AI-Enhanced Agent-Based Modeling to Support Urban Mobility Decarbonization: Driving Restriction Zones in the Paris Region

Tatiana Seregina[1], Nicolas Coulombel[1]
[1] LVMT, École des Ponts, Université Gustave Eiffel, Marne-la-Vallée, France

Presenting author email: tatiana.seregina@enpc.fr

In response to the growing challenges of urban congestion and pollution, driving restriction policies – such as Low Emission Zones (LEZs) and urban tolls – are emerging as strategic levers to promote more sustainable mobility. However, their effectiveness depends on various factors, including user behavior, available transport alternatives, and the structure of the urban network (Bernardo, Fageda, and Flores-Fillol 2021). Accurately assessing the impact of such policies requires models capable of capturing the complex interactions between users, infrastructure, and regulatory measures.

Agent-based modeling provides a powerful framework for representing these interactions (Huang et al. 2022), but its high computational cost limits its ability to explore a wide range of scenarios. This study investigates how artificial intelligence (AI) techniques can be integrated into agent-based transport simulations to accelerate analysis and identify the conditions that enhance the effectiveness of driving restriction policies. Focusing on driving restriction zones (DRZs) in the Île-de-France region, the research addresses several key questions: How can AI optimize and strengthen the use of agent-based simulations to evaluate such policies? Which factors drive their success, and under what conditions can their effectiveness be maximized? This presentation aims to provide insights that support a more effective transition toward decarbonized and resilient urban mobility.

The study follows a two-step approach:

1. **Scenario simulations.** First, simulations are conducted using MATSim (W. Axhausen, Horni, and Nagel, 2016) to assess the impact of various DRZ scenarios in the Île-de-France region. These DRZs are randomly generated, covering either single or multiple municipalities, with both intra- and inter-departmental configurations to reflect territorial and transport network diversity. By incorporating specific geographic data and adjusting parameters to fit each area’s unique characteristics, MATSim enables more realistic simulation of mobility patterns under DRZ policies. The simulation outputs yield key mobility and environmental indicators for each configuration.
2. **AI model** (Figure 1)**.** In the second phase, an AI-based model is developed to replicate MATSim results and predict the impacts of new DRZs without the need for computationally expensive simulations. This model leverages simulation data to identify the key factors driving DRZ effectiveness and assess their applicability in varied urban contexts. A rigorous validation process compares the model's predictions to actual simulation results to ensure reliability and operational relevance.

The proposed approach represents a promising advancement in integrating AI into agent-based modeling for transport policy evaluation. Unlike prior studies - such as the combination of agent-based simulation and machine learning to analyze small-scale traffic restrictions in Bilbao (Shulajkovska et al. 2023), or using neural networks to assess road capacity reduction policies in Paris (Natterer et al. 2025) – this study explores a wide range of DRZ configurations across diverse and large-scale urban contexts. By merging agent-based simulation with AI, it develops a predictive model that accelerates policy evaluation, reduces computational costs, and broadens the scope of scenario analysis. This flexible framework is adaptable to various urban environments and offers new avenues for urban mobility planning and policy optimization. Its potential for transferability to other regions or urban contexts further strengthens its value for public decision-makers.

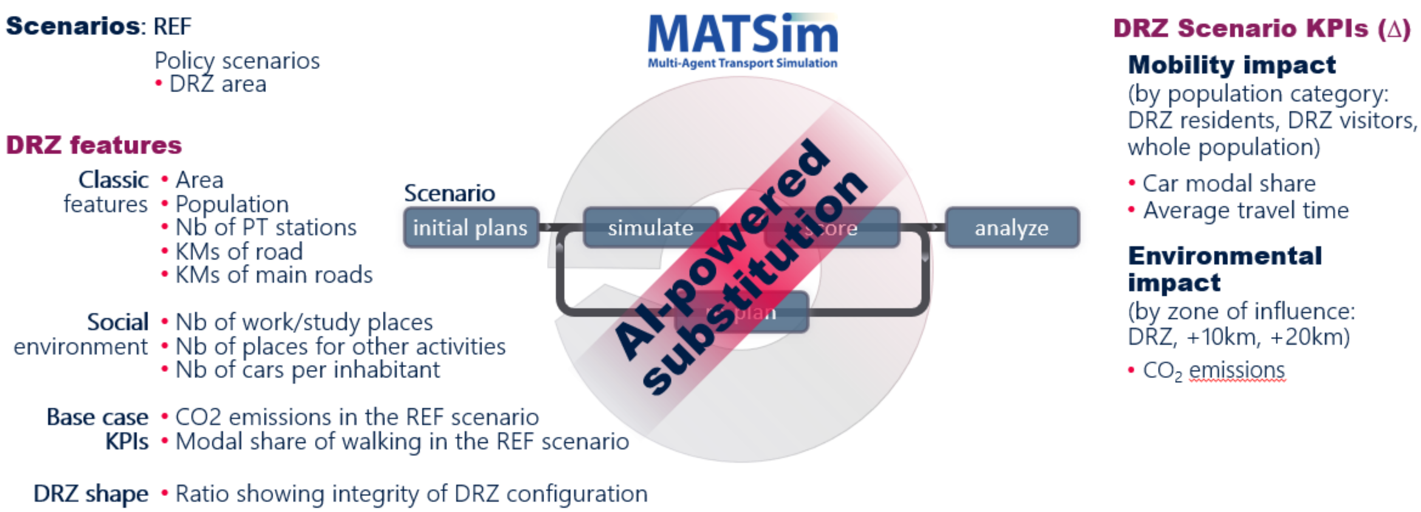

Figure 1 MATSim-AI framework for evaluating DRZ scenarios

Keywords: Agent-based modeling, simulation, artificial intelligence, transportation, mobility policy, impact analysis, evaluation, decarbonization, driving restriction zone

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