Methodological Abstraction for Scalable Agent-Based Modeling with MATSim with Replan.city suite

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Introduction

Despite its scientific robustness, MATSim remains largely confined to academia and isolated corporate forks due to high technical complexity and server infrastructure requirements. Typical deployments demand experienced developers—often graduates from ETH Zurich, TU Berlin, TU München and similar institutions. While some large corporations and MATSim users like Volkswagen or SBB actively contribute to the code base, others maintain customized forks, limiting broader accessibility.
These barriers restrict MATSim's use for municipalities and consultancy firms, despite its potential for large-scale agent-based urban mobility planning. Traditional processes involve complex configuration, deep calibration expertise, and data integration, typically requiring months of manual work.
At the MATSim User Meeting 2025, we will demonstrate how a transport consultancy firm leveraged MATSim for the entire cycle of model creation, calibration, and scenario evaluation—achieving this without prior MATSim experience, coding, or server infrastructure. The project included calibration based on 780 hourly traffic measurements across 70 road segments, validation with municipal stakeholders, and the creation of 30 road variants, 15 public transport configurations, and 80 scenario presets.
We argue that the primary barrier to broader MATSim adoption is the lack of a methodological abstraction layer bridging scientific modeling with practical urban planning. This paper presents how such an abstraction enables non-academic stakeholders to independently build, calibrate, and evaluate large-scale agent-based models.

Problem Statement

While MATSim has proven to be a scientifically rigorous and modular agent-based modeling framework, its adoption in urban planning and consultancy projects remains limited. Despite its flexibility and advanced simulation capabilities, MATSim's application is largely confined to academia and isolated corporate projects. Although powerful, the tool's complexity creates several barriers for broader industry uptake:

1. **High Technical Expertise Requirement:** Deploying MATSim typically demands advanced technical skills, often requiring PhD-level developers. This specialization narrows the pool of potential users, making it challenging for consulting firms and municipalities to adopt MATSim for everyday urban planning tasks.

2. **Configuration and Calibration Complexity:** Building and calibrating large-scale agent-based models requires extensive manual adjustments, data integration, and network fine-tuning. Traditionally, this process could take six months or more, involving full-time technical staff to handle model calibration, validation, and scenario configuration.

3. **Knowledge Transfer and Interoperability:** Although there are excellent examples of open sharing and collaboration—such as code contributions from Volkswagen and SBB—many large-scale corporate projects remain isolated. These custom implementations are often optimized for internal needs and do not always integrate back into the open-source community.

4. **Infrastructure Barriers:** Running large-scale MATSim simulations demands significant computational power and dedicated server infrastructure. For many consultancies and municipal agencies, this requirement creates a prohibitive cost barrier, especially when projects need iterative scenario testing and real-time validation.

5. **Lack of Methodological Abstraction for Non-Academic Users:** Existing tools in the MATSim ecosystem are primarily designed for research applications. They provide powerful simulation analytics but assume a high degree of familiarity with MATSim's internal structure, hindering accessibility for consultants and urban planners.

Methodology

To address these barriers, we propose a structured abstraction framework enabling consultancy firms and municipal planners to independently create, calibrate, and analyze large-scale agent-based models. This framework is organized into three primary abstraction layers:

1. Model Building, Calibration, and Validation

Automated generation of the initial network and population synthesis, structured workflows for loading modal splits, road counts, and transit boardings, and iterative validation processes integrating stakeholder feedback for model refinement.

2. Data Integration and Scenario Configuration

Modular representation of data layers—road networks, public transport, and zoning policies—with preset-based configuration to isolate modifications and prevent cascading errors. Flexible scenario combinations allow testing of various urban development strategies.

3. Scalable Simulation Execution Without Dedicated Infrastructure

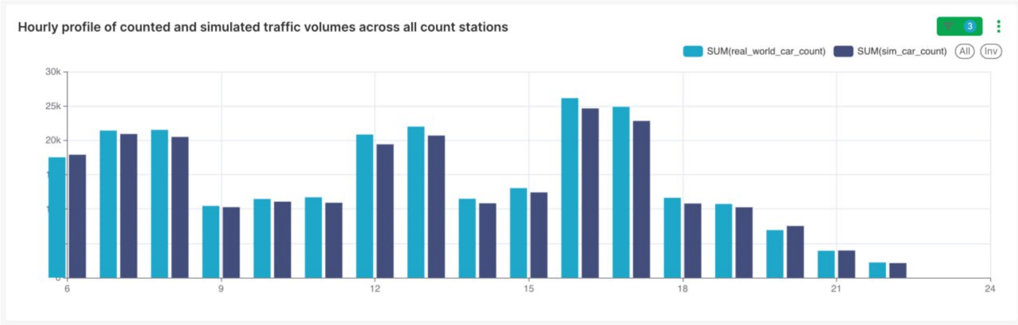
Cloud-based simulation environment eliminates the need for local servers. Real-time dashboards monitor and validate simulation outcomes, supporting iterative scenario runs without additional configuration overhead.

Case Study: Application of Methodological Abstraction in Agent-Based Modeling

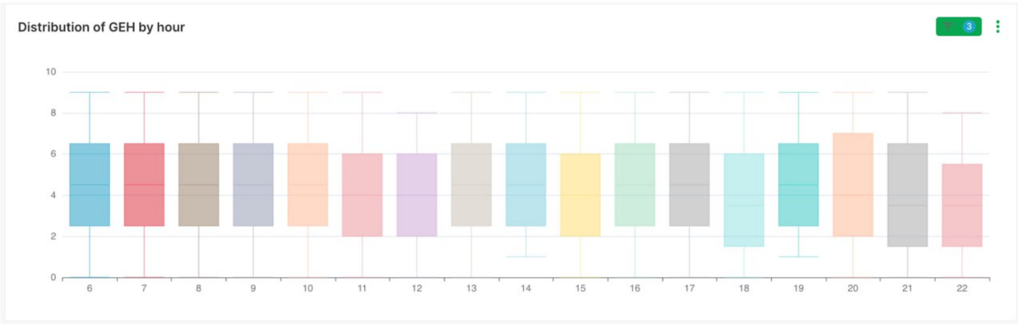
To validate the proposed methodology, we applied the abstraction layers in a real-world consultancy project. A team with no prior experience in MATSim independently built, calibrated, and analyzed a city-scale model for a population of 100,000 using Replan.city cloud-based software.

Model Development and Validation

The calibration process utilized 780 hourly traffic measurements across 70 road segments 1. Validation was conducted iteratively with stakeholder input, focusing on capacity adjustments and travel times. Brute-force methods were applied to detect network inconsistencies and ensure correction.



(a) Hourly profile of counted and simulated traffic volumes across all count stations.



(b) Distribution of GEH by hour.

Figure 1: Comparison of simulated and real-world traffic volumes (top) and calibration quality represented by GEH index (bottom).

Scenario Integration and Testing

A total of 30 road network variants, 15 public transport configurations, and 80 scenario-based presets were created within the GUI-enabled interface of Replan.city. Presets were combined flexibly to evaluate urban expansions and policy shifts, with automated conflict resolution ensuring scenario consistency.

Simulation and Analysis

The team performed 450 simulation runs entirely in the cloud, with interactive dashboards enabling real-time validation and presentation to municipal stakeholders. Scenario adjustments and analysis were conducted iteratively, with feedback loops directly influencing recalculations.

Conclusion

This study demonstrates that structured methodological abstraction can significantly reduce the barriers for large-scale agent-based modeling in MATSim. The proposed abstraction layers enable consultancy firms and municipal planners to independently build, validate, and simulate urban mobility scenarios, bypassing traditional technical constraints. At the same time, experienced MATSim users and researchers are not limited to the predefined abstraction layers. The framework is designed to be flexible, allowing for the integration of custom components, such as proprietary generation methods, calibration techniques, or runner implementations.