Introducing the eqasim pipeline

From raw data to agent-based transport simulation

Other Conference Item

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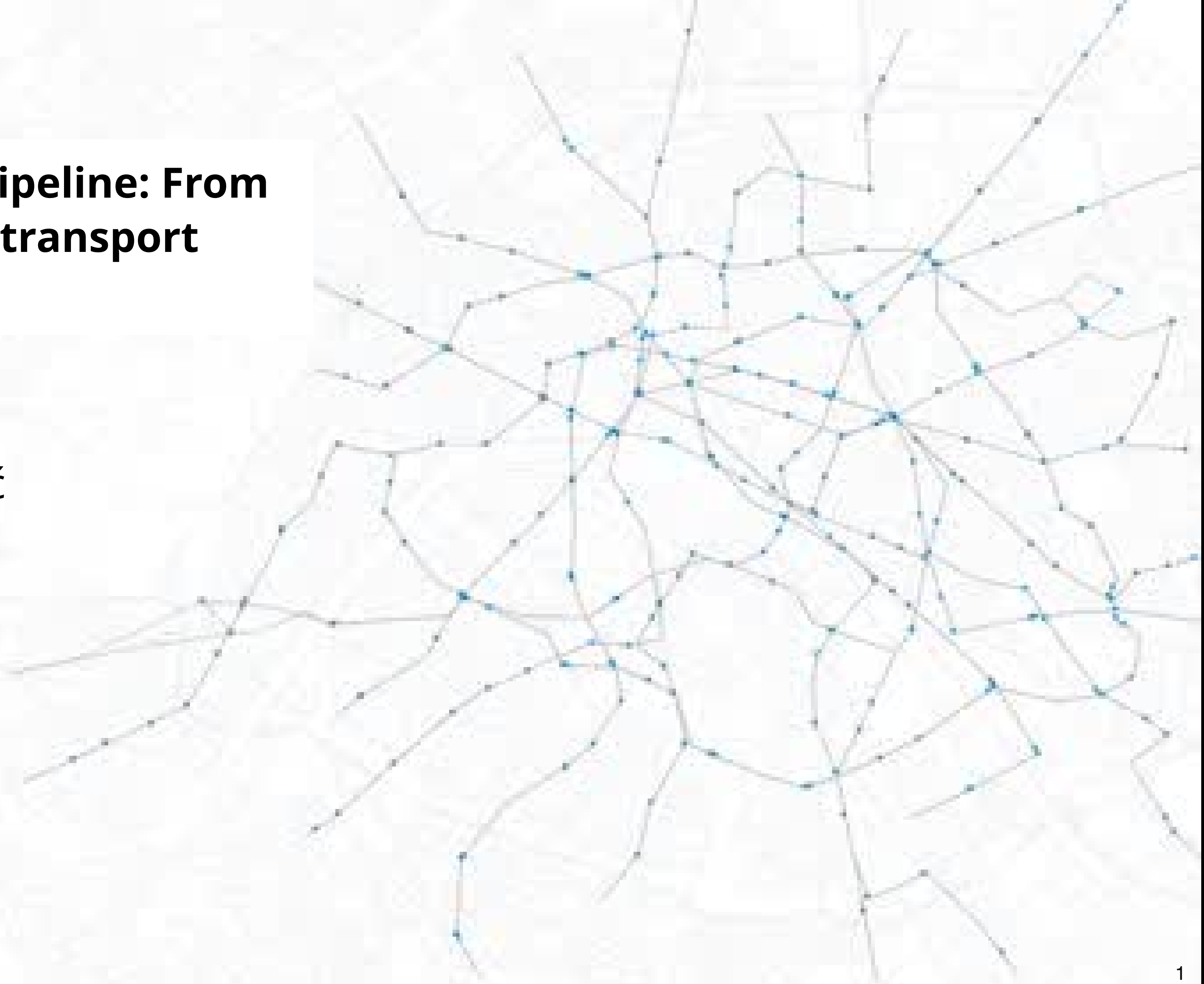
Introducing the *eqasim* pipeline: From raw data to agent-based transport simulation

Sebastian Hörl, Miloš Balać

25 March 2021

ABMTRANS 2021



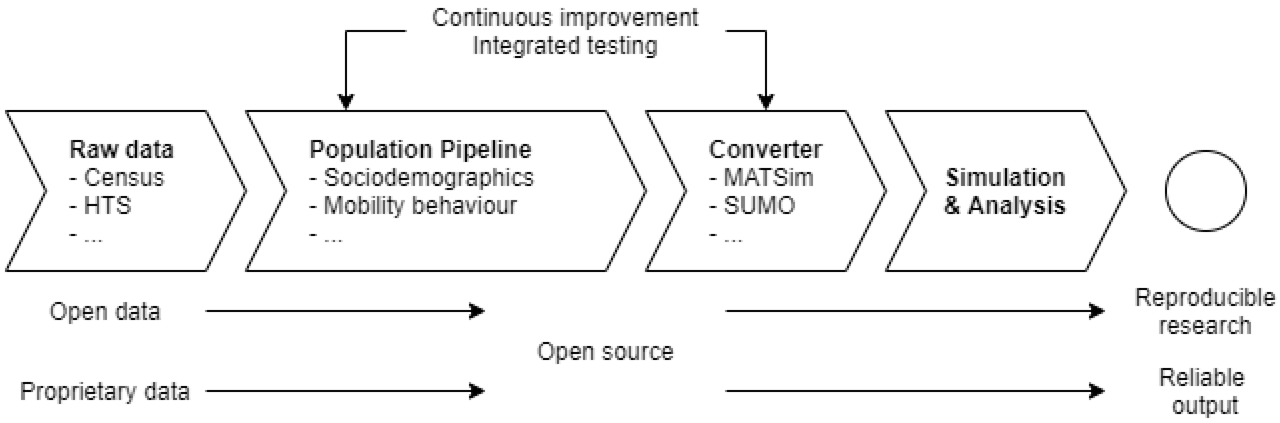
Motivation

- Agent-based transport simulations (studies) require considerable input data, which generally consists of the transport supply and transport demand
- Usually the generation of transport supply and demand is decoupled from the agent-based model itself.
- This leads to situations where one cannot trace back the inputs of the studies, which makes them unreproducible and unverifiable by others.
- Use of proprietary data further complicates the situation

eqasim

An integrated pipeline from raw data to agent-based simulation:

- Synthesis of travel demand
- Agent-based simulation



eqasim

An integrated pipeline from raw data to agent-based simulation:

- **Synthesis of travel demand**
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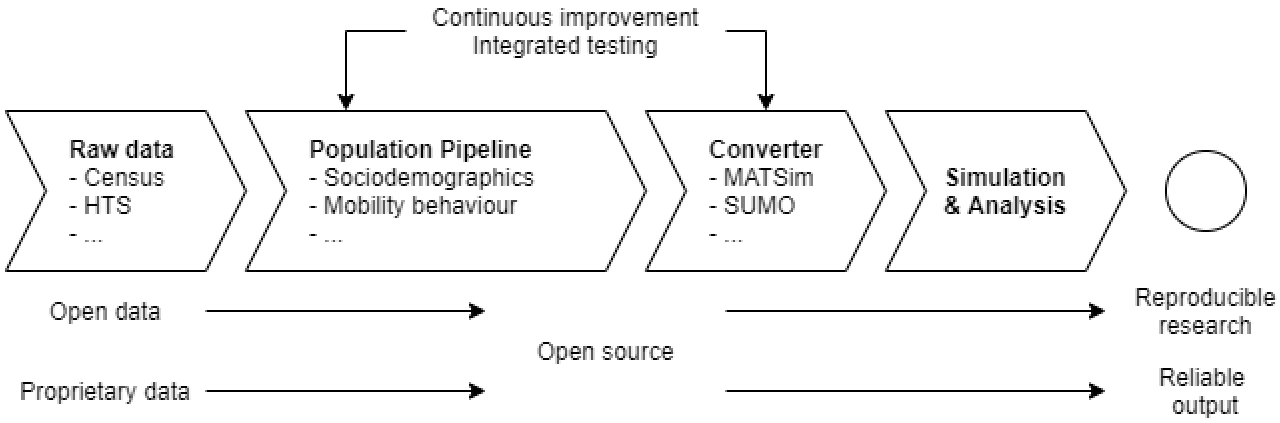

eqasim - Synthesis of travel demand

Île-de-France

RP

Census data

Récensement de la population

Île-de-France

RP

FiLo
SoFi

Dispositif sur les revenus localisés sociaux et fiscaux
Income tax data

Île-de-France

RP

FiLoSoFi

RP
Mob

RP: Flux de mobilité
Commuting data

Île-de-France

RP

FiLoSoFi

RP Mob

S

SIRENE

Enterprise census

BD

BD-TOPO

Address database

Île-de-France

RP

FiLoSoFi

RP Mob

SIRENE

BD-TOPO

EGT

Enquête globale de transport
Household Travel Survey

ENTD

Enquête national transports et deplacements
Household Travel Survey

Île-de-France

RP

FiLoSoFi

RP Mob

SIRENE

BD-TOPO

EGT

Enquête globale de transport
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ENTD

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Household Travel Survey

Île-de-France

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RP Mob

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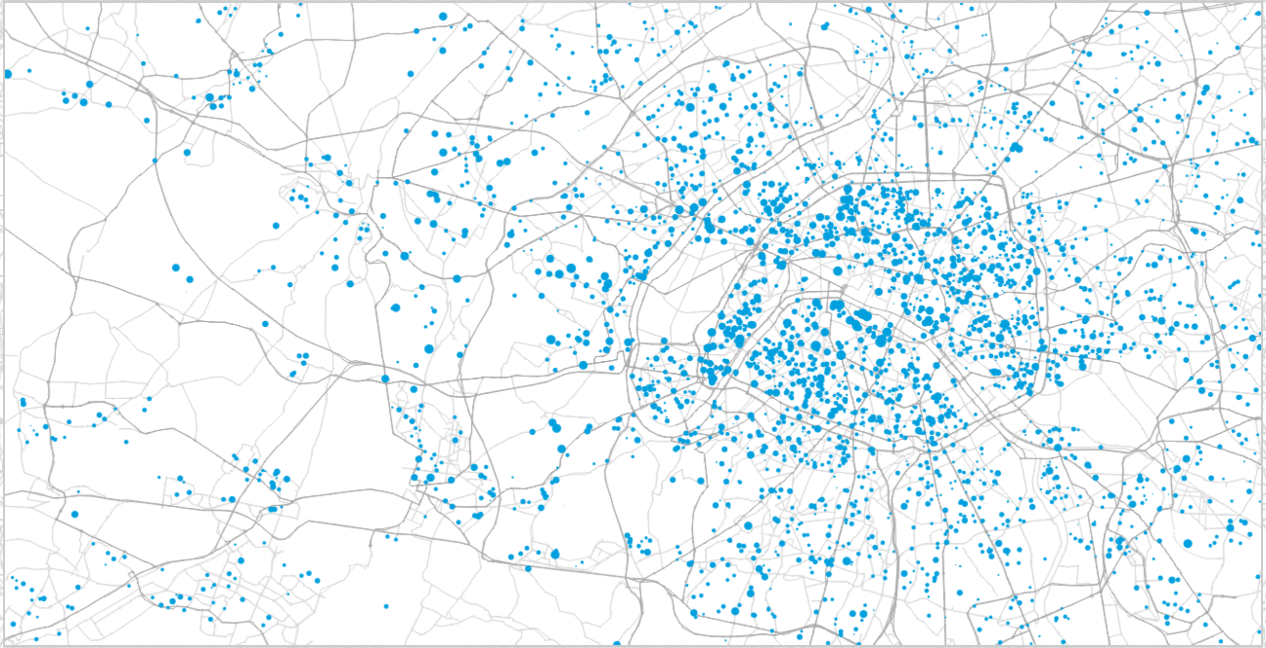
EGT

ENTD

Person ID	Age	Gender	Home
1	43	male	(x,y)
2	24	female	(x,y)
3	9	female	(x,y)



Île-de-France

RP FiLoSoFi RP Mob SIRENE EGT

BD-TOPO ENTD

Person ID	Activity	Start	End	Loc.
523	home		08:00	(x,y)
523	work	08:55	18:12	(x,y)
523	shop	19:10	19:25	(x,y)
523	home	19:40		(x,y)

Person ID	Mode	Start	End
523	Public T.	08:00	08:55
523	Public T.	18:12	19:10
523	Walking	19:25	19:40

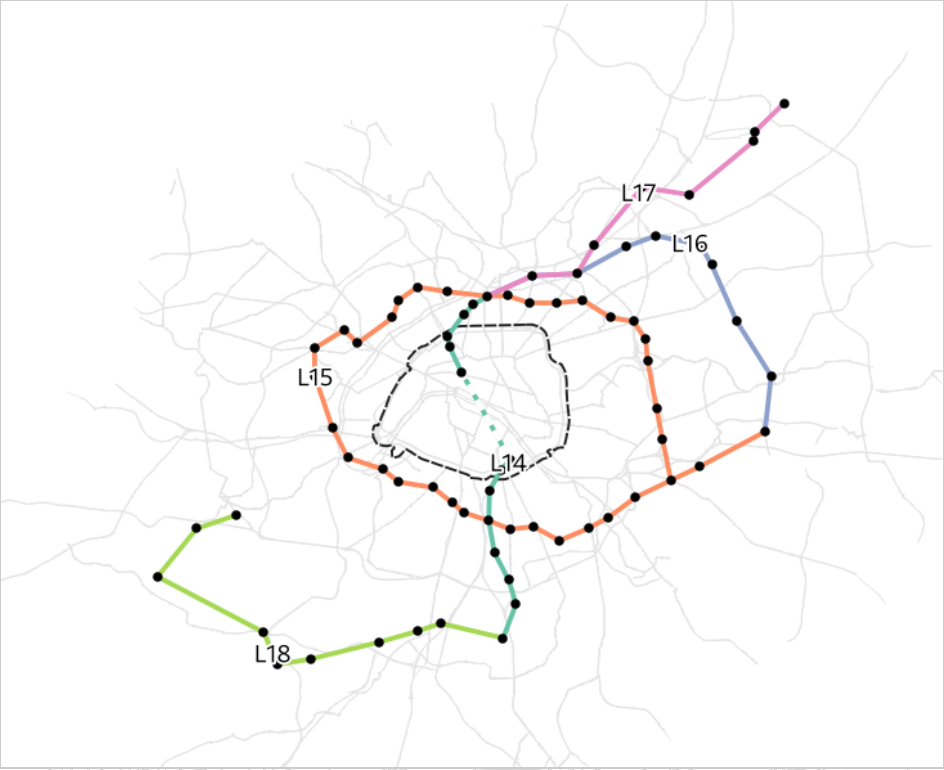
Île-de-France

RP | FiLoSoFi | RP Mob | SIRENE | EGT | OSM

BD-TOPO | ENTD | GTFS

OSM
OpenStreetMap
Road network

GTFS
IDFm GTFS
Public transport schedule



Île-de-France

RP

FiLoSoFi

RP Mob

SIRENE

BD-TOPO

EGT

ENTD

OSM

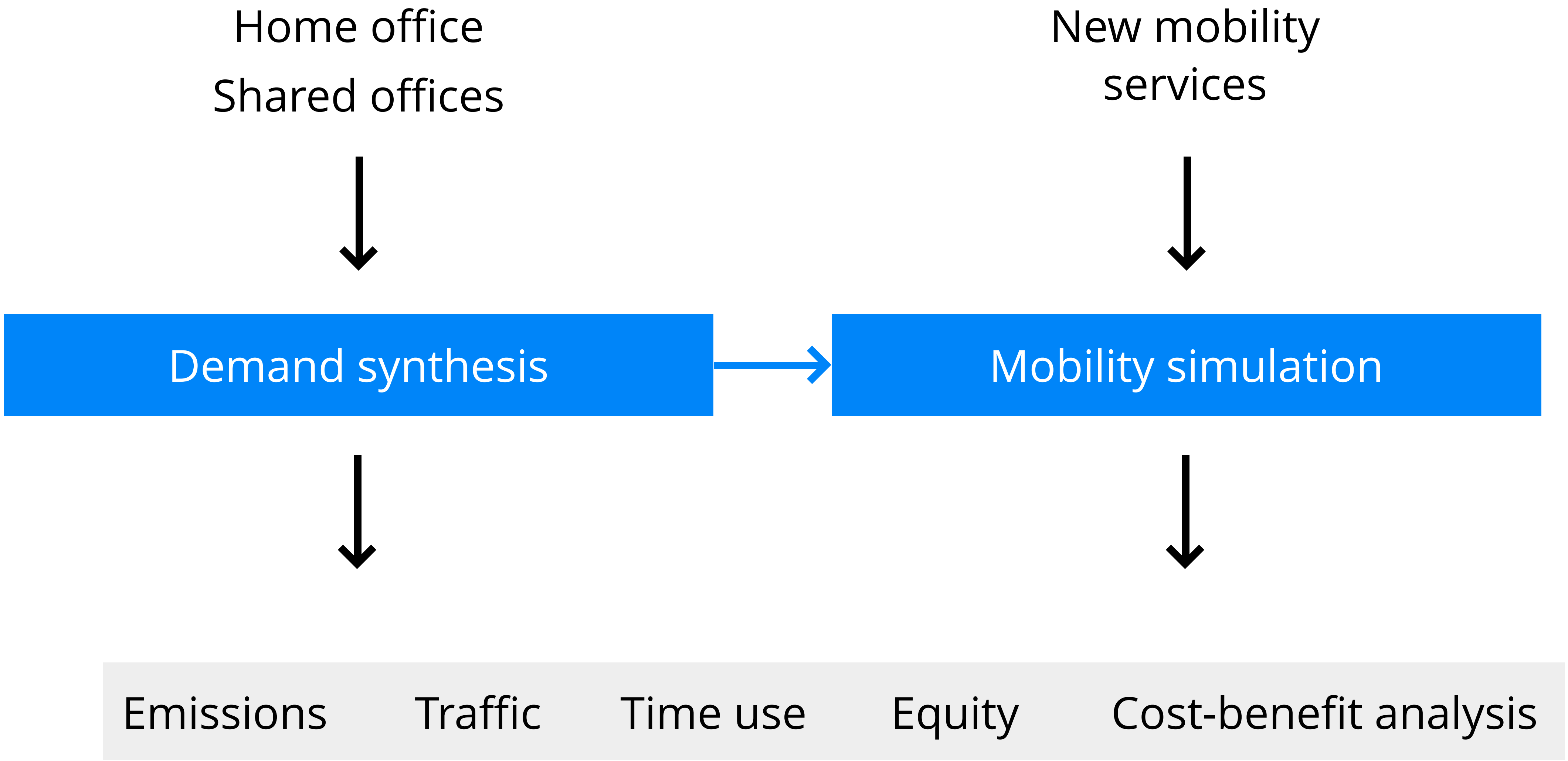
GTFS

MATSim Multi-Agent Transport Simulation

Open Data + Open Software =

- Reproducible research
- Verifiable results
- Integrated testing

Example: Policy and scenario analysis



Île-de-France

RP

FiLoSoFi

RP Mob

SIRENE

BD-TOPO

EGT

ENTD

OSM

GTFS

MATSim
Multi-Agent Transport Simulation

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Open travel demand synthesis for agent-based transport simulation: A case study for Paris and Île-de-France

Sebastian Hörl[a,b,*], Milos Balac[a]

[a] *Institute for Transport Planning and Systems, ETH Zurich*
[b] *Institut de Recherche Technologique SystemX, Palaiseau 91120, France*

Abstract

Synthetic populations of travellers and their detailed mobility behaviour are an important basis for agent-based transport simulations, which are increasingly used in transport planning and research today. While previous applications of such simulations put focus on analyzing policies and novel modes of transport, less importance is put on the aspects of data collection, processing and validation to create the

Current use cases

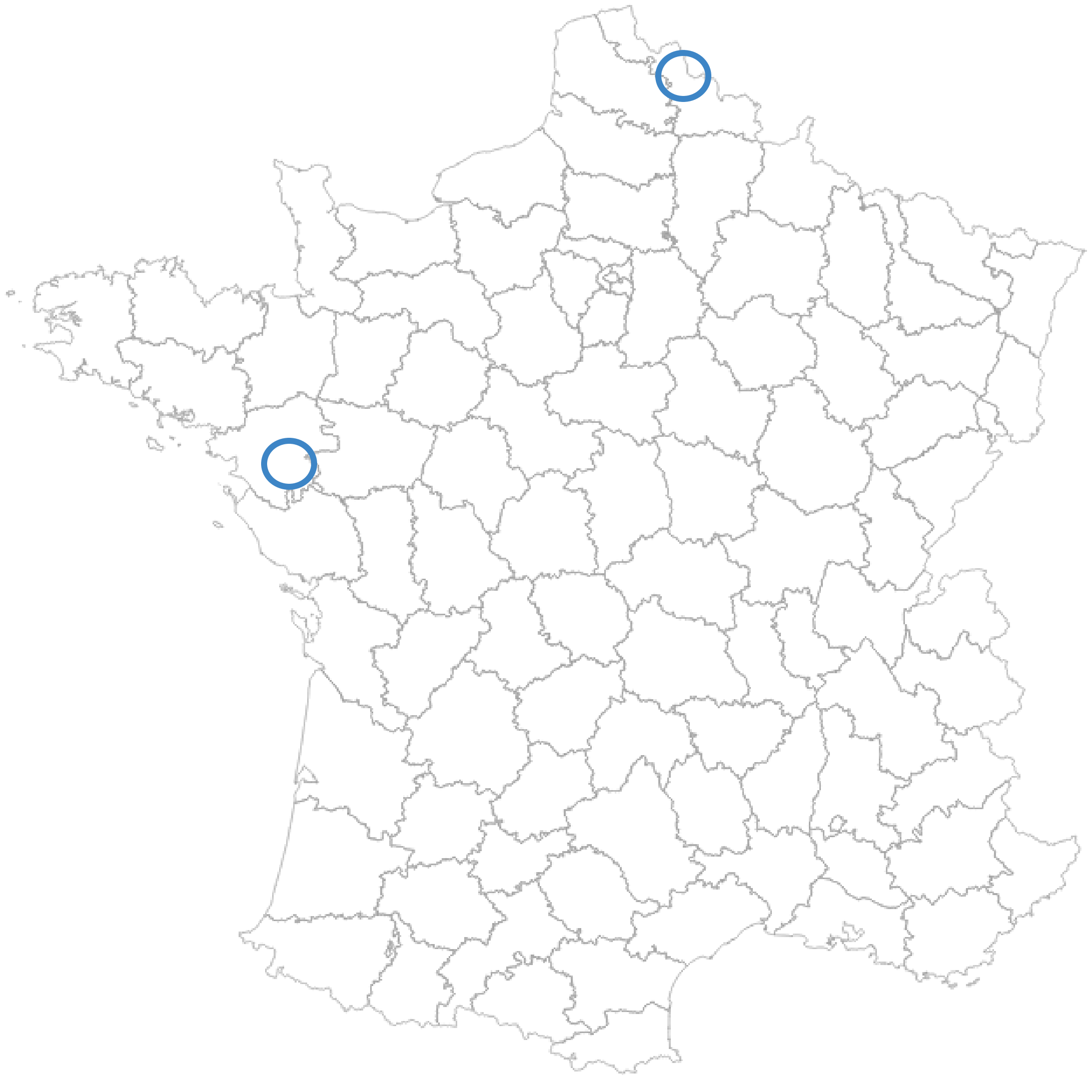
Université Gustave Eiffel

Nantes

- Population synthesis
- Noise modeling

Contact: Valentin Le Besond

Current use cases

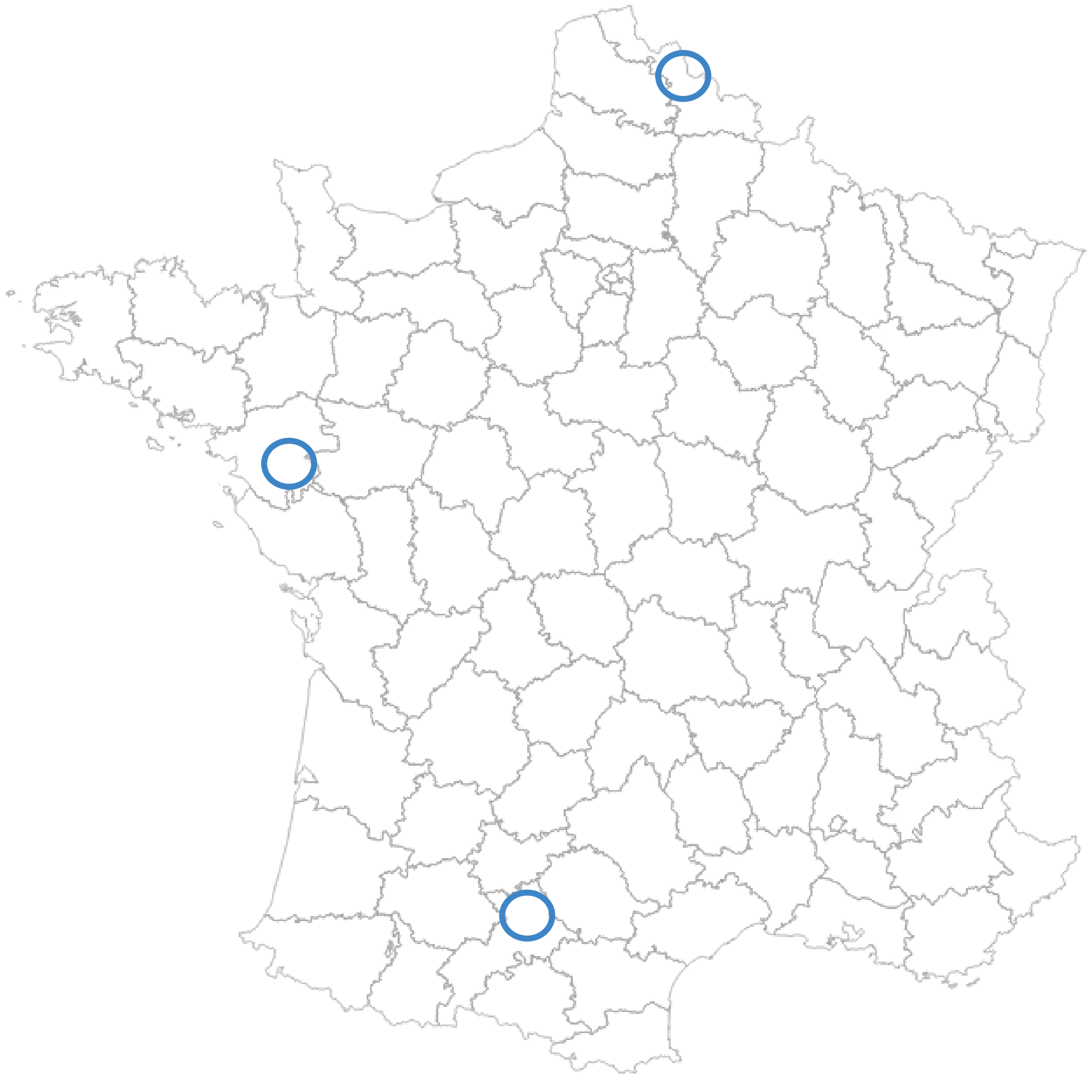


Lille

- Park & ride applications
- Road pricing

Contact: Azise Diallo

Current use cases



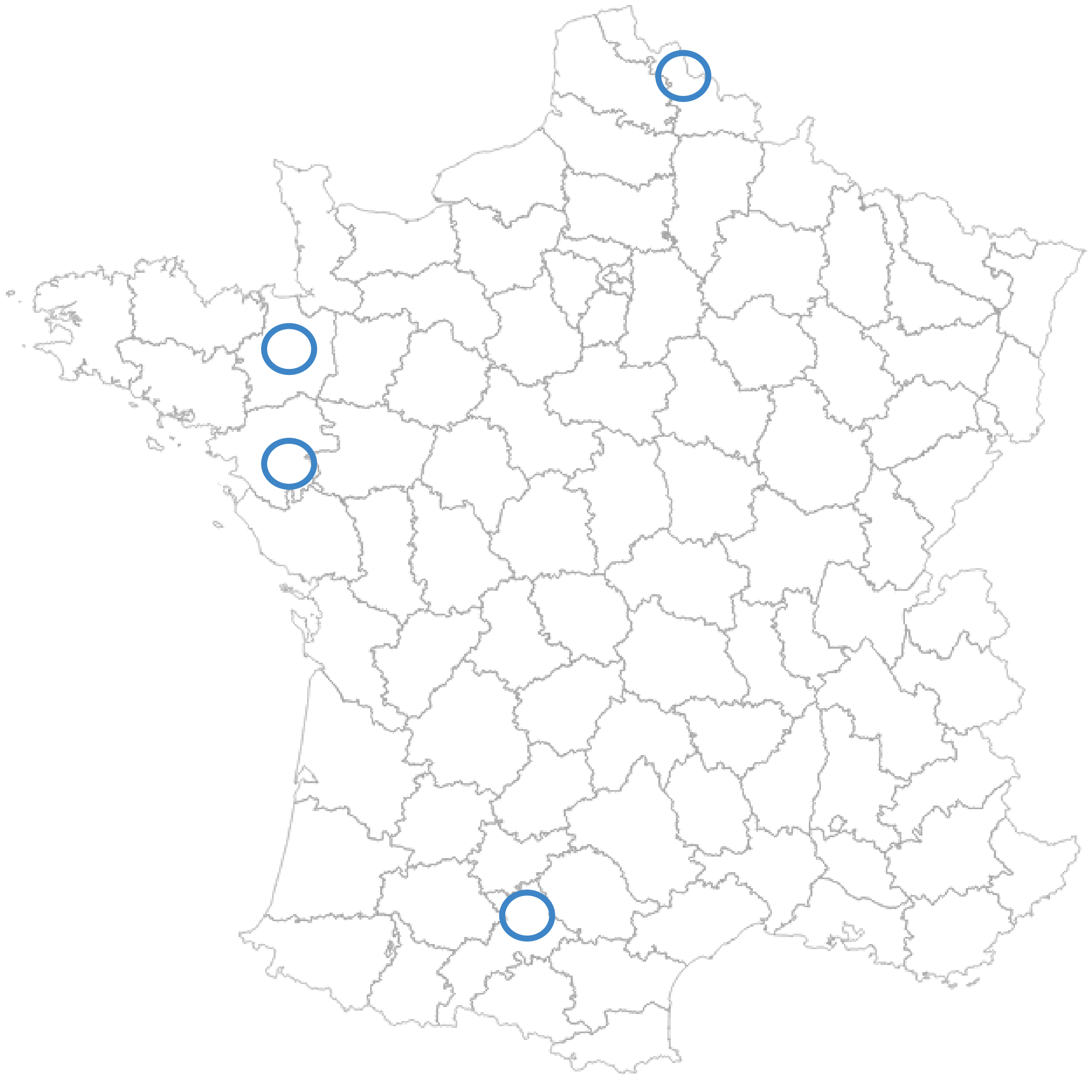
Odyssée

Toulouse

- Placement and use of shared offices

Contact: Vincent Loubière

Current use cases



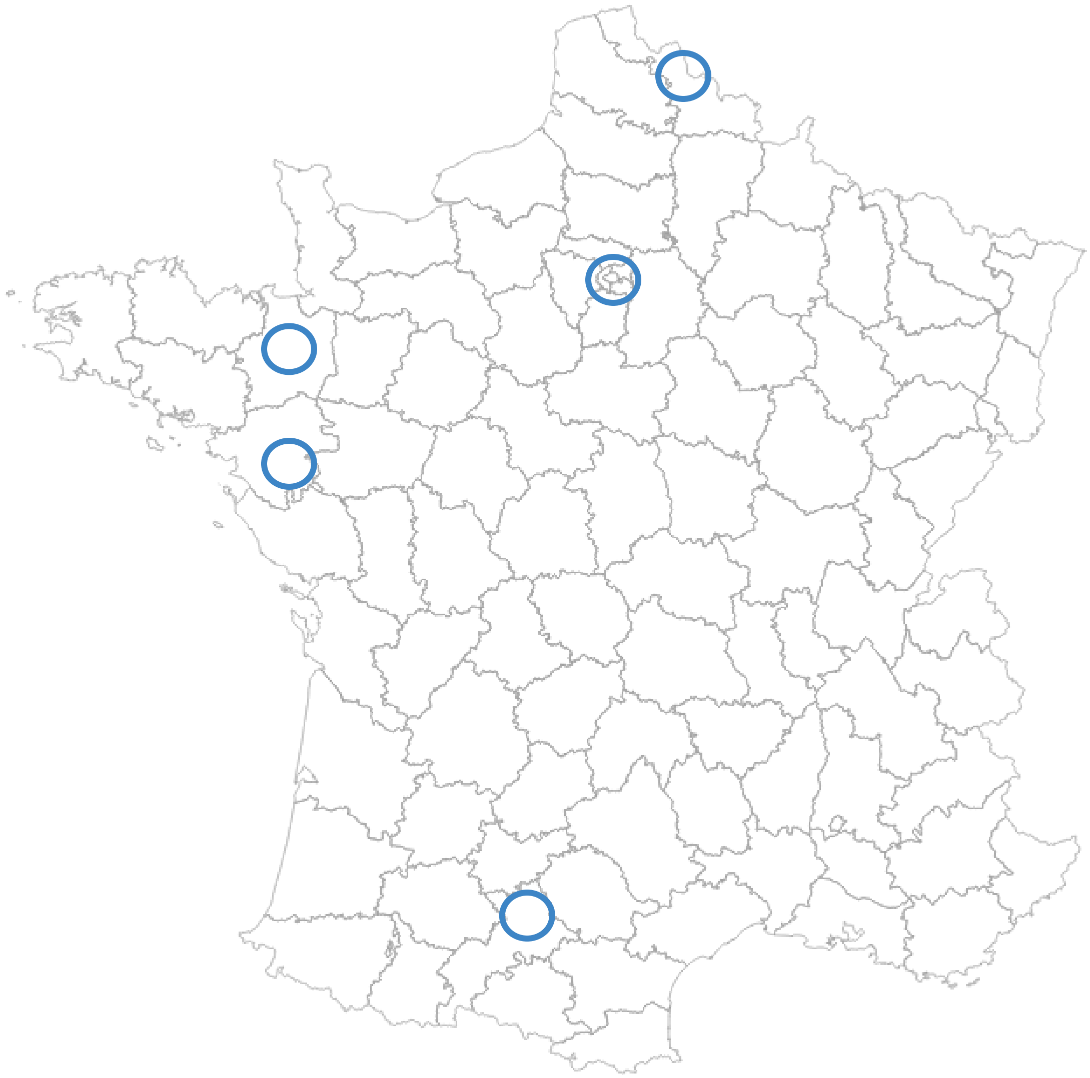
tellae

Rennes

- Micromobility simulation

Contact: Vincent Leblond

Current use cases



Paris / Île-de-France

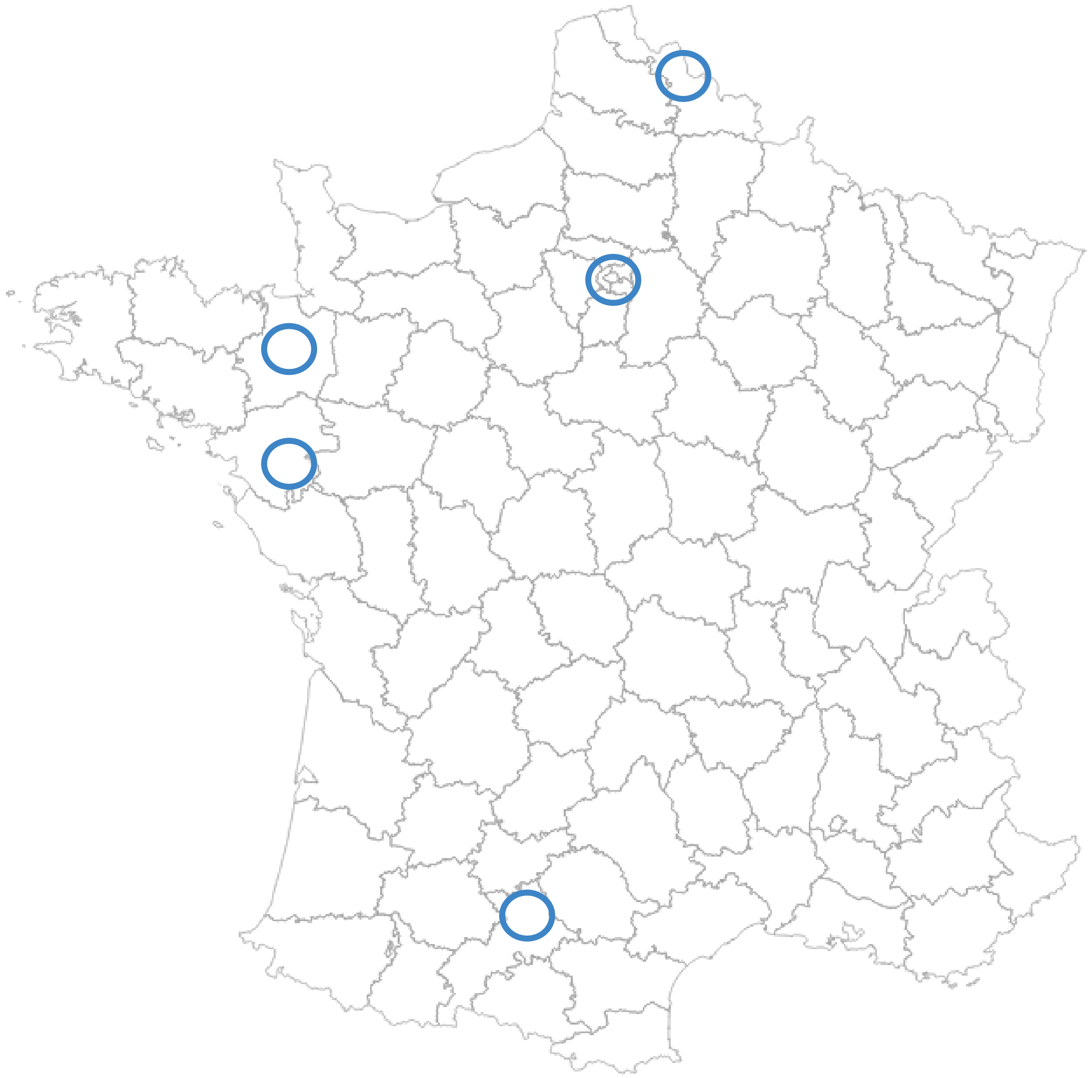
- Scenario development for sustainable urban transformation
- New mobility services

Contact:

Mahdi Zargayouna (GRETTIA / Univ. Gustave Eiffel)

Nicolas Coulombel (LVMT / ENPC)

Current use cases



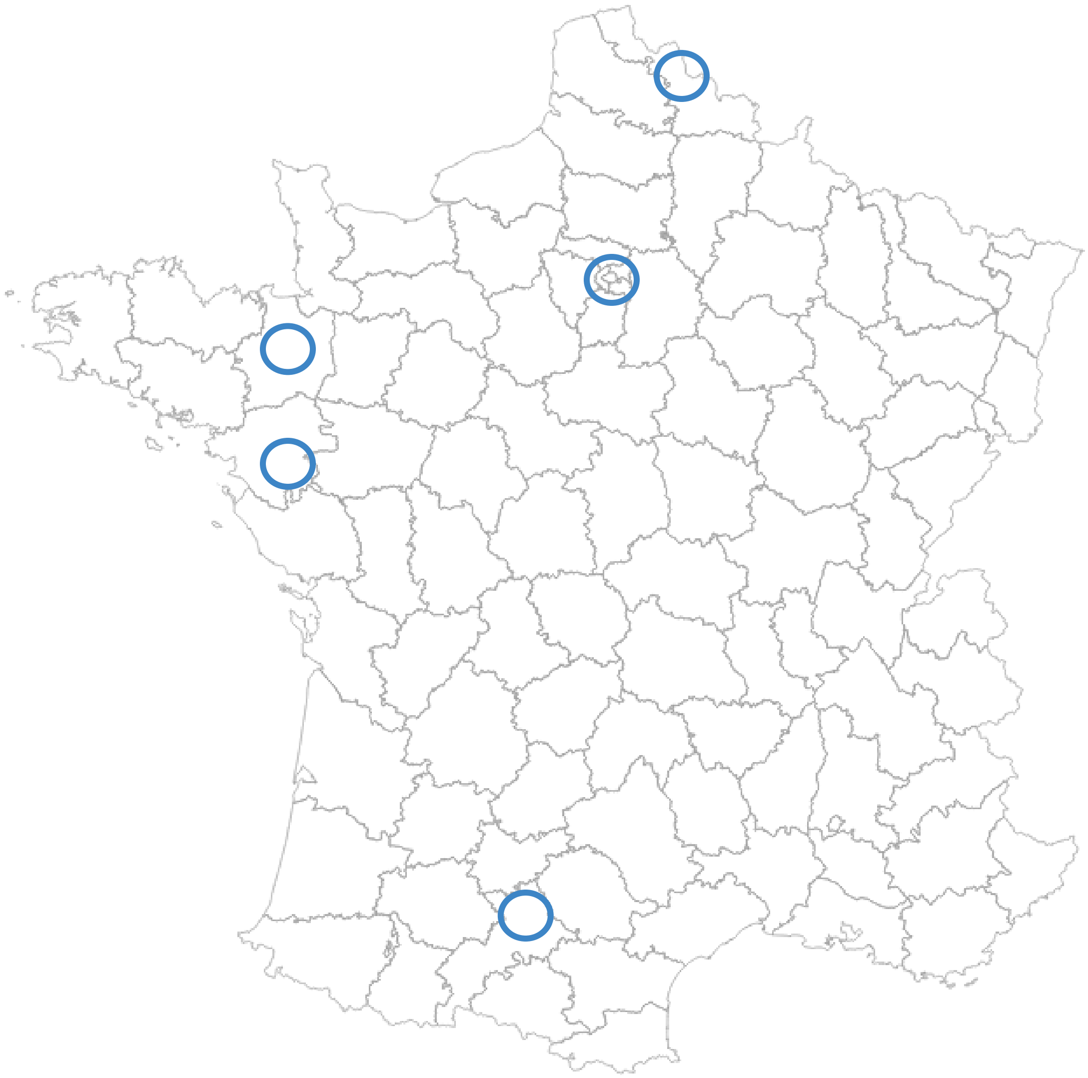
IFP energies nouvelles

Paris / Île-de-France

- Cycling simulation

Contact: Alexandre Chasse

Current use cases



Paris / Île-de-France

- Simulation of automated shuttles

Contact: Sebastian Hörl

Current use cases - Worldwide

Sao Paulo (ETH Zurich)

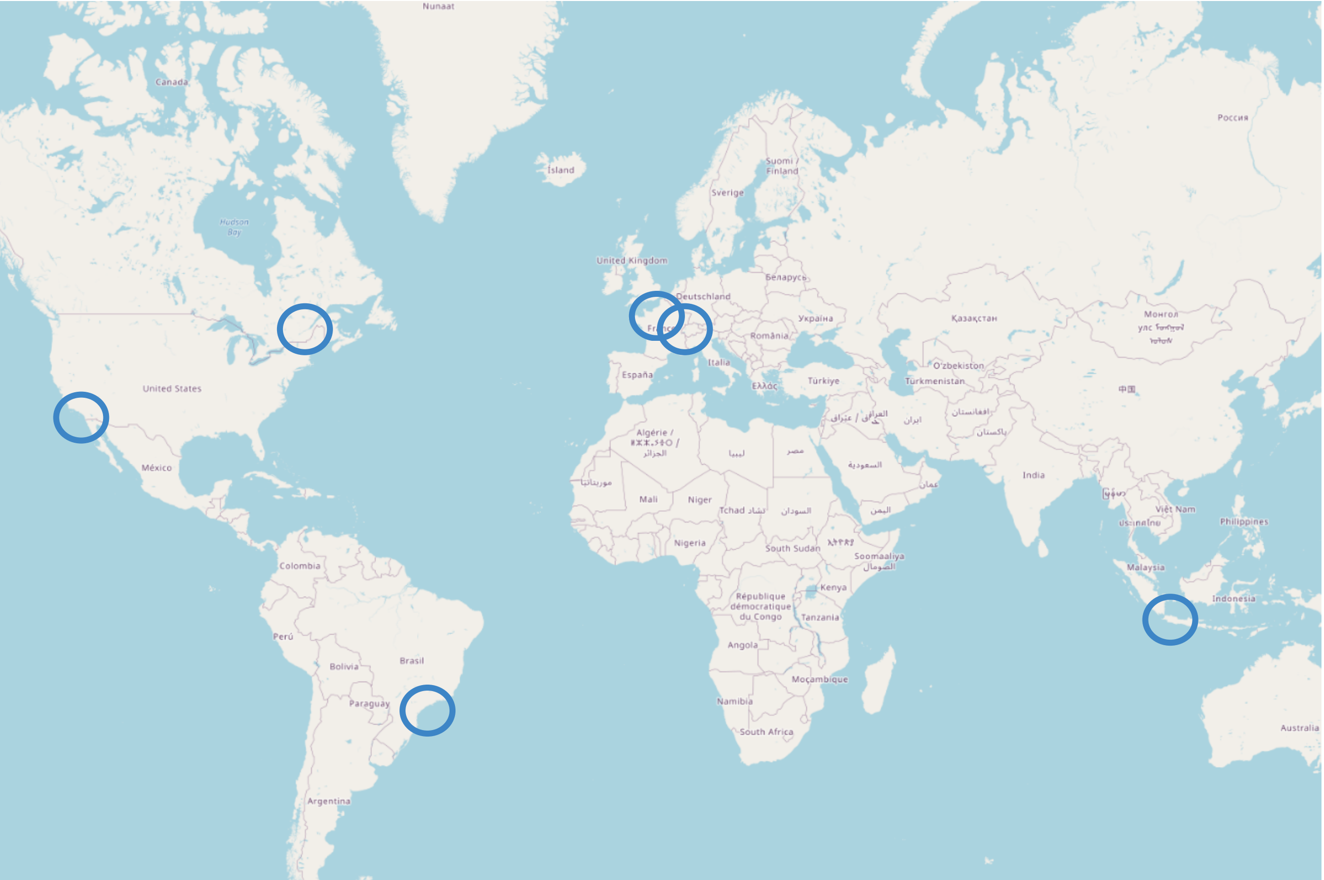
San Francisco Bay area (ETH Zurich)

Los Angeles five-county area (ETH Zurich)

Switzerland (ETH Zurich)

Montreal, Quebec City, Jakarta, ...

Current use cases



eqasim-org/eqasim-java

eqasim-org/ile-de-france

eqasim-org/sao_paulo

eqasim-org/california

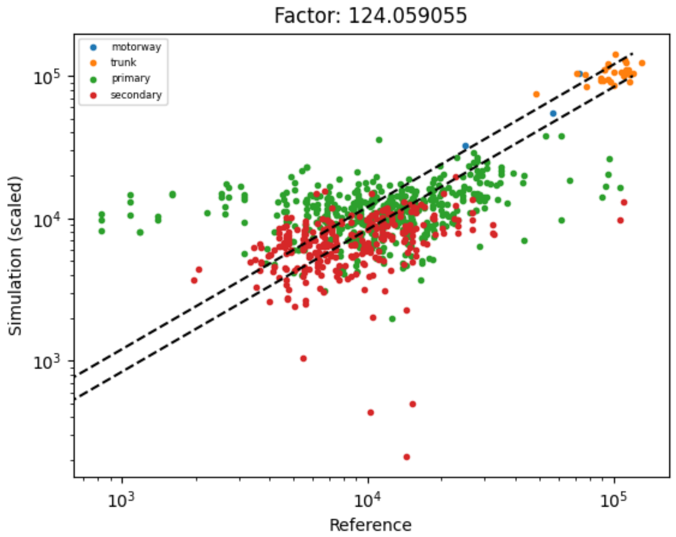
matsim-org/matsim-libs

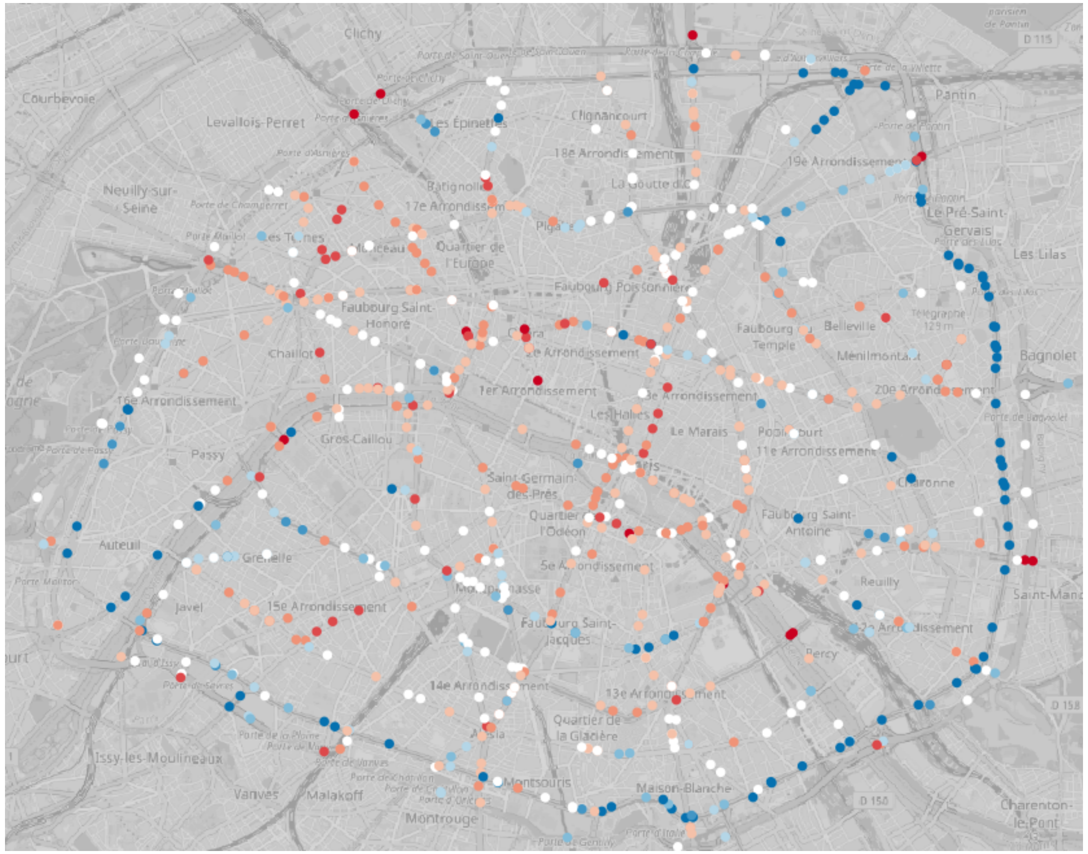
Balac, M., Hörl, S. (2021) Synthetic population for the state of California based on open-data: examples of San Francisco Bay area and San Diego County, presented at *100th Annual Meeting of the Transportation Research Board*, Washington, D.C.

Sallard, A., Balac, M., Hörl, S. (2021) Synthetic travel demand for the Greater São Paulo Metropolitan Region, based on open data, *Under Review*

Some challenges ...

- Easy-to-use user interfaces
- Use of dynamic data
  Road counts, GPS traces, ...
- Automatic calibration

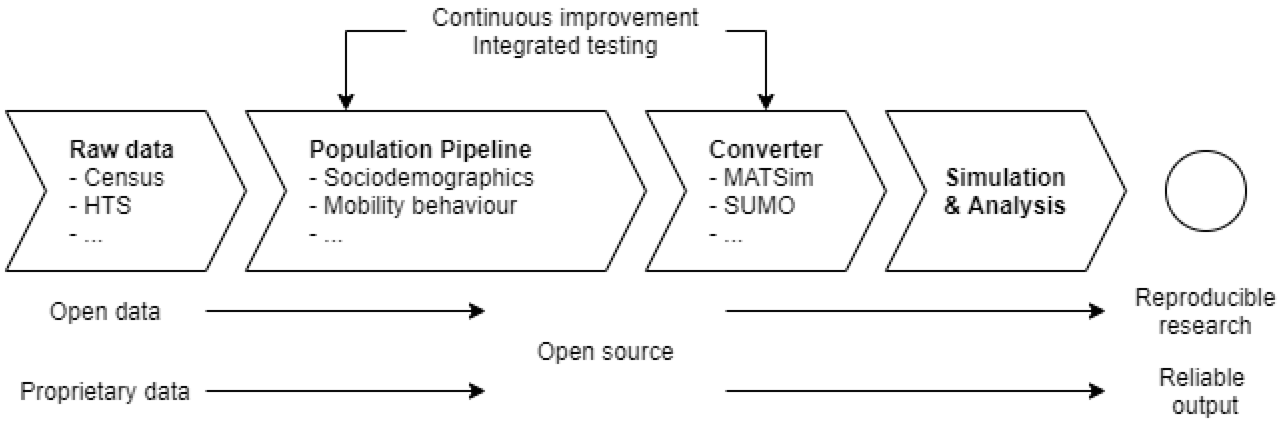




eqasim

An integrated pipeline from raw data to agent-based simulation:

- Synthesis of travel demand
- **Agent-based simulation**



eqasim - simulation using DMC

In cases when you have access to estimated MNL or NL models, these can now be integrated directly using the DMC extension

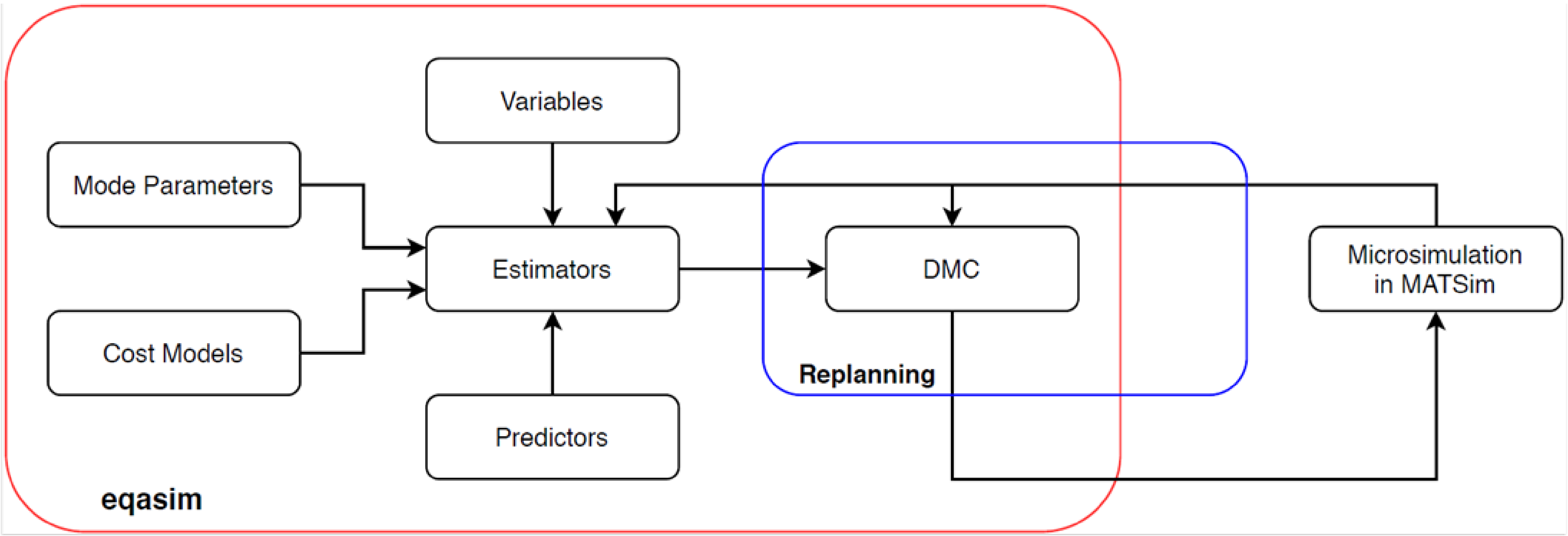
It can be used to override the scoring mechanism of MATSim

It is a default replanning mechanism in eqasim

Hörl, S., M. Balac and K.W. Axhausen (2018) A first look at bridging discrete choice modeling and agent-based microsimulation in MATSim, Procedia Computer Science, **130**, 900-907.

Hörl, S., M. Balac and K.W. Axhausen (2019) Pairing discrete mode choice models and agent-based transport simulation with MATSim, paper presented at the 98th Annual Meeting of the Transportation Research Board, Washington D.C., January, 2019.

eqasim - simulation using DMC



Zurich - Simulation of automated vehicles, MaaS, AToD,...

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Simulation of price, customer behaviour and system impact for a cost-covering automated taxi system in Zurich

Sebastian Hörl *, Felix Becker, Kay W. Axhausen

Institute for Transport Planning and Systems, ETH Zurich, Switzerland

ARTICLE INFO

Keywords:
Automated
Vehicles
AMoD
MATSim
Zurich
Transport
Simulation
Dynamic
Demand
Discrete choice

ABSTRACT

Automated Mobility on Demand (AMoD) is a co
sion. In cases where large-scale adoption of an au
impacts may become relevant to key transport sy
policy-makers as well. In light of this increasin
agent-based transport simulation with (single pas
scenario data (including demand patterns, cost as
for one specific area, the city of Zurich, Switzerla
a detailed bottom-up cost analysis of mobility
Stated-Preferences survey about automated mobi
and a detailed agent-based transport simulation fo
a comprehensive approach is presented that itera
which service cost, waiting times and demand
operator with predefined fleet size. For Zurich,
vehicles leading to the maximum demand of a
attracted by the system. Within these parameters
willing to accept average waiting times of around
covering cases with lower demand are presented
waiting times, or larger fleet sizes lead to highe

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Assessing the welfare impacts of Shared Mobility and Mobility as a Service (MaaS)

Henrik Becker[a,*], Milos Balac[a], Francesco Ciari[b], Kay W. Axhausen[a]

[a] *Institute for Transport Planning and Systems, ETH Zurich, Zurich, Switzerland*
[b] *Polytechnique Montréal, Montréal, Canada*

CT

Service (MaaS) is an attempt to overcome market segmentation by offering transpor
red to the individual traveler's needs. An alternative to prior investment into singl
ls, it may allow less biased mode choice decisions. Such a setting favors share
e fixed costs can be apportioned among a large number of users. In turn, car-sharing
or ride-hailing may themselves become efficient alternatives to public transpor
ly field studies confirm the expected changes away from private car use and toward
red modes, impacts are yet to be studied for larger transport systems. This researc
irst joint simulation of car-sharing, bike-sharing and ride-hailing for a city-scal
tem using MATSim. Results show that in Zurich, through less biased mode choic
ne, transport-related energy consumption can be reduced by 25%. In addition, in
f car-sharing and bike-sharing schemes may increase transport system energy eff

System level policies for Automated Transit On-Demand Services: A case study for Zurich, Switzerland

Yves M. Räth[a], Milos Balac[a,*], Sebastian Hörl[b], Kay W. Axhausen[a]

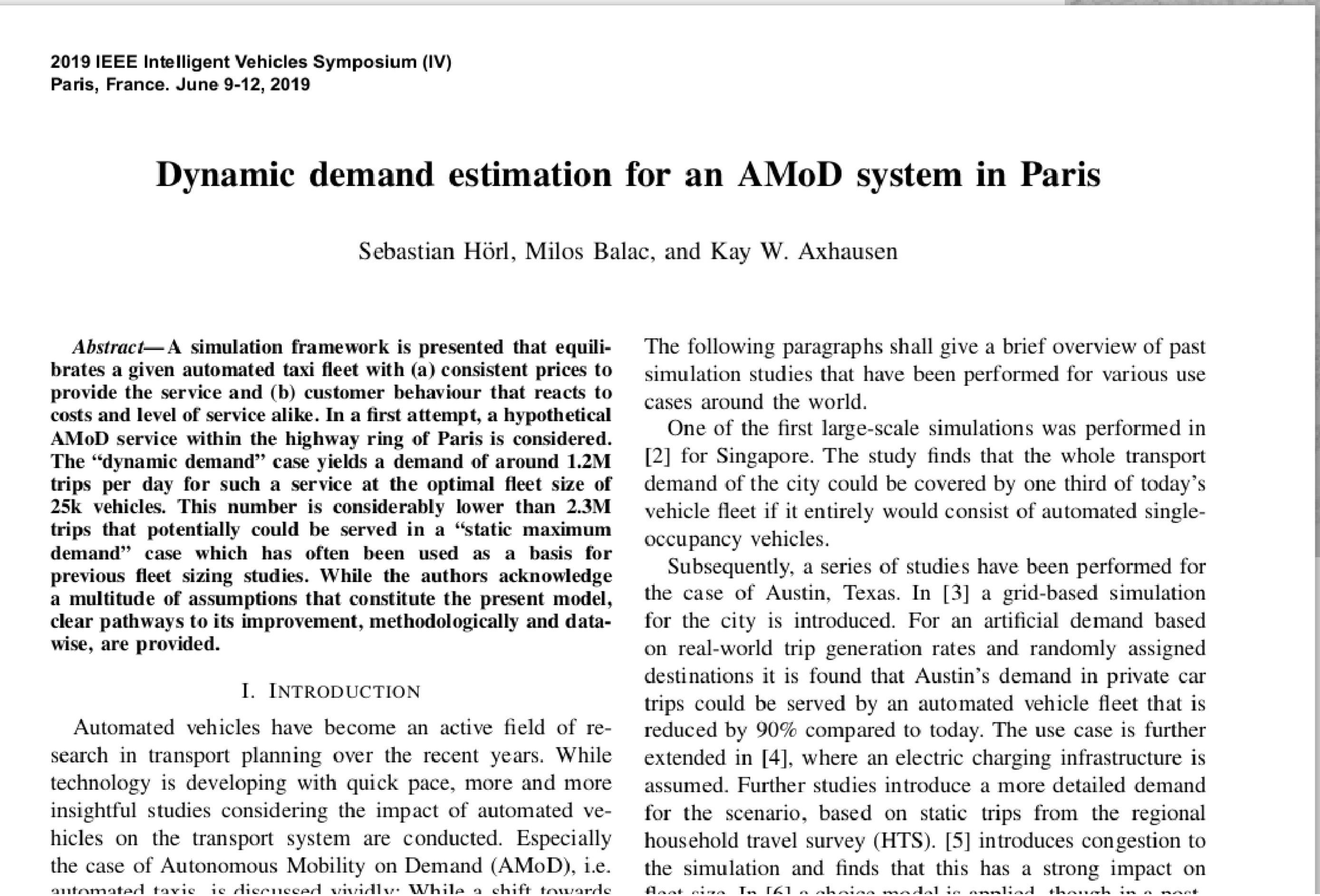
[a] *Institute for Transport Planning and Systems, ETH Zurich, Zurich, Switzerland*
[b] *Institut de Recherche Technologique SystemX, Palaiseau, France*

Abstract

With the introduction of automated vehicles, new operating regimes for public transport services would become possible. A station-based Automated Transit on Demand service could be an attractive alternative to the current modes of transportation. In this paper, the impact of this kind of service on the modal share for the city of Zurich, Switzerland, and its surrounding area is modeled using an agent-based approach. Different policies regarding the operating area, pricing scheme, and a cordon charge are tested on their potential to make use of the benefits of the new service while preventing an overflow of automated vehicles in the urban core. Results show that if left unconstrained the proposed service can substantial impact the modal split. A pricing scheme that bases the pricing of the new service relative to the accessibility of the current public transport service is a promising solution to increase the accessibility of the rural areas while maintaining a high modal share for public transport in the city center. Finally, using an optimization algorithm we show that the total car-fleet and public parking space can be reduced at the cost of a slight increase in vehicle kilometers traveled. Moreover, we find that the cost coverage of the proposed transit service is potentially much higher in comparison to current public transport services.

Keywords: Automated Transit on Demand, Transport Policy, automated vehicles, MATSim, eqasim

Île-de-France



2019 IEEE Intelligent Vehicles Symposium (IV)
Paris, France. June 9-12, 2019

Dynamic demand estimation for an AMoD system in Paris

Sebastian Hörl, Milos Balac, and Kay W. Axhausen

***Abstract*— A simulation framework is presented that equilibrates a given automated taxi fleet with (a) consistent prices to provide the service and (b) customer behaviour that reacts to costs and level of service alike. In a first attempt, a hypothetical AMoD service within the highway ring of Paris is considered. The "dynamic demand" case yields a demand of around 1.2M trips per day for such a service at the optimal fleet size of 25k vehicles. This number is considerably lower than 2.3M trips that potentially could be served in a "static maximum demand" case which has often been used as a basis for previous fleet sizing studies. While the authors acknowledge a multitude of assumptions that constitute the present model, clear pathways to its improvement, methodologically and data-wise, are provided.**

I. Introduction

Automated vehicles have become an active field of research in transport planning over the recent years. While technology is developing with quick pace, more and more insightful studies considering the impact of automated vehicles on the transport system are conducted. Especially the case of Autonomous Mobility on Demand (AMoD), i.e. automated taxis, is discussed vividly: While a shift towards

The following paragraphs shall give a brief overview of past simulation studies that have been performed for various use cases around the world.

One of the first large-scale simulations was performed in [2] for Singapore. The study finds that the whole transport demand of the city could be covered by one third of today's vehicle fleet if it entirely would consist of automated single-occupancy vehicles.

Subsequently, a series of studies have been performed for the case of Austin, Texas. In [3] a grid-based simulation for the city is introduced. For an artificial demand based on real-world trip generation rates and randomly assigned destinations it is found that Austin's demand in private car trips could be served by an automated vehicle fleet that is reduced by 90% compared to today. The use case is further extended in [4], where an electric charging infrastructure is assumed. Further studies introduce a more detailed demand for the scenario, based on static trips from the regional household travel survey (HTS). [5] introduces congestion to the simulation and finds that this has a strong impact on fleet size. In [6] a choice model is applied, though in a post-

Final thoughts

Open Data + Open Software = Reproducible research, Verifiable results

Thank you!

Questions ?

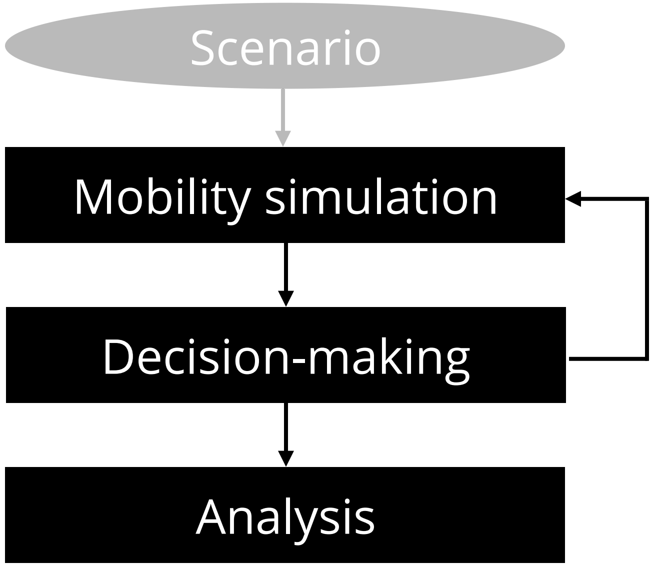
Contact: balacm@ethz.ch and sebastian.horl@irt-systemx.fr

MATSim
Multi-Agent Transport Simulation

Île-de-France

RP FiLoSoFi RP Mob SIRENE EGT OSM

BD-TOPO ENTD GTFS



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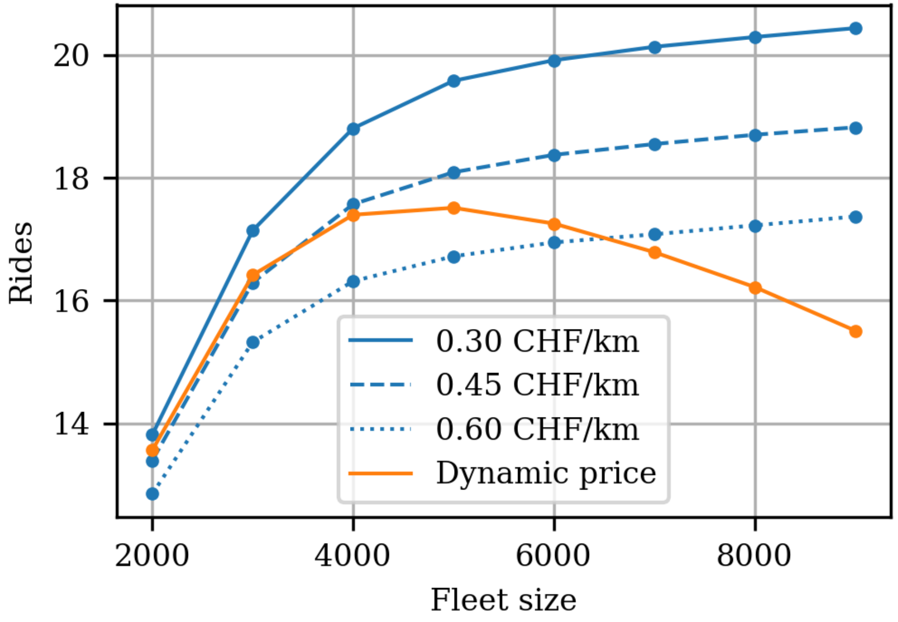

Île-de-France

RP FiLoSoFi RP Mob SIRENE EGT OSM

BD-TOPO ENTD GTFS

MATSim
Multi-Agent Transport Simulation