SBB CFF FFS

MATSim at SBB
Using and contributing to the open-source transport simulation for advanced passenger demand modeling

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What is MATSim (and why is it useful)?

What is MATSim?

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MATSim
is playing SimCity™ using complex econometric behavior.

MATSim = Multi Agent Transport Simulation

- Started at ETH Zürich and TU Berlin 20 years ago

- Originally an academic project

- Many models around the globe, some of them fully open data (e.g., Berlin: https://github.com/matsim-scenarios/matsim-berlin)

- Bigger users include
  - BVG (Berlin)
  - Melbourne
  - Volkswagen
  - SBB

The website:

https://matsim.org/

The code:

https://github.com/matsim-org/

The book:

https://doi.org/10.5334/baw

The license:
GPL v2

The association:
https://matsim.org/association/

How MATSim works.

A lot of (open) input data.

- Synthetic Population & Daily Plans
- Count data
- Econometric data (e.g., value of times)
- Road & public transport supply

Generic algorithms*

Plan Scoring
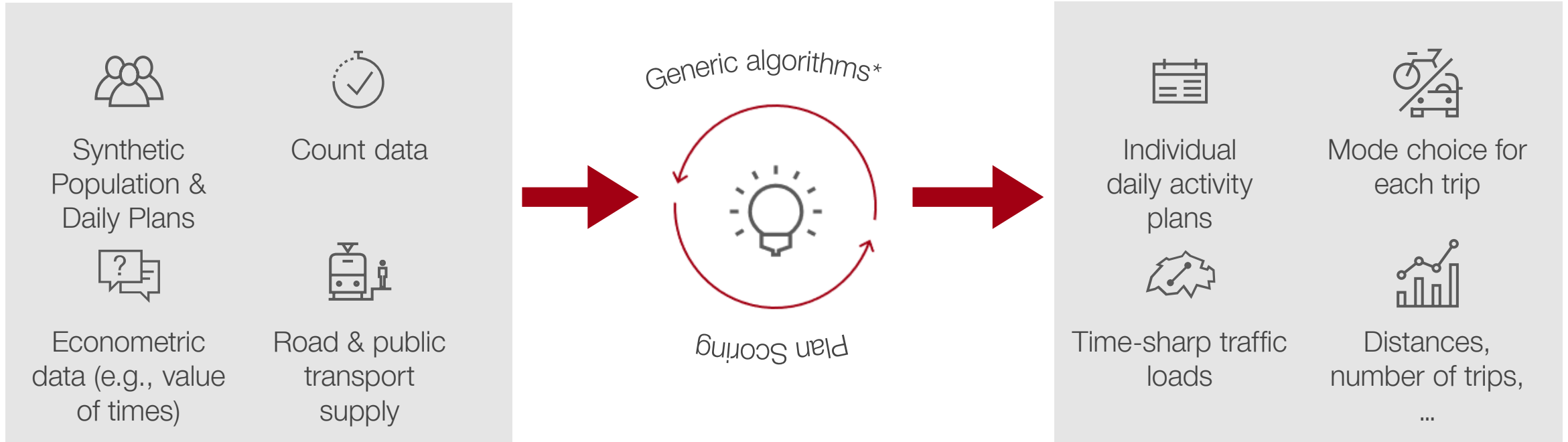
Many Iterations.

*Examples:
Route Choice.
Mode Choice.
Departure Time Choice.
Location Choice.

Even more output.

- Individual daily activity plans
- Mode choice for each trip
- Time-sharp traffic loads
- Distances, number of trips, ...

What can MATSim be used for?
(non exhaustive list)

Transport Policy Evaluation

→ New Roads / Railway lines

Person centric Impact Assessment
→ Who is affected by emissions?

Accessibility Computations

→ Which regions are better connected than others?

On-Demand modes and Mobility as a Service

→ Effectiveness of fleet operations

MATSim is often used as a framework. Being open-source means that anyone add their own contributions or conduct research and use the parts of MATSim that are useful for them.

How MATSim is organized: The association

Historically, **Kay Axhausen's** (ETH Zürich) and **Kai Nagel's** (TU Berlin) work groups are a stronghold in maintaining MATSim and keeping the build together, with an informal support of two companies offering MATSim related services (Senozon and Simunto)

Assigining enough (voluntary) ressources to code maintaining, user meetings, code sprints has been challenging at times

The MATSim association, operative since 2023, has the goal to maintain the code and keep track of developments, as well as officially represent MATSim.

SBB's way to Open Source Travel Demand Modeling

SBB's way to MATSim
A top down decision

- 2016: SBB top management decides to invest in simulation software to answer on-demand transport related questions, MATSim is explicitly mentioned

- The task is delegated to the department dealing with (classical) passenger demand modeling
  - Some challenges: Proper Computer Setup, Java knowledge, …

- 2017: A three-year project to build a Switzerland wide model is established

- Several additions to MATSim are necessary for a performant model of this size
  - Decision is made to feed these directly back into the MATSim project
  - Development of transport-modeling software under GPL is backed by the SBB management

- 2018: A first model version is released

- Since 2020: The project turns into a product: **SIMBA MOBi** is established.

Our contributions to MATSim.

Some SBB contributions to MATSim: The Swiss Rail Raptor

→ **Initial public transport routing in MATSim was far too slow for a complex schedule**

→ Speed-up of the whole CH-simulation: **roughly 3 times**

→ Stop-specific transfer times

→ Range queries: optimal connection within time window

→ **Intermodal access/ egress**

→ Person-specific routing parameters

→ Mode-specific routing parameters

Version 1.0

Version 1.5
«a more realistic router»

Version 2.0
«a fancy router»

Some SBB contributions to MATSim:
HERMES – A faster mobility simulation

Typically, the traffic-flow simulation in MATSim is handled by a queue-based simulation („QSim")

QSim is highly pluggable and extendable:

Support for traffic lights, electric vehicles, on-demand transport modes and many other features

QSim is rather slow, and the traffic flow simulation is not very scalable to multiple threads

Hermes: A development by ETH Zürich and SBB fills the gap: Higher Speed at the price of flexibility

Simulation runtimes for a classic SBB setup have significantly reduced and is now at roughly 24 hours for a sketch run.

What we use MATSim for.

SIMBA MOBi:
SBB's model for multimodal passenger demand modeling

SIMBA MOBi depicts the everyday mobility of 8.5 million people in Switzerland

All major transport modes are depicted: Car (both drive and passenger), Public Transport, Bike and Walk

The model contains a representation of all roads and public transport lines, including cable cars and ships

Agents' behavior is simulated microscopic, including their first- and last mile decisions
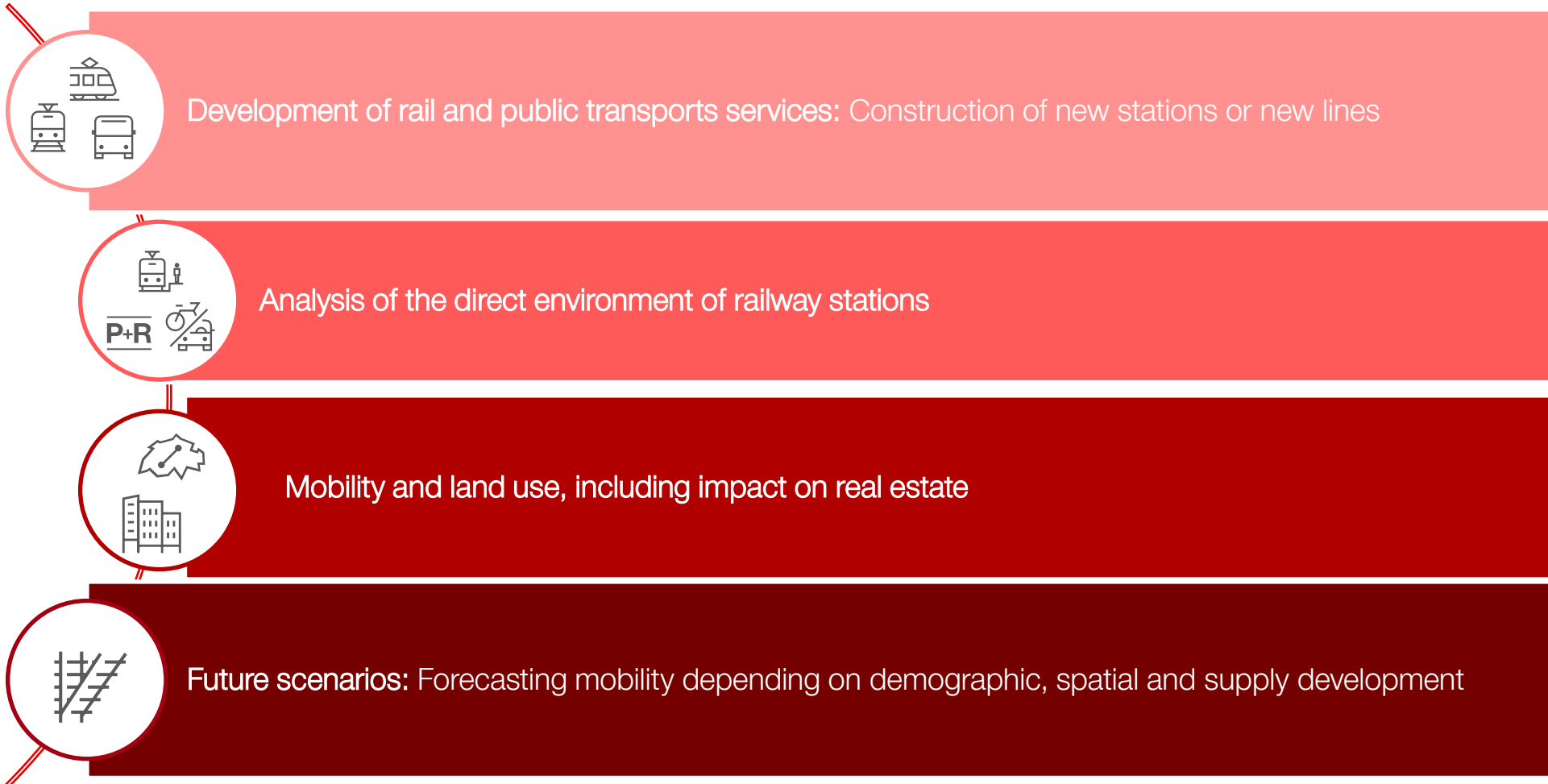
Use cases for SIMBA MOBi.

Development of rail and public transports services: Construction of new stations or new lines

Analysis of the direct environment of railway stations

Mobility and land use, including impact on real estate

Future scenarios: Forecasting mobility depending on demographic, spatial and supply development

Dimensioning of new Railway Stations

- Over the next decades, several dozens of new stations are expected to be opened in Switzerland

- Mostly along existing lines

- In many cases, stations are built to better connect newly developed areas with thousands of new workplaces or houses

- SIMBA MOBi allows adding these new locations and estimate the impact on the overall transport system

Moving and re-dimensioning St. Gallen Bruggen Station
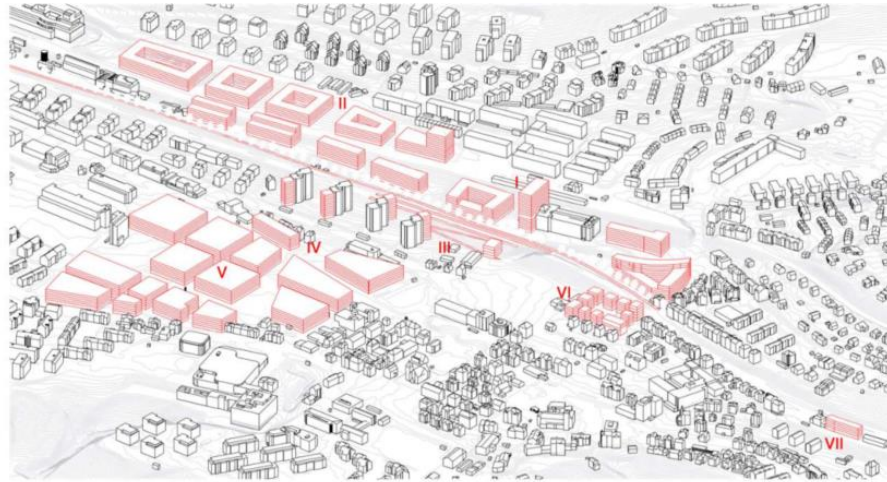
Nutzungsdichte: Variante A

Entwicklungsgebiet	Einwohner/Arbeitsplätze neu	
	Einwohner [EW]	Arbeitsplätze [AP]
I	1'350	540
II	1'500	300
III	175	0
IV	118	377
V	716	2'101
VI	200	0
VII	63	0
I-VII	4'059	3'318
	7'377	
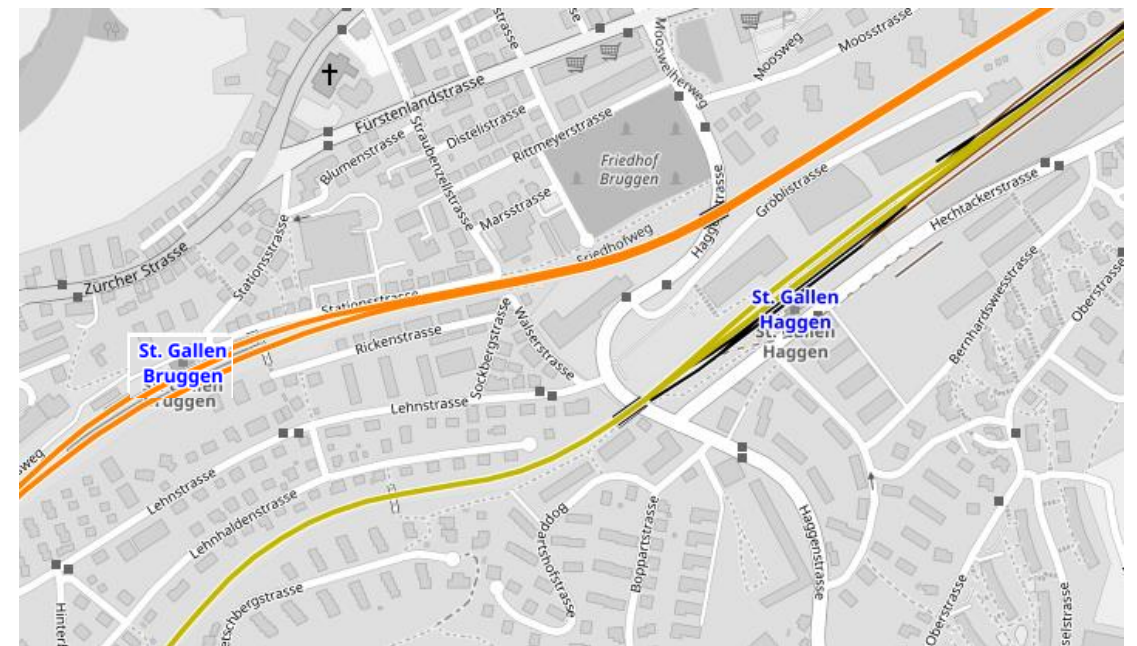
Passenger Development

	Bruggen	Haggen	Total
Basecase	1'500	2'800	4'300
New Station & New Developments	2'400	3'400	5'800

RailSim: Getting trains more realistically on Tracks

MATSim default	Recent extension: deterministic pt	Missing feature

MATSim default

- Transit vehicles are handled as normal vehicles in the QSim engine.
- In some applications this actually makes sense: e.g. buses use the normal road network where they may face traffic congestion (e.g. bus bunching studies).
- In some applications, transit vehicles use exclusive pt links
  - capacity is sufficiently high to avoid traffic congestion
  - freespeed parameter need to be consistent with the travel times defined in the transit schedule

**Recent extension: deterministic pt**

- Transit vehicles strictly follow the schedule.
- Predefined modes are excluded from the default Qsim engine (no queueing dynamics, freespeed parameter is ignored, …).

Missing feature

- Account for the rail-specific dynamics: moving or fixed blocks, reserved train paths, …
- Planned train movements are defined by the transit schedule. Actual train movements are the result of the physical model layer (vehicle attributes, infrastructure, available capacity).
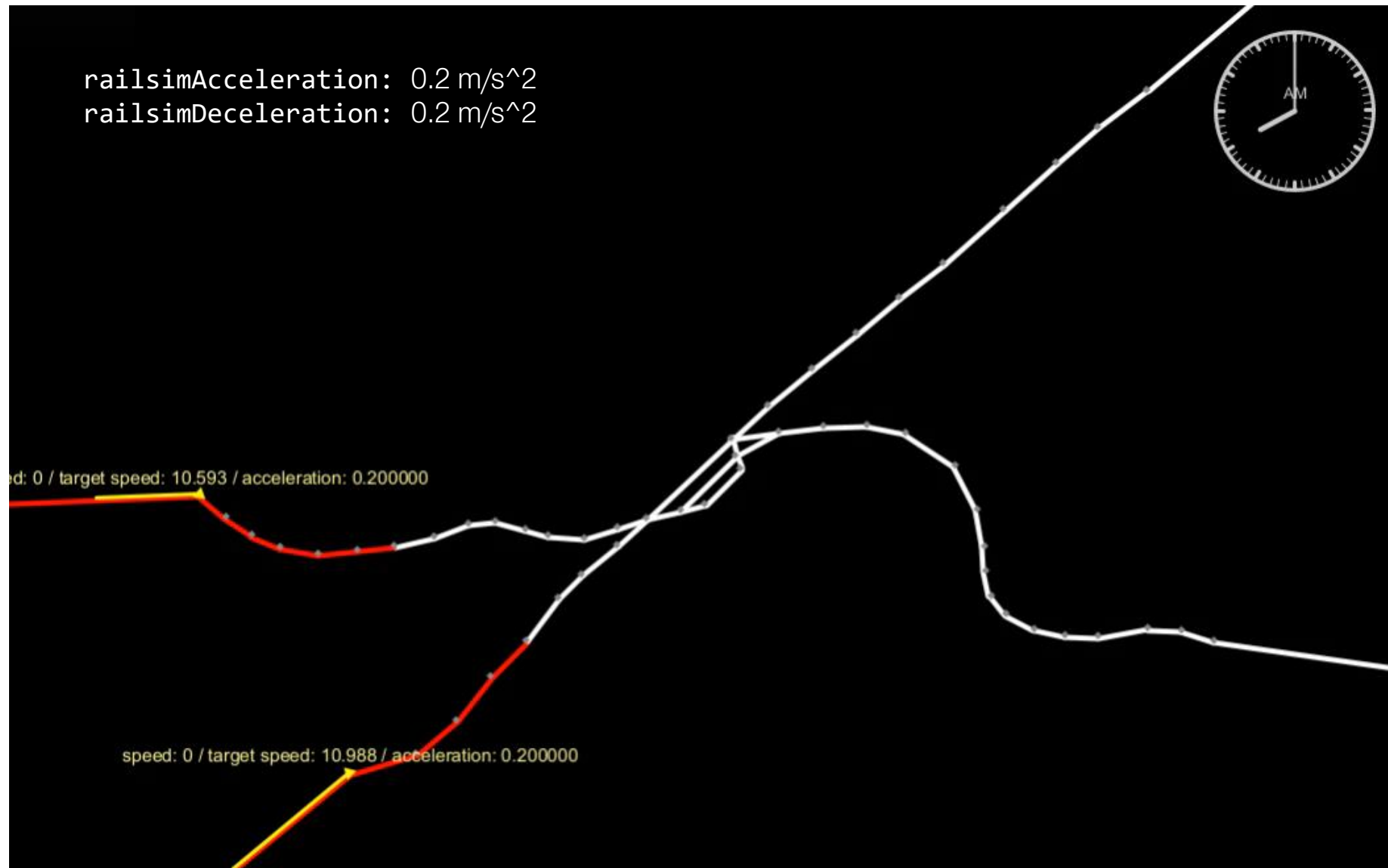
Wrap Up

- MATSim has helped SBB to better understand mobility behavior of its customers and non-customers

- SIMBA MOBi has become a standard product that is part of the business decision process of the company

- Committing to open-source pays off:
  - Several additions and extensions by others to the code initially contributed by us
  - Valuable exchange within the community

- Large-scale computer models require a considerable effort to be maintained. In the end, this requires a lot of in-house knowledge.

MATSim User Meeting

- The annual MATSim User Meeting is a gathering place of the MATSim community

- This year, it will be in conjunction with the hEART Conference

  June 17, 2024 in Aalto (Helsinki), Finland

- More details will be available soon

  https://heart2024.aalto.fi/ and https://matsim.org

Thank you for your attention.

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