Mitigating Urban Traffic Congestion: A Multi-Modal Approach Including DRT for Jerusalem

Extended Abstract – MATSim user meeting 2023

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Introduction

Urban transport faces a dichotomy where individuals mainly rely on either private vehicles or conventional Public Transport (PT). The emergence of ride-hailing and other auxiliary modes hasn't substantially offset car usage (Schaller, 2021). This is attributed to the perceived comfort of car travel despite the negatives such as congestion (Shiftan, 2025). To break this cycle, it is vital to employ strategies that discourage car use. This study focuses on Jerusalem Metropolitan Area (JMA) in Israel and explores the integration of congestion charges, parking fees, and an on-demand shared taxi service (Demand-Responsive Transport - DRT) to influence mode choices. A validated MATSim model of JMA's traffic was built for simulations.

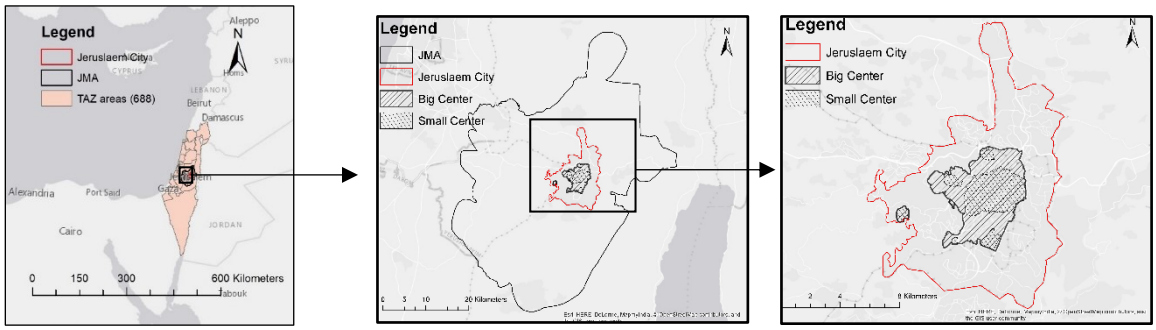
Methodology

The MATSim open-source framework (Horni et al, 2016), renowned for its high-resolution urban traffic simulations and adaptability to varying conditions, was employed to model JMA's multi-modal transport system. JMA's network is represented by 8.5K one-way road links within 688 Traffic Analysis Zones covering 1800 km^2. The model, JMATSim, included six transport modes: private car, walk, bike, bus, rail, and light rail, calibrated using data provided by the Jerusalem Transportation Planning Team for 2020 (JTMT, 2020). JMATSim accommodated 30% of JMA's population, which amounts to 434K agents. The model was calibrated using Cadyts algorithm (Flötteröd, 2009) against traffic data, demonstrating a strong fit with R^2=0.83. To implement the DRT algorithm (Bischof et al, 2017) in JMATSim we extended it in the following ways:

- Constraining DRT trip origins and destinations to designated areas with a stop-based service. Stop-based improves service regarding fleet size, rejections, and waiting times (Ben-Dor et al., 2019); hence the analysis below is performed for this scheme.
- Change of the MATSim DRT iteration loop: MATSim's general approach is that agents with ineffective plans still follow them until mutation happens and a better plan is generated. This approach cannot work for DRT as a "curious" but rejected agent requesting DRT will relapse to an existing plan excluding DRT. A rejected JMATSim agent reverts to the previously used plan without DRT to reflect this drawback.
- Running DRT simulations in MATSim is time-consuming, even with the DRT-Speed-Up module. Therefore, we included the DRT-Speed-Up module (Kaddoura et al, 2020) in the HERMES (Graur et al, 2021) extension of JMATSim

Policy Evaluation

Three mechanisms were analyzed for their impact on traffic congestion: congestion charges for non-residents entering the city center, parking fees for those parking away from their residences, and the introduction of DRT services. Two central areas within Jerusalem were studied: SMALL CENTER (13 km^2) and BIG CENTER (28 km^2) – see Fig. 1c.



(a) (b) (c)

Fig. 1 (a) Israel and JMA (b) Zoom to Jerusalem border (c) Jerusalem city areas with BIG and SMALL versions of the city center

Three policy scenarios were examined: Free entrance (no charge), Congestion charge (10€ for crossing city center border), and Parking price (5€ per hour for non-residential parking). The evaluation also involved considering different DRT fleet sizes (250 and 1,000 vehicles).

Findings and Conclusions

Without DRT, the BIG CENTER experienced more traffic due to its size. A congestion charge increased PT usage by approximately 10% in the BIG CENTER and around 20% in the SMALL CENTER. Parking fees showed an even stronger effect, significantly reducing car use within the centers. Introducing DRT service revealed that a fleet of about 300 vehicles suffices for demand. However, a larger fleet (1,000 vehicles) reduced service rejections from 15% to 3%, potentially attracting more users in the long run. With DRT service, in the Free entrance scenario, the majority of users who switched to DRT came from PT, and congestion remained unchanged. In contrast, charging for entrance (congestion charge or parking fee) made DRT more attractive for both car and public transport users. Parking fees were more effective than congestion charges in reducing car use and were simpler and more affordable to implement.

This study shows that combining congestion charges or parking fees with DRT services can effectively reduce car usage in urban centers. Among the strategies, parking fees appear to be more effective and feasible for implementation. Implementing these measures could contribute to a sustainable modal shift towards PT and shared mobility services, ultimately mitigating urban congestion in Jerusalem.

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