Regulatory and strategic issues of automated driving in mixed traffic flow

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TrafficQuest
CENTRE FOR EXPERTISE ON TRAFFIC MANAGEMENT

memo

FROM : Simeon Calvert, Isabel Wilmink, Henk Taale & Martijn de Kievit

TO : Practitioners in the field of automated driving and its impacts on traffic

CC :

DATE : 11 January 2017

SUBJECT : Regulatory and strategic issues of automated driving in mixed traffic flow

Introduction

Road authorities and transport planners play a role in facilitating a smooth introduction of (partially) automated vehicles[1] on their roads. They need to take their possible effects and requirements into account, as well as regulation that may be needed. It is expected that a mix of conventional and automated vehicles will be present on the roads for many decades to come. The increasing levels of automation influence the performance of traffic flow. There will also be safety and environmental impacts. These aspects are considered in the accompanying document *'Next steps in describing possible effects of automated driving on traffic flow'* by TrafficQuest (Calvert, Wilmink, and Farah 2016). In this memo, a closer look is taken at the challenges that exist on a regulatory and strategic level. These are issues that refer to required and desired preparations for, consequences of, and challenges involving existing resources and infrastructure for automated vehicles on roads in mixed traffic. The described challenges are considered for the case in the Netherlands and mainly focus on areas in which there are significant unanswered questions and on which decisions still need to be made by policy makers or road authorities. (Questions related to standardisation have not been included here.)

The challenges will require (facilitative) action from road planners and operators. The list is a summary of the main challenges that are relevant for the situation in the Netherlands, grouped in the following categories:

- physical infrastructure
- road regulations
- digital infrastructure
- approach to network operations and traffic management
- vehicle capabilities

Physical infrastructure

The physical infrastructure is defined here as the road infrastructure that is visible outside, in other words the road surface, the gantries, the road marking, etc.

Road geometry

Vehicle automation may have an influence on the geometric alignment and the profile of roads. Automated vehicles are expected to be better capable of traversing roads with a tighter curvature than conventional vehicles and drivers due to a greater ability to control vehicles at speed and correct alignment when traversing a curve. This may in turn allow the curvature of roads to be decreased (when the penetration rate of automated vehicles justifies that). Lane widths for

[1] In this publication, automated vehicle relates to any vehicle with any level of vehicle automation, and does not exclusively mean fully automated.

automated vehicles and run-off margins may also be smaller, possibly allowing additional lanes to be present on the same road area. Obviously this cannot be put into effect when a relatively large percentage of vehicles is still manually driven. Nevertheless, there may be a turning point when these and other changes can be made, at first perhaps only on selected road sections with enough capacity to justify separate lanes for automated and manually driven vehicles. How road design can be adapted once all traffic consists of fully automated vehicles is described in Morsink et al. (2016). This report also discusses what changes to the infrastructure can already be made in the short term, in terms of what elements can be left out or can be designed more plainly, or what elements can be added or upgraded to support automated driving. The report also gives a list of research questions (mainly focusing on road design issues).

Current state of infrastructure
Automated vehicles of various levels of automation have certain infrastructural requirements to be able to perform their function properly. This relates to the 'operational design domain' - *the specific conditions under which a given driving automation system or feature thereof is designed to function, including, but not limited to, driving modes* [SAE, 2016]. Vehicles may require the presence of clear and consistent road markings, high quality road surfaces or comprehensive (digital) signage. It is necessary to be aware of these requirements and to review if restrictions for the use of automated vehicles are required under certain circumstances and which measures may be taken to alleviate any difficulties. Some specific questions:

- Are improvements needed on the vehicle or the infrastructure side, or both, to enlarge the operational design domain?
- What do car/truck manufacturers and suppliers consider to be 'clear and consistent road markings'? This question overlaps partly with the next one.
- What are the car/truck manufacturers' (minimum) needs w.r.t. road surface and signage (here, there is also an overlap with digital infrastructure)? How much inconsistency between regions and countries can vehicles be expected to deal with?
- From a road authority point of view it is important to understand these needs, especially since this influences the amount of automated driving that is possible. An important question to 'set the baseline' is how often and on what part of the main road network is the state of the infrastructure such that vehicles will be unable to drive safely in automated mode? This in turn influences investment decisions for infrastructure improvement and renewal (of course based on positive expected impacts of automated vehicles).

Infrastructure degradation and maintenance strategy
Future traffic population will include increasing numbers of automated vehicles. This can have an increased impact on the degradation of the physical infrastructure, and the road surface in particular. For instance, it is conceivable that automated vehicles will be able to maintain a more central lane position and therefore increase the concentration of wear on certain areas of the road surface. There may also be effects on the required load-bearing capabilities of infrastructure, especially when considering the likes of trucks driving in platoons compared to the same number of conventional trucks. This topic is, at least to some extent, addressed in the TU Delft study 'State of art on infrastructure for automated vehicles'.

Road regulations

Traffic laws and regulations
Current traffic laws and regulations exist with conventional vehicles in mind. Undoubtedly, new issues may occur that require adaption of current or additional laws and regulations. These relate to regulations stating the requirements for automated vehicles to be allowed access to roads (in combination with roadworthiness institutes) but also traffic laws for active participation in traffic. Furthermore, existing regulations need to be reviewed to examine if they satisfactorily cover the use of automated vehicles in relation to a wide range of policy goals in mind, such as safety, environmental effects and traffic throughput. Some specific questions:

- Which current traffic laws and regulations make it difficult for automated vehicles to drive efficiently in busy traffic? Could those rules be changed and what would that mean for conventional vehicles? Which laws and regulations are only an issue in the Netherlands?
- Specifically for freight traffic: at what level of automation can laws regarding driving times and rest periods be changed?

Interpretation of regulations
While traffic laws and regulations exist, in reality many are interpreted and applied in a flexible fashion. An example is the manner in which a vehicle is required to enter a motorway on an on-ramp; Traffic regulations in the Netherlands state that a driver should wait at the start of the on-ramp if a suitable gap cannot be found, however in practice this is never done. This is one of the differences between the practical implementation of regulations compared to what is stated on paper. There are questions in relation to how automated vehicles should follow up on these regulations, such as:

- Is it conceivable that they are programmed to ignore the letter of the law, or are changes required to traffic laws for example?
- Will automated vehicles communicate their intent in some way? What strategies for communicating intent are considered? Which ones are easily understood by most (or all) drivers of conventional vehicles?
- How predictable is the behaviour of conventional vehicles for automated vehicles? Can drivers be trained to be more predictable to automated vehicles?

Liability
This is a subject that has been extensively covered, however there are still many issues that need to be investigated (and for which solutions need to be defined), also in relation to interaction with conventional vehicles. The majority of these issues are relevant for incident events and require that road authorities have sufficiently covered their responsibilities – especially since the road authority can be held responsible for negligence, as can also be the case today if, for example, repairs are not properly carried out leading to an incident. Some specific questions:

- What situations or scenarios with mixed traffic need to be looked at when assessing whether or not automated vehicles of different levels can be allowed to drive in automated mode?
- The road authority can currently be held responsible for negligence in some cases; could there be more or other cases in mixed traffic (primarily because of how automated vehicles sense their environment. possibly because of the way automated and conventional vehicles interact)?

Digital infrastructure

The digital infrastructure is mostly invisible on the road (apart from e.g. communication equipment) but offers much information that is needed by automated vehicles.

Required digital infrastructure
While automated vehicles may be able to drive without explicit digital road side information, there may be automated technologies that require or benefit from digital information through digital infrastructure, such as in-vehicle signage. Also for the introduction of cooperative systems in automated vehicles, the use of digital infrastructure becomes more important. Some specific questions:

- What are the requirements from various levels of vehicle automation for digital infrastructure? What is absolutely required, and what can be considered nice to have for safe and efficient automated driving?
- Which road sections would benefit from being equipped with DSRC? Where does cellular communication suffice (3/4/5G)? Where in the network can problems with reception be expected? What is needed to tackle these problems?

Digital mapping
For higher levels of automated vehicles as well as some lower level technologies, the presence of high quality digital maps may be required. Road authorities may need to offer digital data for this and requires collaboration with map makers. Another issue involves the use of digital maps in locations where regular positioning systems are not available, such as tunnels or urban canyons. It may also require additional action from road authorities and infrastructure owners to make suitable digital mapping available everywhere. Questions:

- Which map data do road authorities need to provide that cannot be obtained elsewhere?
- Where in a network can problems be expected with positioning? What can or must road authorities do to solve these problems?

Approach to network operations and traffic management

Suitability of current strategies
Current network operations and traffic management strategies are constructed with manually driven vehicles in mind. It is necessary to investigate to what extent these strategies are still effective for the presence of different levels of automation, or can be made more effective using the particular characteristics and capabilities of automated vehicles. Special attention should be paid to road sections where drivers are expected to switch from manual to automated mode and vice versa. Also, it would be good to explore the added value of connectivity and/or cooperation. Questions:

- Which current strategies are expected to be less effective in mixed traffic? Can they be adapted to be more effective? What role can connectivity and cooperation play?
- Will traffic management be required on more roads because of mixed traffic to maintain current levels of operation? What might be the reasons for this? Where does the transition of control play a role? Will there be higher traffic volumes or different behaviour of vehicles? Should vehicles driving in automated mode be recognisable as such? Should all drivers be counselled on what the introduction of automated vehicles on the public road means for them?

New strategies for traffic management
Automated vehicles and increased vehicle cooperation may come with possibilities to introduce new types of traffic management measures. Possibilities such as advice on vehicle settings (e.g. of following distances, lane choice and changing) and increased possibilities for traffic homogenisation may occur. It may even be possible to directly influence the manner in which a vehicle drives controlled from a central traffic management centre under certain conditions. Question:

- Which new traffic management strategies are possible, desirable and/or acceptable with automated vehicles (e.g. due to '100% compliance of drivers'), with and without connectivity or cooperation? Will new types of data become available and be accessible?

Current traffic functions
At the moment road authorities are responsible for a number of traffic related functions, such as warning traffic for dangerous situations, giving directions and route information, handling incidents, etc. It could be that some of these functions disappear or change. Question:

- Which traffic related functions that road authorities are currently responsible for will disappear or change with the introduction of automated vehicles? And what does that mean for the role of the road authorities?

Vehicle capabilities

Limitations
Currently, the capabilities of different levels of (future) automated vehicles are not entirely known, let alone potential differences between vehicles from different manufacturers. This makes it difficult to envisage the limitations of many of these vehicles. It is therefore important for road authorities

to get a grip on what these limitations may be and how they might affect different aspects. Limitations exist on the level of dynamic capabilities in traffic flow and on the level of design specifications. Question:

- How can the capabilities and limitations of automated vehicles be characterised? What does that mean for traffic flow and road capacity?

Malfunctions

Like any other technology, automated vehicles will undoubtedly encounter malfunctions. These malfunctions can occur on many levels. This forms a challenge for road authorities to know how to deal with these problems. This may be by offering emergency bays, or introducing changed or amended incident management strategies for occurring circumstances. Two example questions:

- How often will automated vehicles experience a malfunction that has consequences for the vehicle's behaviour? And what might these consequences be for traffic flow?
- What fall-back options are manufacturers considering? What does that mean for road authorities, do they need to accommodate the fall-back options in any way?

Irregular and environmental conditions

While automated vehicles are designed and tested for a large number of situations, there are many irregular and unexpected situations that can exist for which the correct working of an automated vehicle needs to be considered. There are many potential environmental conditions that may occur, from the likes of (heavy) snow or rainfall to dense fog. Other unexpected situations may also occur, such as debris on the road surface, of the presence of other irregular items, persons or vehicles. An automated vehicle needs to be able to observe these, interpret them and finally act suitably. This requires additional attention from both car manufacturers as well as road authorities. Questions:

- Which irregular conditions are 'regular' enough (not occurring frequently, but to some extent predictable) that an automated vehicle must be able to deal with them in some way? Can road authorities do anything to improve conditions? Would the benefits outweigh the costs?
- How are such conditions dealt with now, and what is expected for higher levels of automation? Are there conditions that automated vehicles should not be allowed to drive in? Is it safe for humans to operate a vehicle in such conditions (experienced vs. inexperienced drivers)? Can road authorities detect such conditions (more easily than other organisations) and do they need to provide information (e.g. to service providers)?
- Are there any rare conditions that manufacturers may not develop strategies for? Are these conditions that road authorities can anticipate and should additional information be provided?

Conclusions

In this document, a number of challenges regarding automated vehicles in mixed traffic are addressed that require careful consideration on the part of road authorities. The document should be seen as an incentive and starting-point to further look at each area in more detail and to initiate projects in which the questions listed above can be addressed.

References

- Calvert, S. C., I. R. Wilmink, and H. Farah. 2016. Next steps in describing possible effects of automated driving on traffic flow. TrafficQuest.
- Morsink, P., E. Klem, I. Wilmink, and M. d. Kievit. 2016. Zelfrijdende auto's - Verkenning van implicaties op het ontwerp van wegen. RHDHV and TNO for RWS and CROW.
- SAE International. 2016. Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. Standard J3016_201609. Revised 2016-09-30.