorporated in the software it should be validated by authorised parties and or certification processes and assessed with regards to safety, security and environmental performance and other relevant requirements. Non-Certified systems containing AI, shall not influence certified systems in a way it harms the certification. Following that process, the validated software may be deployed in vehicles of a vehicle type.

Data to be used for AI based system development
3. It is assumed that data protection and privacy regulations, and other legal requirements are fully respected. This document is without prejudice to existing market-specific legislations and regulations concerning how personal data is collected and used. Where such regulations exist, they contribute to the overall safety of the AI system through setting personal data management safety standards.

D. Principle for developing the global technical regulation

ECE/TRANS/180/Add.20 Global Technical Regulation on Electric Vehicle Safety (EVS) and Reference document with definitions of Automated Driving under WP.29 and the General Principles for developing a UN Regulation on automated vehicles*
This UN GTR addresses the unique safety risks posed by ADS and/or ADS vehicles , considering the following points:
(a)To ensure a safety level of ADS shall be higher than conventional human driver performance in order to ensure the safety benefit from ADS;
(b)it is desirable to organize them by level as well as by roadway type and to include the range of vehicle types (1: parking area; 2: motorway; 3: urban and interurban road, and both automated vehicles (i.e. existing vehicle classes) and low-speed shuttle buses, pod cars, etc (i.e. new classes of vehicles).
(c)To ensure ADS and/or ADS vehicles shall not cause traffic accidents or disrupt traffic.
(d)To ensure ADS and/or ADS vehicles Performance of the DDT under Nominal Traffic Scenarios
(e) To identify and assess the potential safety risks, depending on the scenarios relevant to the ODD of its features
(f) To be performance-based to the extent possible without disturbing future technology development;
(g) To be reasonable, practicable and effective;
(h) To develop and validate test procedures that are repeatable and reproducible,
(i) The ADS and/or ADS vehicles that avoid dangers caused by unpredictable traffic conditions (goods/luggage dropping, frozen road, etc.) or other drivers' illegal driving behaviors are not considered

25.
This UN GTR was developed to accommodate different types of vehicle certification processes. The following are examples of two primary systems used by Contracting Parties.

(,)

- **WP.29/2019/34/Rev.2 Revised Framework document on automated/autonomous vehicles**

4. Key issues and principles to be considered by WP29 subsidiary bodies as a priority**-**

9. the following is a list of common principles with brief descriptions and explanation. It is expected these would form the basis for further development.

(e) Operational Design Domain (ODD/OD)] (automated mode): For the assessment of the vehicle safety, the vehicle manufacturers should document the OD available on their vehicles and the functionality of the vehicle within the prescribed OD. The OD should describe the specific conditions under which the automated vehicle is intended to drive in the automated mode. The OD 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: Vehicle manufacturers should demonstrate a robust design and validation process based on a systems-engineering approach with the goal of designing automated driving systems 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 Automated Driving System (ADS), for the OEDR, but also for the overall vehicle design into which it is being integrated and when applicable, for the broader transportation ecosystem. Design and validation methods should demonstrate the behavioural competencies an Automated/autonomous 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/autonomous vehicle should be protected against cyber-attacks in accordance with established best practices for cyber vehicle physical systems. Vehicles 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 ersion control environment.

(h) Software updates: Vehicle 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/autonomous vehicles should have the function that collects and records 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/autonomous driving system and the status of the driver. The identification of differences between EDR and DSSAD to be determined.

(j) Vehicle maintenance and inspection: Vehicle safety of in-use vehicles should be ensured through measures such as related to maintenance and the inspection of automated vehicles etc. Additionally, vehicle 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/autonomous vehicle after repair.

(k) Consumer Education and Training: Vehicle 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.

- **WP.29/2024/39 Guidelines and recommendations for Automated Driving System safety requirements, assessments and test methods to inform regulatory development**

4. Overview of ADS safety requirements, assessment, and validation-

4.2.&4.3. Driving can be viewed as an exercise in risk management within the context of achieving strategic goals. An ADS must demonstrate the competency to operate the vehicles safely, to respond to external conditions, and to manage internal failures. Moreover, the ADS must be designed to ensure safe use and the safety of its users throughout the useful life of the vehicle.

- **WP.29/2022/58 New Assessment/Test Method for Automated Driving (NATM) Guidelines for Validating Automated Driving System (ADS)**

VI. Simulation/virtual testing–Pillar 1-

A. Types of simulation toolchain approaches**-**

40. In the short-term virtual testing may only be conducted using simulation toolchains developed and maintained by the ADS manufacturer. Since their design depends on the validation and verification strategies implemented by the manufacturer, it is recommended that simulation toolchains are not being subject to regulation or standardization at this time. Rather, simulation toolchains should be explained and documented by the ADS manufacturer and its suitability assessed during the certification process. For this reason, the output of the NATM related to virtual testing ensures that documentation and data provided by the manufacturer is consistent. Furthermore, virtual testing using modelling and simulation should be credible enough for an assessor to make sound decisions. Credibility is discussed further below.

IX. Audit–Pillar 4-

B. General guidance on the safety assessment of the ADS design-

3. ADS layout and schematics–

(f) Safety Concept and validation of the safety concept by the manufacturer-

97. The manufacturer should provide a statement which affirms that the ADS is free from unreasonable risks for the driver (if applicable), passengers and other road users.

X. In-service monitoring and reporting–Pillar 5-

A. General guidance on ISMR implementation-

132. The ADS' safety performance remains the responsibility of the manufacturer throughout its lifetime.

1. Self-Certification

1 It is the responsibility of a manufacturer of vehicles and/or items of motor vehicle equipment to certify that each motor vehicle and/or equipment item is in full compliance with the performance requirements of all applicable Federal Motor Vehicle Safety Standards (FMVSS). The FMVSS

specify test methods and conditions that would be used to assess compliance of a vehicle or motor vehicle equipment to applicable FMVSS. However, manufacturers may use alternative methods to certify their vehicles.
Manufacturers using alternative methods to certify their vehicles and equipment are responsible for ensuring that the vehicles and equipment would comply with the requirements of applicable FMVSS when evaluated by the methods specified in the FMVSS.
2
The manufacturer must not only be concerned with the initial certification, but should also monitor continued compliance of vehicles and/or items of motor vehicle equipment throughout the production run. The American government does not specify the type of quality control programme that a manufacturer should employ. That decision is left to the manufacturer. However, to accomplish this, an effective quality control program should be established to periodically inspect and test vehicles and/or items of motor vehicle equipment randomly selected from the assembly line to ensure that the original performance is carried through to all other units

2. Type Approval

A proposal for the Definitions of Automated Driving under WP.29 and the General Principles for developing a UN Regulation

The European Union approval scheme is based on the concept of 'type approval' and conformity of production where this process provides a mechanism for ensuring that a type of vehicle and its components meet the relevant environmental and safety requirements.

The type of vehicle and its components is required to be certified and approved by a designated national approval authority4 before it is offered for sale in a particular country (not necessarily the same country where type approval is obtained). This certification includes testing, certification, and production conformity assessment. Once approved, the whole vehicle can be sold throughout Europe Union (EU) with no further test approval needed. The manufacturer has to provide each vehicle with a declaration (certificate of conformity) that the vehicle complies with the approved vehicle type and the type-approval authority shall check the conformity of production.

3 In accordance with the provision of the 1958 Agreement which concerns the Adoption of Uniform Technical Prescriptions, an approval of parts and equipment of a vehicle issued by a designated national Approval Authority (can be non-EU) based on UN Regulations will be accepted in all EU member States and other Contracting Parties to the 1958 Agreement (e.g. Japan, Russian Federation) as an equivalent to domestic approval. Therefore, parts and equipment approved under UN Regulations are recognized for the EU approval of the whole vehicle.

1. (a) The control systems that intervening in case of emergency (AEB, ESC, Dead man, etc.) are not included in these definitions of automated driving;

(b) The control functions that avoid dangers caused by unpredictable traffic conditions (goods/luggage dropping, frozen road, etc.) or other drivers’ illegal driving behaviors are not considered in this table.

2. A UN Regulation on Automated Driving would need to have new specific

performance requirements and verification tests under various conditions as appropriate depending on each level.

3. In discussing system requirements, it is desirable to organize them by level as well as by roadway type and to include the range of vehicle types (1: parking area; 2: motorway; 3: urban and interurban road, and both automated vehicles (i.e. existing vehicle classes) and low-speed shuttle buses, pod cars, etc (i.e. new classes of vehicles).

4. The following table shows distinctive criteria of level of automated driving for the purpose of WP.29 activities to date, considering the results of discussions so far and the assumed use cases. This table should be reconsidered appropriately in accordance with each concept of automated driving system to be placed on the market in the future.....

- **WP.29/2024/39 Guidelines and recommendations for Automated Driving System safety requirements, assessments and test methods to inform regulatory development**

7. Requirements for safe interactions between Users and ADS\

7.2. For a safe use of the ADS by users who may need to take over control of the driving task from the ADS, it is necessary to provide correct information on the capabilities of the ADS to ensure that the user can develop a mental model that correctly reflects these capabilities. This information should be provided before and during with an ADS vehicle.

8. In-Service Monitoring and Reporting

8.1.2 In principle, ISMR is not a pre-deployment validation tool like the other methods presented above, but it can still (especially the monitoring part) be used to validate compliance with ADS requirements. ISMR is mainly designed to provide evidence of in-service safety performance of the ADS, to identify a drift or deviation from the demonstrated performance and to find areas where ADS fails, and not provide evidence that the requirement itself is validated pre-deployment as demonstrated by simulation, track testing and real-world testing.

- **WP.29/2022/57 Proposal for a second iteration of the New Assessment/Test Method for Automated Driving—Master Document**

V.	Scenarios Catalogue-

E. Maturity of the pillar-

58. Virtual testing will have strong relationships with all the pillars of the NATM. In particular: (c) Virtual testing will be a key element in the audit assessment. Results of virtual testing carried out both during vehicle development and in the verification and validation phase will represent an important element to be subject to audit. Manufacturers will need to provide evidence and documentation about how the virtual testing is carried out and how the underlying simulation toolchain has been validated.

X.	In-service monitoring and reporting-

B. Why should this pillar be included in the NATM?-

93. Whatever a safety evaluation is done before market introduction, the actual level of safety will only be confirmed once a sufficient number of vehicles is in the field and once they are subjected to a sufficient range of traffic and environmental conditions. It is therefore essential that a feedback loop (fleet monitoring) is in place to confirm the safety by design concept and the validation carried out by the manufacturer before market introduction. The operational experience feedback from in-use monitoring will allow ex-post evaluation of regulatory requirements and validation methods, providing indications on gaps and needs for review.

C. Strengths and weaknesses of the pillar-

100. Methods to verify the reliability of collected data should be developed. The data collected should be comparable amongst manufacturers. It will create challenges on which data and how these data are collected and reported (definition of suitable reporting criteria). Timewise, another challenge is the development of the in-service safety monitoring framework in a timely manner in order to serve AVs market deployment. Data privacy should also be taken into account. A standardized format for communication of information will be needed to allow processing by authorities in a standard manner and that any outcomes are easily shareable or open for analysis by other authorities. Different type of data may be needed depending on the purpose of the data collection.

- **WP.29-187-08 New Assessment/Test Method for Automated Driving (NATM) Guidelines for Validating Automated Driving System (ADS)–amendments to ECE/TRANS/WP.29/2022/58**

IX. Audit–Pillar 4-

59. It is recommended that the manufacturer is required to demonstrate that:

(a) Robust processes are in place to ensure safety throughout the vehicle lifecycle (development phase, production, but also operation on the road and decommissioning). This shall include taking the right measures to monitor the vehicle in the field and to take the right action when necessary;

(b) Hazard and risks relevant for the system have been identified and a consistent safety-by-design concept has been put in place to mitigate these risks; and

(c) The risk assessment and the safety- by-design concept have been validated through testing by the manufacturer to show that the vehicle meets the safety requirements before it is placed in the market. The vehicle should be free of unreasonable safety risks to the broader transport ecosystem, in particular, the driver, passengers and other road users.

A. General guidance on the audit of the manufacturer safety management system-

61. The purpose of the audit of the manufacturer's safety management system is to demonstrate that the manufacturer has robust processes to manage safety risks and to ensure safety throughout the ADS lifecycle (development phase, production, but also operation on the road and decommissioning). It should include taking the right measures to monitor the vehicle in the field and to take the right action when necessary.

3. ADS layout and schematics-

(k) Type of documentation to be provided-

123. It is recommended that the documentation package show that the "ADS":

(a) Is designed and was developed to operate in such a way that it is free from unreasonable risks for the driver (if applicable), passengers and other road users within the declared ODD and boundaries;

(b) Respects, under the performance requirements specified elsewhere by FRAV;

(c) Was developed according to the development process/method declared by the manufacturer.

- **WP.29/2023/44/Rev.1 New Assessment/Test Method for Automated Driving (NATM) Guidelines for Validating Automated Driving System (ADS)**

VI. Simulation/virtual testing – Pillar 1 -

A. Types of simulation toolchain approaches-

41. It is recommended that when validating the safety of the ADS, particular attention should be placed on the interaction between virtual testing and the other test methods. Virtual testing will have strong relationships with all the pillars of the NATM guidelines.

E. Technical rationale and justification

Section E.1 describes the technical justification for the deliberations on safety requirements for Automated Driving Systems (ADS).

Section E.2 describes the technical justification for validating the safety of ADS using the New Assessment/Test Method for Automated Driving (NATM).

1. Deliberations on safety requirements for ADS

The development of the requirements of this UN GTR involved extensive consideration of what an ADS is and how ADS relate to human roles in driving.

(a) Driving[1]

Driving is a complex activity with traffic laws and codes of behaviour based upon human cognitive strengths and weaknesses.

Driving involves three behavioural levels: strategic, tactical, and operational.

The strategic level concerns general trip planning such as determination of trip goals, the route to be used, the modal choice, and evaluation costs and risks associated with these decisions.

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 (e.g., on whether and when to overtake another vehicle), and executing the manoeuvre.

The operational level concerns vehicle-stabilisation capabilities (e.g., making micro-corrections to steering, braking, and accelerating to maintain lane position in traffic).

These behavioural levels relate to perception, information processing, and decision making under uncertainty. Driving can be considered an exercise in risk management within the context of achieving strategic goals. Drivers assess and respond in real time to perceived risks (including the behaviours of other road users) in the road environment.

The real-time tactical and operational functions required to operate a vehicle in on-road traffic are collectively known as the Dynamic Driving Task (DDT). As noted above, these functions may be performed within the context of strategic goals, but the DDT itself excludes such strategic functions. These functions may overlap or operate in combination such as in a tactical decision in response to road conditions to deviate from the original

[1] ECE/TRANS/WP.29/39 Annex 1 paragraph 5-9, 11-13, 16.

strategy to follow a particular route. Strategic decisions nonetheless may be made during a trip (for example, a decision to leave the motorway for lesser roads).

Although the DDT comprises several subtasks (sensing, cognitive processing, action), the DDT itself refers to performing the whole driving task within its Operational Design Domain (ODD). Within the ODD, the ADS or the driver performs the DDT. A system that cannot perform the entire DDT can only assist the driver's performance of the DDT.

The DDT cannot be apportioned between a driver and a driving system because these functions are interdependent and operate as a whole. Operational and tactical functions are inherent in monitoring the driving environment (object and event detection, recognition, classification, and response preparation) and in object and event response execution.

(b) Automated driving[2]

Unlike human drivers broadly licensed to operate a vehicle on all roadways under all conditions, ADS may be designed for specific purposes and to operate under specific conditions.
Safety requirements must account for the role(s) a user may have in the use of the ADS and/or ADS vehicle such as driver or passenger. These human-user roles may involve vehicle occupants, or they may be external to the vehicle.

Roles may change during the course of a trip. For example, in some configurations, a driver may activate the ADS while the vehicle is moving such that the ADS becomes the sole vehicle operator (i.e., performing the DDT within the ODD of the activated feature) and the driver shifts to the role of fallback user. For safety reasons, this fallback-user role might entail an obligation to remain receptive and responsive to ADS requests to assume control over the vehicle (i.e., to return to the role of driver). In other configurations, human occupants might not be expected to play any DDT-relevant role during the course of an entire trip.

The requirements specified in this document address misuse prevention and the safety of user interactions such as transitions of vehicle control.

The ADS requirements must address the diversity of driving conditions that may arise singly and in combination within the ODD.

In addition, the requirements must address ADS that may be designed to operate in more than one ODD. As long as the ADS safely performs the DDT within each ODD, there is no reason to limit the definition of sets of ADS capabilities designed to operate the vehicle under separate sets of ODD conditions.

For an ADS, the operational and tactical functions of the DDT can be logically grouped under three general categories:

· Sensing and Perception

ADS sensing and perception functions include monitoring the driving environment to achieve object and event detection, recognition, and classification. These functions include perceiving other vehicles and road users, the roadway and its fixtures, objects in the vehicle's driving environment, and relevant environmental conditions, including sensing ODD boundaries, if any, of the ADS feature and positional awareness relative to driving conditions.

· Planning and Decision

[2] ECE/TRANS/WP.29/39 Annex 1 paragraph 18, 20, 21, 24-26.

Planning and decision include anticipation and prediction of actions that other road users may take, response preparation, and manoeuvre planning.

· Control

Control refers to lateral and/or longitudinal motion control and enhancing vehicle conspicuity via lighting and signalling.

(c) Automated Driving Systems[3]

Based on the above, ADS need to be described in terms that cover the DDT (tactical and operational functions required to operate the vehicle in traffic) and the ODD (conditions under which such ADS capabilities are made available to a user).

In order to cover the diversity of ADS configurations, uses, and limitations on use, these recommendations define ADS in terms of functions and features.

ADS functions: DDT Performance Capabilities

ADS functions, in general, correspond to system-level capabilities integrated into the ADS design.

A function enables the ADS to perform one or more elements of the DDT (e.g., sensing the environment).

Functions represent the first level of safety that an ADS must fulfil. These functions correspond to essential capabilities without which an ADS cannot be deemed safe for use in traffic.

However, functions that enable performance of the DDT and capabilities that ensure safe use, including the safety of user interactions, have distinctly different objectives and requirements.

Safe ADS performance of the DDT

Requirements to ensure safe ADS performance of the DDT address the functional and behavioural objectives described by the WP.29 Framework Document on Automated Vehicles[4]: ADS operation shall not cause any traffic accidents resulting in property damage, injury, or death that are reasonably foreseeable and preventable.

The requirements specified in this UN GTR aim to ensure that each ADS is capable of performing the entire DDT to the extent necessary to operate the vehicle within the ODD of the ADS feature(s). Because the performance of tactical and operational functions is dependent on the prevailing traffic conditions, these DDT requirements specify that the ADS must demonstrate behavioural competencies across traffic scenarios covering its ODD. The behavioural competencies inherently require functional capabilities to perform the DDT.

By ensuring that an ADS will be subjected to traffic scenarios representative of what the ADS is reasonably likely to encounter in its ODD, the assessment of the behavioural competencies demonstrated by the ADS under those scenarios verifies the capability of the ADS to perform the entire DDT necessary to navigate its ODD.

[3] ECE/TRANS/WP.29/39 Annex 1 paragraph 27, 30, 32-37, 39-42, 50-53.

[4] ECE/TRANS/WP.29/2019/34/Rev.2

Additional ADS Capabilities: Safe use of ADS and ADS vehicles

In addition to DDT-specific functions, an ADS may require capabilities that contribute to ensuring the safe operational state of the ADS and/or preventing use when the ADS is not in a safe operational state.

ADS functions might also ensure the correct use of the ADS and safe interactions with a user such as in transitions of control.

Ensuring the safety of interactions between ADS and their users demands a human-centred focus on user needs, strengths, and weaknesses.

ADS features

An ADS feature refers to an application of ADS capabilities designed for use within a defined ODD. In the case of an ADS designed to operate within a single ODD, the ADS and the ADS feature are synonymous. Examples of ADS features are highway-only driving and automated parking.

Although an ADS performs the entire DDT on a sustained basis, an ADS may be designed to operate within more than one ODD.

Each set of ODD-specific capabilities has a unique set of constraints defining the conditions under which the ADS may be used.

ADS functions enable each ADS feature to operate the vehicle within the ODD of the feature. ADS functions may be used by more than one ADS feature and ADS features may use some or all of the ADS functions.

(d) Overview of ADS safety requirements[5]

Driving can be viewed as an exercise in risk management within the context of achieving strategic goals. An ADS must demonstrate the competency to operate the vehicle safely, to respond to external conditions, and to manage internal failures.

Moreover, the ADS must be designed to ensure safe use and the safety of its users throughout the useful life of the vehicle.

These requirements address the conditions an ADS might be expected to encounter via a framework for the development of traffic scenarios under which an ADS should be assessed. Establishment of scenarios depends primarily on analysis of the Operational Design Domain(s) (ODD) within which the ADS will operate.

The framework differentiates among nominal, critical, and failure scenarios. Nominal scenarios enable assessment of the ADS competency to operate the vehicle safely. Critical scenarios enable assessment of the ADS competency to manage conflicts and mitigate external risks. Failure scenarios enable assessment of the ADS competency to manage and respond to system failures.

2. Validating the safety of ADS using the NATM

The purpose of the NATM is to provide a framework for assessing an ADS and its ability to demonstrate safe behaviour when operating in the real world.[6]

Validating these capabilities is a highly complex task which cannot be done comprehensively nor effectively through one validation methodology alone. As a result, it

[5] ECE/TRANS/WP.29/39 paragraph 4.2-4.5.
[6] ECE/TRANS/WP.29/2022/57 IV. Paragraph 12.

is necessary to adopt a multi-pillar approach for the validation of ADS. This approach is comprised of the scenarios catalogue and five validation methodologies (pillars).[7]

These pillars are intended for use in combination(s) to produce an efficient, comprehensive, and coherent assessment of ADS compliance with the guidelines on safety performance. Each of the testing methodologies possesses its 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 above illustrates relationships across the ADS safety requirements, ODD analysis and scenario generation, and the validation pillars.[8]

(a) A scenario catalogue

It consists in descriptions of real-world driving situations that may occur during a given trip, will be a tool used by the NATM-pillars to validate the safety of an ADS.[9]

(b) Simulation/virtual Testing

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.[10]

(c) Track testing

It uses a closed-access testing ground with various scenario elements to test the capabilities and functioning of an ADS.[11]

(d) 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.[12]

(e) 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.[13]

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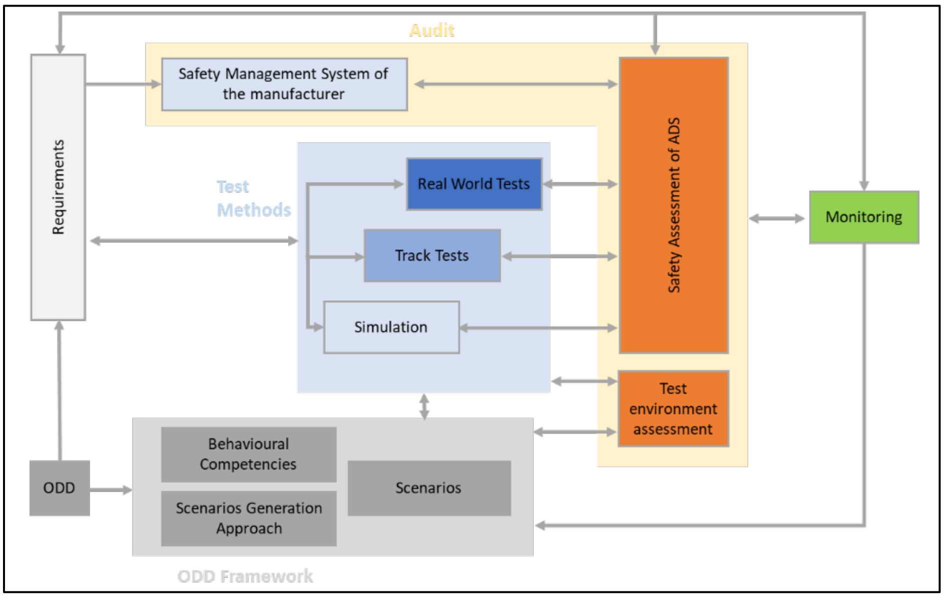
[7] ECE/TRANS/WP.29/2022/57 IV. Paragraph 13.
[8] ECE/TRANS/WP.29/39 paragraph 4.18.
[9] ECE/TRANS/WP.29/2022/57 IV. Paragraph 14.
[10] ECE/TRANS/WP.29/2022/57 IV. Paragraph 15.
[11] ECE/TRANS/WP.29/2022/57 IV. Paragraph 16.
[12] ECE/TRANS/WP.29/2022/57 IV. Paragraph 17.
[13] ECE/TRANS/WP.29/2022/57 IV. Paragraph 18.

(f) 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.[14]

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



F. Recommendations

x. //

G. Existing regulations, directives, and international voluntary standards

x. //

H. Benefits and costs

***<u>Feedback Guidelines</u>**: We believe that the potential benefits and drawbacks analysis might include, but not be limited to, technology, market, environment, regulatory implications, transportation modes, etc. We hope that members can provide content on these aspects from their respective organisational perspectives.*

1. At this stage of ADS development, there is now quantitative data to support a thorough cost-benefit analysis. With the accumulation of data from various deployments and testing, the GTR can begin to quantify both the costs and benefits of ADS regulation. As the goal remains to facilitate increased market penetration of ADS vehicles, the

[14] ECE/TRANS/WP.29/2022/57 IV. Paragraph 19.

available data allows for more accurate estimations of the potential rates and degrees of penetration, making a quantitative analysis both feasible and necessary.

2. The data collected by contracting party's Automated Driving Demonstration Zone showed, from the benefits perspective, the accident rate in automated driving mode for passenger vehicles is significantly lower than in manual driving. This year, the number of accidents per million kilometers for passenger cars in the demonstration zone is 7.83. In automated driving mode, there are 6.48 accidents per million kilometers, of which 2.48 are at-fault accidents. In manual driving mode, there are 19.95 accidents per million kilometers, with 12.77 being at-fault accidents. The number of accidents in automated driving mode is far lower than in manual driving. Among the companies participating, the best-performing company recorded zero at-fault accidents per million kilometers in automated driving mode.

From the costs perspective, automated driving can lead to slightly lower traffic efficiency during peak hours. The study conducted in contracting party's Automated Driving Demonstration Zone on the traffic efficiency of automated vehicles showed that the current average daily speed of automated vehicles is about 24 km/h, with the highest-performing company reaching 29 km/h. During morning and evening rush hours, the average speed is around 20 km/h, with the best company reaching 23 km/h. Real-world tests on automated vehicle traffic efficiency during peak hours indicate that the best-performing company only required 2.28% more travel time compared to manual driving, while the less efficient companies required 23.05% more time. On average, automated vehicles took about 10% longer than human drivers. Analysis suggests that in complex traffic scenarios, issues such as overly long following distances, unreasonable lane selection, and suboptimal route planning in automated vehicles negatively impact traffic efficiency.

3. 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, requiring a deeper examination to ensure comprehensive regulation. By combining both quantitative and qualitative analyses, the GTR can better inform decision-making and optimize the benefits of ADS technology.

3. Some costs might occur from greater market penetration of ADS vehicles. For example, building the infrastructure required to safely operate ADS vehicles might entail significant investment costs for the private and public sectors, depending on the country. Especially in the early years of ADS vehicle sales, individual purchasers, as well as manufacturers of ADS vehicles, are also likely to face greater costs than purchasers and manufacturers of conventional, non-automated vehicles. However, such costs incurred would essentially be voluntary as a market choice.

4. While some costs might occur, the contracting parties believe that the benefits of the GTR are likely to greatly outweigh costs. Widespread use of ADS vehicles, with the establishment of the necessary infrastructure, is anticipated to reduce the number of fatal and serious traffic accidents and to improve the waste of driving time and driving fatigue for ordinary users significantly. At the same time, emissions are expected to be reduced and traffic flow to be enhanced due to a conservative, predictable and considerate driving behaviour of ADS vehicles. It shall be noted that those benefits could be obscured by an increase of mobility and mileage. At the same time, however, the equal ability of all parts of society to be mobile must be seen as a major achievement of vehicle automation. The GTR might also speed up market penetration of conventional vehicles with traffic safety-related driver-assistance systems due to decreases in the associated sensor and technology costs or by benefiting from infrastructure elements, initially installed for ADS vehicle operation. Although not covered by this GTR, the GTR might create benefits in terms of the standardisation of traffic rules. The GTR might also increase vehicle safety in general

by enhancing the capabilities of using virtual methods in the process of vehicle certification and by improving software and hardware safety design, especially those that can be used together for driver assistance systems and automated driving systems..

5. The contracting parties have also not been able to estimate net employment impacts of the GTR. The new market for innovative design and technologies associated with ADS vehicles might create significant employment benefits for those countries with ties to ADS vehicle production and associated technologies. On the other hand, employment losses associated with the lower production of conventional vehicles and in the professional driving sector could offset those gains. The building and retrofitting of infrastructure needed to support the introduction of ADS vehicles might generate net additions to the job market.

II. Text of Regulation

To be prepared by the IWG on ADS

Annex 1 - Appendix