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Assessing the impacts of traffic calming at network level. A multimodal agent-based simulation

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Background: The reduction of speed limits in urban roads have been proposed by many urban and transport planners over the past 20 years aiming to ensure safer traffic conditions among road users, i.e. pedestrians, cyclists, car drivers etc. [1]. According to Yannis et al. [2], traffic calming intends to reduce crashes with fatalities or serious injuries in urban roads; such measures are: speed humps, roundabouts, curb extensions, chicanes, raised intersections, median barriers or islands etc. In addition, there are design factors related to the urban environment, which affect the driver compliance [3]. At the end, the success of traffic calming designs is determined by the compliance rate. According to the last study, "the presence of median or physical separation encourages speeding and therefore increases the probability of speed limit violation". The drivers' compliance also influences the free flow speed and therefore road capacity. In the literature, this relationship has been widely examined at micro-level (e.g. a motorway link) aiming to predict the impacts on traffic operations [4].

Objective: The objective of this study is to assess the effects of traffic calming at urban road network level considering different compliance rates. The tested hypothesis is the following: lower speed limits (i.e. ≤ 30 km/h) and high compliance rates (i.e. ≤ 1) are able to cause capacity drop in urban roads; due to this change, car as a transport mode becomes a less attractive choice to cross these urban areas leading some travelers to change either the mode or the route; in the next step, this change may result in lower traffic congestion in road links reaching a new equilibrium point [5]. In this research, drivers' compliance is integrated by importing different scenarios. In general, it should be noted that this study examines the concept of traffic calming from a different perspective than the previous ones, as it aims to discuss whether traffic calming schemes can improve or downgrade the overall efficiency of the transport system.

Method: To meet this research objective, an open-source multimodal agent-based simulation tool, namely: MATSim is used. Furthermore, this study considers an already calibrated base scenario that has been developed in Berlin, Germany, i.e. the MATSim Open Berlin scenario [6], as the experimental field. By developing a new external tool, we update the free flow speed and road capacity of each network link based on new speed limits and different compliance rates, which are set per road hierarchy level [7]. In essence, the scenarios present extreme realities, where the speed limit in the majority of urban roads of Berlin drops to 30 km/h. To assess the impacts of the imported scenarios, a sensitivity analysis is performed considering drivers' compliance as the unknown factor [8].

Results: The findings of this study show a considerably high increase in trips, passenger hours and passenger kilometers using public transport modes, when the speed limits are reduced and more traffic calming areas are created. The reserve change is observed in private cars trips. Although the speed limits are reduced in inner urban roads in most of the scenarios, the decrease of average travel speed of private cars is not so high as it was expected. Surprisingly, private cars are used for longer distances in all test scenarios. Car drivers seem to use already existed motorways and private roads to commute. Driver compliance is a determinant factor; yet it is strongly influenced by the design of the urban road.

Conclusions: In conclusion, public transport seems to be the main competitor of private car when speaking for large metropolitan or urban areas like Berlin, where the travel distances between home and work are large compared to smaller cities. In this new reality, the increased usage of public transport leads to a noticeable reduction of passenger

car kilometers and consequently congestion points at peak hours. The reduction in passenger kilometer with private car could lead to significant reduction of CO2 emissions, noise in urban areas and less accidents. These indirect positive impacts of traffic calming were not assessed in this study; yet, MATSim provides a plethora of simulation data to extend the assessment analysis and the discussion around traffic calming. However, there are some major limitations, which are related to the simulation dynamics and level of detail of a mesoscopic simulation tool like MATSim [9], [10]. In the tested scenarios, no penalties have been introduced in transfers for a public transport mode/line to the other. In practice, transfer, access/egress and waiting time highly raise the disutility of public transport modes. Last, MATSim does not simulate cycling or walking trips; it applies a simplistic teleportation algorithm using the Euclidean distance instead of the network distance [11].

Keywords: agent-based simulation; traffic calming; impact assessment; urban road network.

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