Summary

Societal consequences of automated vehicles – Norwegian scenarios

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Along with the ongoing rapid development of automation in transport, the literature on automated vehicles is overwhelmingly increasing. Overall, it is suggested that automated vehicles will have a great potential in improving individual mobility and traffic safety and reducing environmental burden, whereas goals of less driving and more active mobility will be challenged. The first automated vehicles are already driving around in some designated Norwegian settings. They have set a new agenda, highlighting the need for active preparation, not reactively waiting for the further technological progress. Steering the future direction depends on dedicated policies and organisational facilitation. Will the automated vehicles be private, shared or public and used for private or rideshared trips? Where, when and with what consequences? Based on these criteria we have selected five scenarios: Private automated cars for all; Curbing urban congestion; Shared automated car fleets; Automated vehicles for ridesharing; Automated vehicles in scheduled public transport. A further introduction of automated vehicles in the Norwegian context will probably draw primarily on the various sharing models, organised by a mixture of public or private transport network companies.

Assessing the societal consequences of automated vehicles for personal mobility

Automation is considered to be the next disruptive innovation in transport and are expected to become an integral part of future transport systems. Overall, it is suggested that automated vehicles (AVs) will have a great potential to positively contribute to solving many urban and environmental problems. They will improve mobility and traffic safety. However, AVs are also expected to present various challenges when it comes to important policy goals, such as zero-growth for car use in urban regions, reduced urban sprawl and improved public health.

The focus of the present study is to understand the possible societal impacts that AVs will have, rather than studying the technological solutions themselves. The emphasis is on the impacts on personal mobility, while the introduction of AVs for freight transport is outside the scope. As for many other innovations, this is a topic where no blueprint solution is available. Whereas the technological literature for the future of automated vehicles already is overwhelming, this study is the first in the Norwegian context presenting updated research to identify a set of possible future scenarios and schematically describe its *societal* consequences according to relevant policy goals.

The project has had the following main objectives:

i) Define and operationalise central terms and policy goals

ii) Update the knowledge of current and future development of automated vehicles and driving technologies (chapter 3)

iii) Assess how automated vehicles influence urban transport

iv) Show how the findings from ii) and iii) are relevant in a regional context

v) Put forward some policy implications for future urban and regional transport policies

Five scenarios for societal consequences of automated vehicles

The study considers the current and future development of automated driving technologies in connection with the five levels of automation and geographical differentiation and other conditional factors. We discuss the distinction between individual and public transport. AVs can be individually privately owned or included in more or less collectively organized solutions where the vehicles belong to a central fleet. The distinction within shared mobility between carsharing and ridesharing is drawn. We can conceive future ownership and organizational principles for AVs based on today's carsharing concepts such as B2C (business-to-consumer), CarCoop (cooperative, non-profit membership) models, and P2P (peer-to-peer) models.

Next we provide an overview of the literature that focuses on the societal consequences of AV technology. The societal implications of AVs are complex and involve several dynamic interactions. Through this review effort, we identify several main dimensions that are likely to stir the direction of such implications. To evaluate the implication of automated technology on different factors of society and urban transport, we separate implications of AVs in two categories, directly and indirectly. We define the more direct and immediate effects on urban transport and mobility in contrast to the societal or indirect impacts of AVs. More in detail, we discuss effects of AVs on travel cost and road capacity, demand and travel choice, ownership, transport infrastructure, accessibility, safety and security, energy consumption, air pollution, social equity, industries, and public health.

For a systematic scenario development we review some main principles and previous scenario analyses in transport and for AVs, in order to select the most relevant scenario criteria. Three significant dimensions are selected. We distinguish first between private or shared *ownership*; second, between private or shared *use* of the vehicles, and third, the *political* dimension, what kind of policies that will follow the introduction of AVs. We suggest five distinct scenarios:

- One where there will be cheap privately owned, *individual automated cars (AVs) available for all*, with no particular policy regulation
- One with policies aiming at *curbing congestion* of private AVs in urban areas
- One where the AVs is privately used and organised in a *shared AV fleet*, whether public or private
- One where there is a *rideshared use of the AVs*, primarily integrated in a mobility-as-a-service-solution
- And finally, a scenario where the main policy emphasis is on *intensified and automated dpublic transport.*

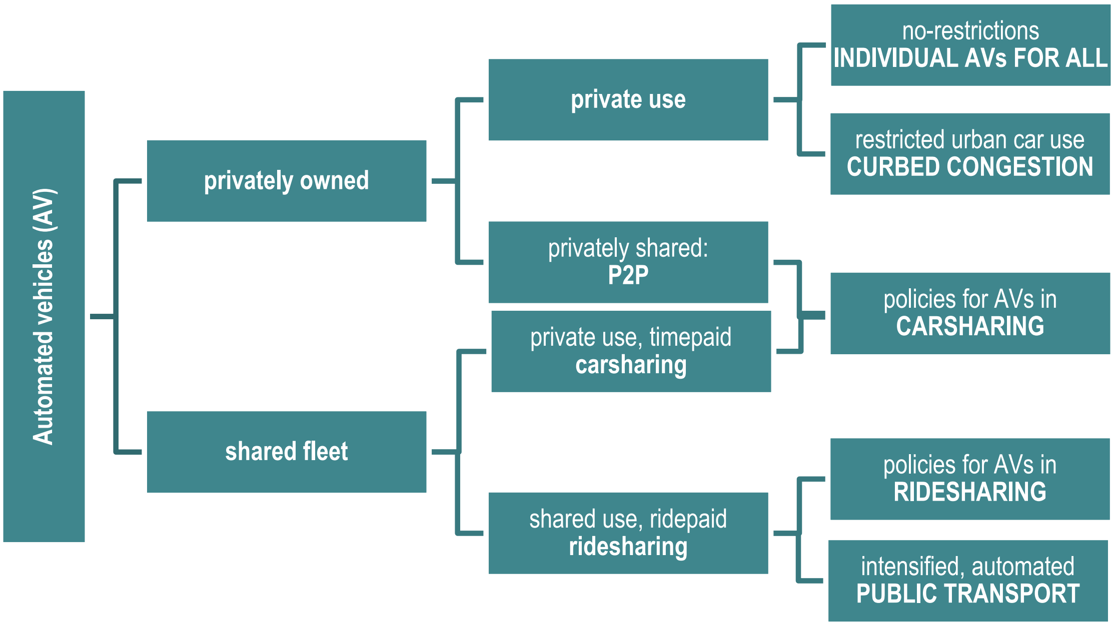

Figure 1.1: Societal consequences of automated vehicles. Five scenarios.

The possible impacts of the various scenarios are discussed. From the call the following impacts are in particular requested: 1) social impacts for the users, 2) consequences for the environment and land use and 3) consequences for the public transport. Table S1 sums up some of the assumed impacts and main characteristics of each of the scenarios, differentiated between urban, suburban and rural areas.

Table 1: Main impacts for the five scenarios, by regional differentiation (colours indicate positive (green) and negative (red) development and strength (darker))

		SCENARIOS				
		privately owned AVs			*shared AVs*	
		private use of AVs			*shared use of AVs*	
		AUTOMATED CARS FOR ALL	**CURBED CONGESTION**	**SHARED FLEET OF AVs**	**RIDESHARED AVs**	**PUBLIC TRANSPORT**
REGION	Urban	*congestion*		*congested if empty cruising*	*feeding PT*	*scheduled (in MaaS)*
	Suburban	*queues on arterial roads*	*AVs for the few*	*(in MaaS)*	*(on-demand) (in MaaS)*	
	Rural		*irrelevant*	*P2P*	*on-demand*	*costly*

Private automated cars will be best suited in rural areas, whereas automated buses, trams and trains in scheduled public transport will be best suited within the main public transport grid. The question is where and for whom ridesharing with small automated minibuses run by the public transport companies will be the most appropriate. These already familiar vehicles and schemes (as they are already tested in real traffic, e.g. in Fornebu, Forus and Kongsberg), will probably be the point of departure for the further development in the Norwegian context.

To sum up for the Norwegian context the shared models will be the most probable, either a shared automated car fleet for private car use, or shared rides in minibuses (microtransport) run by public or private companies. Only these companies, already having a legal permission for transport services, are legible to execute pilots with selfdriving vehicles in Norway.

National and regional policy goals of reduced urban car use make the policies and measures from the *curbed urban congestion* scenario necessary. At the same time, an intensified *public transport* scenario with automated trains and buses is highly probable. Only the latter will require public investments or financial support. On-demand automated vehicles in carsharing schemes will probably draw on today's carsharing providers. These vehicles will resemble a driverless taxis. Even if there is a limited use of private taxis today, the situation will be quite different when the cost of the driver is gone. An excessive use might easily be foreseen.

Different types of carsharing are well-suited both in urban, in suburban and rural districts. Private trips in carshared vehicles are, however, not very suitable for routinized travels (to work, for regular transport services for special groups, e.g.). This is a field where microtransport, in the form of small automated minibuses, will be relevant. These are schemes that might be run by public or private (commercial or non-profit) transport companies.

The expectations of the timing of the first introduction and further implementation of automated vehicles vary considerably. Some studies suggest automated vehicles on motorways early in the 2020s, and in urban traffic only a few years later. Some expect every 10th vehicle to be conditionally automated in 2030, and 60 percent of the fleet fully automated in 2060. Also, the expectations of the changes in the modal split are highly uncertain. Since previous research is only based on simulations, it is only possible to indicate the internal shift in modal split (between private car usage; rideshared, public or active transport) on an ordinal level (more/less), not exact quantification.

In general, the potential for lower costs, reduced environmental burden and improved traffic safety substantiates that automated vehicles may change our transport system fundamentally in the decades to come. And – based on previous early transport policies and early initiatives in the Norwegian context (i.e. from the public transport companies Ruter, Brakar and Kolumbus), the expectations could be that much will occur in the Oslo, Buskerud and Stavanger region in the first place.