Distr.: General
19 September 2022

Original: English

Economic Commission for Europe

Inland Transport Committee

Global Forum for Road Traffic Safety

Eighty-fifth session
Geneva, 19-23 September 2022
Item 3 (c) (ii) of the provisional agenda

Automated driving

Submitted by the United Kingdom

This document revises Informal document 1 (September 2021). It concerns situations where dynamic control of the vehicle is performed by a remote driver.

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

I. Scope

1. The scope of this paper concerns situations where full dynamic control of the vehicle is performed by a remote driver. This can be defined as the ***performance of all the Dynamic Driving Task (DDT) (including braking, steering, acceleration, and transmission shifting), by a remote driver.*** This can also be referred to as full tactical and operational control.

2. Owing to the demands of undertaking all of the DDT, this paper only envisages situations where the remote driver will be controlling only a single vehicle at any time.

3. It is acknowledged that there is technology under development which enables a remote driver to exercise dynamic control of more than one vehicle at a time (namely where there is either platooning, or delegation of the dynamic driving task to an automated driving system (ADS). The role of the driver in those circumstances is not discussed in the current paper, but will be worth exploring either as this paper evolves, or in a separate paper.

4. In the annex to this paper, there is greater detail on possible roles for remote drivers, who may perform a more limited form of remote driving than the full dynamic driving task, and to more than one vehicle at a time. This serves to acknowledge broader scenarios and corresponding use cases beyond the scope of the current paper, with an emphasis on how these technologies can aid fully automated vehicles without a human driver.

II. Background

5. Remote driving systems have considerable potential as they can provide new capabilities for multiple applications: they can be used to provide services, provide solutions for dealing with safety-critical situations (e.g., incapacitated driver in the vehicle), or may provide a tool for the development of an ADS.

6. 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. Article 13 of the 1968 Convention points out that the driver must "be at all times in a position to perform all manoeuvres required of him", in a context which is focused on functionality of control: The driver must control the vehicle so as to be in a position to perform all manoeuvres required.

7. Discussions at the 75th 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 the informal group of experts on automated driving (IGEAD), parties developed a discussion paper which was submitted to the 78th 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 79th 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.

8. There is a need to take account of relevant scientific evidence when regulating and introducing new technologies. Technology for remote driving is entering trialling and commercial deployment, so it seems timely to develop guidelines in order to promote road safety.

9. It is important to note that like other types of vehicle technology such as automation, the operational design domain (ODD) for remote driving is a key consideration. Application in off-road sites such as in mining operations and ports have been performed safely because they are

controlled environments, often considerably less complex than road traffic. More complicated ODDs pose a greater challenge to the technologies.

10. In the discussions at the 21st meeting of IGEAD, participants signaled that further discussion of the wider use cases for remotely facilitating driving would be useful. The new version of this paper and annex aims to fulfill this request.

III. Remote driving in conventional and automated vehicles

11. Remote driving (full tactical and operational control) may be used in any of the below scenarios for conventional and automated vehicles.
    a. For exercising dynamic control of non-automated vehicles, including those with driver assistance systems; or
    b. When a driver is requested by an automated vehicle to exercise dynamic control, or;
    c. When a driver is expected to exercise dynamic control of an automated vehicle if the journey continues beyond the parameters of the vehicle's operational design domain, or;
    d. In any other situation where taking dynamic control of the vehicle is required or desirable.

12. Indeed, full automation and remote driving technologies may be used together, even when not required by either system.

13. Use of automated vehicles in road traffic should fulfill the requirements set out in the 2018 resolution on the deployment of highly and fully automated vehicles in road traffic, and in the 2022 resolution on safety considerations for activities other than driving undertaken by drivers when automated driving systems issuing transition demands exercise dynamic control

IV. Requirements for remote driving systems

14. Development of technical standards to meet the functional requirements set out in this section to ensure that remote driving can be safely performed in real time may require collaboration between WP.1, WP.29 and their respective groups.

15. To safeguard road safety, any remote driving system should at the minimum:

    a. Allow the remote driver to have an appropriate field of view of sufficient resolution and clarity, 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 enable 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, including considering the demands placed on bandwidth.
    f. Have strategies to reduce the effects of the remote driver suffering motion sickness, information overload and change blindness (where that remote driver may fail to detect relatively large changes in visual scene).
    g. Have a consistency in data transmission to address variability in latency or time lag.
    h. Be designed to operate only where signal (audio, video, commands) transmission times are shorter than a specified safety threshold between the technical equipment for remote driving located in the motor vehicle and the technical equipment for remote driving located outside the motor vehicle.
    i. Be designed to operate only in compliance with operational or technical safety measures to mitigate the risks arising from transmission times of signals in the higher range of the maximum permitted transmission time (e.g., maximum safety speed for the transmission time, braking and stopping distances, projected pathway).

j. Be IT-secure by design, using state of the art technologies and standards, 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.
k. Meet appropriate technical standards and be tested against these.
l. Be capable of continuous self-monitoring to ensure that all systems relevant to the remote driving function are operating correctly.
m. Enable the remote driver to adjust the workstation, to ensure it is comfortable and adapted to their needs.

16. A vehicle with a remote driving system should have the ability to reach a suitably safe 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 or the vehicle is unable to react in an appropriate and timely manner (i.e. neither the remote driver nor the vehicle can exercise dynamic control).
    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, or the safety of the system is compromised.
    d. An ADS cannot take over dynamic control and perform it on a sustained basis.

17. The minimum risk condition that the remote driving system is required to reach will depend on whether an ADS is capable of safely taking over the dynamic driving task to continue the journey.

18. The following requirements on the remote driving system apply when carrying passengers within the vehicle:

    a. It must provide passengers with solutions for them to 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 human-machine interface (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 be fitted with mechanism to prevent passengers from interfering with vehicle controls while the remote driving function is activated; except for the use of emergency systems (such as emergency stop).

19. A remote driving system must have mechanisms to deal with medical emergencies and crashes involving the remotely driven vehicle, 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.

V. Remote Driver

20. To enable the safe deployment of remote driving, the remote driver must:

    a. Have the physical and mental capabilities, and the competence, to undertake remote driving and to exercise dynamic control in the scenarios listed in the section entitled “Remote driving in conventional and automated vehicles” and those set in domestic legislation and rules (including the possibility of health checks as a condition for insurance and special licence for remote driving if required in domestic legislation).

b. Hold the appropriate licences to use and operate the vehicle, in the country where the vehicle is driven, and where required in domestic legislation a special licence for remote driving.
c. Be ready and able to exercise dynamic control when required and minimise any other activity that would restrict or impair their ability to take dynamic control.
d. Be able to remotely activate and de-activate the ADS in an automated vehicle.
e. Be able to remotely activate and de-activate the remote driving function.

21. To safeguard the transport of passengers or freight 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. Ensure that the vehicle is a safe environment for its passengers, including monitoring the vehicle to prevent theft.
c. Ensure that all waiting passengers have boarded before closing the doors, or otherwise verify that the doors have been closed.
d. Ensure that passengers are in an appropriate standing position (where the vehicle allows, for example on buses), or safely seated and wearing seat belts where legally required, before moving the vehicle.
e. 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.
f. Be adequately trained and able to communicate with passengers, other road users and emergency services following an incident.
g. Ensure that the number of passengers / vehicle load on the vehicle does not exceed its limit.
h. Monitor cargo and luggage to ensure that they 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.
j. Comply with relevant domestic and international rules for the transport of freight.

VI. Requirements for service providers

22. Where remote driving is provided as a service, the service provider takes the following responsibilities for remote driving, instead of the remote driver, except where they are both the same legal entity:

a. Bear ex ante responsibility to support and supervise the remote driver to meet the requirements imposed on them set out in part V above.
b. Bear ex post responsibility for the actions of the vehicle where they are due to a failure in meeting the requirements of the system set out in part IV above.
c. Ensure that the attention of the remote driver is managed safely, and that adequate breaks are built into their schedules.
d. Ensure that the workload of the remote driver is managed appropriately, including through the allocation of jobs.
e. Consider the appropriateness (including insurance and legal requirements) of health checks for remote drivers, as is the case already for other safety critical shift work.
f. Ensure planned and careful execution of transfers of control, where handovers occur at break times and at the end of shifts.
g. Ensure that all remote drivers are adequately trained (in compliance with domestic requirements where applicable) to undertake the task under the specific remote driving system and conditions used.
h. Ensure that remote drivers hold the appropriate licences (for example a valid licence for the territory in which the vehicle will be deployed).
i. Ensure the technology and machinery used are properly maintained, including ensuring that the vehicle is roadworthy.
j. Have a clear identification of who is remotely driving the vehicle at any given time.
k. 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.

l. Consider the need for a backup connection system.

m. Consider the need for a safety case for each specific application of remote driving.

VII. Requirements for the developer / manufacturer

23. To safeguard road safety, the developer or manufacturer of a remote driving system and/or vehicle must:

    a. Bear responsibility for the vehicle meeting the requirements set out in the section of this paper entitled "Requirements for remote driving systems", and those set in domestic legislation and rules.
    b. Ensure that the design of the human machine interface is based on a proper assessment of human need and limitations.
    c. Ensure that the remote driving system fosters safe interaction with other road users, including vulnerable road users and cyclists.
    d. Ensure appropriate software updates are made available to the system to maintain safety and security.
    e. Consider the need for mechanisms to monitor remote driver attentiveness and performance.
    f. Consider the need for consumer awareness and understanding of remotely driven vehicles, including the accurate depiction of the capabilities and limitations of the technology in vehicle marketing.

VIII. Passengers in vehicle driven remotely

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

IX. Final considerations

25. 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.

26. We are aware that the location of the remote driver, and the question of whether they physically operate inside or outside of the jurisdiction in which the vehicle is driven, has implications on the enforcement of traffic laws against remote drivers. Parties may wish to consider how to address these issues.

27. Noting that at this stage very little evidence on the safety of remote driving exists, limited, careful and controlled deployments could be permitted to collect necessary evidence and further data regarding the technologies. Contracting parties should consider the need for convincing evidence of safety before remote driving is permitted.

Annex A: Scenarios for Remotely Facilitating Driving

28. The above paragraphs focus 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.

29. The scenarios listed below include situations where a remote driver has a more limited role than when performing the full dynamic driving task, such as support and assistance - particularly in association with vehicle automation which represents an increasingly important set of use cases. This is especially true for remote facilitating driving in fully automated vehicles (as defined by the 2018 resolution on highly and fully automated vehicles) where any humans in the vehicle will be passengers only. The real-world application of these technologies together could help facilitate publicly and commercially valuable endeavors such automated passenger services or for freight and logistics. These tend to have predefined routes or areas of operation and require remote assistance in order to maintain safety and ensure traffic flow

30. 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 82nd WP.1 meeting in March 2021. For this reason, the above paragraphs of this paper did not attempt to address each of the scenarios.

31. Remote Support
    a. Operator has no direct 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. Possible use case: 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.
    f. Possible use case: Where there is a driver in the vehicle, they may receive initial advice and diagnostics from a breakdown company to better manage a vehicle fault and navigate to safety.

32. Remote Assistance (Strategic)
    a. Operator has no direct 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 (e.g., destination, roads to avoid);
    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.
    f. Possible use case: Passenger or freight services in fully automated vehicles.

33. Remote Assistance (Strategic/Tactical)
    a. Operator has no direct line of sight to the vehicle, technology is required to see vehicle and surroundings;
    b. Operator provides mostly strategic and occasional tactical elements of DDT;
    c. Operator has no direct longitudinal or lateral control, acceleration or deceleration, but can instruct an ADS to perform specific manoeuvres;
    d. Operator may be responsible for determining vehicle manoeuvres throughout the journey, e.g. in response to objects or events which the ADS is incapable or responding to;

e. And 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.
f. Possible use case: Automated passenger services operators, for example small buses with pre-defined routes.

34. Remote Driving (Line of sight)
    a. Driver 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. Possible use case: Parking within line of sight.

35. Remote Driving (No line of sight, already covered in the paper)
    a. Driver has no direct line of sight to the vehicle, technology required to see vehicle and surroundings
    b. Driver provides all of DDT including full tactical control
    c. Driver performs other requirements for the remote driver covered in the paper
    d. Possible use case: Complex road traffic situations that exceed the capability of an ADS, or where an ADS has suffered failure and a vehicle needed recovery.