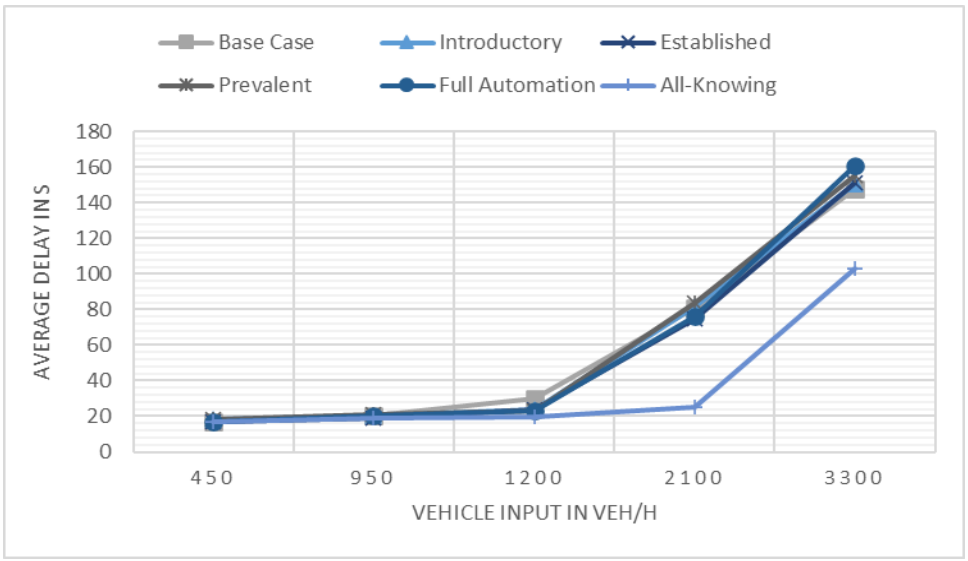
Simulation Analysis of the Effects of Advanced Traffic Control Methods on Urban Traffic Parameters under Consideration of Automated Driving

Master‘s Thesis by Viviane Dang

Mentors:
Dr.-Ing. Matthias Spangler
M. Sc. Philipp Stüger
M. Sc. Gabriel Tilg

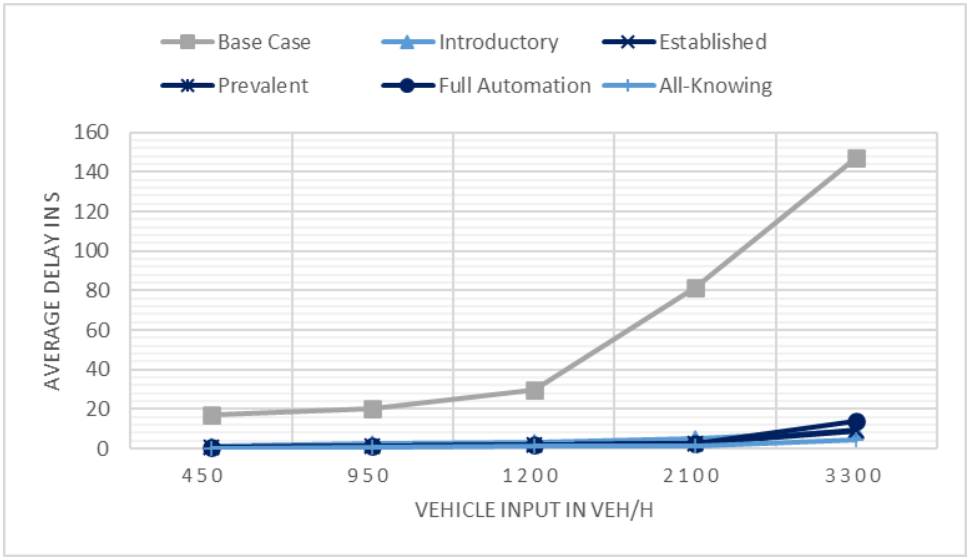
Urban Intersection with CAV involvement (@CITY, 2021)

On the basis of the simulation, the data, and a conducted t-test, the main hypothesis is entirely approved. The results from the t-test show clearly significant improvement in traffic efficiency for AIM operated intersections compared to fixed-time SIM operated intersections. An increase of 57 % to 175 % in road capacity, a reduction of 49 % to 80 % for average travel time, and a reduction by 91 % to 100 % in average delay, depending on traffic flow can be observed. However, the sub research question is rejected for all scenarios that have mixed vehicle compositions (human driven and/ or CAVs of different levels of vehicle automation). Solely, for the “All-Knowing” scenario wherein all vehicles possess the capabilities of an autonomous vehicle, the hypothesis was accepted. In the case of a scenario with the “perfect” penetration rate that is compared to a SIM operated intersection, the average delay can be decreased by 33 % to 70 %, and the average travel time can be reduced by up to 50 %. In conclusion, the results show that an efficient traffic control method can impact traffic efficiency more than increased CAV penetration. The different penetration rates of CAV in combination with AIM barely show differences in traffic efficiency based on the simulation results and the range of traffic volumes. However, differences probably will be apparent with increased traffic flows. The road capacity can increase further.



Average Delay of Autonomous Intersection Management (AIM) with different CAV penetration rates compared to base case with no intelligence

The gradual introduction of CAVs (Connected and Automated Vehicles) into current road traffic will influence the dynamic and characteristics of urban traffic. Even though, many uncertainties are still involved, the possible impacts that CAVs have on urban traffic need to be examined and studied to prepare and adjust to the changes induced by CAVs. Although CAVs can create positive effects that are beneficial to a transport system, yet the factors that can influence the effect of CAVs positively or negatively need to be further examined. This master’s thesis focused on the influence of mixed vehicle compositions (that is composed of both human driven vehicles and CAVs) in combination with urban traffic controls on urban traffic. Based on a profound two-part literature research, one main research question and hypothesis, and a sub research question and sub hypothesis were formulated. The main research question and hypothesis examine whether intersections operated by AIM improve traffic efficiency compared to intersections operated by fixed-time SIM. The sub research question and hypothesis address whether CAV involvement in SIM will increase traffic efficiency or not.



Average Delay of Signalized Intersection Management (SIM) with different CAV penetration rates compared to base case with no intelligence

Even though AIM outperforms SIM by far, certain aspects need to be taken into account and put into relation to the simulated results and reexamined. CAVs in combination with AIM certainly bring along possibilities to improve current transport systems. However, before implementation in reality, especially in urban networks, more holistic experiments need to be conducted. Microscopic traffic simulation experiments give great insights towards possible outcomes in reality but are too simplified to derive realistic outcomes or base decisions on such results. For further steps, it is proposed to annihilate the assumption that all vehicles, including conventional human driven vehicles, are connected and able to perform AIM instructions. Furthermore, the implemented algorithm should be assessed regarding its suitability for urban settings, since this AIM system is intended to be utilized in urban settings. Based on that appraisal, safety factors and inclusive measures for pedestrians, bicyclists, and public transport should be integrated into the algorithm.All in all, AIM in combination with CAVs has great potential to improve traffic efficiency in present transport systems.