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| **Reference** | CP53 |
| **Project Title** | Report on the safety and traffic flow impact of mixed traffic condition |
| **Coordinator** | VTI |
| **Project Manager** | Jiali Fu (jiali.fu@vti.se) |
| **Project Duration** | 2021-03-01 – 2021-12-31 |


# Contents


## Summary

Heterogeneous project is a collaboration between VTI, Chalmers, Volvo AB and Volvo Cars to study the coupling relationship between different automated driving behaviours and manual driving behaviour. The aim of Heterogenous project is to develop methods for evaluating the safety and traffic flow impact when autonomous vehicles mix with manually driven vehicles.

In the pre-study funded by SAFER, we intended to summarize part of the results in the Heterogenous project into a scientific publication. The resulting paper investigates if and how human drivers adapt their driving behavior, and how the behavior adaptation effects traffic safety. A paper was submitted to a well-known international conference, IEEE Intelligent Vehicle Conference 2022 (expected notification of acceptance April 10th, 2022).


# Report on the safety and traffic flow impact of mixed traffic condition

## 1. Background

The development and application of automated driving technology has shown a great potential in improving traffic safety and traffic efficiency. It will not only bring tremendous impact to the operating mode of the entire traffic system, but also change the future direction of the transport system. However, since the technology is not yet mature, it can be foreseen that the situation of automated driving mixed with manual driving will last for a long time in the preliminary stage of automated driving. Therefore, VTI initiated the Heterogeneous project together Chalmers, Volvo AB and Volvo Cars to study the coupling relationship between different automated driving behaviours and manual driving behavior. The project is under the scope of CTS - The China Sweden Research Centre for Traffic Safety. The aim of Heterogenous project is to develop methods for evaluating the safety and traffic flow impact when autonomous vehicles mix with manually driven vehicles.

In the pre-study funded by SAFER, we intended to summarize part of the results in Heterogenous project into a scientific publication.

## 2. Project set up

### 2.3 Purpose

The Heterogenous project has great market and social potential since it will provide knowledge that can be used for strategic implementation of traffic safety and decongestion measures, developing and evaluating effectiveness of new advanced safety systems, as well as supporting adoption of a safe system approach e.g., Vision Zero. Moreover, the project will also provide knowledge on human machine interaction for the design of autonomous driving, particularly the effects of different driving styles.

### 2.4 Objectives

This pre-study project funded by SAFER intends to summarize the work in Heterogenous project and report the result in a scientific publication at the end of the pre-study project. The resulting paper is intended for submission to a well-known international conference and will report the results from a driving simulation in a heterogeneous traffic setup.


### 2.5 Project period

2021-03-01 – 2021-12-30

### 2.6 Partners

VTI and Chalmers

## 3. Method and activities

In the Heterogeneous project, the classic traffic control theory is first adapted to model the mixed traffic circumstance. Further, we formulate an intelligent cooperative control strategy for heterogeneous traffic groups (mixed with automated driving vehicles, manual driving vehicles and infrastructure) under the mixed traffic circumstance and develop corresponding simulation and analysis tools for the mixed traffic circumstance. Moreover, behavioural studies are performed using VTI's advanced driving simulator as well as traffic simulations software for quantification on the impact of human factors on traffic flow. The research is essential to ensure the traffic safety and traffic efficiency under the development of automated driving.

## 4. Results and Deliverables

The resulting paper presents results from a driving simulation study on effects of autonomous vehicles on traffic flow and safety in a heterogeneous traffic setup. The paper was first submitted to a well-known international conference, IEEE Intelligent Transportation Conference 2021. Unfortunately, the paper was not accepted to the conference. However, we received positive review comments, such as

"In general, the paper is of good quality. However, the methodological contributions need to be clarified. "

"The paper is well written and easy to follow. But there are some organizational issues that preclude clarity on its intent and contributions."

We have revised the paper based on the comments from reviewers and submitted the revised version to another international conference, IEEE Intelligent Vehicle Conference 2022 (notification of acceptance April 10th, 2022).

## 5. Conclusions, Lessons Learnt and Next Steps

Our study in the Heterogenous project explores whether drivers would adapt their behavior in mixed traffic conditions and how the behavior adaptation affects traffic safety. Experiments were conducted at VTI using the advanced driving simulator. Results from the simulation experiment showed that significant differences in


behaviour were found in more than 90% of the research participants. However, the behaviour adaptation is dependent on both driving scenario and traffic characteristics. An investigation into long-term effects would be crucial future work to better understand behaviour adaptation, as this study explores the adaptation under a short period of time. Nevertheless, our study shows that such adaptation can already be observed in a short time period, and thus this should be investigated further in future research.

## 6. Dissemination and Publications

Parts of the results in the Heterogenous project have been presented at Chalmers University and in several SAFER seminars in 2020, and 2021. Further, one more presentation is planned in SAFER seminar on April 28th, 2022.

The expected notification of acceptance for the conference submission is on April 10th, 2022.

## 7. Acknowledgement

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