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Remote management of automated vehicles

Submitted by Finland and the United Kingdom*

This document describes remote management of automated vehicles which includes various modes of remote human intervention in the operation of automated vehicles in traffic.

* Reproduced as received

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Concept of remote management and terminology

Remote management refers to the activities that aim to manage one or more automated vehicles which do not have a responsible human inside. In fully automated vehicles (as defined by the 2018 WP.1 Resolution on the deployment of highly and fully automated vehicles in road traffic), it is possible that any humans in the vehicle will be passengers only. Remote management in this paper refers to the operations beyond-line-of-sight.

Remote management could be considered as a top level term that may cover various modes of remote human oversight in the operation of automated vehicles in traffic. The least intervening form would cover oversight without a need for intervention in the DDT and the range would reach as far as actual remote driving of the vehicle (remotely acting human would have the dynamic control of the vehicle instead of the ADS).

The terminology for various forms of remote management is proposed as follows:

- Remote management = top level term covering all the various modes of remote human intervention in the operation of automated vehicles in traffic. The following forms of remote management operations can be identified:
 - a. Remote support = A scenario in which the DDT is undertaken by an automated system, but tasks relating to the responding to alerts from the automated driving system (but not monitoring of the road or how the vehicle is driven) and tasks relating to interaction with passengers are undertaken by a human located outside the vehicle.
 - b. Remote assistance = In addition to remote support, the human outside the vehicle has the ability to change strategic elements of the DDT.
 - c. Remote operation = The human outside the vehicle provides mostly strategic but also occasional tactical commands relating to the DDT. The human outside the vehicle has no direct longitudinal or lateral control, acceleration or deceleration, but can instruct an ADS to perform specific manoeuvres or approve manoeuvres proposed by the ADS. The vehicle may request the intervention of the human outside the vehicle, or the human outside the vehicle could for example trigger an MRM, but the ADS remains responsible for the road safety at all times.
 - d. Remote driving = situations where dynamic control of the vehicle is performed remotely by a human driver (the remote driver). Dynamic control can be defined as “Real-time performance of part or all of the Dynamic Driving Task, DDT, (including braking, steering, acceleration, and transmission shifting), by a remote driver.

It is also proposed here that the entity organising remote management operations (usually a company) would be called “remote management provider” and the individual human being acting on behalf of the entity would be called “remote management agent”.

In the end, it may be difficult to separate various forms of remote management, and in many cases there is also the question whether the attempt to distinguish the various modes is even needed. Roles may overlap and one remote management agent could perform more than one role. However, there is a clear distinction between forms a-c on the one hand, and form d on the other: the question is who has the responsibility for the DDT, the human or the ADS. In forms a-c, the human is not responsible for any part of the DDT, including tactical control of the vehicle or monitoring of the road with a view to a time and safety critical intervention. This distinction may also be relevant to assign liabilities. It is possible that the vehicle manufacturers or system manufacturers may allow only certain forms of remote management, most typically remote driving might not be allowed with all automated vehicles. Various aspects of human intervention can be described below:

- a. Remote Support
 - i. Remote management agent has no direct line of sight to the vehicle; technology is required to see vehicle and surroundings;
 - ii. Remote management agent is not expected to have full situational awareness;
 - iii. Remote management agent provides guidance to the passengers;
 - iv. The remote management agent is responsible for user and vehicle status monitoring; summoning assistance and managing technical incidents and breakdowns;
 - v. Remote management agent has no ability to affect vehicle action; the DDT is undertaken by an ADS;
 - vi. Where there is no responsible human inside the vehicle and the DDT is being undertaken by an ADS, remote support extends ensuring some driver responsibilities are fulfilled, including communicating vehicle and insurance information to relevant road users and law enforcement after an incident.

b. Remote Assistance (Strategic)

In addition to the responsibilities relating to as remote support:

- i. Remote management agent provides the strategic elements of the driving task only (e.g., destination, roads to avoid);
- ii. Remote management agent has no tactical control of vehicle manoeuvres;

c. Remote Operation (Strategic/Tactical)

In addition to the responsibilities relating to as remote support and assistance:

- i. Remote management agent provides mostly strategic and occasional tactical commands relating to the DDT;
- ii. Remote management agent has no direct longitudinal or lateral control, acceleration or deceleration, but can instruct an ADS to perform specific manoeuvres or approve manoeuvres proposed by the ADS;
- iii. Remote management agent 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.

d. Remote driving (beyond line of sight)

- i. Remote driver has no direct line of sight to the vehicle, technology is required to see vehicle and surroundings;
- ii. Remote driver can assume dynamic control from the ADS and also monitor the vehicle and its path with a view towards safety critical situations.

Motivation and scope

WP.1 has in its 84th Session in March 2022 given IGEAD a mandate to study issues relating to remote operations¹. As explained above, it is proposed here that the term “remote management” would be used as a top level term instead of “remote operations”.

The insight and understanding of the issues relating to remote management have developed in the context of discussions relating to remote driving. The work on remote driving has been led by the United Kingdom since 2019, and more recently also by Germany. Also Finland has joined as a co-author in the discussion paper on remote driving.

The scope of this paper concerns situations where there are automated vehicles with no responsible humans inside them. This paper aims to present various aspects and considerations relating to remote management. It aims to address remote management as a whole, making only some references to especially remote driving, which may pose more challenges in some respects. However, it does not go deeper in the area of remote driving, since the situation where such vehicles are driven remotely by a human operator (remote driving) is covered in more detail in paper “Safe operation of a vehicle by a driver outside of the vehicle – “the concept of remote driving”” (23rd meeting of the WP.1 Informal Group of Experts on Automated Driving (WP1-IGEAD) November 2022). This paper lays out preliminary considerations and is intended to inspire discussion. It also points out issues that will require further discussions and decision making in the future.

General considerations

Smaller shuttle bus –type automated vehicles which are designed to operate without a responsible person in the vehicle have been tested widely around the world, and in many places are at the threshold for commercial deployment. They form one spearhead of road transport automation, and many countries have already taken steps, including at legislative level, for making their operation possible on public roads nationally. These operations may be used for providing passenger or freight transport services. At the moment, these vehicles tend to have predefined routes or areas of operation.

¹ Report of the WP.1 84th Session, Agenda item 8, para. 41: The Informal Group of Experts on Automated Driving (IGEAD) Chair provided an update on the informal Group’s work on the definition and role of the driver, driver education and training, as well as remote driving (Informal document No. 8). As a result, the WP.1 Chair invited IGEAD to continue to work following the mandate given by WP.1. In particular, to focus on the driver/user roles and driver education in the context of evolving technical progress; on remote operations; and to continue to collaborate with the World Forum for the harmonization of vehicle regulations (WP.29) and GRVA.

However, there are many aspects relating to remote management, where common understanding within UNECE would be very helpful. As the technology develops, there will also be multiple kinds of vehicles with multiple kinds of remote management schemes and multiple business models.

Safety considerations

The following aspects need to be considered in order to elaborate on the safe integration of remote management:

- A. Remote management as a safety increasing feature relating to the provision of transport services
- B. Minimum risk manoeuvre
- C. Issues relating to the carriage of passengers and freight
- D. Remote management from another jurisdiction and enforcement
- E. Requirements for remote management providers and their licencing
- F. Requirements for the remote management agents, licencing and permits
- G. Requirements for organising remote management operations (connections, latency, work stations, shifts, breaks)

The technological aspects of the systems implemented shall not be considered here. However, they may be touched upon for clarification purposes.

Remote management as a safety increasing feature relating to the provision of transport services

When new types of ADS vehicles and new types of business models are being tested, it is common that the vehicles have a safety driver inside to vehicle, in order to guarantee traffic safety. However, in the future some automated vehicles will only carry passengers and/or freight, and there will be no responsible humans inside the vehicle to deal with possible incidents inside or outside the vehicle. In such cases, some features of remote management will be needed in order to maintain safety, ensure traffic flow or provide reassurance. Some main aspects relating to offering remote management services are being dealt with below.

Minimum risk manoeuvre

One essential safety feature for all ADS vehicles is that the ADS must be able to perform a minimum risk manoeuvre (MRM) without any human input or intervention. This requirement also relates to such ADS vehicles that are remotely managed. The vehicle must be able to carry out the manoeuvre safely and in a such manner that it does not pose concerns to road traffic safety. Ability to perform a MRM is such essential safety feature that it might be worth mentioning it explicitly in national or international legislative framework also in the context of remote management.

Issues relating to the carriage of passengers and freight

Another essential safety feature and a requirement worth mentioning explicitly is the necessity to arrange methods for communication between the remote management agent and the humans inside the vehicle. This concerns obviously mostly passenger transport. Communication method must allow the passengers to contact a remote management agent at any time. It also must allow two-way communication, so that the remote management agent is also able to communicate with the humans inside the vehicle.

All modes of remote management must also offer the remote management agent possibility to monitor appropriately both the passengers and the freight. Recording the events inside the passenger vehicle is often necessary, and allowing this has to be taken into consideration in the legislative framework, taken appropriately into account the need to protect privacy and data protection. For example, clear regulations for managing personal data may be needed on national level.

In the case of possible emergencies inside the vehicle or traffic incidents or accidents the remote management agent must be able to provide immediately necessary help and assistance. This may also require sending personnel on the site of the event. Enforcement officers and first responders must also be able to identify remote management provider and contact the remote management agents acting on behalf of it and give orders or instructions if need be.

Remote management from another jurisdiction and enforcement

With remote management it is also necessary to consider, whether it is possible to organise remote management operations from the territory of another country, in a way that maintains the level of increased safety, which is the essential purpose of remote management.

Authorities need to have the information concerning responsible remote management provider, its contact information and the means to contact without any delays the remote management agents in duty. Necessary enforcement and inspections of various legal responsibilities also require possibilities for the authorities to implement their powers, which is most often rather limited in cross-border jurisdictions.

Furthermore, as explained under C., essential issues for remote management services is the possibility for two-way communication and the capability of the remote management agent to organise necessary help and assistance in the case of need. Remote management agent must be able to ensure that provision of remote management operations using automated vehicles comply with the applicable domestic and international legislation, including the provision of the service in a local official language. Organising help may require sending personnel on site. Necessary networks of various players on the field and the necessary knowledge of local procedures and traffic culture, as well as effective ways to interact may be hard to achieve from outside the country.

Accordingly, there may be arguments in favour of countries to require that the remote management provider is at least established in the country in question and that the remote management centre/-s are physically situated in the country in question.

Requirements for the remote management providers and their licencing

Countries may need to consider licencing schemes or other prior approvals by the authorities for carrying out remote management operations. There are already some national legislations or plans for legislations concerning licencing. One essential thing with remote management providers is the need for the administration and enforcement agents to have necessary information about the company, the responsible persons and contact information. It is also necessary to consider how this information can be provided for the competent authorities and enforcement agents in other jurisdictions.

It may also be necessary to consider, what kind of requirements will be posed to the remote management providers to ensure they are capable of meeting their duties. Typically it may be required that the remote management provider has necessary economic and other resources to run the operations. The responsible persons of the entity must have clean records e.g. from certain type of criminal activities.

Requirements for the remote management agents, their licencing and permitting

Remote management agents may be required to hold necessary licences and permits in order to run the operations in practice (particularly if they are performing at least part of the DDT), as well as to receive appropriate trainings for the tasks they will be required to perform. At the time being, there are no clear legal requirements concerning permits or training for the remote management agents or other staff involved in remote management. In the absence of clear legal requirements for training/qualifications of remote agents, it may be appropriate to require remote management agents to hold drivers' licences even when performing other forms of remote management than remote driving, since it is a way to demonstrate necessary knowledge of existing traffic rules. However, it is to be considered, whether any kind of drivers' licence would be enough for other modes of remote management than driving. With remote driving, countries may require licences for heavier vehicles, as they are required also from conventional drivers of such vehicles. However, it needs to be considered, whether remote driving differ so much from conventional driving that this would not be necessary. There is a need for further studies and discussions on the subject.

At the moment, there are no requirements or standards for professional training and permits of the personnel either. The necessary training may differ according to the mode of remote management operations and even according to the various vehicles used. At the moment, training according to each type of the vehicles organised by vehicle manufacturers is of key importance.

It will also be necessary that they maintain their physical and mental capabilities at all times. It would probably go without saying that zero tolerance towards being under the influence of alcohol or drugs should be required at least in the company policy. But maintaining necessary physical and psychic capabilities means also for example controlling

the tiredness and monotony. For those, the ways in which the remote management provider has organised the activities play a big role. Lessons could possibly be learned for example from industry automation.

So far the studies show already that the remote managers can suffer from motion sickness or change blindness. There are also some ethical concerns associated with remote management agent's physical detachment to the vehicle they are managing. This detachment may mean that remote management agent experience a decreased sense of risks, or a lack of empathy and sensitivity towards their surroundings. There may be differences between the individuals, on how much they are affected by such phenomena. There may also be differences between various modes of remote management, on how severe such concerns may be. Possible aptitude tests could be considered by the remote management providers. However, there are no guidelines or standards on such tests at the moment. Furthermore, appropriate training may reduce various negative effects mentioned on this paragraph. Again, more studies and discussions will be needed.

Requirements for organising remote management operations (connections, latency, security, work stations, shifts, breaks)

One of the major aspects for all the modes of remote management is the quality of network connections, as well as data security. Remote management operations require connections that are fast and reliable and secure. For example, the latency in the connections can not grow too big without causing serious safety concerns. However, there may also be differences between various modes of remote management. Remote driving would obviously be most demanding. Countries may need to consider setting clear requirements for e.g. the tolerance for the latency. Remote management providers may also need to consider back-up systems, for example multiple network connections, in order to secure their operations.

One major responsibility of the remote management provider is to make sure, that the remote management operations are adequately staffed at all times, and the personnel hold necessary licences required from them and have adequate skills for the operations. As explained above, further studies and discussions are required necessary training and licencing of the personnel, but also in the future the safety culture of the companies will play a big part in securing the skilled personnel.

Organising the ways of working have a major effect on the safety of the operations, and it is the responsibility of the remote management provider to have clear internal rules and safety management processes/systems that address various aspects of organisation the ways of working. So far, there is only little guidance or ready experiences of these issues, which means that companies need to consider carefully for example the set up for work stations and the equipment needed there, as well as organising necessary breaks and shifts. There are no regulations on either working or resting periods for the remote management agents. They may need to differ from those concerning e.g. traditional professional drivers. Furthermore, there are no guidelines or regulations on how many vehicles can be managed by one remote management agents simultaneously. It is presumed though, that this would vary according to the modes of remote management, while support could be given to multiple vehicles but only one vehicle could be remotely driven at the same time. However, more studies and discussions will be needed, and remote management providers should act prudently when establishing their operations.