Évaluation des émissions dues au transport avec simulations multi-agents: avantages, limites et implications de la transformation du transport

Assessing emissions of transportation with agent-based simulations : advantages, limitations and implication of transportation transformation

F Ciari

Workshop: Assessing emissions of transportation - Chair en transformation du transport
February 14, 2020 in Montreal (QC)

Outline

- Agent based simulations (ABS)
- Assessing emission with ABS
- What transportation transformation implies for emission assessment

What is an agent?

An agent:

- Represents an individual
- Has a set of attributes/characteristics
- Follows given behavioral rules
- Has decision making capability
- Is goal oriented
- Acts in an environment and interacts with other agents
- Is autonomous
- Can learn

Agents can be:

- Heterogeneous
- Attributes can change dynamically

(Macal and North, 2005)

The actors of the (real) modeled system are represented individually and implement simple rules.
The behavior of the system is not explicitly modeled but emerges from the simulation

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Simple rules implemented at the micro-level (individual) allows modeling complex behavior at the macro-level (system)

Agents

Individus → Agents

Attributs personnels → Age, Sexe, Permis conduire, Véhicules, Abonnements, Études, Revenu, etc.

Plans d'activités → Domicile, Travail, Études/École, Achats, Loisirs, etc.

Objective → Maximiser le temps des activités, minimiser le temps de déplacement

Decisions → Modify some parameters of their travel (time, mode, route, activity location)

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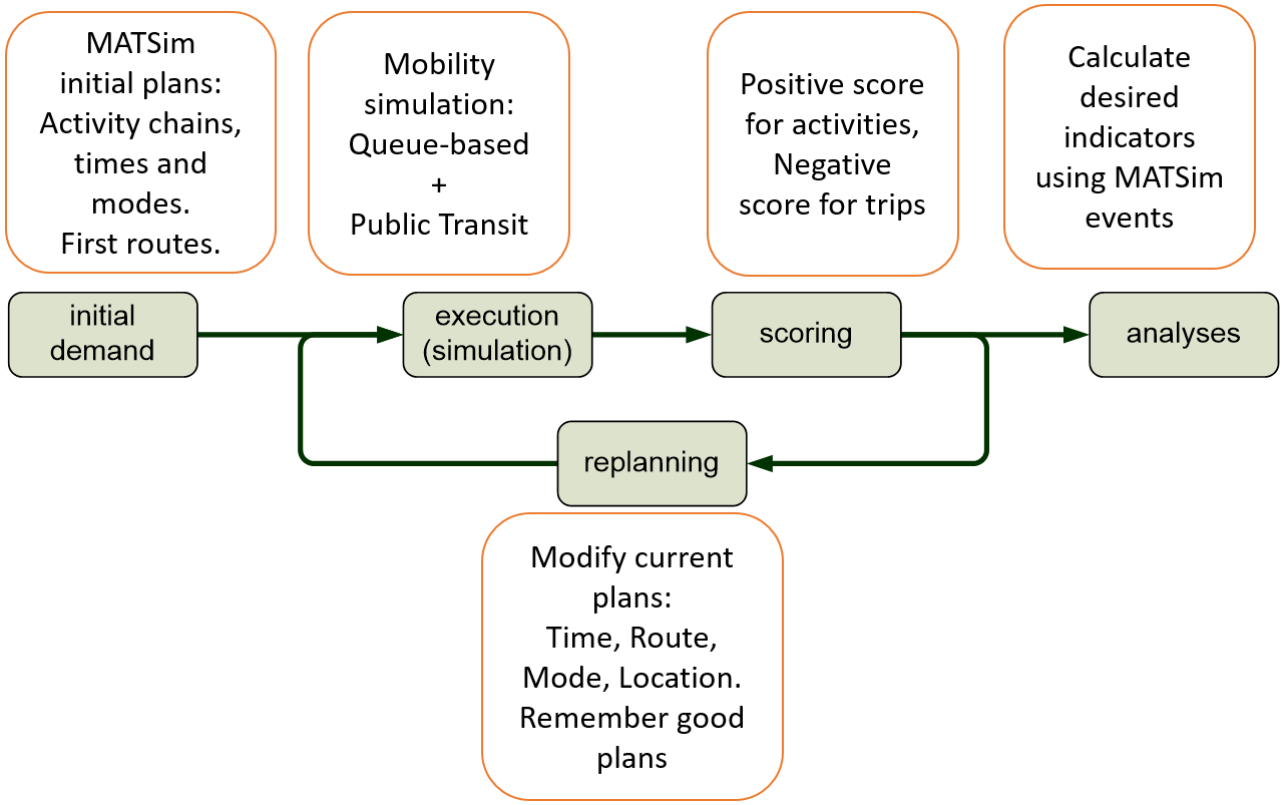
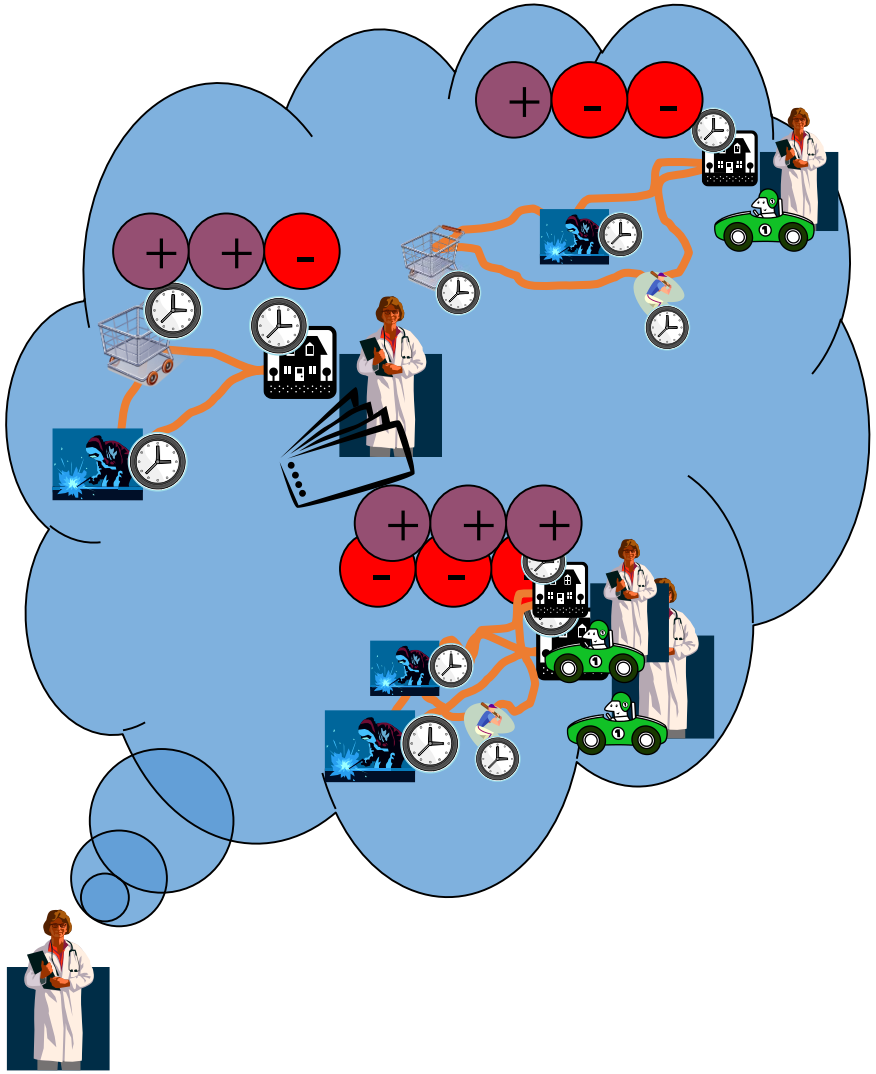
MATSim

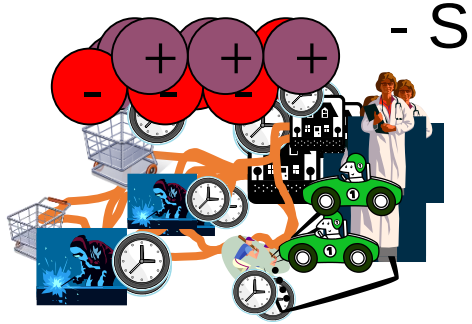
- Multi Agent Transport Simulation
- Open source framework written in Java (GNU License)
- Started 15+ years ago, large international user community
- Developed by Teams at ETH Zurich, TU Berlin, (and soon Poly Montréal…)
- www.matsim.org



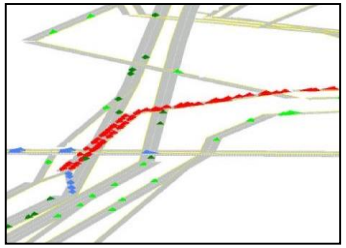
Evolution: agent's viewpoint



+ Sport
- Congestion
- Shop closed

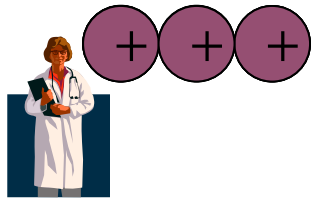


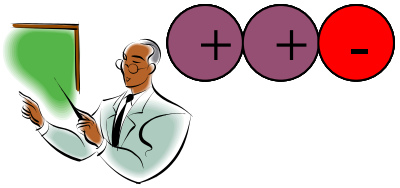
MATSim



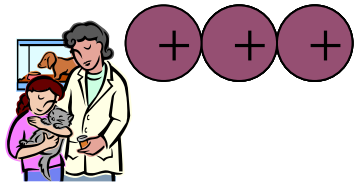
Co-evolutionary algorithm

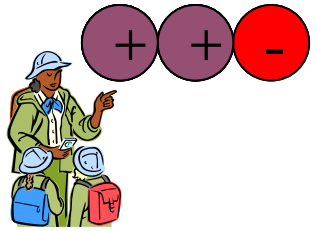
Iteration n





etc.





➔ **Equilibrium**

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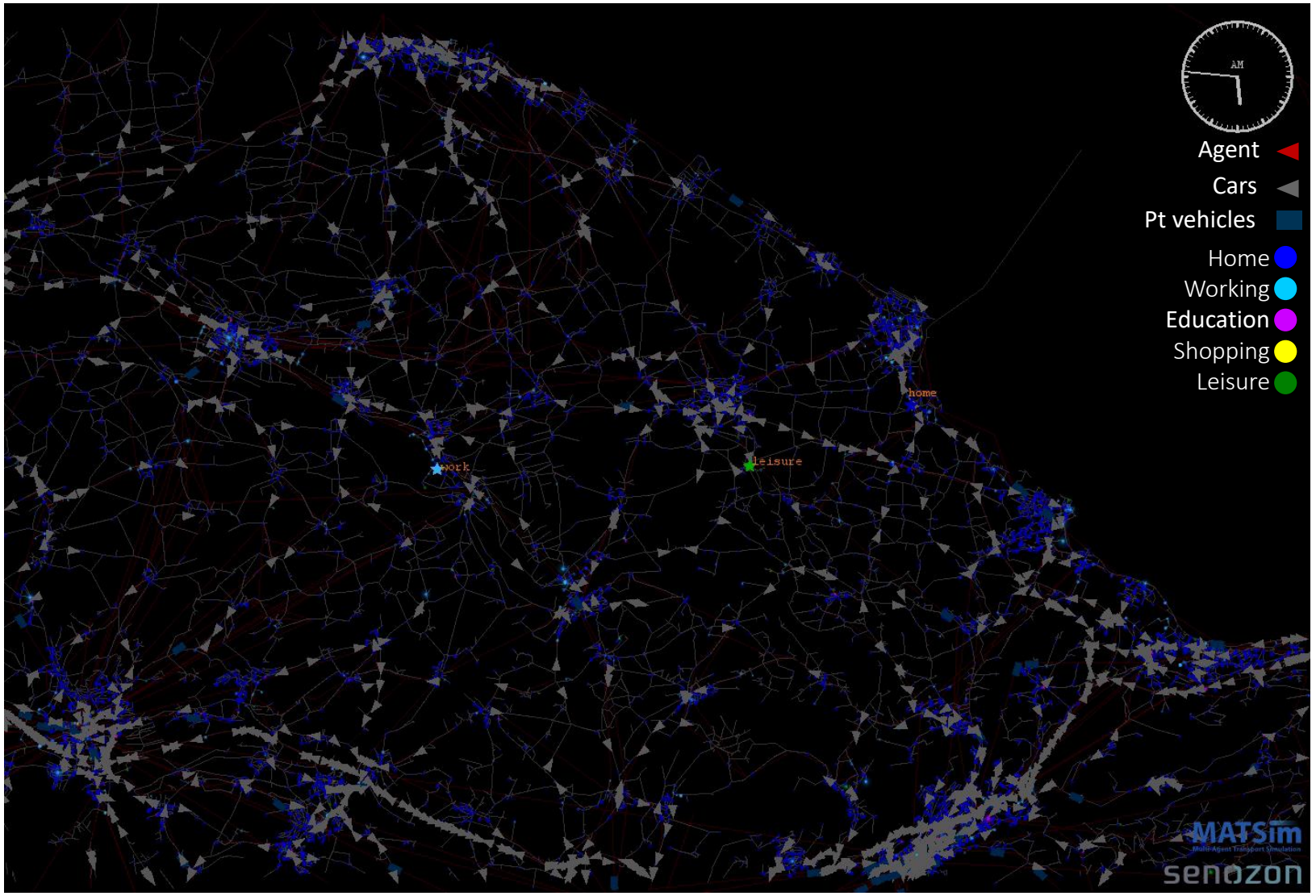

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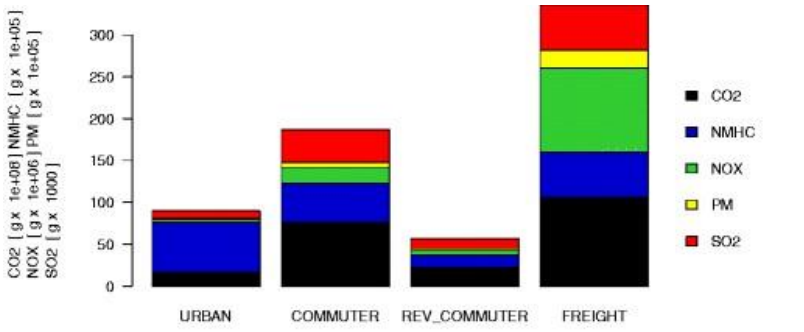
What MATSim provides

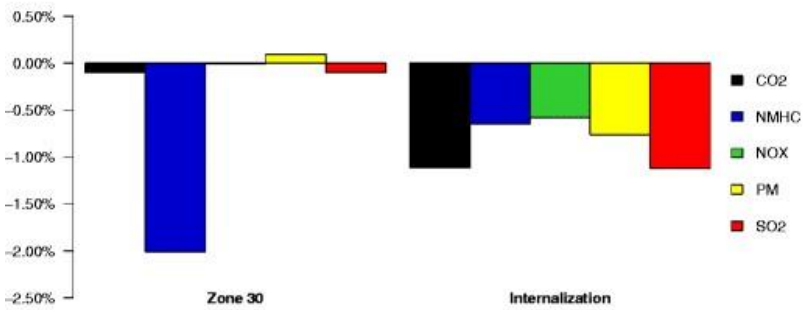
- Modeling of all modes to better understand their integration/competition including innovative mobility
- Assessment of scenarios even very different from status quo, thanks to explicit modeling of individual preferences
- Good compromise between detail (single individual, single vehicles, queue model with explicit modeling of congestion) and performance (scenarios with millions of agents)
- A natural way to implement the activity-based paradigm

Assessing vehicle gas emission with MATSim

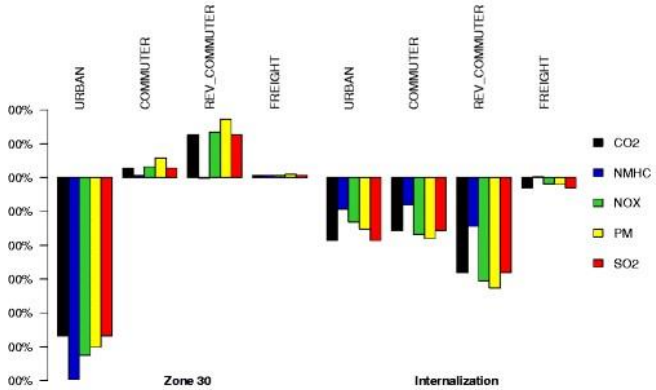
- Emissions can be assessed for each vehicle according to its specific characteristics at high spatial resolution
- Warm or cold start
- Can be assessed for different population segments or type of trips



(a) Base case: absolute emissions by type and subpopulation; values scaled to a 100% scena



(b) Policy cases: relative changes in emissions by type

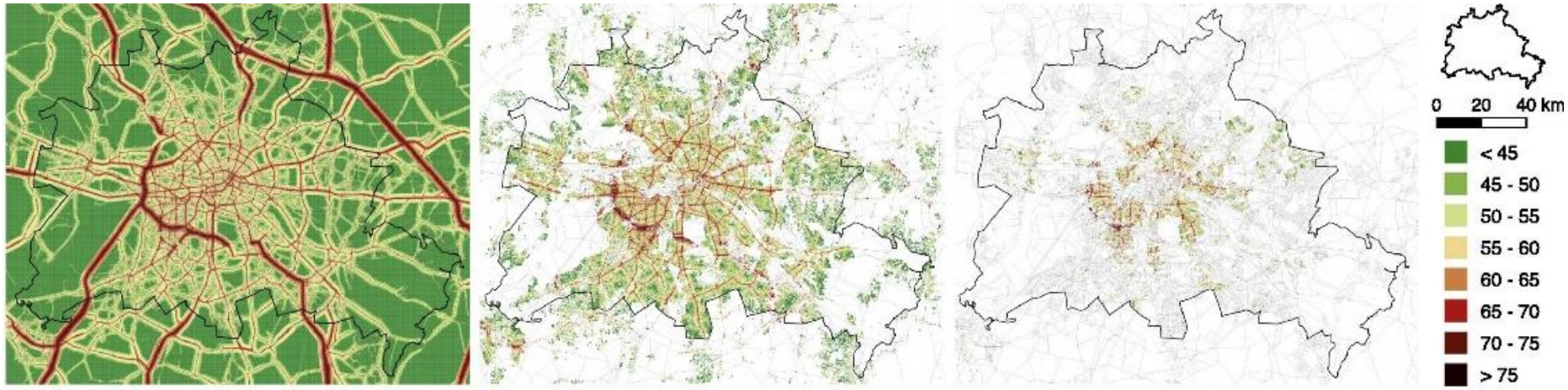


(c) Policy cases: relative changes in emissions by type and subpopulation

Towards high-resolution first-best air pollution tolls, 2016, B Kickhöfer, K Nagel, Networks and Spatial Economics 16 (1), 175-198

Assessing noise emissions with MATSim

- Noise estimation based on vehicles positions at high temporal resolution (1s)
- As activity location/type are known, exposure can be calculated



(a) all receiver points (b) > 0 affected agent units (c) > 50 affected agent units

An activity-based and dynamic approach to calculate road traffic noise damages, 2017, I Kaddoura, L Kröger, K Nagel, Transportation Research Part D: Transport and Environment 54, 335-347

Advantages & Limitations

Advantages

- Track emissions for individual vehicles within a DTA equilibrium model
- Look at different travelers profile
- Look at individual exposure

Limitations

- Average day
  - Average travel behavior
  - Average conditions (potentially relevant for emissions, for example weather)
  - Limited level of detail regarding driving behavior (queue model)

- Focus on urban mobility
  - Solutions only for urban or commuter travel, generally disregards long distance travel, no flights (except UAM)

Transformation: what do we have in mind?

Technology/Systems

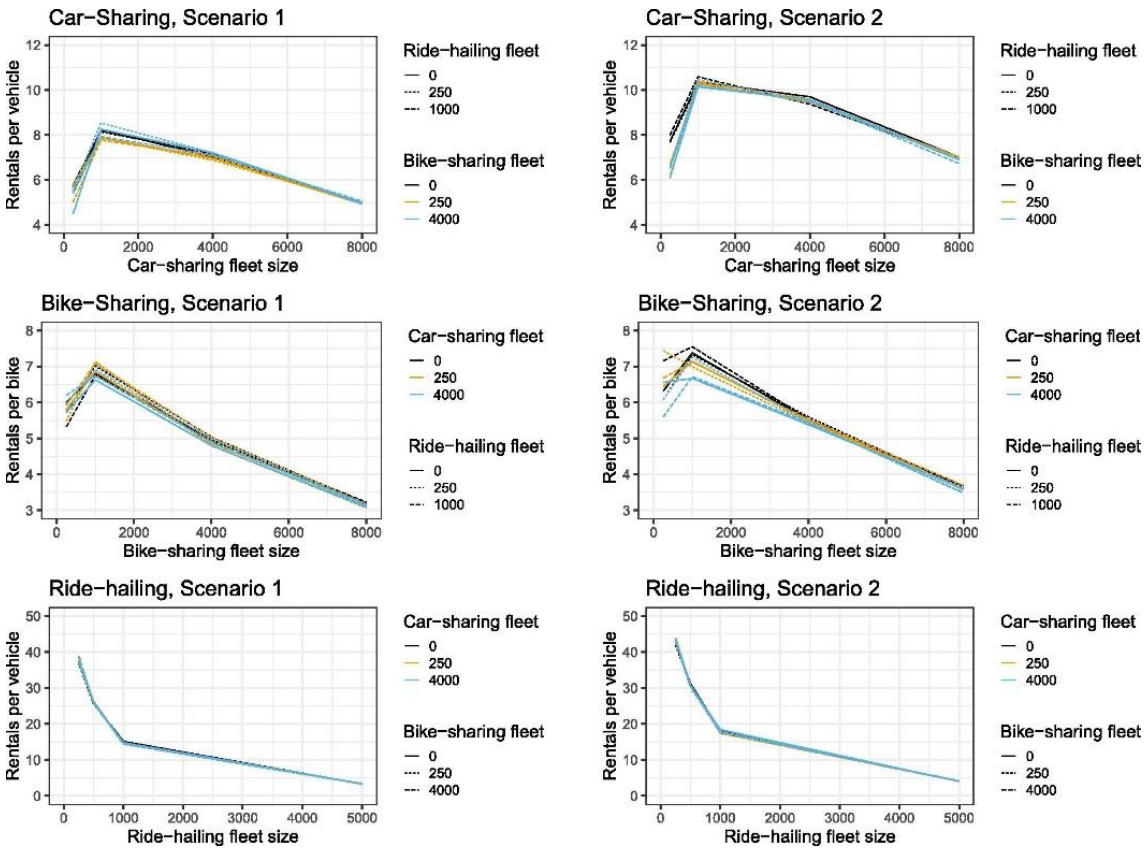
- EV / Hybrid / Fuel Cell
- Shared Mobility
- Driverless vehicles
- Micromobility
- Microtransit
- UAM
- MaaS
- Virtual activities
- …

Reduce emissions through:

- More efficient or new powertrain
- More efficient use of resources
- Less travel

Evaluation of transport transformation scenarios

Assessing an MaaS system



What we do?

- Assess direct emissions (operation
- Simulate complex scenarios

Assessing the welfare impacts of shared mobility and Mobility as a Service (MaaS), 2019**,** H Becker, M Balac, F Ciari, KW Axhausen, Transportation Research Part A: Policy and Practice 131, 228-243

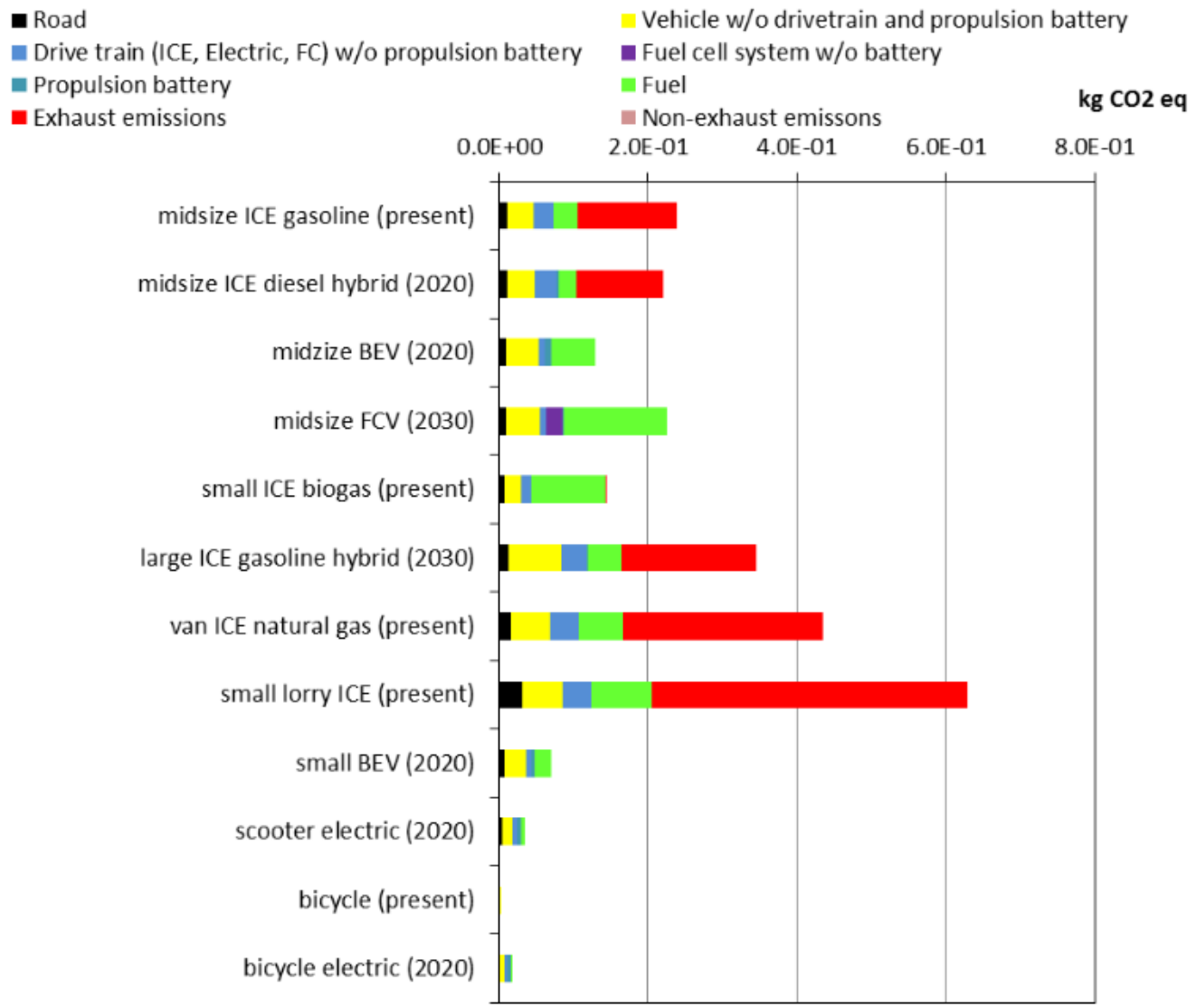
A few questions

- Can we really compare different systems and powertrain on an average day?

- Is an average day sufficient anyway to understand and assess the transformation of the transportation system?

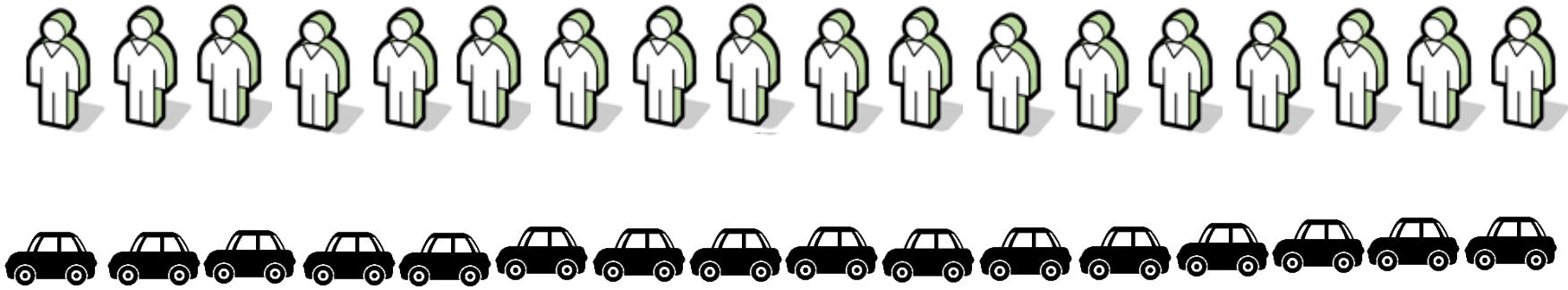
- As several different components of the system might change, shouldn’t we have holistic models?

Different life cycles? (I)



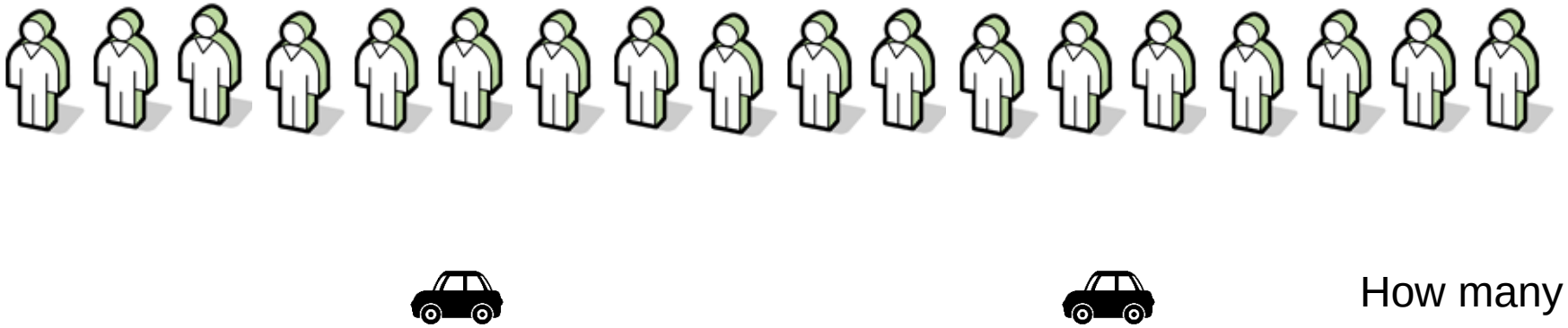
Different life cycles? (II)

Personal vehicle



10 years

Shared vehicle



How many years?

Complex dynamics in shared mobility systems

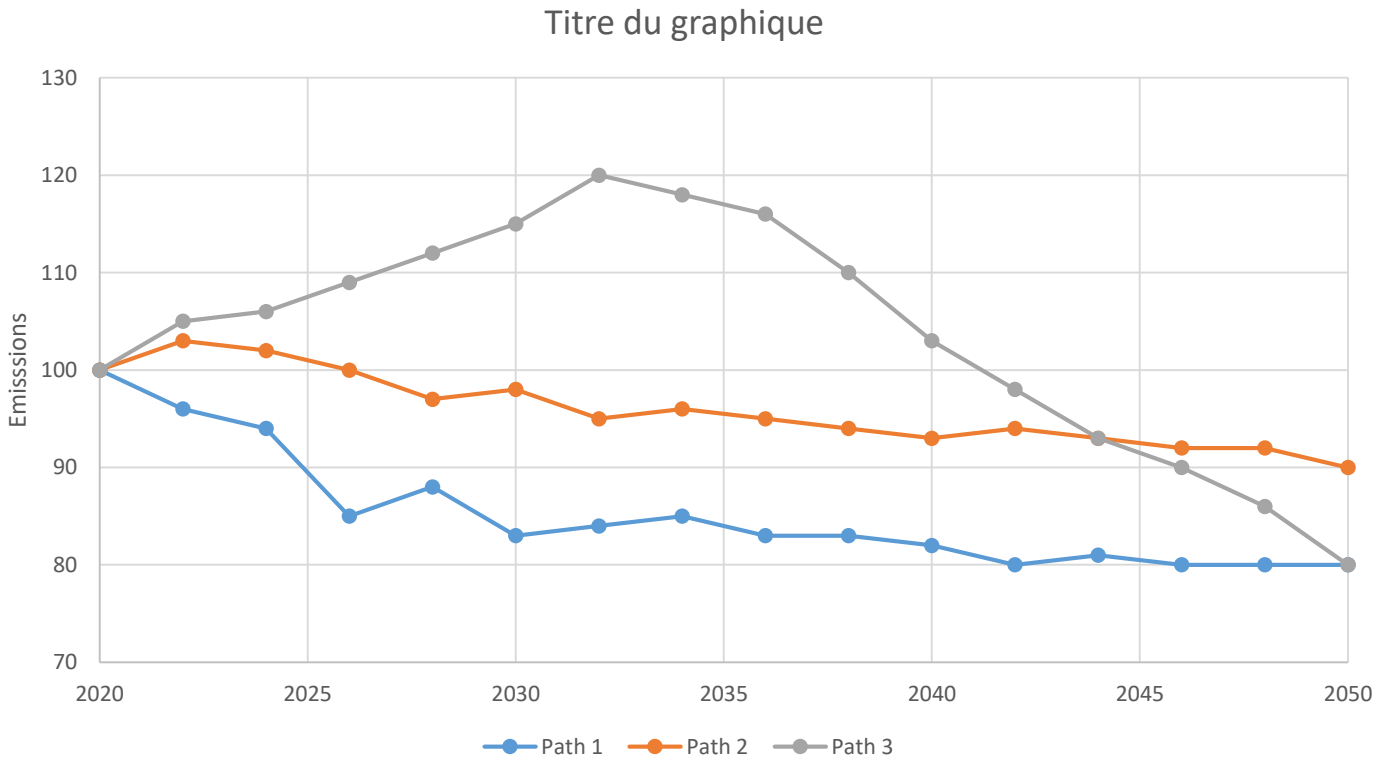
It is yet unclear if shared mobility could really become the backbone of a transformed transportation system as:

- We do not fully understand several important trade-offs (# Vehicles vs. #Users vs. Profitability)
- Scaling up could be problematic because potential customers might have very different travel patterns than current users.
- We are not yet sure if shared mobility directly causes behavioral change or is rather an enabler

What if the path is important?

Is the evaluation of future scenarios (placed more or less precisely into the future) enough or should we care about how such scenarios can be reached?

The difference in emissions can be huge!



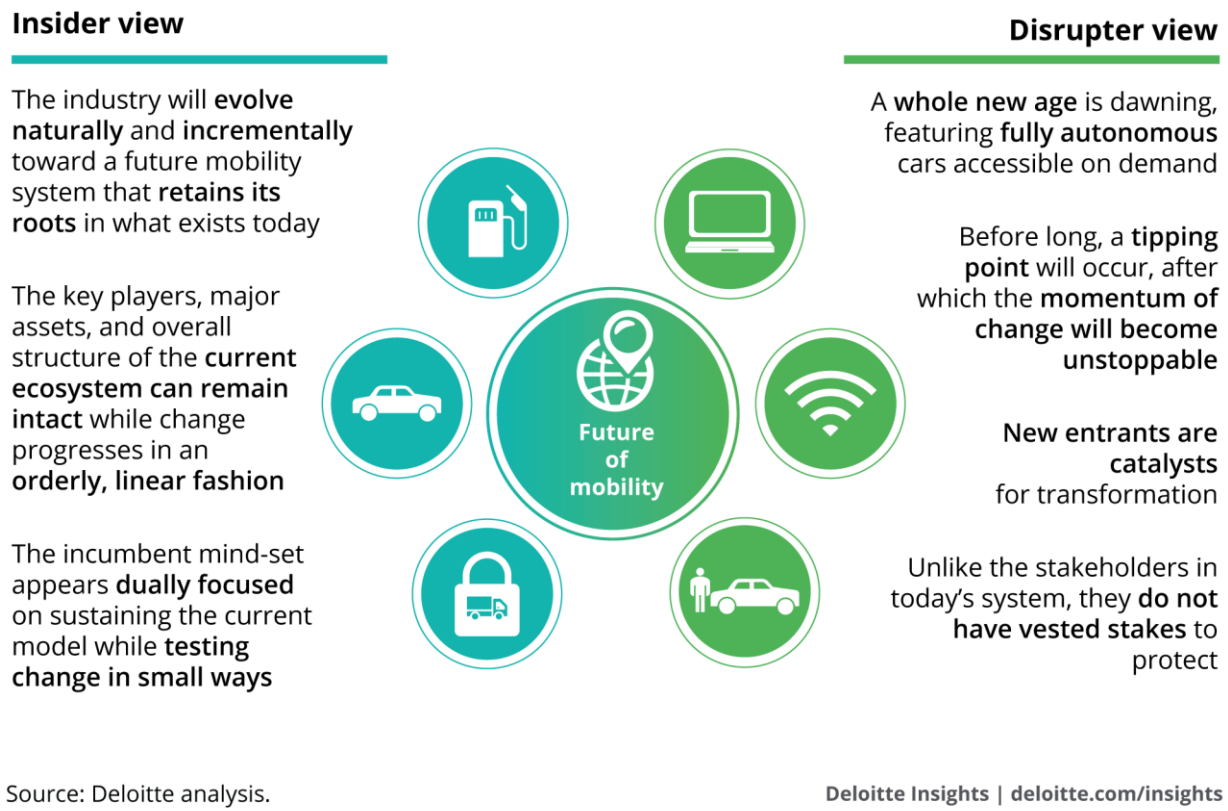
Some other thoughts

- Probably, we won't find a single model that will capture all →Integrated use of different models, holistic approach

- Agent-based models are well placed to simulate innovative scenarios but not necessarily transformation paths → They are definitely part of the solution but not alone a solution, although there are still many aspects that could relatively easily be plugged-in (for instance driving style, weather conditions, etc.)

- Predicting transformation paths is difficult → we might rather want to learn how to asses their plausibility/consistency

Evolution or revolution?



We might need disruption rather than slow organized change, but planning is rather about the second. Meaningful (path dependent) scenario assessment in a disruption context is challenging to say the least!

Thank you for your attention!