IDF_02: Setting-up of a dynamic Digital Twin of the territory

Description of the measure and main outcomes expected

To better understand its transport system and evaluate future mobility scenarios in its territory, VGP wishes to acquire a modelling and simulation tool (digital twin) on the scale of its geographical area. Versailles Grand Parc – Île de France measure 02 consists of setting up a multi-agent simulation platform (MATSim) for journey' on the scale of VGP's territory. The tool will make it possible to observe mobility in the territory more precisely by simulating the chains of activities and trips of individuals and to provide estimations on specific non-measurable indicators such as pollutant emissions. Moreover, this tool will allow the design and assessment of new mobility policies, such as low-emission zones.

Preparation of the measure

Selection of appropriate digital twin

The first step during the preparation phase of measure 02 consisted of describing the objective and scope of the digital twin with VGP's partners. This phase was necessary to identify VGP's real needs and expectations regarding the simulation platform to be set up. In terms of functionalities, the digital twin should allow:

To simulate as faithfully as possible the journeys of individuals on the scale of the VGP territory in terms of choice of transportation mode, origin/destination (O/D), and routes.

To produce non-measurable indicators such as pollutant emissions.

To evaluate the mobility policies already implemented and those to come such as the low-emission zones (LEZ).

After this step, the multi-agent simulation software MATSim was selected as the most appropriate digital twin. MATSim is an open activity-and-agent-based multimodal transportation simulation framework[1]. Agents in MATSim are utility maximisers. Each agent seeks to maximize its utility by performing all planned daily activities like work, education, leisure, or shopping, minimizing unproductive travel time by choosing appropriate travel modes, routes, and departure times. MATSim is suitable for large-scale simulations. There are MATSIM models for Berlin, Switzerland, and the Ile de France region.

Moreover, IFPEN has substantial experience and expertise using MATSim through various studies with the Greater Paris and Lyon Metropolises.

Data collection and processing

Different data sources have been collected and processed to generate the inputs necessary to carry out the MATSim simulations. Table 1 summarizes the primary data sources, including the production areas available in France, relative to their usefulness for simulating individual trips.

Field	Source	Provider	Usefulness
Travel	Household travel survey (EMD, EGT)	Local authorities, IDFM	Transport demand
	Census survey	INSEE[2]	

[1] https://matsim.org/

[2] https://www.insee.fr/fr/information/8183122

	Service and facility census (BPE)	INSEE[3]	Activity location
	Buildings database (BD TOPO)	IGN[4]	
	OpenStreetMap (OSM)	Geofabrik[5]	
Road network	OSM	Geofabrik[6]	Transport supply
PT network	GTFS	IDF mobilités[7]	

Table 1: Main sources of data on transport demand and supply in France.

Travel demand is typically derived from a synthetic population. This synthetic population is defined as a set of agents with attributes such as place of residence, age, gender, socio-professional category, and possession of transport cards/equipment. Travel demand groups the activities and trips performed by agents. It includes elements such as activity types and their location, activity start and end times, and travel mode. Finally, the above data is combined via the open-source EQASIM[8] to generate MATSim transport demand and supply.

Calibration

A first calibration phase of the tool was carried out to reproduce the current situation of individual mobility at the territorial level. This calibration phase was performed using travel survey data by considering the number of trips, modal shares, and distribution of travel distances and durations.

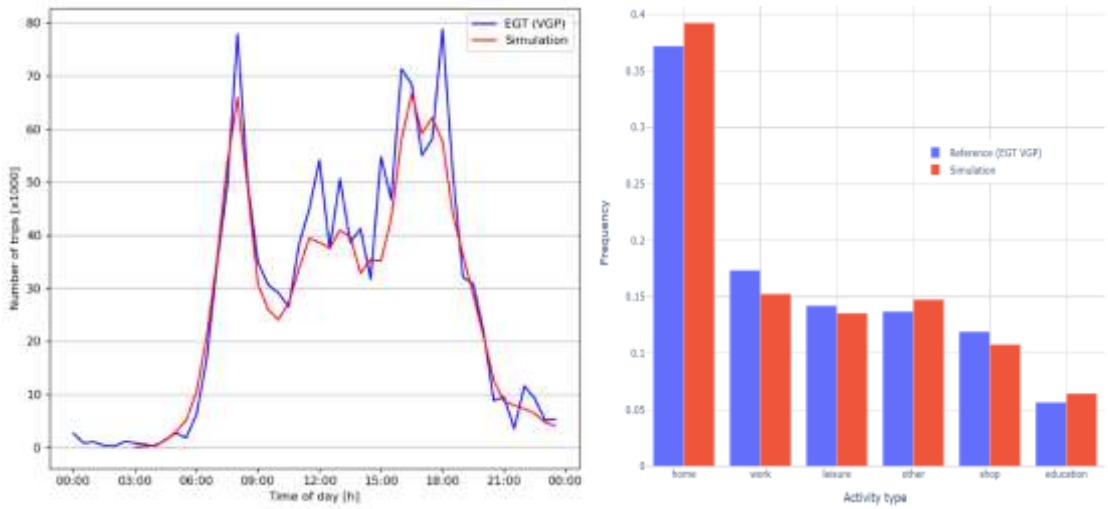

Figure 1: Comparison of departure time distributions and shares of activity types at ends of trips

[3] https://www.insee.fr/fr/statistiques/3568638

[4] https://geoservices.ign.fr/bdtopo

[5] https://download.geofabrik.de/europe/france/ile-de-france.html

[6] https://download.geofabrik.de/europe/france/ile-de-france.html

[7] https://prim.iledefrance-mobilites.fr/fr/jeux-de-donnees/offre-horaires-tc-gtfs-idfm

[8] https://github.com/eqasim-org/ile-de-france

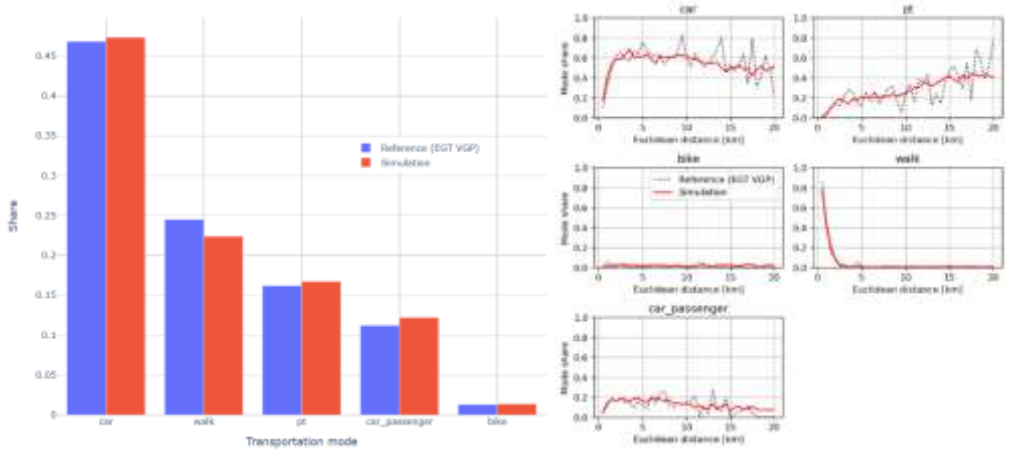

Figure 2: Comparison of global modal shares and according to the distance.

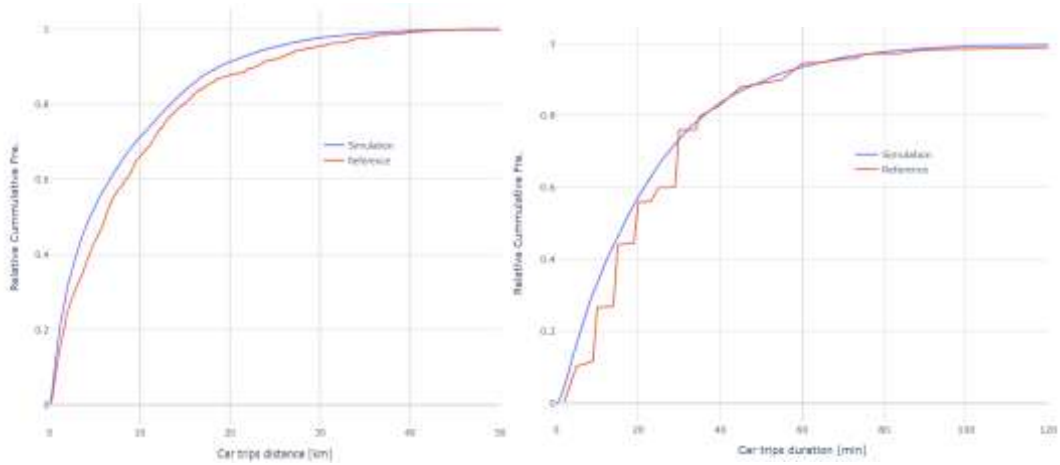

Figure 3: Comparison of beeline distance and duration of trips performed by car.

The simulation produced results that were very similar to those of the survey. The departure time distributions for simulation and survey have almost the same flow dynamics distributed between the morning, midday, and afternoon peak hours (left of Figure 1). The share of activity types at trip destinations is reproduced succinctly (right of Figure 1). Figure 2 provides the simulated mode shares after completing the mode choice calibration. The overall modal shares are on the left, while those according to the distance are on the figure's right. The simulation tends to slightly overestimate the use of the car on short distances, which results in a decrease in walking on these distances. Finally, distances and travel times match very well (Figure 3).

Emissions assessment

An emissions calculation module based on HBEFA factors[9] was integrated into MATSim to estimate CO2, PM, and NOx emissions within the VGP territory. These emissions come from all travel within the territory, both for residents and other users. However, it is essential to emphasize that these estimates do not consider logistics (freights) flows and other service traffic (e.g., craftspeople, mobile nursing service). Table 2 gives an overview of total emissions.

[9] https://www.hbefa.net/

Emissions	Unit	Total
CO2	Tones/day	796
NOx	Tones/day	1.66
PM	Kg/day	39.32

Table 2 Emissions from the digital twin

Challenges & Mitigations

One of the main difficulties encountered during the preparation phase of this measure concerned the availability of counted traffic and air pollution data on the VGP territory. Traffic counting data will come from video surveillance cameras. The change in the counting solution at VGP partly explains this absence of data availability. A new service provider has been identified, and the data should be available soon. In addition, atmospheric pollutant sensors will be installed next to specific cameras to obtain an estimate of the actual emissions from road traffic in this neighbourhood.

Next steps towards implementation

A second calibration/validation step will use dynamic counting data from cameras and atmospheric pollutant sensors. The VGP side is currently acquiring this data. This step will allow us to refine the quality of the simulation results, particularly on traffic dynamics and pollutant emissions.