Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

WagonSIM – Simulation tool for Optimisation of Wagon-based Production Schemes

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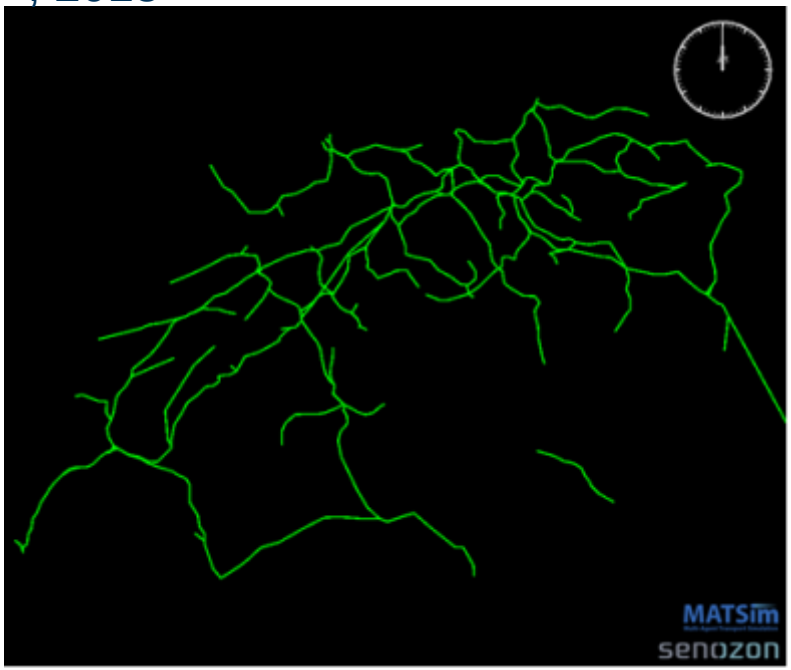
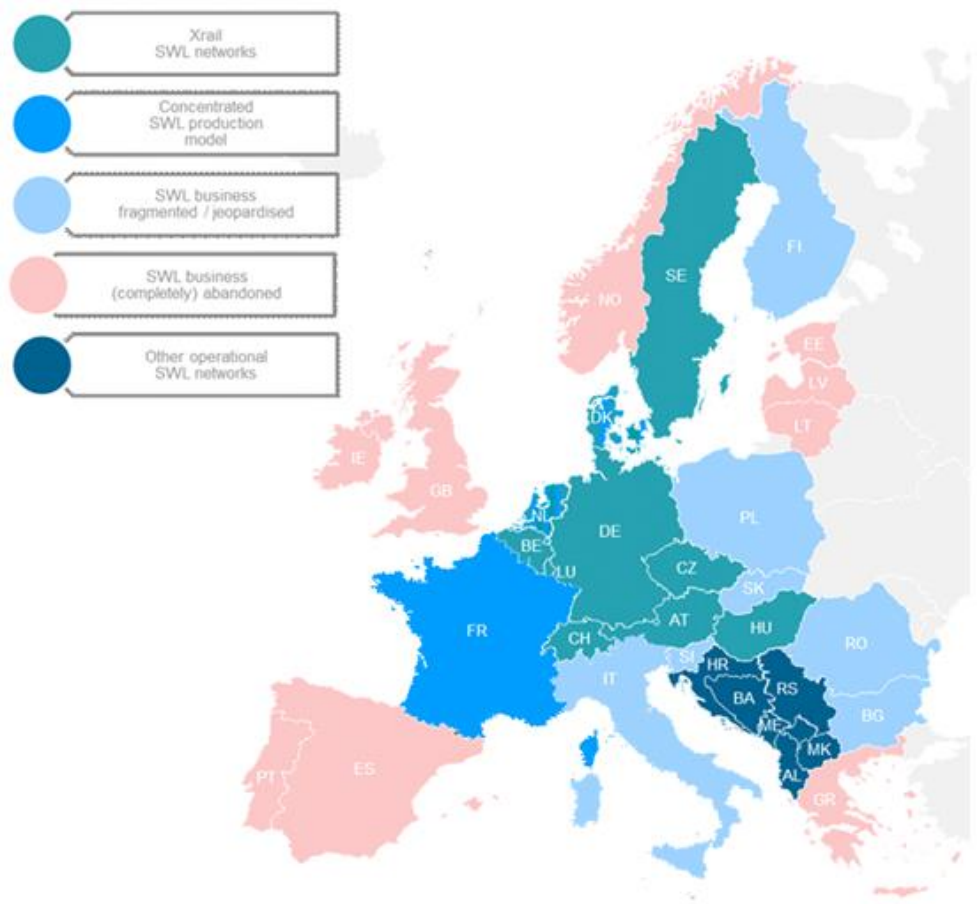
ViWaS – Viable Wagonload Production Schemes
Final conference
Lucerne, October, 23rd, 2015

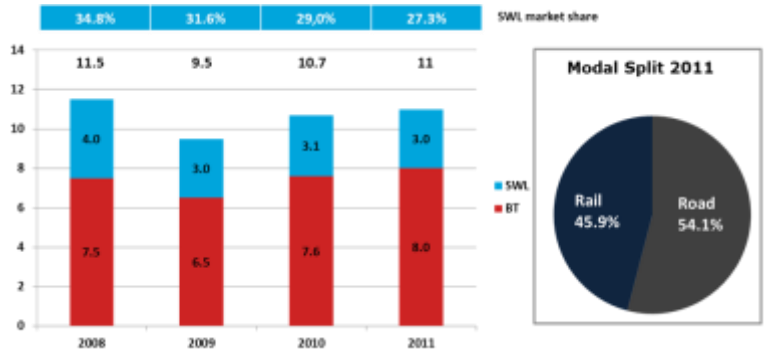


The status of SWL in Europe

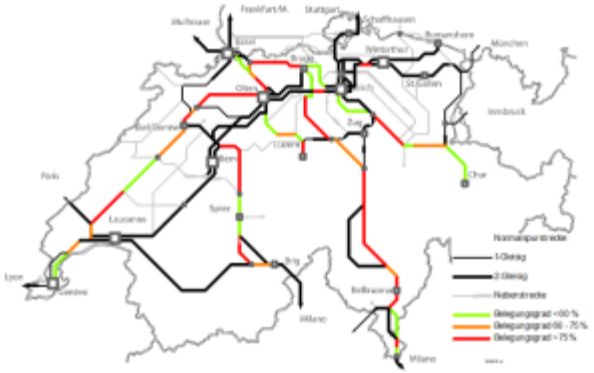
SWL networks in Europe



Modal Split of SWL in Switzerland

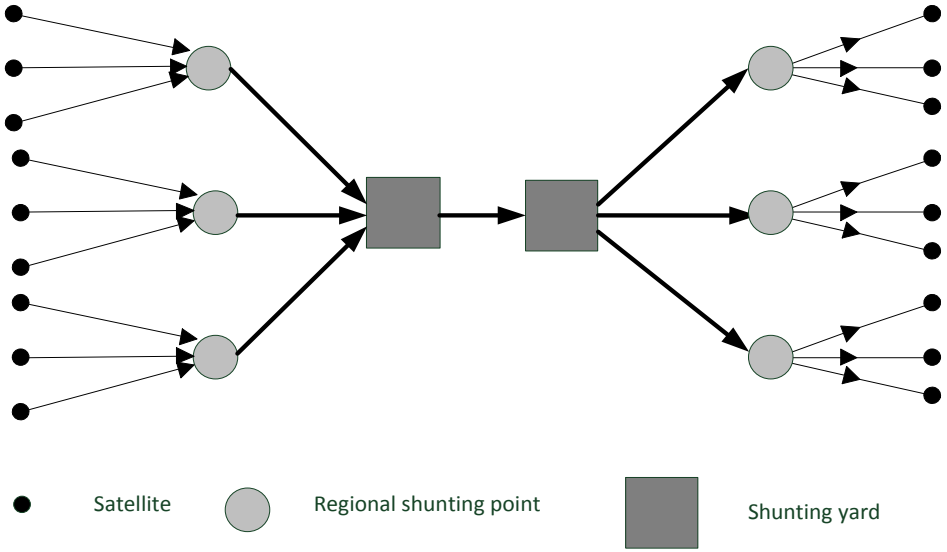


Infrastructure bottlenecks in Switzerland



Optimisation approaches for Single Wagonload networks

SWL production schemes



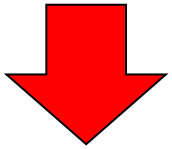
Optimisation approaches for SWL

- Optimisation of the train operation on the lines (between the shunting points)
- Optimisation of the shunting processes
- Optimisation of the network structure

Optimisation approaches and simulation requirements

Optimization goals for SWL networks

- Increase of the utilization of trains – to reduce the number of trains,
- Stabilization of the train occupancy,
- Reduction of the deviation of wagons,
- Enhancement of the supplied services by shorter transport times.



Simulation and Network Optimisation tool requirements

- Covering the production schemes of SWL,
- Including maximum train occupancy (weight and length),
- Dealing with the transport requirements (closing time and latest time of arrival in the Satellites),
- Covering time requirements for shunting processes
- Optimization of wagon routing depending on the train occupancy.

Methodological gap in (freight) railway simulation

Macroscopic approaches
Conventional transport planning software, dealing with O-D matrices and an aggregated infrastructure network on line basis. Simulation almost on a daily basis.

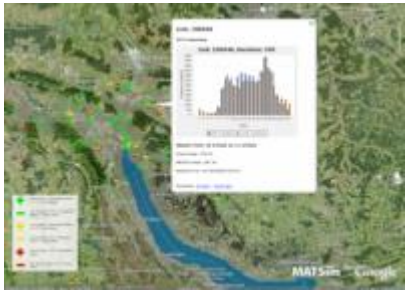
Microscopic approaches
Railway Simulation, dealing with detailed infrastructure data and concrete schedules, but not considering the demand structure. Simulation on a basis of seconds

WagonSim as mesoscopicic approach
Modeling the SWL network on basis of wagons. Dealing with a generalized infrastructure network, considering the network structure and capacity restraint. Modeling a concrete timetable. Considering shunting times etc.

MATSim as agent-based simulation software

WagonSIM is developed on basis of the MATSim system:

- **Fast Dynamic and Agent-Based Traffic Simulation**
  Simulate whole days within minutes
- **Private and Public Traffic**
  Both private cars and transit traffic can be simulated
- **Supports Large Scenarios**
  MATSim can simulate millions of agents or huge, detailed networks
- **Versatile Analyses and Simulation Output**
  E.g. compare simulated data to real-world counting stations
- **Modular Approach**
  Easily extended with your own algorithms
- **Interactive Visualizer**
  See what each agent is doing during the simulation
- **Open Source**
  You get the Java Source Code, which runs on all major operating systems

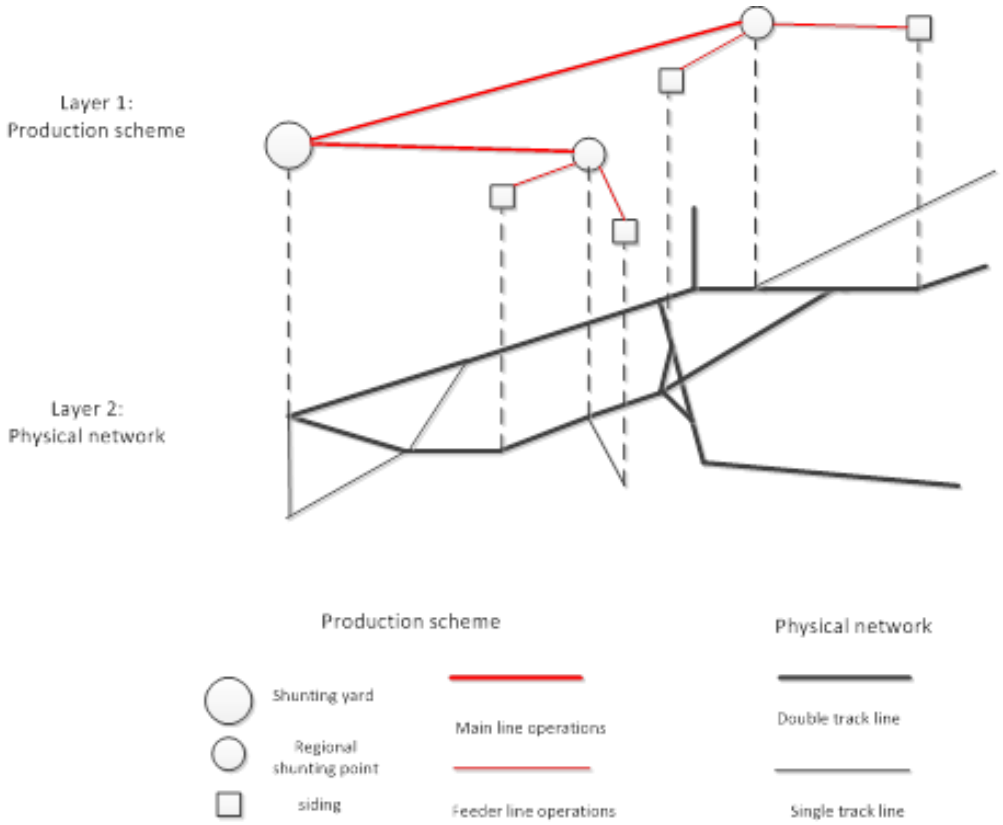


Friday, October 23rd 2015

Adaptions in MATSim to model WagonSIM

MATSim element	Representation in WagonSIM
Agent	Wagon with its weight and length
Activity plan	For each Wagon: Origin siding with earliest departure time –> destination siding with latest arrival time
Population of agents	Set of all wagons
Transport vehicles	Trains with their maximum length and weight
Schedule for vehicles (PT)	Train schedules (production network)

The two network layers: production scheme and infrastructure network



Wagons
Activity plan

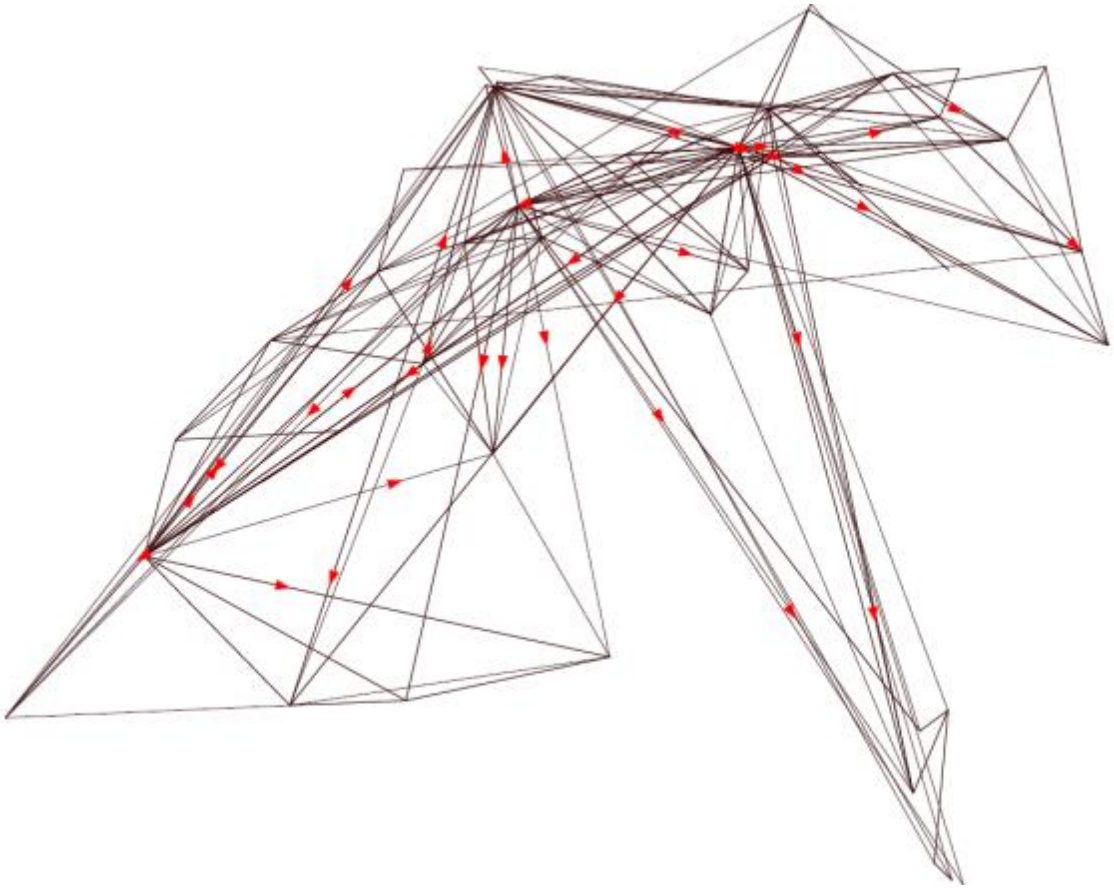
Routing on the schedule (and the production scheme)

WagonSIM Schedule
Train network including the production scheme

Routing on the infrastructure network

Production scheme
(commercial stops)

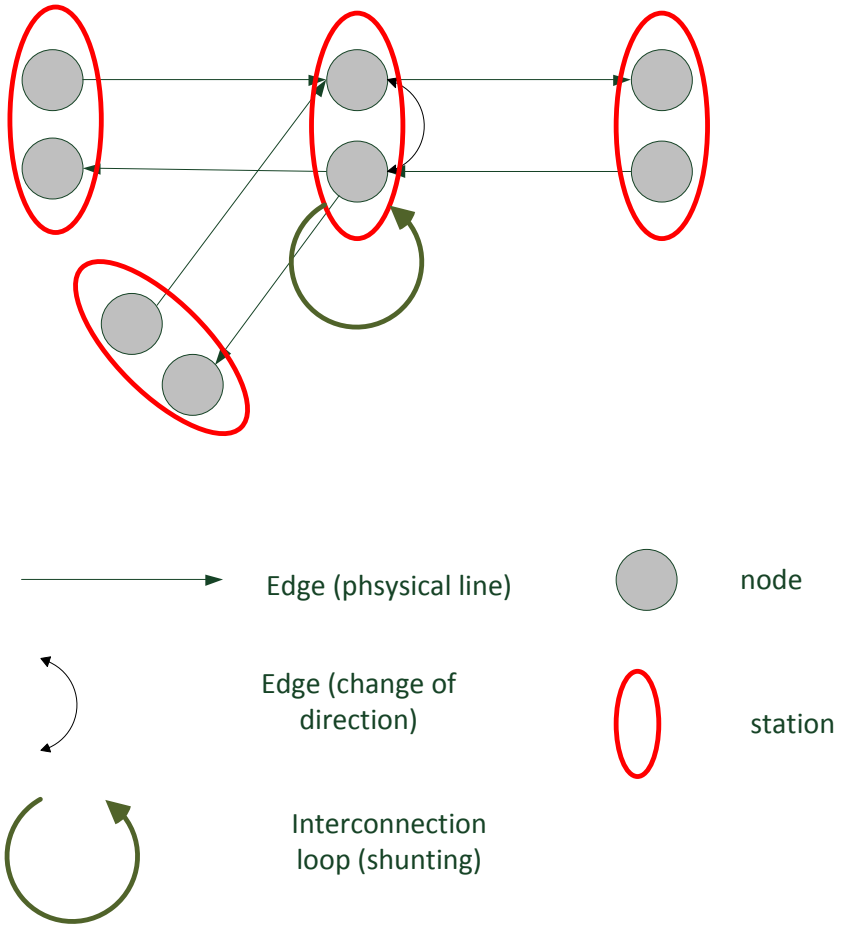
The production scheme



Elements of the production scheme

- **Nodes** representing the commercial stops to pick up and set down wagons.
- **Edges** representing the trains with their commercial stops

The infrastructure model – including attributes and capacity restraints



Elements of the infrastructure network

- **Edges** with their length, maximum speed and maximum capacity.
- **Nodes** with a maximum capacity for the number of shunted wagons and minimum times to set up and drop down wagons.
- **Interconnection loops** at the nodes with a minimum time to change between different trains.

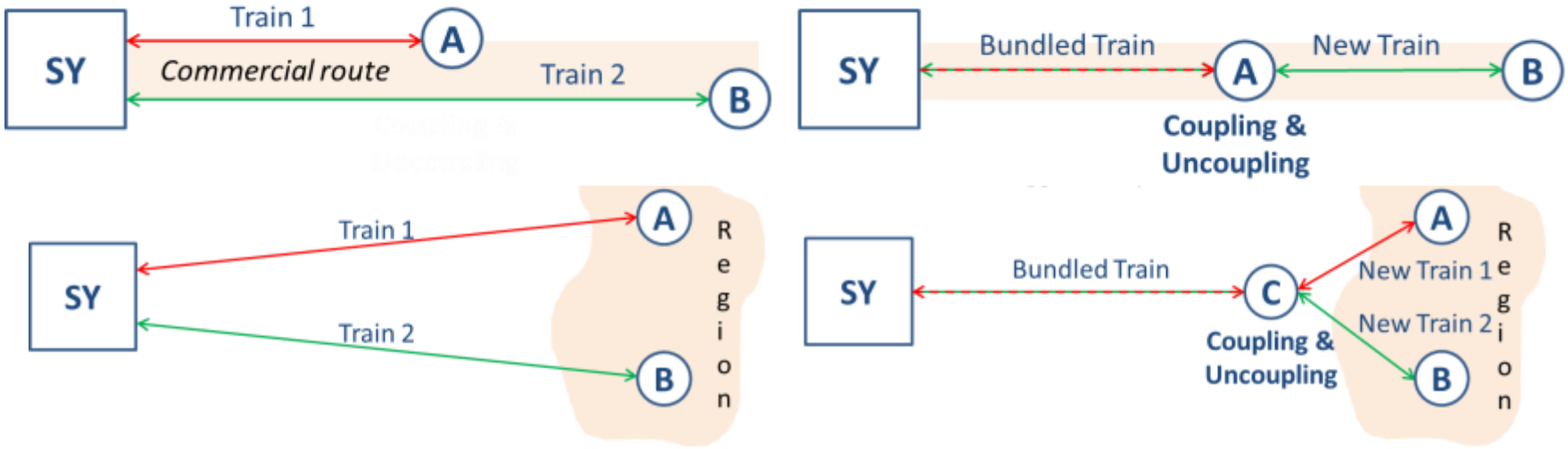
The WagonSIM Schedule

- Merged from the production scheme and the infrastructure network
- All railway lines in Switzerland with SWL are integrated in the model

WagonSim video

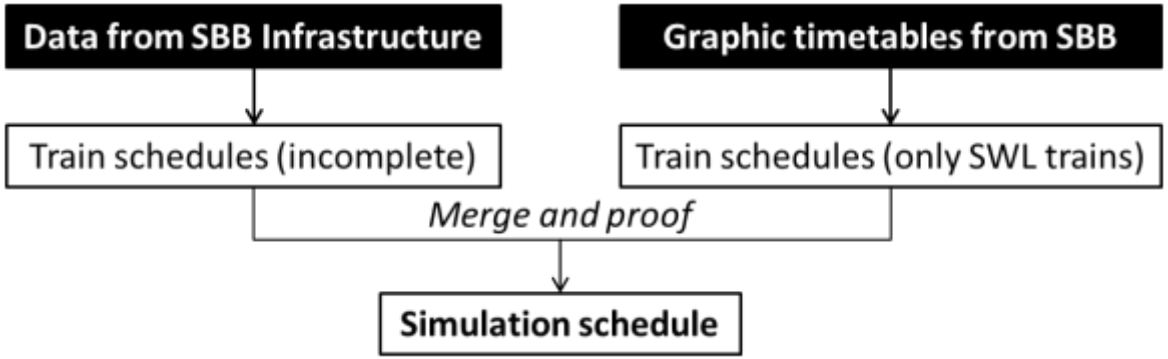
Case study - Concept

- Six regions and/or commercial routes have been selected



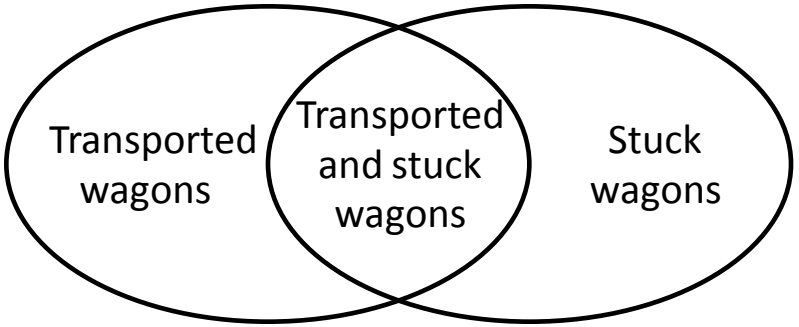
- Identification of all trains serving the selected shunting yard and regional shunting points
- Substitution for a new service: 3 trains per day in each direction, none intermediate stops, coupling and decoupling activities allowed.
- New schedule includes these changes and keeps original services in the rest of the network

Case study - Data preparation



Case study - Simulation and results (1)

- 5 KPIs:
  - train-kilometers;
  - train-hours;
  - wagon-kilometers;
  - wagon-hours, and
  - ton-kilometers



- Wagons counted as
  - Transported wagons, or
  - Stuck wagons

Stuck wagons	Transported wagons	Train-kilometers	Train-hours	Wagon-kilometers	Wagon-hours	Tonne-kilometers
22.59%	97.41%	102896	2463	401519	68378	15,546,472

Case study - Simulation and results (2)

Local modifications simulation results

	LM 1	LM 2	LM 3	LM 4	LM 5	LM 6
Stuck wagons	-5.40%	4.32%	1.73%	2.70%	-4.06%	1.19%
Transported wagons	0.02%	0.03%	-0.15%	0.03%	0.55%	0.03%
Train-kilometers	0.17%	-3.25%	-0.13%	1.88%	-5.95%	0.18%
Train-hours	-0.13%	-1.08%	0.61%	1.68%	-7.22%	0.08%
Wagon-kilometers	-3.95%	-11.42%	-4.88%	-4.27%	-0.91%	1.44%
Wagon-hours	-0.55%	0.00%	-2.26%	-0.12%	2.23%	-2.42%
Tonne-kilometers	-4.33%	-12.08%	-5.45%	-5.40%	-1.57%	0.60%

Conclusions

- WagonSIM is an scalable agent-based model time-table based freight network, if infrastructure and schedule data are provided.
- Case study in the Swiss SWL network is presented as illustration case for WagonSIM performance.
- Improvements on the current Swiss SWL production schemes are possible.
- WagonSIM is proved as a valid tool to study the current production schemes and find modifications that improve the performance.
- WagonSIM has a potential for further development.

Thank you for your attention !

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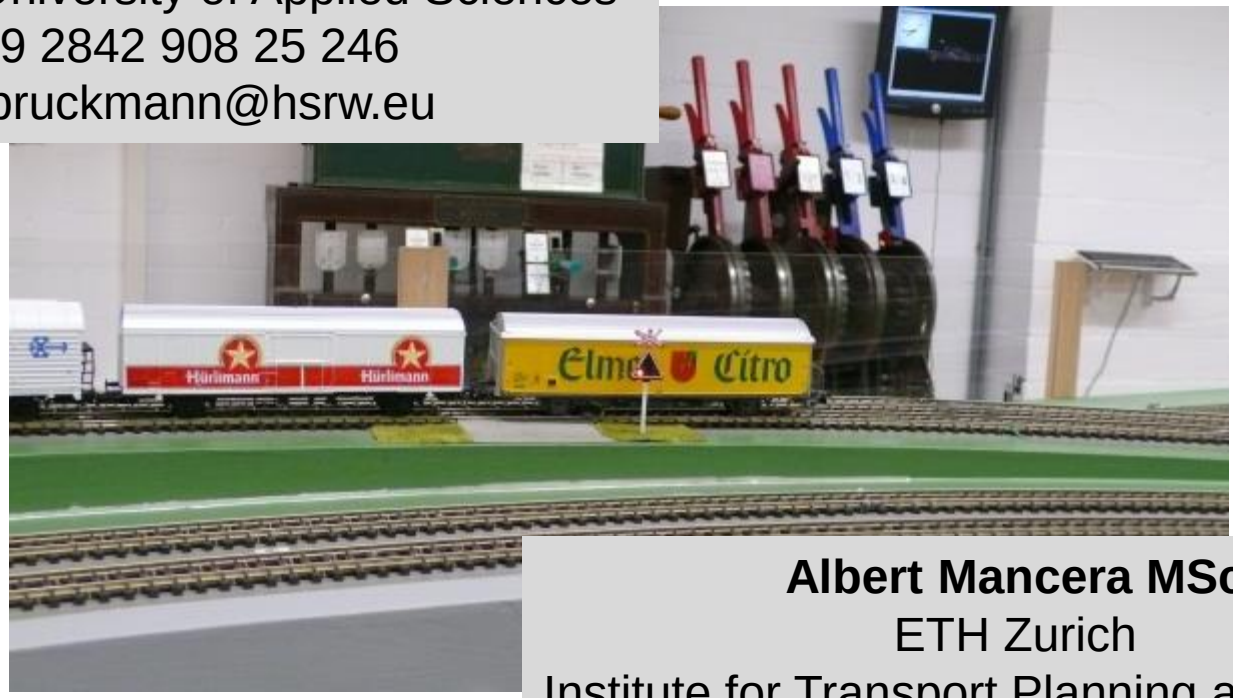

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