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**Informal paper on remote driving**

**Situations when a driver operates a vehicle from the outside of the vehicle**

**Submitted by the United Kingdom of Great Britain and Northern Ireland**

This document, submitted by the United Kingdom, provides a discussion paper on remote driving and it replaces the “Proposed Draft Resolution on Remote Driving” (submitted as ECE/TRANS/WP.1/2019/2 by the UK).

## I. Scope

1. The scope of this paper is derived from the definition of ‘Remote Driving’ in SAE International’s Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles revised in April 2021. However, for the purpose of the discussion in this paper, we are only considering the situation where full dynamic control of the vehicle is performed by a remote driver. This can be defined as the ***Real-time performance of all the Dynamic Driving Task (DDT) and/or DDT fallback (including, real-time braking, steering, acceleration, and transmission shifting), by a remote driver.***
2. Owing to the demands of undertaking all of the DDT, this paper only considers instances where the remote driver is in control of a single vehicle at any time. While acknowledging technology enabling a remote operator to safely control more than one vehicle is under development (particularly with use of Automated Driving Systems, ADS), this paper does not cover those scenarios. However, in the annex to this paper, there is greater detail on possible scenarios for remotely facilitating driving, where a remote operator may provide support, monitoring or assistance to more than one vehicle at a time. This serves to acknowledge broader use cases beyond the scope of the paper.

## II. Background

3. Remote driving systems have considerable potential as they can provide new capabilities for multiple applications: they can be used to provide services, provide flexibility in safety-critical situations, or may provide a tool for the development of ADS. The technology is in use and being developed.
4. The role of the driver is paramount in road safety and has been continually evolving with motoring technology, including connectivity. Although the 1949 and 1968 Conventions on Road Traffic set out the role and obligations of the driver, neither convention specifies the location of the driver.
5. Discussions at the 75<sup>th</sup> UNECE/WP.1 session on remote-control parking functionality saw contracting parties to both the 1949 and the 1968 Conventions deem that the use of a remote-control parking device used by a driver outside of their vehicle “does not endanger road safety” provided that the system conforms with the UNECE technical regulations. At the same session, WP.1 agreed to immediately work to address the issue of a driver operating a vehicle from the outside (other than remote control parking). Through IGEAD, parties developed a discussion paper which was submitted to the 78<sup>th</sup> Session of WP.1 but not discussed; to progress the discussion, the UK submitted a draft resolution on remote driving as a formal paper for the 79<sup>th</sup> WP.1 session. However, there has not been enough time at WP.1 meetings to consider the draft resolution in detail and we felt that it would be more helpful to revert to an informal paper setting out principles for how remote driving can be performed safely and in compliance with the 1949 and 1968 Conventions.

## III. Requirements for remote driving systems

6. To safeguard road safety, any remote driving system should at the minimum:
  - a. Allow the remote driver to have an appropriate field of view, and to receive appropriate auditory information (recognizing that auditory information may not be essential); and supplement this information with additional cues (haptic, auditory or visual) to alert the driver to high risk situations.
  - b. Present information to the remote driver which provides appropriate situational awareness for the task they need to perform, and accurate feedback on how the vehicle is responding to their commands.
  - c. Provide relevant information to the driver on the state of the vehicle, including failures, errors and vehicle/ passenger load.
  - d. Allow the remote driver to give appropriate and timely input to dynamically control the vehicle and allow the vehicle to react to that input in an appropriate and timely manner.

- e. Have strategies to minimize the risk of signal loss and/or degradation, such as redundancy in sensing and connectivity.
  - f. Have a consistency in transmission to address variability in time lag.
  - g. Be secure by design, including consideration of operational resilience and response in the event of cyberattacks, to ensure that they can survive particular types of attack at fleet level, and prevent potential malicious use.
  - h. Meet appropriate technical standards and should be tested against these.
  - i. Enable the remote driver to adjust the workstation, to ensure it is comfortable and adapted to their needs.
7. A vehicle with a remote driving system should have the ability to reach a minimum risk condition any time a trip cannot or should not be completed, such as when:
- a. The remote driver does not, or cannot, provide appropriate and timely input and the vehicle is unable to react in an appropriate and timely manner (cannot undertake the DDT).
  - b. The latency of the connection between the remote driver and vehicle has exceeded safety tolerances.
  - c. The connection between the remote driver and the vehicle fails or is degraded.
8. The following requirements on the remote driving system apply when carrying passengers within the vehicle:
- a. It must provide passengers with solutions to communicate and request emergency stops as well as regular stop requests.
  - b. It must provide the ability to properly communicate any unexpected events, including any remote driver initiated trip interruptions, to avoid passenger confusion.
  - c. It must provide HMI solutions and protocols between passengers and remote drivers to support communication and interaction for both daily and emergency operation. These should be designed inclusively, including for people who cannot see a visual display screen or hear audible announcements, for people with limited dexterity or reach, and for those with impaired cognition.
  - d. It must have mechanisms to deal with any medical emergencies and crashes as these pose the most serious safety concern, are time critical, require accurate perception, comprehension, and an effective response. These incidents will require stopping, securing the vehicle, attending the injured, coordinating passenger emergency exit and on-board communication with dispatch and emergency crew. This complex coordinated response may require the input of multiple remote drivers. This should apply even when passengers are not in the remotely driven vehicle itself, for example in instances where the vehicle injures another road user.

#### IV. Remote Driver

9. To enable the safe deployment of remote driving, the remote driver must:
- a. Have the physical and mental capabilities to exercise dynamic control if they are:
    - i. in control of a non-automated vehicle including those with driver assistance systems,
    - ii. required to resume dynamic control of a conditionally automated vehicle as the safety fallback for the ADS, or
    - iii. expected to resume dynamic control of a highly automated vehicle if the journey continues beyond the parameters of the vehicle's operational design domain.
  - b. Hold the appropriate licences to use and operate the vehicle, in the country where the vehicle is driven
  - c. Be ready and able to exercise dynamic control and should minimise any other activity that would restrict or impair their ability to resume dynamic control.
  - d. Be able to remotely activate and de-activate the ADS when driving automated vehicles.
10. To safeguard the transport of passengers in a remotely driven vehicle, the remote driver must:

- a. Be aware of any passengers inside the vehicle which they are operating. This includes how many passengers and if any children are on board.
- b. Meet their legal requirements regarding use of seat belts by passengers.
- c. Ensure that the vehicle is a safe environment for its passengers, including preventing theft of the vehicle.
- d. Ensure that all waiting passengers have boarded before closing the doors, or otherwise verify that the doors have been closed.
- e. Ensure that passengers are safely seated or in an appropriate standing position (where the vehicle allows, for example on buses), before moving the vehicle.
- f. Support disabled passengers to use the vehicle confidently, comfortably, and safely, including by operating accessibility equipment, providing remote assistance, and by communicating audibly and visibly to passengers waiting for and travelling on the vehicle regarding its route and location.
- g. Ensure that the number of passengers/ vehicle load on the vehicle does not exceed its limit.
- h. Ensure that cargo, luggage, and passenger possessions are secured to prevent them from coming loose and posing a safety risk.
- i. Comply with any other relevant domestic requirements set by contracting parties.

#### **V. Requirements for service providers**

11. Where remote driving is provided as a service, the remote driver may be an employee of the service provider and some responsibilities fall to the employer, rather than the remote driver. In such cases, the service provider must:
  - a. Ensure that the attention of the remote driver is managed safely, and that adequate breaks are built into their schedules.
  - b. Ensure that the workload of the remote driver is managed appropriately, including through the allocation of jobs.
  - c. Consider the appropriateness of health checks for remote drivers, as is the case already for other safety critical shift work.
  - d. Ensure planned and careful execution of transfers of control, where handovers occur at break times and at the end of shifts.
  - e. Ensure that all remote drivers are adequately trained to undertake the task under the specific system and conditions used.
  - f. Ensure that remote drivers hold the appropriate licences (for example a valid licence for the territory in which the vehicle will be deployed).
  - g. Ensure the technology and machinery used are properly maintained.
  - h. Have a clear identification of who is remotely driving the vehicle at any given time.
  - i. Address the diverse needs of vehicle occupants, including those who are disabled, by ensuring that the service is provided inclusively, including complying with domestic accessibility requirements, and incorporating features on vehicles to mitigate the absence of staff providing direct assistance.
  - j. Consider the need for a backup connection system.
  - k. Consider the need for a safety case for each specific application of remote driving.

#### **VI. Requirements for the developer/ manufacturer**

12. To safeguard road safety, the developer or manufacturer of a remote driving system and/or vehicle must:
  - a. Ensure that systems are designed to reduce the effects of motion sickness, information overload and change blindness (where a remote driver may fail to detect relatively large changes in visual scene).
  - b. Ensure that the remote driving system complies with requirements in the section of this paper entitled “Requirements for remote driving systems”, and those set in domestic legislation and rules.
  - c. Ensure appropriate software updates are made available to the system to maintain safety.
  - d. Consider the need for mechanisms to monitor remote driver attentiveness and performance.

#### **VII. Passengers in vehicle driven remotely**

13. Passengers inside a vehicle being remotely driven, must comply with rules on passengers set in applicable international and domestic legislation relating to road vehicles.

#### **VIII. Final considerations**

14. The driver definitions in the 1949 and 1968 conventions do not preclude a driver from being located outside of the vehicle. The principles contained in this paper are designed to fulfill the requirements from both conventions, including those stemming from Article 8. Furthermore, providing that the above principles are addressed, a combination of the remote driver and vehicle will be able to safely exercise the DDT.
15. We are aware that the location of the remote driver and whether this is inside or outside of the jurisdiction in which the vehicle is driven, has implications on the enforcement of traffic laws against remote drivers, including seizing the vehicle and banning the remote driver from operating on a country's roads. Parties may wish to consider how to address these issues.

**IX. Annex A: Scenarios for Remotely Facilitating Driving**

16. This paper focused on instances where the remote driver has full tactical control of the vehicle to establish principles for safe deployment of remote driving. However, we acknowledge that as technologies develop, remote driving may be performed in a range of different scenarios, including some in conjunction with ADS. In this annex, some examples are provided of these scenarios.
17. The scenarios listed below include situations where a remote operator has a more limited role, such as support and assistance - particularly in association with vehicle automation. Exploring these scenarios with regards to remote driving will require a consideration of the roles of the driver, which is one of the topics of interest for future work identified in Informal Paper 9 of the 82<sup>nd</sup> WP.1 meeting in March 2021. For this reason, the current paper did not attempt to address each of the scenarios.
18. Remote Support
  - a. Operator has no line of sight to the vehicle; technology is required to see vehicle and surroundings.
  - b. Operator provides guidance to the driver and passengers
  - c. The operator is responsible for user and vehicle status monitoring, summoning assistance and managing breakdowns
  - d. Operator has no ability to affect vehicle action; the DDT is undertaken by the driver or an ADS.
  - e. Where there is no driver in the vehicle and the DDT is being undertaken by an ADS, remote support extends to some driver responsibilities, including communicating vehicle and insurance information to relevant road users and law enforcement after an incident.
19. Remote Assistance (Strategic)
  - a. Operator has no line of sight to the vehicle; technology is required to see vehicle and surroundings.
  - b. Operator provides the strategic elements of the driving task only
  - c. Operator has no tactical control of vehicle manoeuvres
  - d. Operator is not expected to have situational awareness
  - e. Where there is no driver in the vehicle and the DDT is being undertaken by an ADS, remote assistance extends to some driver responsibilities, including communicating vehicle and insurance information to relevant road users and law enforcement after an incident.
20. Remote Assistance (Strategic/Tactical)
  - a. Operator has no line of sight to the vehicle, technology required to see vehicle and surroundings.
  - b. Operator provides strategic and tactical elements of DDT
  - c. Operator may be responsible for determining vehicle manoeuvres throughout the journey, including object/event recognition and response planning
  - d. Operator has no direct longitudinal or lateral control, acceleration or deceleration, but can instruct an ADS to perform specific manoeuvres.
  - e. Where there is no driver in the vehicle and the DDT is being undertaken by an ADS, remote assistance extends to some driver responsibilities, including communicating vehicle and insurance information to relevant road users and law enforcement after an incident.
21. Remote Controlling
  - a. Operator must have direct line of sight of the vehicle (and its path), which operates only at low speed
  - b. The driver can perform from limited commands up to all the DDT
  - c. This includes the use of applications such as remote control parking.