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Shared Autonomous Vehicles as Park-and-Ride Transfer Alternatives Towards Cities with Zero Private Vehicles: a MATSim Simulation Study for Brussels, Belgium

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Extended Abstract

Shared Autonomous Vehicles (SAV) have attracted considerable attention in recent years due to their potential to deliver notable benefits to urban mobility networks, such as significant CPV (Conventional Private Vehicles) replacement ratios with desirable service levels, increased traffic safety, plus reduced transport emissions. With the increase in simulation algorithms and computational powers, research projects using the agent-based approach to understand to what extent SAVs can replace conventional transport modes towards a more sustainable future have been conducted in case studies worldwide (Li et al., 2021). While most SAV simulation studies assume SAVs operate within predefined service areas (primarily within urban regions) for better service efficiencies, one primary limitation is simplifying the travel demands of travellers with activities outside the service area. Most existing studies ignore the travel demands of these individuals (Bischoff & Maciejewski, 2016). This is particularly problematic for metropolitan cities with frequent travellers from other regions. In contrast, other studies extract the inner service area part of trips into new agents for SAV simulations. However, by excluding the external parts of agents' original travel patterns, these studies may overlook the SAVs' potential impacts on agents' original trip chaining. Still, the simulation cannot adequately reflect the future mobility scenario with SAVs.

This research aims to develop a realistic approach for allocating both internal and external travellers in the future with SAVs and to explore to what extent such an approach can further extend SAV benefits towards sustainable futures. One key challenge is providing a transport solution with comparable service and comfort levels for travellers currently with external CC trips. Bundling SAV, LEZ (Low Emission Zone), PT (Public Transit) and Park-and-Ride (PnR) into a coherent Mobility-as-a-Service concept is one promising solution. Figure 1 illustrates the brief concept of such service: Travellers from suburban areas can drive CPV to designated facilities on the city outskirt and transfer to either SAVs or PT towards trip destinations based on each mode's perceived utilities. For trips within the city, travellers could opt for SAV (with similar convenience and comfort levels to CPV) or PT as alternatives. Individuals will further pick up their CPV at the original PnR facility if there are still trips towards external locations. Guidon et al., (2020) proves that users will highly value such a service. Nevertheless, the macroscopic impacts of such a service on traveller accessibility, transport network efficiency and sustainability are still unclear.

Our research fills the above research gaps in the literature. We investigate to what extent LEZ policies with SAVs can reduce private vehicle ownership within a city and its relative impacts on the perspectives of SAV operators (fleet sizes, prices, distance travelled), users (service level) and overall society (transport emissions, mode shares and road capacities). An agent-based simulation using MATSim and its *drt contrib* (Maciejewski et al., 2017) is carried out. Brussels, Belgium, is selected as the case study region. Brussels was chosen for two reasons: Firstly, it is the most densely populated region in Belgium with a large proportion of external travellers (around 40% of the total Brussels

residents) (VIAS Institute, 2017); Then, an urban-wide LEZ policy has been adopted in Brussels since 2018, which eliminates the most polluting vehicles, regardless of the locations of registrations, from entering the city. Using PnR facilities as transfer points to PT has already been adopted as an alternative for the respective car users in Brussels since 2022 (LEZ.Brussels, 2023). With the deployments of SAVs in pilot projects, this research strives to study the most feasible PnR market penetration with the proposed service bundle under the existing and projected road infrastructures. The transferability of such service to other regions is further discussed to offer practical recommendations to policymakers for future applications.

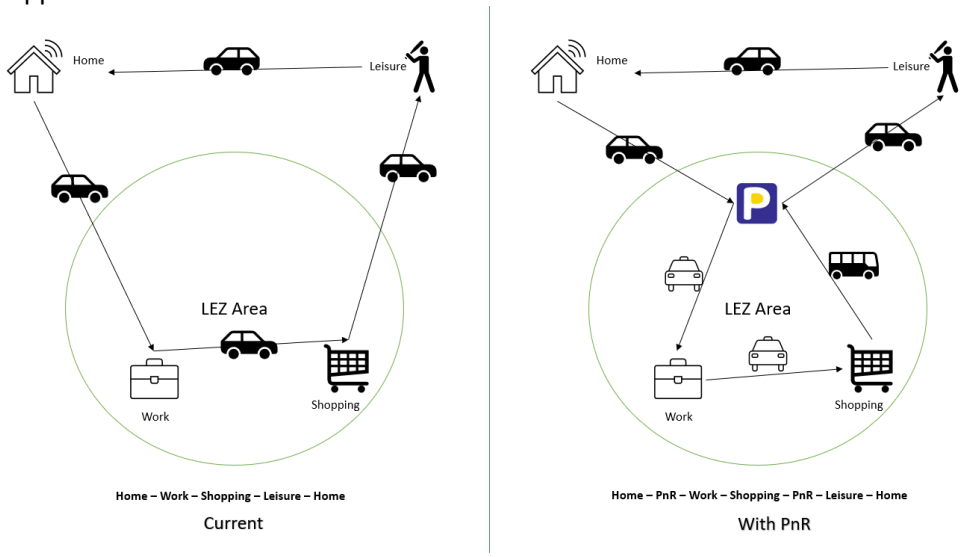

Figure 1 Travel Pattern Comparison Between Current and Projected LEZ Scenarios

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