Converting OpenStreetMap geo data into railML® for a Railway Simulation Environment

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Overview

- Motivation
  - Railway driver‘s cab simulation RailSET
  - OpenStreetMap (OSM)
- Approach
  - Defining OSM Layers
  - The OSM-4-Railway tool chain
  - The SimWorld tool chain
  - Adapting the SimWorld tool chain
- Implementation
- Summary

Motivation

Railway Driver‘s Cab Simulation RailSET*

- Purpose: Human Factors analyses for train drivers
- Requires: realistic 3D model of the railway line to be used for simulation (topology, geometry)

** **RailSET** = Railway Simulation Environment for Train Drivers and Operators*

Motivation

Initial Situation

- Simulation in the RailSET laboratory is based on ZUSI

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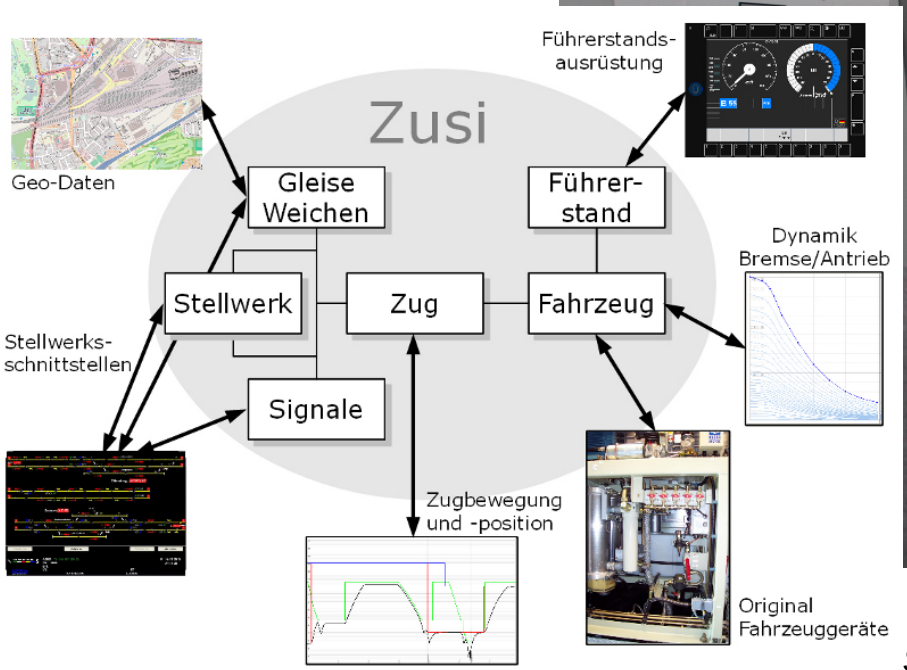

Source: www.zusi.de

Motivation

Initial Situation – Problems

- The number of lines to be simulated within the RailSET laboratory environment is limited
- The generation of tracks/lines for simulation is expensive (time, students)
- Zusi does not consider the combination with existing real geo data, e.g. digital terrain models
- **Currently, it is not possible to model/visualize/simulate arbitrary lines in short term**

- **Goal:** to model, visualize and simulate arbitrary tracks within the RailSET laboratory environment
- **Task:** Concept and implementation of a process chain for simulation-based scenario and landscape generation using existing geo data sources

Motivation
OpenStreetMap

- OpenStreetMap (OSM) project was founded in 2004
- Goal: free world map

#users	1,791,598
#GPS points	4,208,062,937
#nodes	2,526,790,312
#ways	252,581,837
#GPX files 18.09.2014	200
Size Planet.osm	>498 GB (36 GB compressed)

Sources:
- *OpenStreetMap stats report run at 2014-09-18 00:00:14 +0000; http://www.openstreetmap.org/stats/data_stats.html*
- *Planet.osm; http://wiki.openstreetmap.org/wiki/Planet.osm*

Motivation
OSM Data Model

- OpenStreetMap (OSM) project was founded in 2004
- Goal: free world map
- Data model: „the simplest thing that could possibly work“ [1]

TABLE I

THE BASIC OSM DATA TYPES AND THEIR ATTRIBUTES

nodes	ways	relations
changeset ID	id	id
visible	version	version
latitude	timestamp	timestamp
longitude	changeset ID	changeset ID
tile + tags	visible	visible
	{wayNodes}	{relationMembers}
	+ tags	+ tags

Tag: Key-Value pair
e.g. Key = „railway“, Value = „subway“

[1] Ramm, F.; Topf, J.; Chilton, S.: 'OpenStreetMap. Using and Enhancing the Free Map of the World.' UIT Cambridge, 2010.

Motivation

OSM Railway Tag

- Railway data are not that exactly modelled like roads and streets
- There are **470 different values for the tag „railway“** [4]

TABLE II

COMMONLY USED VALUES FOR THE KEY ”RAILWAY”

abandoned	construction	disused	funicular
light_rail	miniature	monorail	narrow_gauge
preserved	rail ***> 50 %***	subway	tram
halt	station	tram_stop	buffer_stop
derail	crossing	level_crossing	turntable

[4] OpenStreetMap: „taginfo keys railway“; http://taginfo.openstreetmap.org/keys/?key=railway#values; last access: 17.09.2014

Motivation

OSM Railway Tag

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- There are 470 different values for the tag „railway“ [2]

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preserved	rail	subway	tram
halt	station	tram_stop	buffer_stop
derail	cros		

Map-matching / routing: There is no clear topological and geometrical map representation.

- **How to use these data e.g. for building a simulation environment?**

Approach
OSM Layers

- Regarding the OSM data model there are only three „layers“:
  - **Nodes**
  - **Ways**
  - **Relations**

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visible	visible	visible
latitude	{wayNodes}	{relationMembers}
longitude		
tile		

Approach
OSM Layers

- Regarding the OSM data model there are only three „layers“:

Nodes

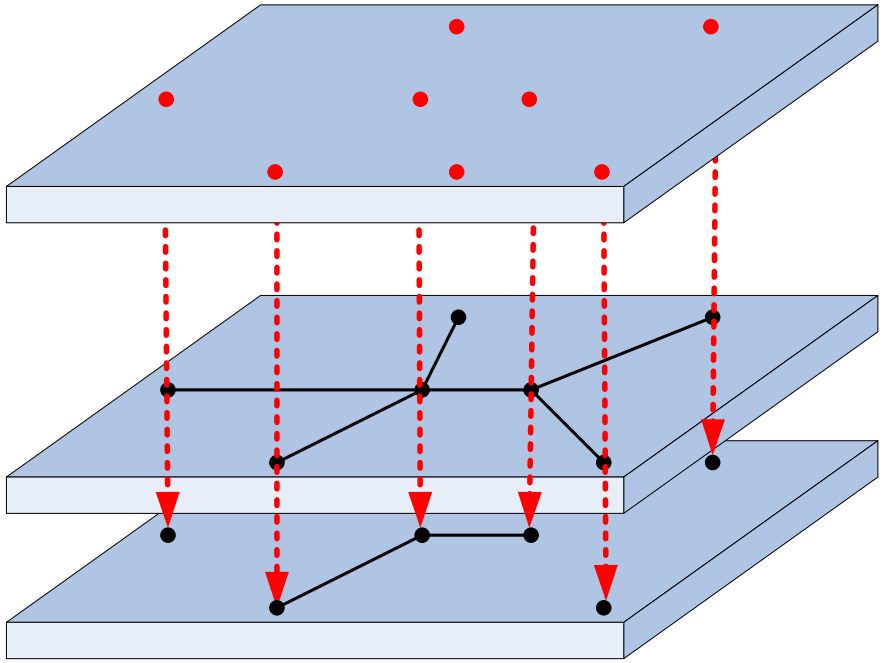
→ Coordinates Layer

Ways

Referencing nodes

Relations

Referencing nodes, ways and relations



Approach
New OSM Layers

- We want to define topic-specific layers:

Nodes

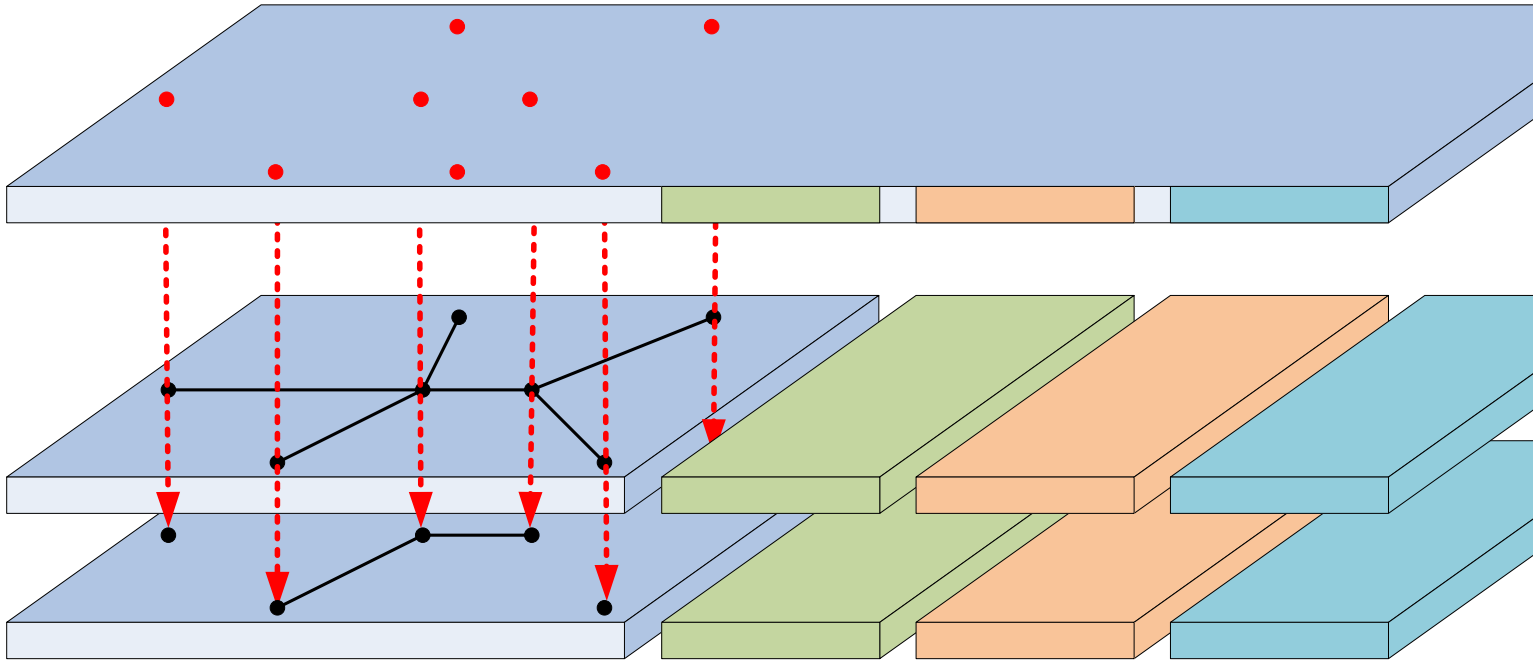
→ Coordinates Layer

Ways

Referencing nodes

Relations

Referencing nodes, ways and relations



Approach
New OSM Layers

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Nodes

→ Coordinates Layer

Ways

Referencing nodes

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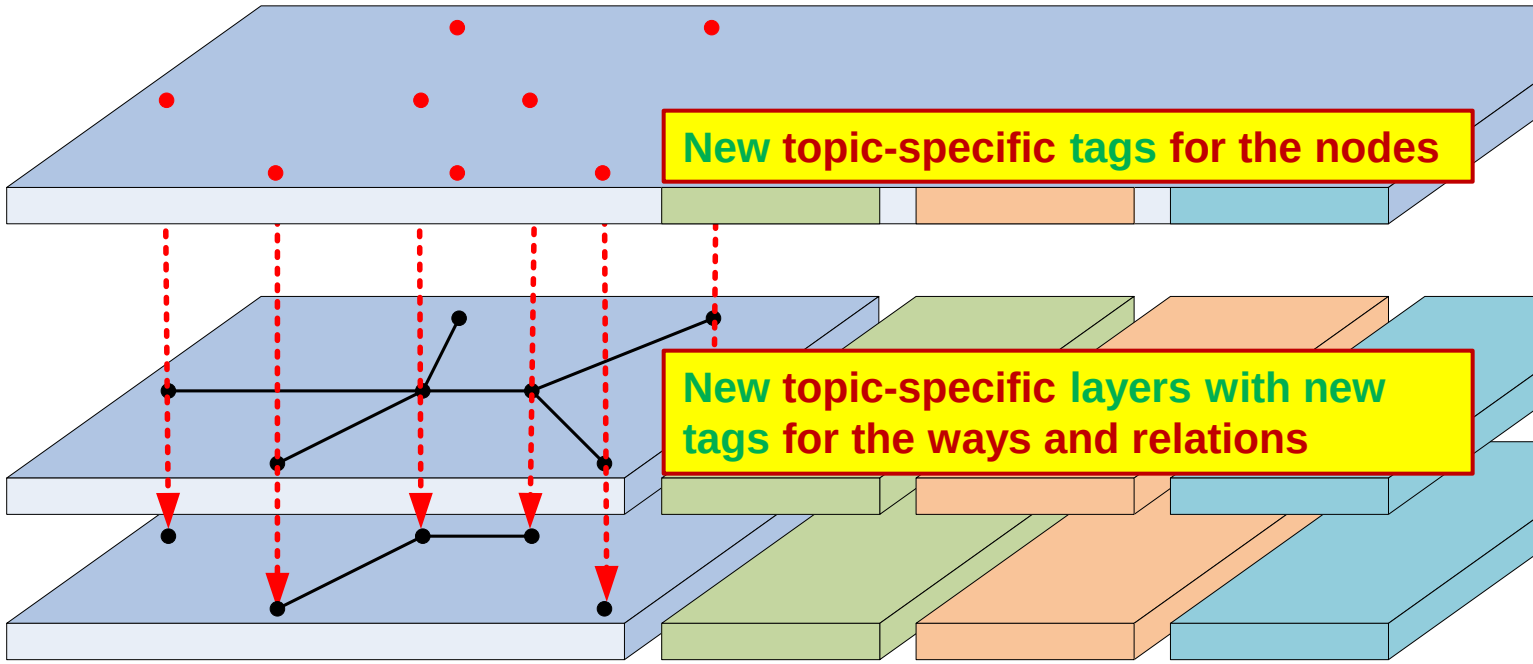
Referencing nodes, ways and relations



Approach
Layer-specific OSM tags

Table 1: Keys for railway topology modelling

node	way	relation
topologyName	topologyName	topologyName
	dir	**type** = "connection"
	length	course

micro topology

Approach
Layer-specific OSM tags

Table 1: Keys for railway topology modelling

node	way	relation
topologyName	topologyName	topologyName
	dir	**type** = "connection"
	length	course

Table 2: Keys for railway geometry modelling

node	way	relation
geometryName	geometryName	geometryName
pos	fromPos	**type** = "complexGeometry"
	toPos	
	geometryType	geometryType
	length	
curvature	curvature	
gradient	gradient	
superelevation	superelevation	

alignment

Approach

Layer-specific OSM tags

Table 1: Keys for railway topology modelling

node	way	relation
topologyName	topologyName	topologyName
	dir	**type** = "connection"
	length	course

Table 4: Keys for railway accuracy modelling

node	way	relation
sigmaLon	maxCamber	
sigmaLat		
sigmaAlt		

We define 38 tags for the description of the railway track network as needed by most of the railway geodata applications.

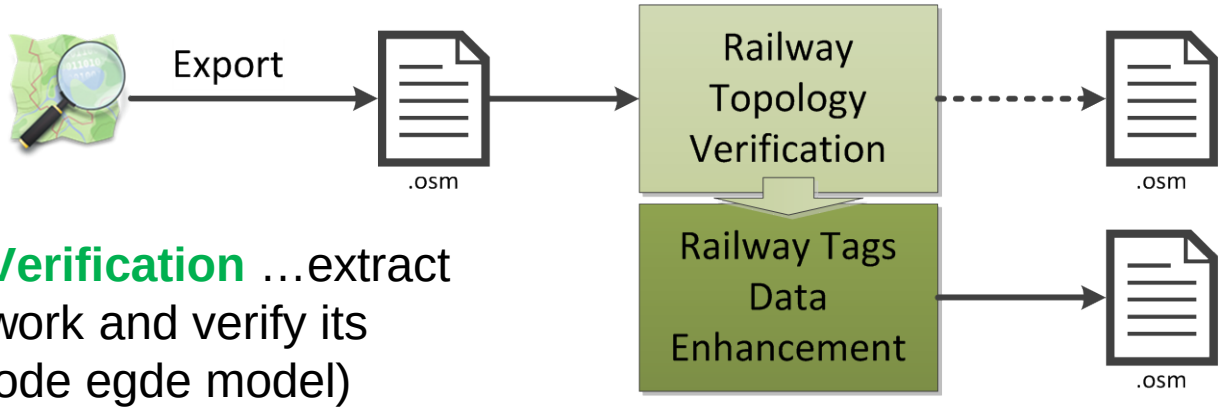
Table 2: K … **ng**

node	way	relation
geometryName	geometryName	geometryName
pos	fromPos	**type** = "complexGeometry"
	toPos	
	geometryType	geometryType
	length	
curvature	curvature	
gradient	gradient	
superelevation	superelevation	

node	way	relation
topographyName	topographyName	topographyName
pos	fromPos	**type** = "railNodeElement" / "railWayElement"
dir	toPos	elementType
distanceToTrack	distanceToTrack	

Approach

The OSM-4-Railway Tool Chain

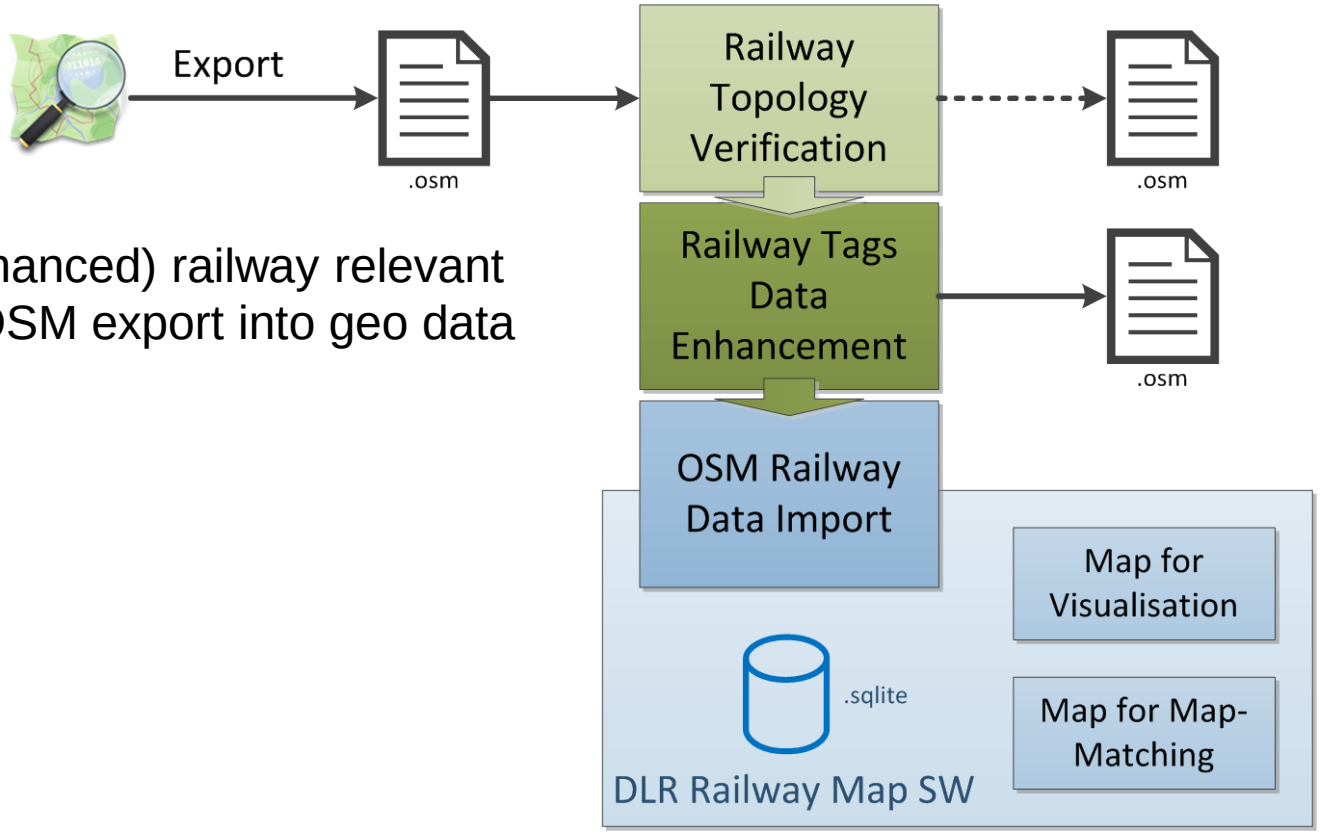


- **Topology Verification** …extract railway network and verify its topology (node egde model)
- **Railway Data Enhancement** …add layer-specific tags to the railway elements in the map

Approach

The OSM-4-Railway Tool Chain

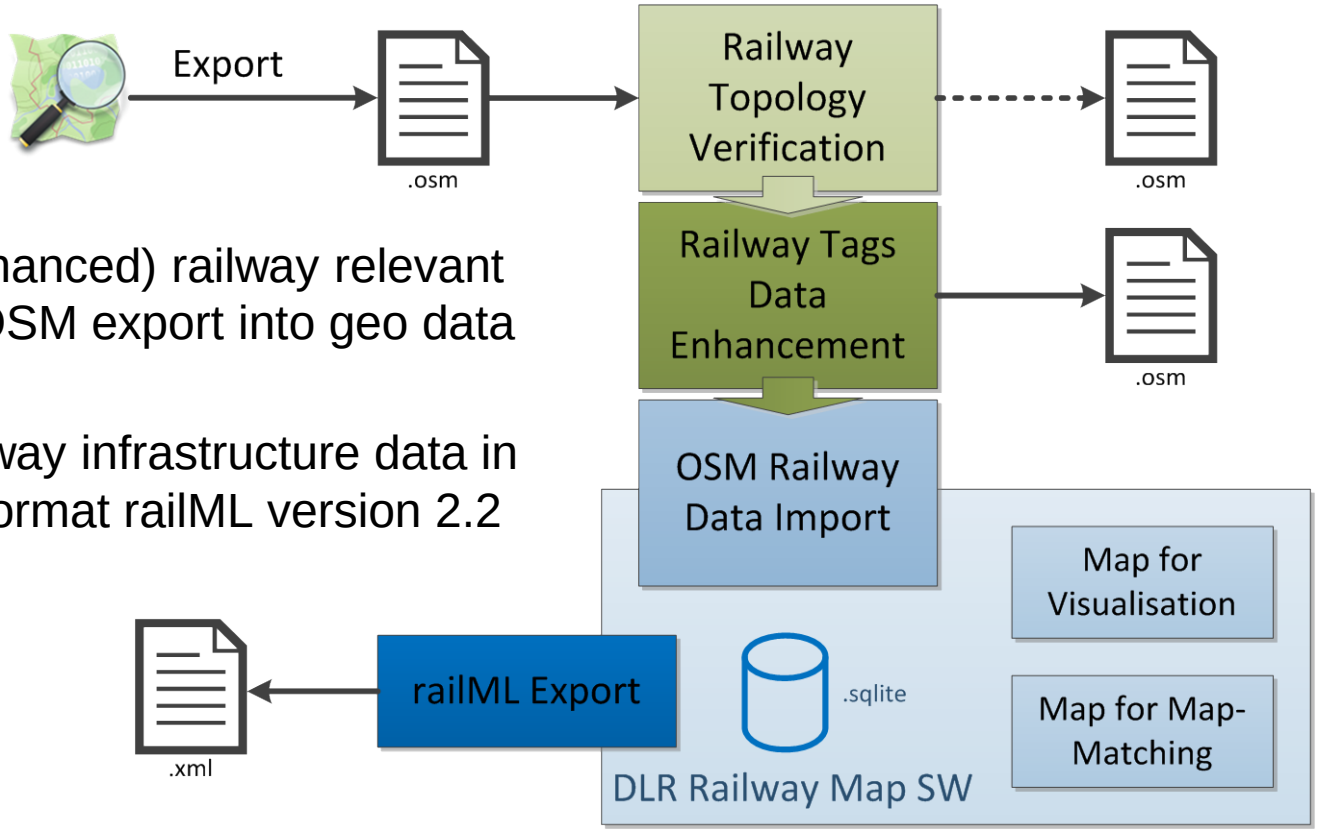
- **Import** (enhanced) railway relevant data from OSM export into geo data base



Approach

The OSM-4-Railway Tool Chain

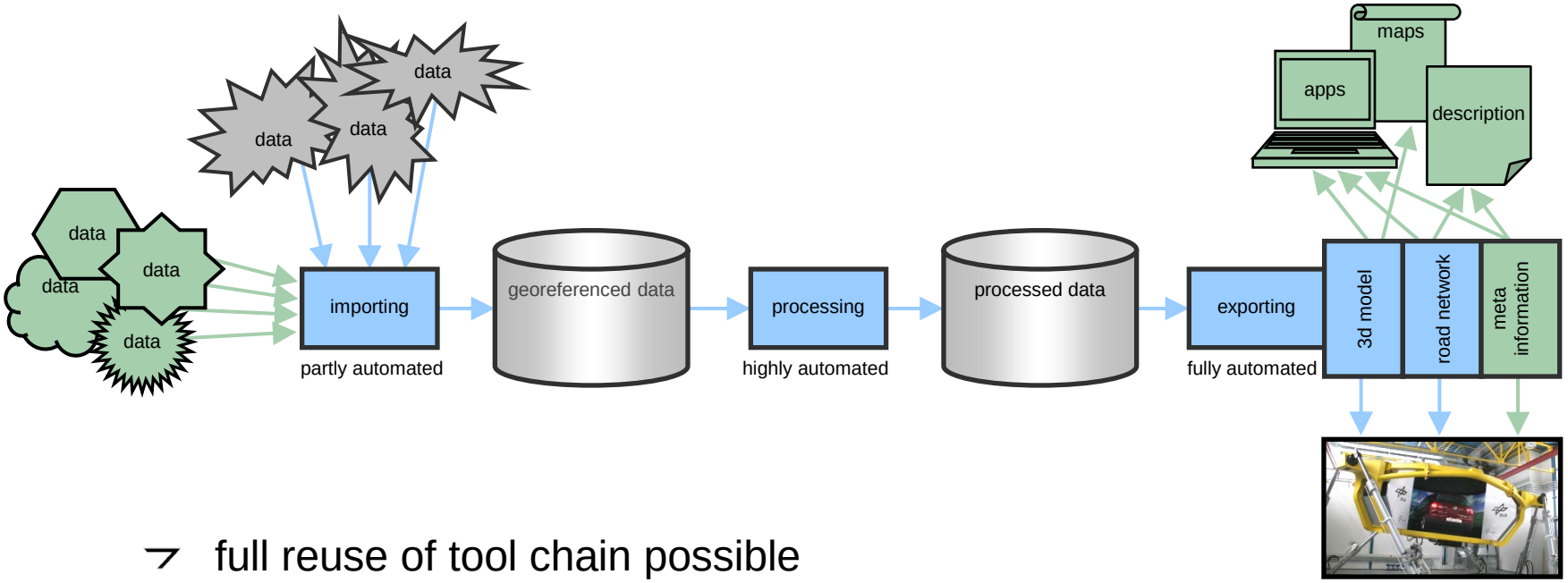
- **Import** (enhanced) railway relevant data from OSM export into geo data base
- **Export** railway infrastructure data in exchange format railML version 2.2



Approach

The SimWorld Tool Chain

- adding new data sources (from partners)
- adding new targets (for partners or third party use)

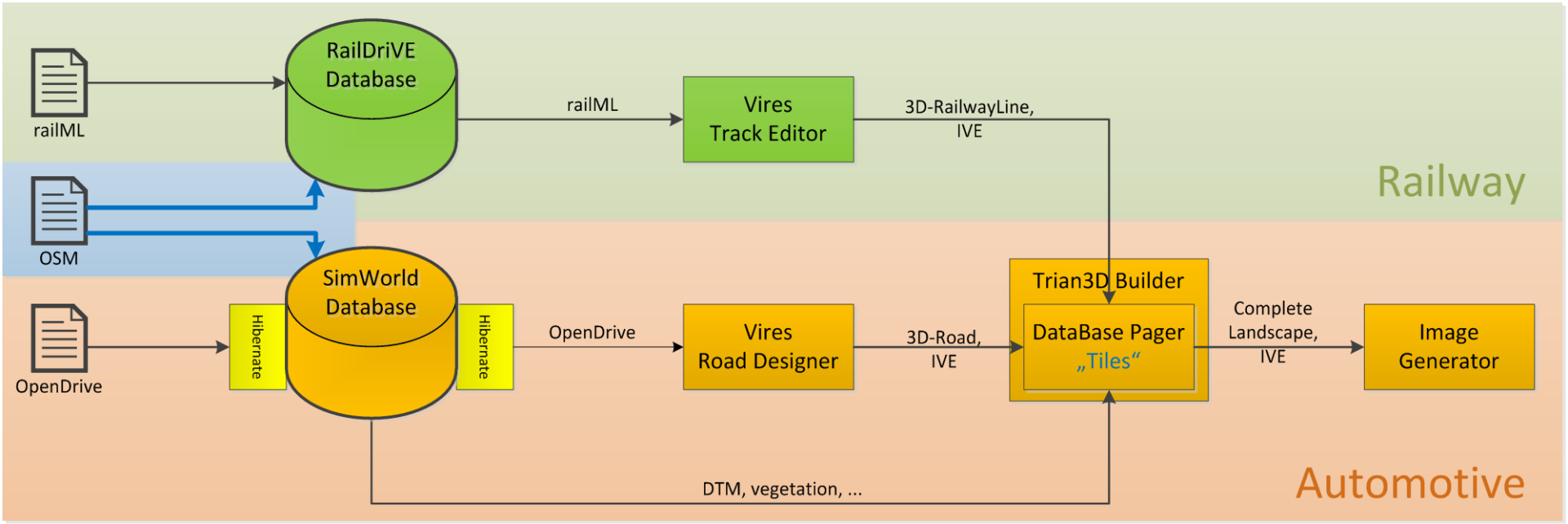


- full reuse of tool chain possible
- additional data in driving simulation available

Approach

Adapting the SimWorld Tool Chain

- Use Vires Track Editor to create railway lines for the RailSET simulation
- The result of the Track Editor is a 3D model of the railway line, which is fused with the 3D landscape model in the Trian3D-Builder software.



Implementation

RailSET Simulation Laboratory Environment

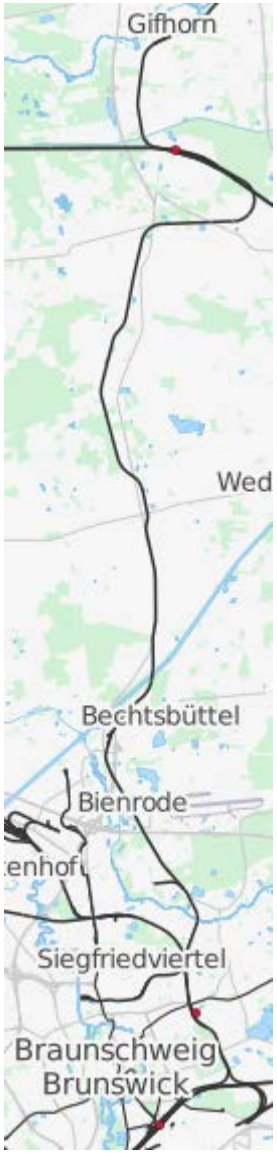
- The RailSiTe/RailSET laboratory is being adapted from ZUSI to Vires

Source: www.vires.com

- Vires-based simulations are used already in the Automotive Department of the Institute

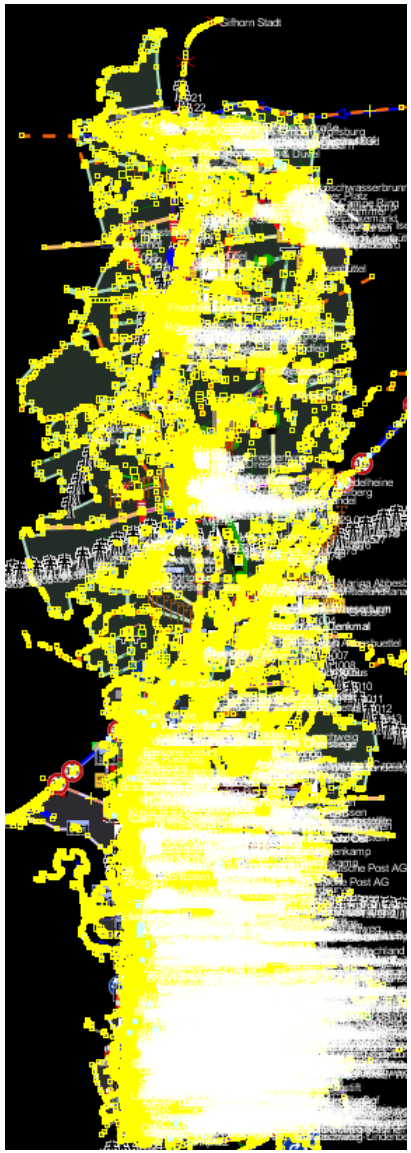
Implementation

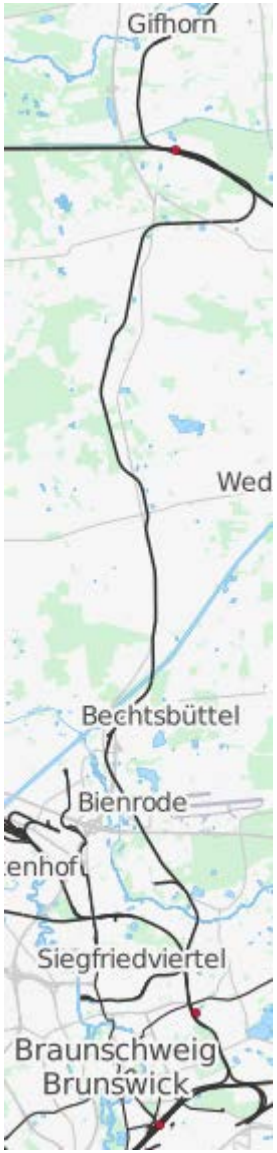
- The railway line from Braunschweig to Gifhorn has been selected for testing the OSM-4-Railway tool chain implementation
- Additionally, Vires built the railway reference line Braunschweig-Gifhorn within the AIM project for being used in the RailSET laboratory environment → can be used as reference



Implementation

- Export OSM data

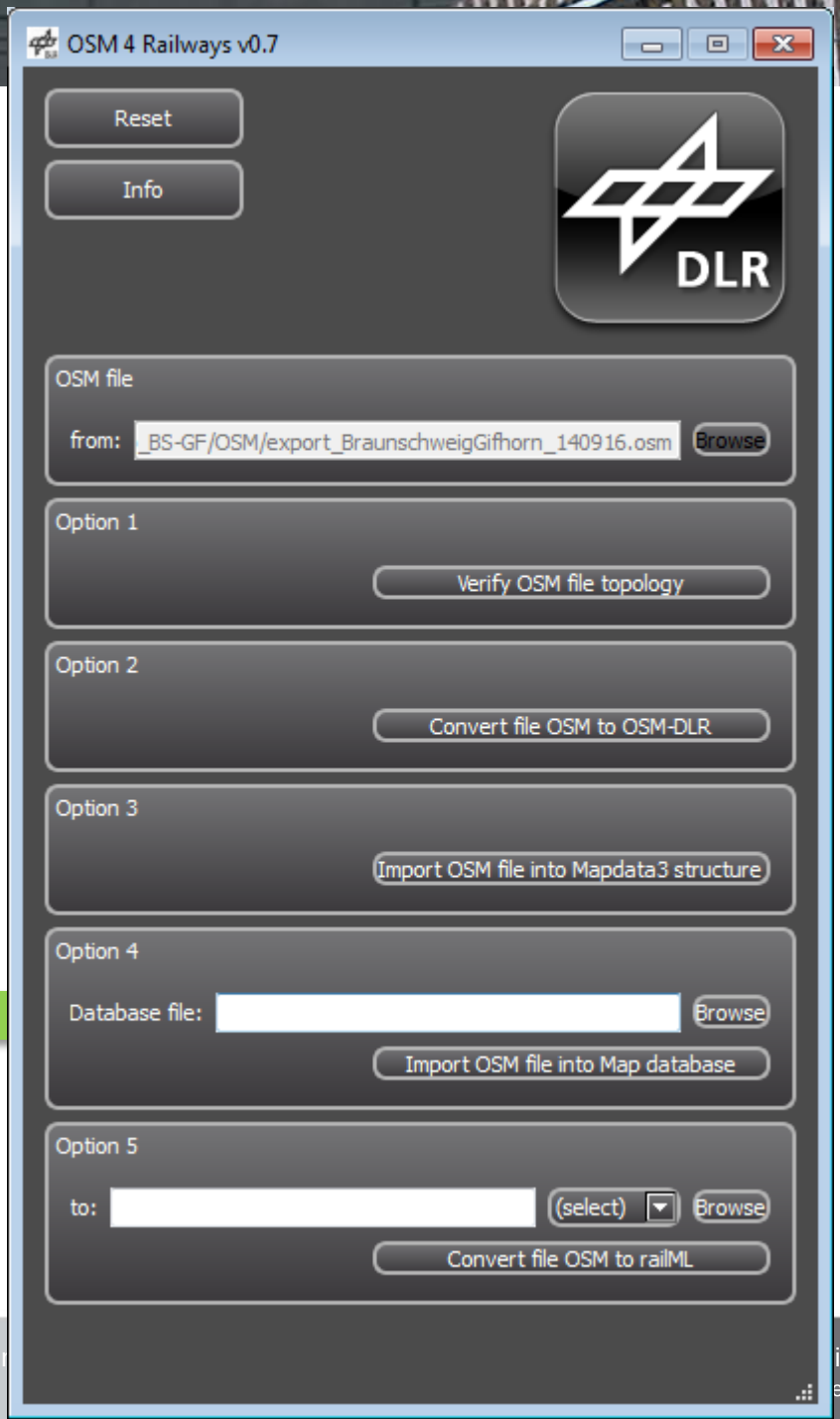




Implementation

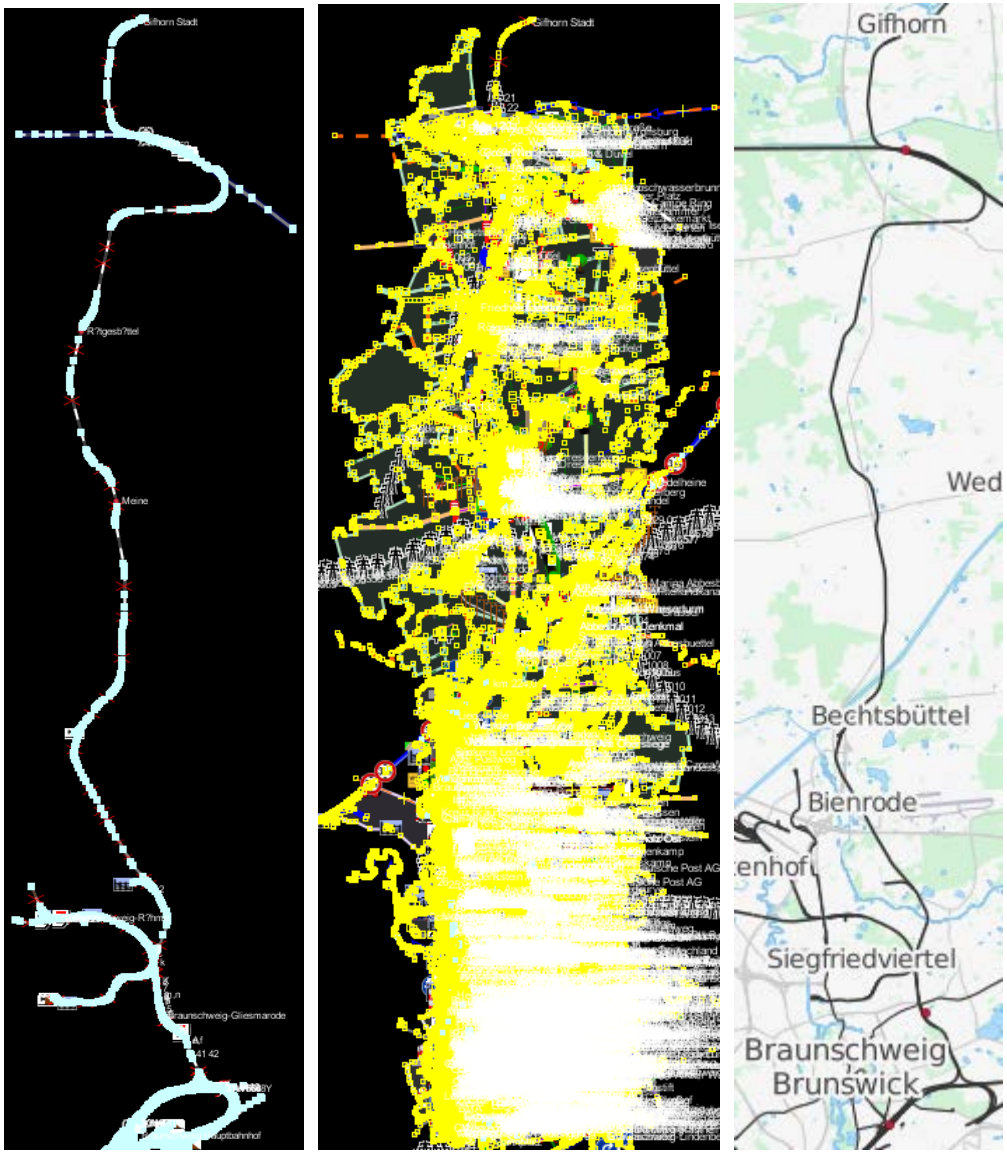
- Run the OSM-4-Railway tool chain – Option 5
  - Verify OSM topology
  - Enhance data with OSM-DLR tags
  - Import into Map data base
  - Export to railML 2.2

railML



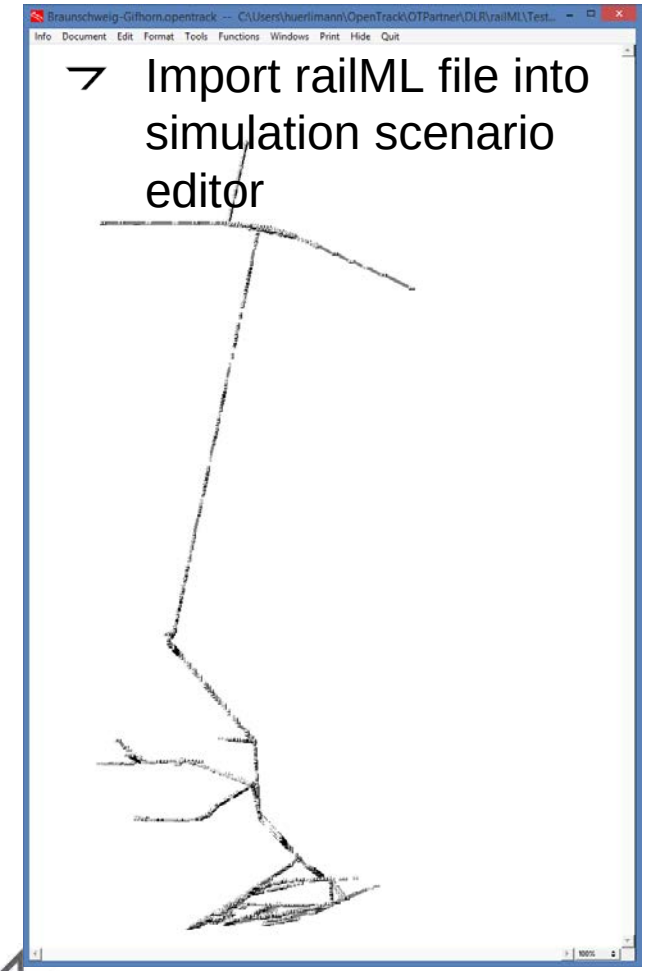
Implementation

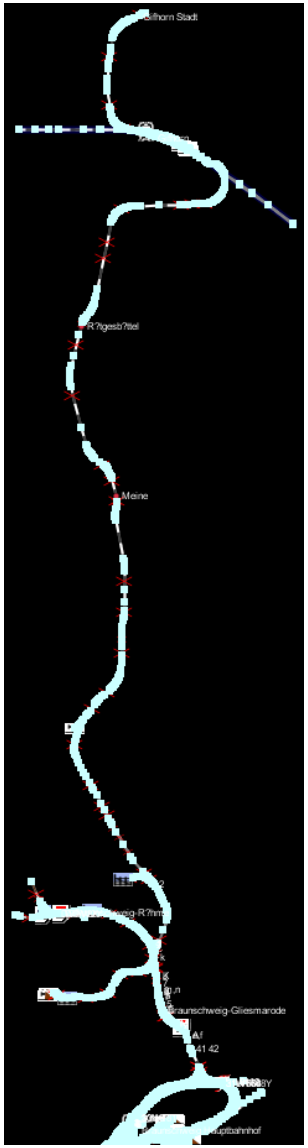
- OSM-4-Railway tool chain: data verification and enhancement

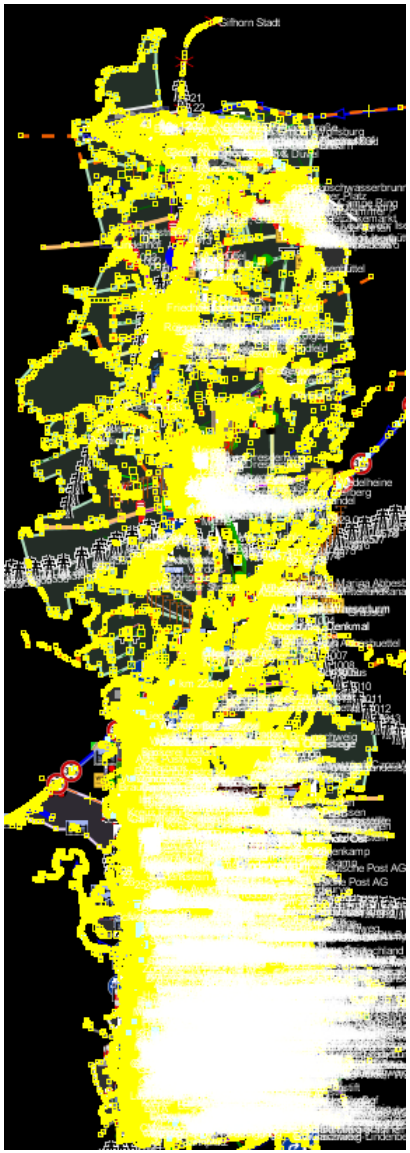


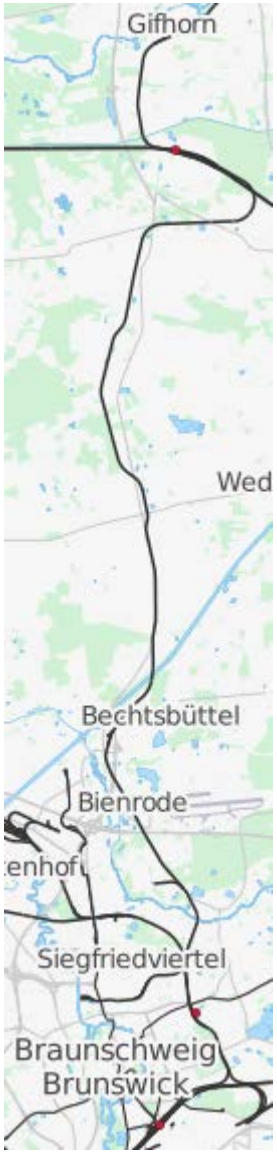
Implementation

- Import railML file into simulation scenario editor





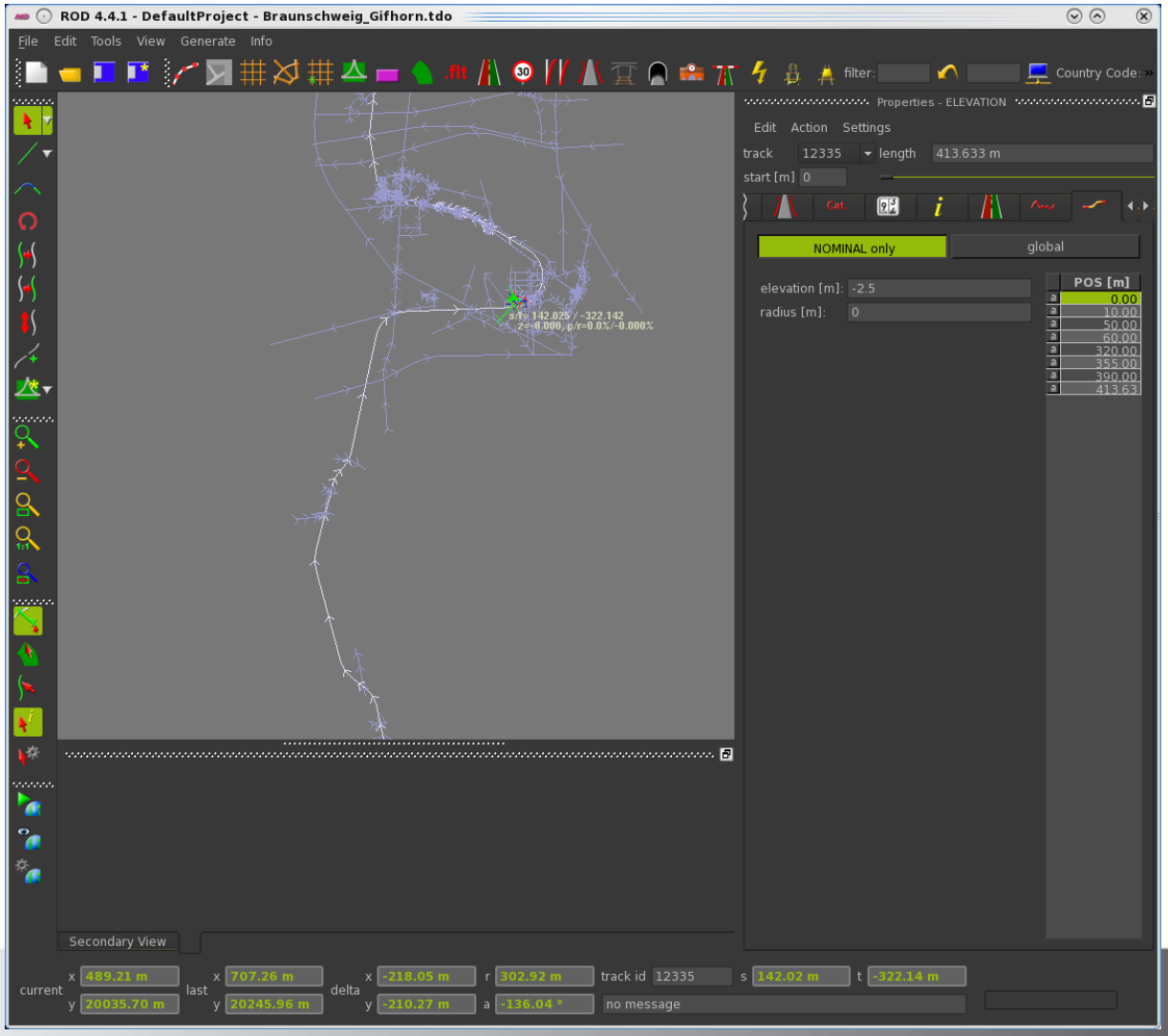




Implementation

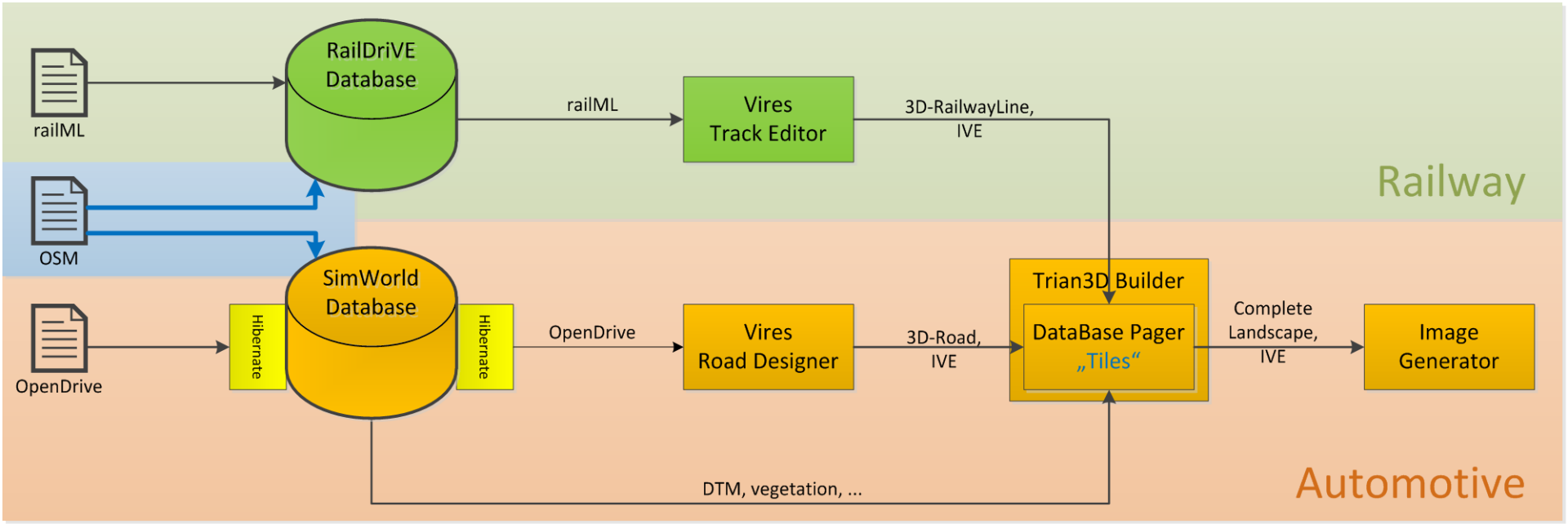
Vires Track Editor

- The resulting railML infrastructure file is imported into the Vires Track Editor
- Purpose: create a 3D railway line model based on the given topology and geometry.



Implementation
Trian3D-Builder

- The result of the Track Editor is a 3D model of the railway line, which is fused with the 3D landscape model in the Trian3D-Builder software (connection with SimWorld tool chain).



Implementation

Result

Summary

- The current simulation environment of the railway driver‘s cab laboratory RailSET is not able to include existing geo data from various sources
- OpenStreetMap provides a free world map and an alternative to conventional geodata sources, which often lack of actuality or availability
- The OSM data model is very simple defining only three basic data types: nodes, ways and relations; elements are parametrized by arbitrary tags, which are not sufficient for many applications, e.g. routing
- **Layer approach**: we defined **new topic-specific tags (layers)**, which enable OSM data usage providing track topology and track geometry; Many of the new tags can be calculated using existing OSM data
- By adapting the **SimWorld tool chain**, spatial data from various sources can be fused for building an integrated model of the railway line
- Future work will focus on the comparison of the OSM-based with the manual railway simulation landscape creation

Thank you for your attention!

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