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Convention on Road Traffic (1968)

Automated driving

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

Submitted by Finland, Germany, and the United Kingdom*

This document revises Informal document 1/Rev.1 (September 2021) discussed by WP.1 in September 2022. It concerns situations where dynamic control of the vehicle is performed by a remote driver. The Global Forum will be invited to discuss it.

*Reproduced as received.

Safe operation of a vehicle by a driver outside of the vehicle – "the concept of remote driving"

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I. Introduction to the general concept

Remote driving refers to the concept that a human located outside of a vehicle is driving the vehicle. The human may do so by a control station (workstation) or other means of remote controlling the vehicle.

Remote driving as such differs from:

- the conventional driving concept where a suitably qualified and trained human is located inside a vehicle while driving the vehicle (conventional driving concept), or
- the concept of an automated driving system (ADS) exerting full dynamic control of the vehicle (automated driving concept) via onboard control systems.

Remote driving thus represents an additional concept of driving.

Remote driving enables new models of mobility by having an externally located human take responsibility for the driving task instead of either:

1. the human driver in the vehicle or;
2. the automated driving system of the vehicle.

Remote driving also differs conceptually from where a human oversees and supports the operation of an ADS that is driving the vehicle (i.e. the human supervises or surveils the vehicle without performing any part of the dynamic driving task, including real-time safety-critical intervention).

Current UNECE road safety conventions focus on the conventional driving concept. A convention addressing the automated driving concept is currently being discussed.

This paper focuses on the remote driving concept and aims to point out the issues concerning WP.1, arising from the ongoing implementation of remote driving on public roads. These relate to the WP.1 competences of safe traffic integration, international legal framework for road traffic, driver education and training, licencing and permits.

The concept of remote management in the context of automated vehicles is explored in the paper entitled 'Remote management of automated vehicles'.

II. Situations where remote driving may occur, including the interaction between remote and automated driving

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 to exercise dynamic control of an automated vehicle that can issue transition demands. The driver should however not be a backup for ensuring road safety; the transition of control must enable the remote driver to gain sufficient situational awareness, and the system must be able to bring the vehicle to a safe condition if the human does not take dynamic control, or;
c. In any other situation where taking dynamic control of the vehicle is required or desirable.

Indeed, full automation and remote driving technologies may be used together, even when not required by either system. Use of automated vehicles in road traffic should fulfil 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.

*Remote Driving is not Automated Driving.

III. Motivation

In order to develop safe and sustainable traffic, new mobility models and driving concepts have been discussed and developed in the last decade. Numerous automated driving systems are being developed and tested in many countries. Also, remote driving concepts have been developed and tested.

While there are many outstanding safety questions associated with the technology, remote driving has considerable potential as the technology enables:

- Decoupling of the driver and vehicle to significantly increase the efficiency of personnel deployed in non-automated vehicles. For example, in the optimization of shared vehicles fleets.
- Increasing the range and operational domain of automated vehicles, by switching over from the automated driving system in the vehicle to the remote driver when the boundaries of the system's operational design domain are reached.

As in the conventional driving concept, the role of the driver is paramount to road safety in remote driving. 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 be in a position to perform all manoeuvres as required to control the vehicle.

Remote driving brings a distinct set of opportunities and challenges to road traffic, their regulators, drivers and other road users. This paper seeks to explore the safety challenges posed by remote driving in order to support its development and safe deployment in road traffic.

IV. Scope

The scope of this paper concerns situations where dynamic control of the vehicle is performed remotely by a human driver (the remote driver) not in direct line of sight of the vehicle and its path. Dynamic control can be defined as "Real-time performance of part or all of the Dynamic Driving Task, DDT, (including for example braking, steering, acceleration, and transmission shifting), by a remote driver. This can also be described as full tactical and operational control." (Adapted from SAE-J3016, BSI).

Owing to the safety concerns of a remote driver performing the DDT on more than one vehicle simultaneously, this paper only envisages situations where the remote driver will be controlling only a single vehicle at any given time.

This paper lays out preliminary considerations and is intended to inspire discussion. Such discussion is needed to support harmonization of approaches for facilitating the safe deployment of remote driving in road traffic

V. General considerations

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 to promote the performance of remote driving which is safe and in compliance with the 1949 and 1968 Conventions.

Noting that at this stage limited evidence on the safety of remote driving exists, careful and controlled trials, including those to examine potential commercial use cases may serve to collect necessary evidence and further data to support their safe use. Contracting parties should consider the need for convincing evidence of safety before remote driving is permitted. An approach which gradually introduces complexity and risk into trialling and as appropriate, market deployment may help enable this.

There is a need to take account of relevant scientific evidence to inform the development of policies and safety regulations for new technologies. Technologies for remote driving are entering trialling and small scale commercial deployment as the technology continues to be refined and commercial use cases are tested, so it seems timely to develop guidelines in order to promote road safety.

Not discussed in the main paper is a scenario in which a human driver provides the full DDT while having direct line of sight of the vehicle and its surroundings. However, to facilitate future discussions, this scenario shall be defined as follows:

a. Driver must have direct line of sight of the vehicle (and its path) without the need for technology to have situational awareness;
b. The driver can perform from limited commands up to all the DDT within line of sight;

VI. Safety considerations

The following aspects need to be considered in order to elaborate on the safe deployment of remote driving in road traffic:

A. The operational design domain of the remotely driven vehicle
B. The capabilities and obligation of the remote driver
C. The considerations of the operator (company) of remotely driven vehicles (if different from the driver)†
D. The considerations of the system manufacturer†

The technological aspects of the systems implemented shall not be considered here because they tend to fall under the jurisdiction of the UNECE World Forum for Harmonization of Vehicle Regulations (WP.29). However, they may be touched upon for clarification purposes.

†The responsibilities mentioned under C and D should be clarified between the service operator and system manufacturer when they are jointly responsible for the safe operation of the remote driving system.

A. Operational Design Domain of the remotely driven vehicle

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 and other public places where there is traffic interaction. More complicated ODDs pose a greater challenge to the remote driver as well as to the technology used.

B. Capabilities and obligations of the remote driver

The role of a remote driver brings new challenges to the human exerting dynamic control over the vehicle. The main challenges for a remote driver arise from the technological concept of remote driving itself:

1. Signals must be transferred between the vehicle and the remote driver's workstation. Transferal is not immediate. For humans, it is a challenge to deal with the resulting latency. In detail latency refers to the combination of:
    a. The time lag between an action or occurrence in or around the vehicle and it's representation at the remote driver's workstation.
    b. The time lag between a command given by the remote driver and the vehicle being able to exercise that command.
2. In addition, to challenges arising from latency, the remote driver's perception of the vehicle's surroundings and dynamics differs from the perception of a driver in the vehicle itself.

Currently, training and licencing requirements assume that the driver is inside the vehicle. Further specific training is required to perform the driving task remotely, for example to ensure the driver uses the data available to maintain appropriate situational awareness.

To support the safe deployment of remote driving, the remote driver must at least:

a. Have the physical and mental capabilities, and the competence, to undertake remote driving and to exercise dynamic control in all applicable scenarios 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). Consideration should be given to the potential ethical concerns arising from the remote driver's physical detachment to the vehicle. For example, detachment may mean that the remote driver experiences a decreased sense of risks, urgency, or a lack of empathy and sensitivity towards their surroundings.
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.

To safeguard the transport of passengers or freight in a remotely driven vehicle, the remote driver should:

d. Be aware of any passengers inside the vehicle which they are operating. This includes how many passengers and if any children are on board.
e. Ensure that the vehicle is a safe environment for its passengers, including monitoring the vehicle to prevent its theft.
f. Ensure passenger safety when boarding or leaving the vehicle, such as ensuring that all waiting passengers have boarded before closing the doors, or otherwise verify that the doors have been closed.
g. 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.
h. 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.
i. Be adequately trained and able to communicate with passengers, other road users and the emergency services following an incident.
j. Ensure that the number of passengers / vehicle load on the vehicle does not exceed its limit.
k. Monitor cargo, luggage and mobility devices, such as wheelchairs and strollers, to ensure that they are secured appropriately to prevent them from coming loose and posing a safety risk.
l. Ensure that the speed and driving style are appropriate for the vehicle and its load.
m. Comply with any other relevant domestic requirements set by contracting parties.
n. Comply with relevant domestic and international rules for the transport of passengers and freight.

C. Considerations for the operator (company) of remotely driven vehicles

Where remote driving is provided as a service, the operator providing the service is responsible for that service. This includes, but is not limited to, the following responsibilities where they must:

1. Driver Supervision and Responsibility

a. Support and supervise the remote driver to meet the requirements imposed on them set out in Part B above.
b. Bear responsibility for the actions of the vehicle where these are due to a failure in meeting the requirements of the system set out in Part D below.
c. 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.

2. Driver Management
    d. Ensure that the attention of the remote driver is managed safely, and that adequate breaks are built into their schedules.
    e. Ensure that the workload of the remote driver is managed appropriately, including through the allocation of tasks.
    f. Ensure safe transfer of control between remote drivers, e.g. through planned and careful execution of transfers of control where handovers occur at break times and at the end of shifts.
    g. Have a clear identification of who is remotely driving the vehicle at any given time.
3. Driver Training and Licensing
    h. 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.
    i. Ensure that remote drivers hold the appropriate licences (for example a valid licence for the territory in which the vehicle will be deployed).
4. Vehicle Maintenance
    j. Ensure the technology and machinery used are properly maintained, including ensuring that the vehicle is roadworthy.
5. Inclusivity and Accessibility
    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.
6. System Management
    l. Consider how they would safely address system failures, including those relating to connectivity and connection to the remote driving workstation.
    m. Consider the need for a safety case which covers each specific application of remote driving.
7. Remote Driver Workstation
    n. Enable the remote driver to adjust the workstation appropriately, to ensure it is comfortable and adapted to their needs.
    o. Have strategies to support the remote driver such as limiting the effects of motion sickness, information overload and change blindness (where that remote driver may fail to detect relatively large changes in visual scene).
8. Passenger Communication
    p. Provide passengers with solutions for them to request emergency stops as well as regular stop requests.
    q. Provide the ability to properly communicate any unexpected events, including any remote driver-initiated trip interruptions, to avoid passenger confusion.
    r. 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.
    s. 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).
    t. Have procedures and facilities 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 personnel. 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.

D. Considerations for the system manufacturer

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

a. Bear responsibility for the system to comply with the requirements set out in relevant parts of this paper and those set in domestic legislation and rules.
b. Ensure that the system enables a competent remote driver to exercise safe dynamic control of the vehicle in road traffic.
c. Ensure that the design of the human-machine interface is based on a proper assessment of human needs and limitations, including enabling the necessary situational awareness.
d. Ensure that the remote driving system fosters safe interaction with other road users, including vulnerable road users and cyclists.
e. Ensure appropriate software updates are made available to the system as required to maintain safety and security.
f. Consider the need for mechanisms to monitor remote driver attentiveness and performance.
g. Consider the need for public and consumer awareness and understanding of remotely driven vehicles, including the accurate depiction of the capabilities and limitations of the technology in system marketing.
h. Consider the need to deploy state-of-the-art safety systems to support safe remote driving, including crash avoidance systems for other vehicles and vulnerable road users such as automatic emergency braking (AEB).
i. Ensure vehicles with remote driving systems have the ability to bring the vehicle to a safe condition any time a trip cannot or should not be completed, such as when:
    i. 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).
    ii. The latency of the connection between the remote driver and vehicle has exceeded safety tolerances.
    iii. The connection between the remote driver and the vehicle fails or is degraded, or the safety of the system is compromised.
    iv. An ADS cannot take over dynamic control and perform it on a sustained basis.

The remote driving system should have sufficient capability to ensure road safety at all times, either by bringing the vehicle to a safe condition, or having an ADS safely take over the dynamic driving task to continue the journey. The safe condition which the vehicle reaches should be compatible with the safety case.

VII. Final considerations

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 fulfil the requirements from both conventions, including those stemming from Article 8.

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 and other outstanding considerations.