Simulating transport and societal effects of automated vehicles

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Background: Not long ago self-driving cars were nothing more than an unrealistic (boyhood) dream in science fiction movies and books. The most famous examples of autonomous, intelligent vehicles are probably the VW Beetle “Herbie”, from the 1970s Disney movie series, and K.I.T.T. (Knight Industries Two Thousand), from the television series Knight Rider produced in the 1980s. In 1990 Arnold Schwarzenegger's sci-fi movie "Total Recall", directed by Dutch director Paul Verhoeven, starred automated taxis which were branded as "Johnny Cab". Today, technological progress made in recent decades brings the dream of fully automated vehicles more and more into the realm of possibility.

Two potential paths may lead towards fully automated vehicles. Car manufacturers favour a stepwise, evolutionary approach from driver assistance systems towards fully automated vehicles. New players particularly from the field of information technology, such as Google or Apple, favour a revolutionary aiming directly at driverless operation (Glotz-Richter, 2017). The latter attempt to develop automated vehicles (SAE levels 4 and 5) from scratch, while the former think in typical product development cycles and successively added innovations. Recently, several car makers announced dates for the market entrance of their first "eyes off vehicles" (SAE level 3) and level 4 and 5 prototypes (Auto Bild, 2017) , (Kleine Zeitung, 2017a).

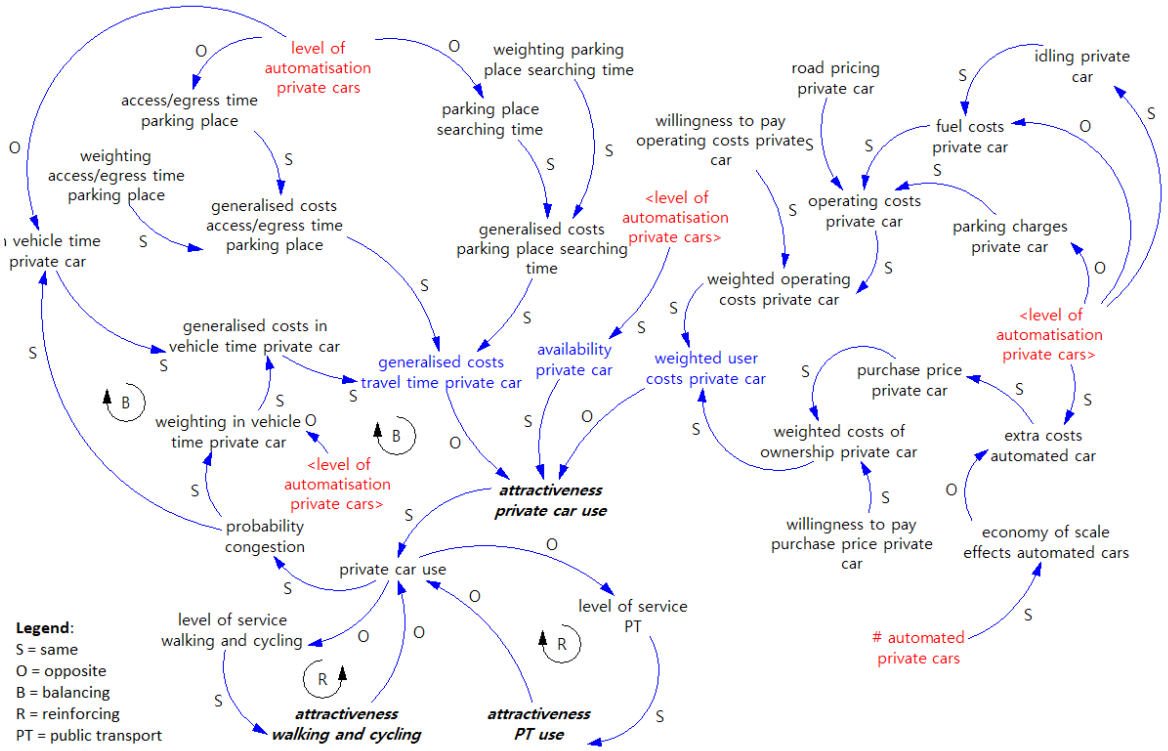
Automated vehicles can either substitute private cars, car sharing or taxi fleets or be part of public transport. In the United States ride hailing company Uber is experimenting with automated driving (Kleine Zeitung, 2017b). Pilot studies with automated busses are undertaken e.g. in the Austrian municipality Koppl (Lagler, 2017) or the Swiss city Neuhausen (Müller, 2017). The International Association of Public Transport (UITP) defines three different potential future scenarios of automated driving: automated vehicles replacing private cars, automated vehicles used in shared fleets, which compete with public transport or are integrated into public transport (UITP, 2017).

Early simulation results: The project CityMobil (Towards Advanced Road Transport for the Urban Environment) funded by the European Commission in the 6th Framework Program was one of first testing automated vehicles on al large scale. The overall objective was to achieve a more effective organisation of urban transport, resulting in a more rational use of motorised traffic with less congestion and pollution, safer driving, a higher quality of living and an enhanced integration with spatial development. As part of this, the System Dynamics based model MARS (Metropolitan Activity Relocation Simulator) was used to investigate long-term impacts of local and city-wide implementation of new automated technologies in four European cities (Shepherd, et al., 2008). Information about MARS different case studies and example models in the formats Vensim® Packaged Application (.vpa) and Vensim® Packaged Model (.vpm) could be found at http://www.fvv.tuwien.ac.at/forschung/mars-metropolitan-activity-relocation-simulator/.

In total five different scenarios of private and shared automated vehicles have been tested. In two of them automated vehicles are used to enhance inner city public transport. In one scenario

automated vehicles act as feeder system for public transport. Another scenario deals with busses running automated on specially equipped tracks and finally one scenarios deals with automated private cars. The simulations show that automated vehicles integrated into the public transport system have a potential for strengthening public transport and improving the carbon footprint of European cities. Although depending on the size of the scheme city wide effects can be relatively small. On the contrary, privately owned automated vehicles lead to an increase in car mileage travelled.

Ongoing research and revision of MARS: Currently a revised and actualised version of the model MARS is developed in the project SAFiP (System Scenarios Automated Driving in Personal Mobility), funded by the Austrian Ministry of Transport, Innovation and Technology. The first step was the development of detailed causal loop diagrams identifying the connection between automated vehicles and attractiveness and use of different means of transport. Results of this analysis concerning private and shared cars are shown in the figure below and have so far been programmed into a prototype MARS model of the city of Leeds, UK. First preliminary results show a significant increase in car-km travelled in both scenarios. Peak speed decreases with low fleet shares of automated vehicles, but recovers to higher speeds when fleet shares of automated vehicles reach about 40-50%.



Summary and conclusions: An accelerating development and market maturity of highly and fully automated vehicles can be observed. Expectations of policy makers and the public concerning positive transport and societal effects of vehicle automation are very high. There is still no consensus whether automated driving will happen in form of private cars, shared fleets (car sharing, taxis) or integrated into public transport. This leads to uncertainty about transformation paths and future ownership models. First results using qualitative and quantitative models demonstrate that it is likely that automation of private as well as shared car fleets will significantly increase mileage travelled.

References

Auto Bild. 2017. Alle Infos zum neuen A8. Retrieved November 23, 2017, from http://www.autobild.de/artikel/audi-a8-d5-2017-test-5698059.html.

Glotz-Richter M. 2017. Wenn Autos autonom werden - Automatisiertes Fahren in der Stadt- und Verkehrsentwicklungsplanung. *Planerin* (5): 36-39.

Kleine Zeitung. 2017a. Autonomes Fahren: Wettrennen zwischen BMW und Mercedes. Retrieved November 15, 2017, from http://www.kleinezeitung.at/wirtschaft/wirtschaftktnhp/5195402/Ab-2020-marktreif_Autonomes-Fahren_Wettrennen-zwischen-BMW-und.

Kleine Zeitung. 2017b. Bosch will Robotertaxis bereits 2018 auf die Straße schicken. Retrieved November 15, 2017, from http://www.kleinezeitung.at/wirtschaft/wirtschaftaufmacher/5248833/ElektroIndustrie_Bosch-will-Robotertaxis-bereits-2018-auf-die.

Lagler C. 2017. Der fahrerlose Bus hat noch Tücken. *Die Presse*, Issue Saturday, November 18, 2017.

Muir H, Pfaffenbichler P, Emberger G, Shepherd S, Wagner P, Martin P, Shires J, May T, Levin T. 2008. Deliverable D2.3.1: WP2.3 Modelling Background Report - MARS, microsimulation, cities and scenarios. Retrieved January 26, 2018, from http://www.citymobil-project.eu/downloadables/Deliverables/D2.3.1-PU-Modelling%20report-CityMobil.pdf.

Müller D. 2017. Ein Open-Air-Labor für den öffentlichen Verkhr der Zukunft. *Verkehr und Technik* (10): 367-369.

Pfaffenbichler P. 2011. Modelling with Systems Dynamics as a Method to Bridge the Gap between Politics, Planning and Science? Lessons Learnt from the Development of the Land Use and Transport Model MARS. *Transport Reviews*, **31**(2): 267 - 289.

Pfaffenbichler P, Emberger G, Shepherd S. 2008. The Integrated Dynamic Land Use and Transport Model MARS. *Networks and Spatial Economics*, **8**(2-3): 183-200.

Pfaffenbichler P, Emberger G, Shepherd S. 2010. A system dynamics approach to land use transport interaction modelling: the strategic model MARS and its application. *System Dynamics Review*, **26**(3): 262 - 282.

Ruberti G, Schrijver J, de Kievit M, Egeter B. 2007. Deliverable 2.2.3: Scenarios for Automated Road Transport - Passenger and freight application scenarios. Retrieved January 26, 2018, from http://www.citymobil-project.eu/downloadables/Deliverables/D2.2.3-PU-Application%20scenarios-CityMobil.pdf.

SAE International. 2018. Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, Retrieved July 12, 2018, from https://www.sae.org/standards/content/j3016_201806/.

Shepherd S, Muir H. 2009. Deliverable 2.3.2 Strategic Modelling Results - Summary of results across four cities. Retrieved January 26, 2018, from http://www.citymobil-project.eu/downloadables/Deliverables/D2.3.2-PU-Results%20Model%20Tests%204%20cities-CityMobil.pdf.

Shepherd S, Muir H, Pfaffenbichler P., 2008. Modelling automated technologies within a strategic transport model. *REAL CORP 008*, Wien, AT, Retrieved January 26, 2018, from https://www.corp.at/archive/CORP2008_60.pdf.

UITP. 2017. Policy Brief - Autonomous Vehicles: A Potential Game Changer for Urban Mobility. Retrieved January 25, 2018, from http://www.uitp.org/sites/default/files/cck-focus-papers-files/PolicyBrief_Autonomous_Vehicles_LQ_20160116.pdf.