

# Chapter 24

## When Autonomous Vehicles Are Introduced on a Larger Scale in the Road Transport System: The Drive Me Project

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### 24.1 Introduction

During the past decades, road transport in urban areas has been dominated by cars, and this has resulted in increasing levels of traffic congestion and loss of time. As we approach 2020, there is substantial renewed interest in revitalizing urban road transport as one way of combating the challenges in metropolitan areas.

Autonomous driving opens up for possibilities for improved safety, improved fuel economy, reduced problems with congestions in urban areas, more efficient use of land for city planning, reduced emissions, and driving possibilities for the physically impaired. This new technology also opens up new possibilities to optimize the infrastructure in cooperation with the vehicle's ability to be more accurately controlled. It is generally accepted that, in about 90–99% of all incidents and crashes, human behavior is partially or fully responsible [1, 2]. In the push toward reaching the goal of zero serious injuries and fatalities, there is a clear potential in automating the driving task, as it could take away the root cause of almost all accidents.

The debate is currently running high on the legality and desirability of having the car fully or partially assuming the control or if the driver should always be in control. For many of the involved parties, however, in assessing what is needed for reaching very low numbers of casualties, there is a shared view that more advanced assistance systems leading toward autonomous driving are desired or needed in reaching this goal. Analysis of a larger-scale deployment of autonomous vehicles is needed.

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## 24.2 Problem Definition

The Drive Me project has a high-profile ambition to define and evaluate how autonomous vehicles will have a major importance for quality of life and achievement of a sustainable urban environment. To handle future challenges, society has to continue its positive development, and transport solutions have to be safe and environmentally sustainable as well as meet mobility requirements for citizens. Drive Me takes important steps toward vision zero in traffic safety (the vision that any loss of life is unacceptable) and the more ambitious future crash-free road transport system. In addition, a more efficient use of infrastructure and the space required for traffic are core areas in the project. A more sustainable mobility solution, based on increased automation of vehicles and optimization in the infrastructure, is measured on six main qualities: punctuality, capacity, robustness, usability, and traffic safety.

The Drive Me project is a research platform comprised of a number of contributing research projects and partner organizations. Volvo Car Group along with Swedish Transport Administration, Swedish Transportation Agency, the City of Gothenburg, Lindholmen Science Park, Chalmers University, and Autoliv are part of the Drive Me research platform. In addition, numerous additional projects and collaborating organizations will contribute to Drive Me.

Drive Me focuses on studying potential benefits when autonomous vehicles are introduced on larger scale in the road transportation system. The Drive Me platform is unique in international terms by focusing on the integration of autonomous vehicles with the infrastructure as well as the citizen. A holistic system approach is thereby possible, enabling optimization of transport at a whole new level. This is a possible paradigm shift within mobility and for creation of livable urban areas. This research initiative aims to combine knowledge from society, academy, and industry to create the sustainable mobility system of tomorrow. It aims to answer the following research questions:

1. How can *traffic safety* be improved?
2. How can *traffic flow* be improved? What is the impact on punctuality, capacity, robustness, and usability in the road transportation system?
3. How can *energy efficiency* be improved?

The ambition to put a fleet of 100 autonomously driving cars in the hands of real customers as advanced measuring probes on real road infrastructure is the largest project defined in the world today. These probes will be used to study the effect on safety, traffic flow, and energy efficiency. It is expected that rebuilt vehicles working as test probes with measuring equipment and test functionality for automated driving will provide sufficient information/data to evaluate the possible benefits and effects on the above research questions.

During the first stages of the project, estimated benefit potentials will be defined through computer simulations, desktop studies, and test-track studies. Later, test probes will be put into a real traffic environment (a section of about 55 km of motorway in Gothenburg, Sweden) to collect data for analyses, modeling, and quantification.

### **24.3 Measuring Probes: The Autonomous Vehicles**

The objective with the autonomous vehicles, or test probes, is to allow ordinary Volvo customers to operate an autonomous vehicle on public roads such that the overall effects of these vehicles on the road transportation system can be studied. As opposed to modern production vehicles, these customers do not need to continuously supervise the vehicle operation during certain driving situations, and therefore they will be allowed to spend time on other activities. This of course puts strict requirements on the probe design, far beyond the requirements on ordinary production vehicles. All engineering details will have to be addressed in order to allow customers to use these probes in a safe way.

All test probes will be equipped with data logging tools such that the vehicle and driver behavior can be monitored continuously and its impact on the overall traffic can be analyzed.

### **24.4 Safety**

The research on safety addresses the general question of how can traffic safety be improved? It focuses on (a) how the test probes will manage safety conflicts and pre-crash scenarios and (b) quantification of the impact of the implemented solutions on traffic safety. The safety-related functionality of the test probes will be developed in close interaction with an iterative evaluation of the functionality in virtual, test-track, and on-road environments. Safety-related impacts will not only result from the real-time avoidance behavior of the test probes in response to traffic conflicts (e.g., steering/braking to avoid a parked vehicle) but also result from compliance with rules and regulations (e.g., speed reduction in traffic flow), from functional safety (e.g., dependability and malfunction handling), and handling unforeseen consequences. A safety impact methodology will be used whereby safety benefits are expressed in terms of degree of crash avoidance and reduction of injury (e.g., [3]).

The following research questions will be addressed:

- How should the safety impact of the Drive Me test probes be quantified?
- Which safety conflict situations (load cases) should the test probes be tested on?
- How do the self-driving vehicle and the driver react in safety conflict situations?

- To what proportion and degree are crash types avoided or mitigated? If possible to determine, the main causes for the crash reduction and mitigation will be determined (e.g., rule compliance, types of human behavior).
- How can automation contribute to a crash-free road transport system?
- What are the main safety challenges with self-driving cars?

## 24.5 Traffic Flow

The traffic flow research will study how autonomous vehicles can contribute to a more efficient road transportation system, analyzing how autonomous vehicles can:

- Increase the capacity of the traffic system, i.e., allow more vehicles to pass through a given section of road infrastructure.
- Increase the robustness of traffic system, e.g., by minimizing incidents such from low-speed collisions or critical lane changes.
- Minimize travel time, e.g., by creating a smoother flow.
- Accurately predict time of arrival, thereby allowing travelers to optimize their trip.

This research will be conducted by taking two different perspectives. The first perspective is to analyze and modify the behavior of self-driving vehicles such that traffic efficiency is optimized. It is known that the behavior of the vehicle in terms of, e.g., acceleration profiles, distance keeping, and lane changing, affects the overall traffic flow. Vehicles driven by humans vary significantly such that the overall traffic system is never operated in an optimal way. When a significantly large set of vehicles is behaving in an optimal way, it will in the end affect the overall traffic system. The research questions are:

- How should the optimal behavior for an autonomous vehicle be defined?
- How does the amount of autonomous vehicles affect the overall traffic system?

The second research perspective is to modify the road infrastructure such that traffic efficiency is optimized. When a future road traffic system knows a significant amount of autonomous vehicles, one does not necessarily have to design the road infrastructure in the same way as today. We assume that, e.g., lanes can be made smaller as the road does not have to cater for all lateral oscillations that result from different behavior in the human driver population. This may mean that more lanes can be constructed or the remaining space can be used for nonmotorized traffic such as bicycle, hereby increasing efficiency. In a similar way, efficiencies may be obtained in the design of lightweight and low-cost overpasses and underpasses. The basic research question is:

- How should an efficient road infrastructure be designed, given a large amount of autonomous vehicles with optimal behavior for traffic efficiency?

## 24.6 Energy Efficiency

Sound data on the realistically achievable effect of autonomous vehicles on energy consumption and other environmental aspects is lacking [4]. While single potentials within autonomous vehicles are widely known and may give improvements up to 30 % in energy efficiency [5], there are currently no established methods to estimate the expected impact in real traffic situations. Aspects adding to the complexity of the subject are expected dependencies on surrounding traffic (density and patterns) as well as the necessity that the driver accepts changes in the vehicle behavior.

The main research question “How can energy efficiency be improved by autonomous vehicles?” has been detailed into the following research questions:

- Which energy efficiency potential can be realized with autonomous vehicles for individual mobility?
- Which functionality is required in the traffic control system to support efficient traffic control, and how can this effect be quantified by measurement?
- How large is the potential benefit for different degrees of automation and different shares of such vehicles in real traffic environment?
- How are environmental aspects as traffic noise and emissions affected by the introduction of autonomous vehicles?

A scientific method for the assessment of environmental aspects of automated driving will be developed and applied. This method is intended to help provide accurate, robust, cost-efficient, and practical information available to authorities, consumer organizations, and the automotive industry.

## 24.7 Conclusion

The Drive Me project has a high-profile ambition to define and evaluate how autonomous vehicles will have a major importance for quality of life and achievement of a sustainable urban environment. It focuses on studying potential benefits for safety, traffic flow, and energy efficiency when autonomous vehicles are introduced on larger scale in the road transportation system.

## References

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