Developments of Urban Air Mobility Analyses using Multi-Agent Transport Simulation

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With further development of electric vertical takeoff and landing (eVTOL) vehicles, it becomes relevant to analyze potential business cases and implementation strategies of a new mobility service with eVTOL vehicle fleets in urban areas. The Multi-Agent Transport Simulation (MATSim) was introduced here, allowing the Urban Air Mobility (UAM) transport system to be analyzed in competition with ground-based transport systems for commuter travel [1,2]. While a small market share of up to one percent of mobility trips is identified, the research question of total costs of a UAM service from a fleet operator perspective needs to be addressed. Recent work has established a cost optimization model that takes into account vehicle and recharging specific decisions within the MATSim Scenario Ruhr [3,4]. This approach of cost optimization analysis in post-processing, where MATSim allows simulation of relevant scenario data for possible on-demand flights, provides particular potential due to minor adjustments in the simulation scenario. Recent results have found that some eVTOL vehicles that might be more cost-efficient for one single reference mission do not allow cost-efficient flight operations within an overall urban mobility network [3,4].

In this context, a cost-price loop between output of fleet-level cost optimization and input for mode choice of the agent's utility function has been introduced and applied [5]. The results here particularly show that simulated UAM service scenarios, in contrast to previous market potential studies, set higher requirements on vehicle design on the one hand and for the transportation system optimization on the other. Besides these considerations of both MATSim studies and cost optimization, mainly three aspects are in the focus of the most recent research work based on sustainability requirements and feasibility assessment [5]: the consideration of the environmental friendliness of UAM, the connection of the station network to noise emission costs of the additional mobility system, and the modeling of UAM user acceptance.

Regarding environmental friendliness, initial studies show that substituted trips of private cars and public transportation represent an important portion of UAM sustainability assessment. Thus, this consideration needs to be taken into account in future life cycle analyses and acceptance surveys [5].

For the integration of noise emission costs in the UAM post-processing, it is shown that the station network needs to be built much smaller than previously assumed and a linkage of noise emissions from eVTOL vehicles to the affected residents is relevant. With the inclusion of the surrounding real estate properties around potential UAM locations, the hedonic pricing method allows insights into feasibility of UAM as a business case for many parameter studies. This aspect of noise emission costs on UAM transportation system level using MATSim represents a new potential for eVTOL vehicle design [5].

Besides costs and travel time savings, recent work underlines environmental friendliness, level of autonomy and connection of new potential mobility stations as relevant part of user acceptance [6]. From there, current work focuses on the implementation of user acceptance in either the agent's

utility function or post-processing approaches. Here, one approach that is under consideration is the UAM user acceptance modeling based on structural equation models that are derived from surveys [7].

In summary, current approaches towards the adoption of Urban Air Mobility includes the detailed analysis on network level including strategic, operational and sustainable planning where MATSim allows relevant mobility data simulation for further modeling or optimization approaches. For the analyzed aspects, both extending MATSim UAM and extended analyses on post-processing level can be regarded as feasible.

[1] Rothfeld, R., "Agend-based Modeling and Simulation of Urban Air Mobility Operation: An Evaluation of Travel Times and Transport Performance", *Doctoral Dissertation*, Technische Universität München, 2021

[2] Horni, A., Nagel, K., and Axhausen, K., "Introducing MATSim". In: *Multi-Agent-Transport Simulation MATSim*, 2016. ISBN 978-1-909188-75-4

[3] Husemann, M., Kirste, A., and Stumpf, E., "Analysis of Cost-Efficient Urban Air Mobility Systems: Optimization of Operational and Configurational Fleet Decisions", European Journal of Operational Research, 2023. https://doi.org/10.1016/j.ejor.2023.04.040

[4] Kirste, A., Husemann, M., and Stumpf, E., "Analysis and Evaluation of Urban Air Mobility Fleet Operations using Agent-based Transport Simulation", Paper presentation, *Deutscher Luft- und Raumfahrtkongress 2022*, 2022

[5] Kirste, A., Husemann, M., and Stumpf, E., "Analysis of Sustainability Specifications of Urban Air Mobility Fleet Operations using Agent-based Transportation Simulation", *Deutscher Luft- und Raumfahrtkongress AIAA Aviation 2023 Forum*, 2023. https://doi.org/10.2514/6.2023-3264

[6] Lotz, V., Kirste, A., Lidynia, C., Ziefle, M., and Stumpf, E., "User Acceptance of Urban Air Mobility (UAM) for Passenger Transport: A Choice Based Conjoint Study", *Human-Computer Interaction International 2023 Conference*, 2023

[7] Burbach, L., Kojan, L., Ziefle, M., and Valdez, A. C., "SEM2Agent – A Scheme for the Use of Structural Equation Model Data in Agent-Based Models", *Social Simulation Conference 2021*, 2021