



Federal Ministry
of Transport and
Digital Infrastructure

ETHICS COMMISSION

AUTOMATED AND CONNECTED DRIVING

REPORT (EXTRACT)
JUNE 2017

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Appointed by the Federal Minister of
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Introduction

Throughout the world, mobility is becoming increasingly shaped by the digital revolution. The „automation“ of private transport operating in the public road environment is taken to mean technological driving aids that relieve the pressures on drivers, assist them or even replace them in part or in whole. The partial automation of driving is already standard equipment in new vehicles. Automated systems which, without human intervention, can autonomously change lanes, brake and steer are available or about to go into mass production. In both Germany and the US, there are test tracks on which highly automated vehicles can operate. For local public transport, driverless robot taxis or buses are being developed and trialled. Today, processors are already available or are being developed that are able, by means of appropriate sensors, to detect in real time the traffic situation in the immediate surroundings of a car, to determine the car's own position on appropriate mapping material and to dynamically plan and modify the car's route and adapt it to the traffic conditions. As the „perception“ of the vehicle's environment becomes increasingly perfected, there is likely to be an ever better differentiation of road users, obstacles and hazardous situations. This makes it likely that it will be possible to significantly enhance road safety. Indeed, it cannot be ruled out that at the end of this development there will be motor vehicles that are inherently safe, in other words will never be involved in an accident under any circumstances. Nevertheless, at the level of what is technologically possible today, and given the realities of heterogeneous and non-interlinked road traffic, it will not be possible to prevent accidents completely. This makes it essential that decisions be taken when programming the software of highly and fully automated driving systems.

The technological developments are forcing government and society to reflect on the emerging changes. The decision that has to be taken is whether the licensing of automated driving systems is ethically justifiable or possibly even imperative. If these systems are licensed – and it is already apparent that this is happening at international level – everything hinges on the conditions in which they are used and the way in which they are designed. At the fundamental level, it all comes down to the following question. How much dependence on technologically complex systems – which in the future will be based on artificial intelligence, possibly with machine learning capabilities – are we willing to accept in order to achieve, in return, more safety, mobility and convenience? What precautions need to be taken to ensure controllability, transparency and data autonomy? What technological development guidelines are required to ensure that we do not blur the contours of a human society that places individuals, their freedom of development, their physical and intellectual integrity and their entitlement to social respect at the heart of its legal regime?

Ethical rules for automated and connected vehicular traffic

- 1.** The primary purpose of partly and fully automated transport systems is to improve safety for all road users. Another purpose is to increase mobility opportunities and to make further benefits possible. Technological development obeys the principle of personal autonomy, which means that individuals enjoy freedom of action for which they themselves are responsible.
- 2.** The protection of individuals takes precedence over all other utilitarian considerations. The objective is to reduce the level of harm until it is completely prevented. The licensing of automated systems is not justifiable unless it promises to produce at least a diminution in harm compared with human driving, in other words a positive balance of risks.
- 3.** The public sector is responsible for guaranteeing the safety of the automated and connected systems introduced and licensed in the public street environment. Driving systems thus need official licensing and monitoring. The guiding principle is the avoidance of accidents, although technologically unavoidable residual risks do not militate against the introduction of automated driving if the balance of risks is fundamentally positive.
- 4.** The personal responsibility of individuals for taking decisions is an expression of a society centred on individual human beings, with their entitlement to personal development and their need for protection. The purpose of all governmental and political regulatory decisions is thus to promote the free development and the protection of individuals. In a free society, the way in which technology is statutorily fleshed out is such that a balance is struck between maximum personal freedom of choice in a general regime of development and the freedom of others and their safety.
- 5.** Automated and connected technology should prevent accidents wherever this is practically possible. Based on the state of the art, the technology must be designed in such a way that critical situations do not arise in the first place. These include dilemma situations, in other words a situation in which an automated vehicle has to “decide” which of two evils, between which there can be no trade-off, it necessarily has to perform. In this context, the entire spectrum of technological options – for instance from limiting the scope of application to controllable traffic environments, vehicle sensors and braking performance, signals for persons at risk, right up to preventing hazards by means of “intelligent” road infrastructure – should be used and continuously evolved. The significant enhancement of road safety is the objective of development and regulation, starting with the design and programming of the vehicles such that they drive in a defensive and anticipatory manner, posing as little risk as possible to vulnerable road users.

6. The introduction of more highly automated driving systems, especially with the option of automated collision prevention, may be socially and ethically mandated if it can unlock existing potential for damage limitation. Conversely, a statutorily imposed obligation to use fully automated transport systems or the causation of practical inescapability is ethically questionable if it entails submission to technological imperatives (prohibition on degrading the subject to a mere network element).
7. In hazardous situations that prove to be unavoidable, despite all technological precautions being taken, the protection of human life enjoys top priority in a balancing of legally protected interests. Thus, within the constraints of what is technologically feasible, the systems must be programmed to accept damage to animals or property in a conflict if this means that personal injury can be prevented.
8. Genuine dilemmatic decisions, such as a decision between one human life and another, depend on the actual specific situation, incorporating “unpredictable” behaviour by parties affected. They can thus not be clearly standardized, nor can they be programmed such that they are ethically unquestionable. Technological systems must be designed to avoid accidents. However, they cannot be standardized to a complex or intuitive assessment of the impacts of an accident in such a way that they can replace or anticipate the decision of a responsible driver with the moral capacity to make correct judgements. It is true that a human driver would be acting unlawfully if he killed a person in an emergency to save the lives of one or more other persons, but he would not necessarily be acting culpably. Such legal judgements, made in retrospect and taking special circumstances into account, cannot readily be transformed into abstract/general ex ante appraisals and thus also not into corresponding programming activities. For this reason, perhaps more than any other, it would be desirable for an independent public sector agency (for instance a Federal Bureau for the Investigation of Accidents Involving Automated Transport Systems or a Federal Office for Safety in Automated and Connected Transport) to systematically process the lessons learned.
9. In the event of unavoidable accident situations, any distinction based on personal features (age, gender, physical or mental constitution) is strictly prohibited. It is also prohibited to offset victims against one another. General programming to reduce the number of personal injuries may be justifiable. Those parties involved in the generation of mobility risks must not sacrifice non-involved parties.
10. In the case of automated and connected driving systems, the accountability that was previously the sole preserve of the individual shifts from the motorist to the manufacturers and operators of the technological systems and to the bodies responsible for taking infrastructure, policy and legal decisions. Statutory liability regimes and their fleshing out in the everyday decisions taken by the courts must sufficiently reflect this transition.

- 11.** Liability for damage caused by activated automated driving systems is governed by the same principles as in other product liability. From this, it follows that manufacturers or operators are obliged to continuously optimize their systems and also to observe systems they have already delivered and to improve them where this is technologically possible and reasonable.
- 12.** The public is entitled to be informed about new technologies and their deployment in a sufficiently differentiated manner. For the practical implementation of the principles developed here, guidance for the deployment and programming of automated vehicles should be derived in a form that is as transparent as possible, communicated in public and reviewed by a professionally suitable independent body.
- 13.** It is not possible to state today whether, in the future, it will be possible and expedient to have the complete connectivity and central control of all motor vehicles within the context of a digital transport infrastructure, similar to that in the rail and air transport sectors. The complete connectivity and central control of all motor vehicles within the context of a digital transport infrastructure is ethically questionable if, and to the extent that, it is unable to safely rule out the total surveillance of road users and manipulation of vehicle control.
- 14.** Automated driving is justifiable only to the extent to which conceivable attacks, in particular manipulation of the IT system or innate system weaknesses, do not result in such harm as to lastingly shatter people's confidence in road transport.
- 15.** Permitted business models that avail themselves of the data that are generated by automated and connected driving and that are significant or insignificant to vehicle control come up against their limitations in the autonomy and data sovereignty of road users. It is the vehicle keepers and vehicle users who decide whether their vehicle data that are generated are to be forwarded and used. The voluntary nature of such data disclosure presupposes the existence of serious alternatives and practicability. Action should be taken at an early stage to counter a normative force of the factual, such as that prevailing in the case of data access by the operators of search engines or social networks.

- 16.** It must be possible to clearly distinguish whether a driverless system is being used or whether a driver retains accountability with the option of overruling the system. In the case of non-driverless systems, the human-machine interface must be designed such that at any time it is clearly regulated and apparent on which side the individual responsibilities lie, especially the responsibility for control. The distribution of responsibilities (and thus of accountability), for instance with regard to the time and access arrangements, should be documented and stored. This applies especially to the human-to-technology handover procedures. International standardization of the handover procedures and their documentation (logging) is to be sought in order to ensure the compatibility of the logging or documentation obligations as automotive and digital technologies increasingly cross national borders.
- 17.** The software and technology in highly automated vehicles must be designed such that the need for an abrupt handover of control to the driver (“emergency”) is virtually obviated. To enable efficient, reliable and secure human-machine communication and prevent overload, the systems must adapt more to human communicative behaviour rather than requiring humans to enhance their adaptive capabilities.
- 18.** Learning systems that are self-learning in vehicle operation and their connection to central scenario databases may be ethically allowed if, and to the extent that, they generate safety gains. Self-learning systems must not be deployed unless they meet the safety requirements regarding functions relevant to vehicle control and do not undermine the rules established here. It would appear advisable to hand over relevant scenarios to a central scenario catalogue at a neutral body in order to develop appropriate universal standards, including any acceptance tests.
- 19.** In emergency situations, the vehicle must autonomously, i.e. without human assistance, enter into a “safe condition”. Harmonization, especially of the definition of a safe condition or of the handover routines, is desirable.
- 20.** The proper use of automated systems should form part of people’s general digital education. The proper handling of automated driving systems should be taught in an appropriate manner during driving tuition and tested.

