



A Railway Simulation Landscape Creation Tool Chain Considering OpenStreetMap Geo Data

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Overview

- Motivation
 - Railway driver's cab simulation RailSET
 - OpenStreetMap (OSM)
- Approach
 - Defining OSM Layers
 - The OSM-4-Railway tool chain
 - Excursus: railML infrastructure
 - 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

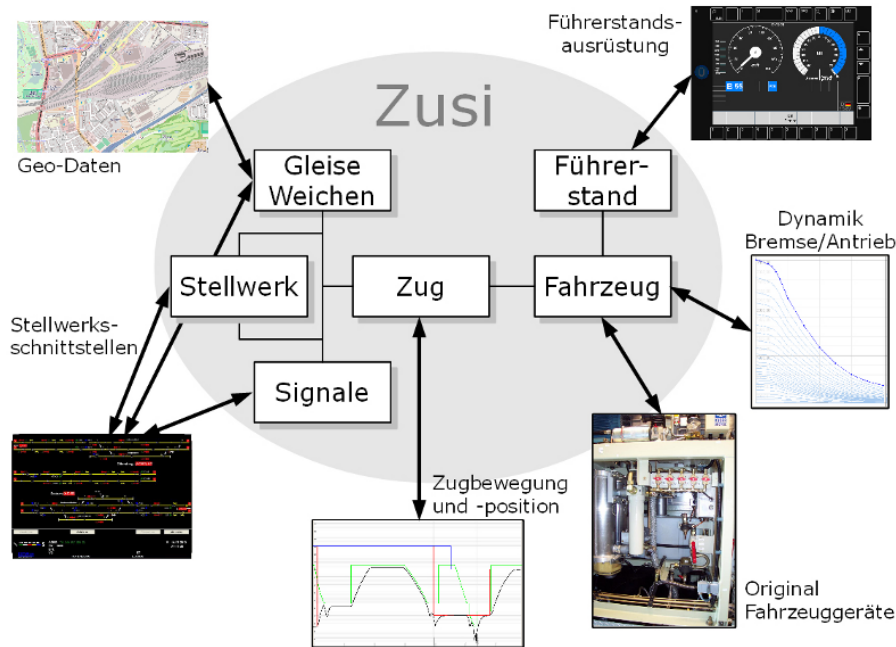
- Simulation in the RailSET laboratory is based on ZUSI



Motivation

Initial Situation

- Simulation in the RailSET laboratory is based on ZUSI



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
Die freie Wiki-Weltkarte

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

#users	1.591.275
#GPS points	3.938.715.439
#nodes	2.301.912.824
#ways	228.191.041
#GPX files 14.04.2014	224
Size Planet.osm	>400 GB (29 GB compressed)

Sources:

- *OpenStreetMap stats report run at 2014-04-15 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
Die freie Wiki-Weltkarte

- OpenStreetMap (OSM) project was founded in 2004
- Goal: free world map
- Data model: „the simplest thing that could possibly work“ (Ramm, 2010)

TABLE I

THE BASIC OSM DATA TYPES AND THEIR ATTRIBUTES

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

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

[Ramm, 2010] 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 **388 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 52.8 %	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: 15.04.2014

Motivation

OSM Railway Tag



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halt	station	tram_stop	buffer_stop
derail	crossing		

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**

TABLE I

THE BASIC OSM DATA TYPES AND THEIR ATTRIBUTES

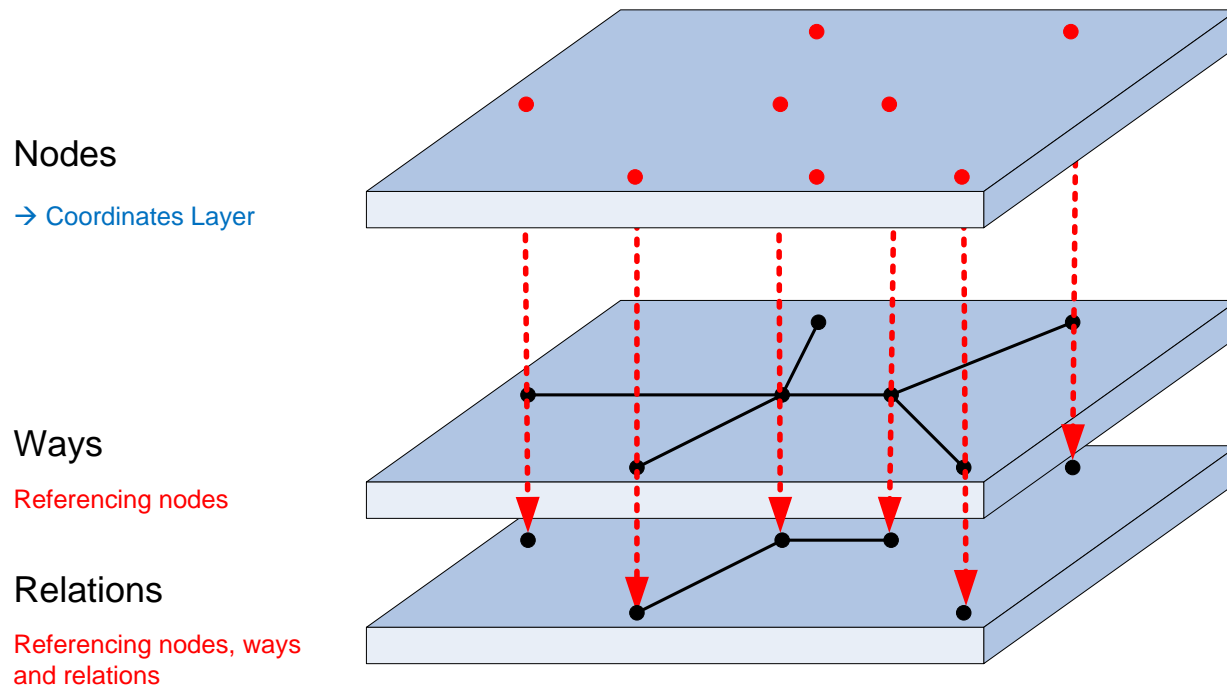
nodes	ways	relations
id version timestamp changeset ID visible latitude longitude tile	id version timestamp changeset ID visible {wayNodes}	id version timestamp changeset ID visible {relationMembers}

Approach

OSM Layers



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

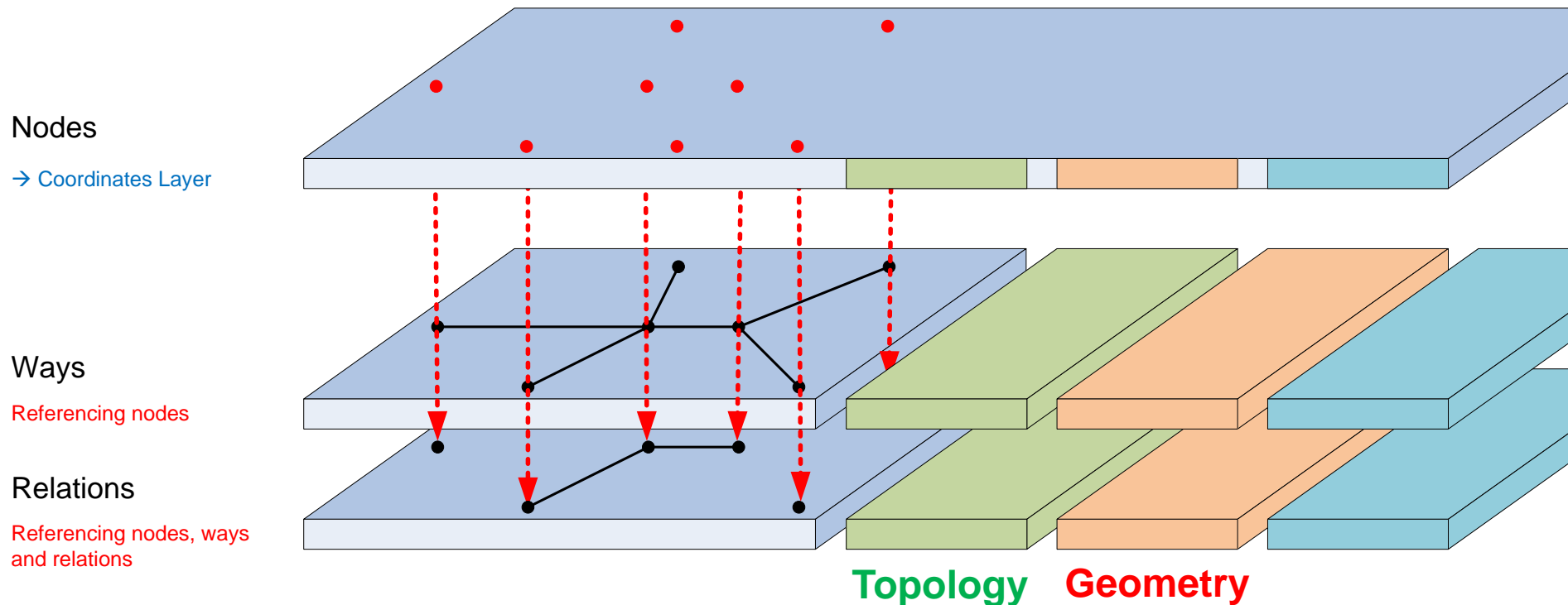


Approach

New OSM Layers



→ We want to define topic-specific layers:

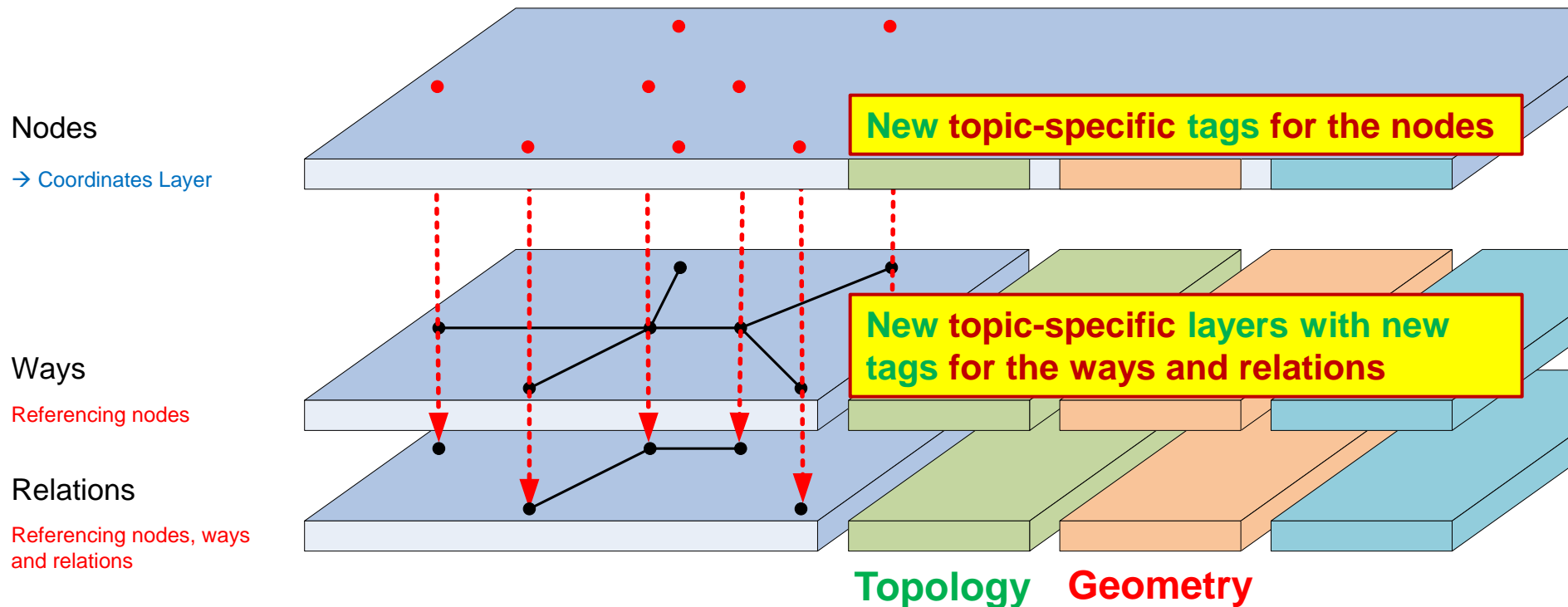


Approach

New OSM Layers



➤ We want to define topic-specific layers:



Approach

Layer-specific OSM tags

Table 1: Keys for railway topology modelling

node	way	relation
topologyName	topologyName dir length	topologyName type = “connection” course

Approach

Layer-specific OSM tags

Table 1: Keys for railway topology modelling

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

Table 4: Keys for railway accuracy modelling

node	way	relation
sigmaLon sigmaLat sigmaAlt	maxCamber	

We define 37 tags for the description of the railway track network as needed by most of the railway geodata applications.

Table 2: Keys for railway geometry modelling

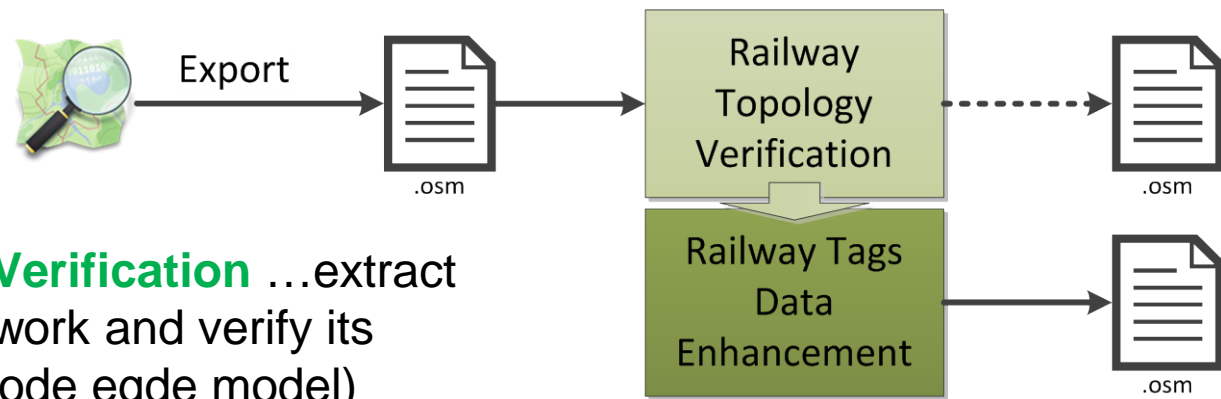
node	way	relation
geometryName pos	geometryName fromPos	geometryName type = "complexGeometry"
curvature gradient superelevation	toPos length curvature gradient superelevation	geometryType

Table 3: Keys for railway topography modelling

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

Approach

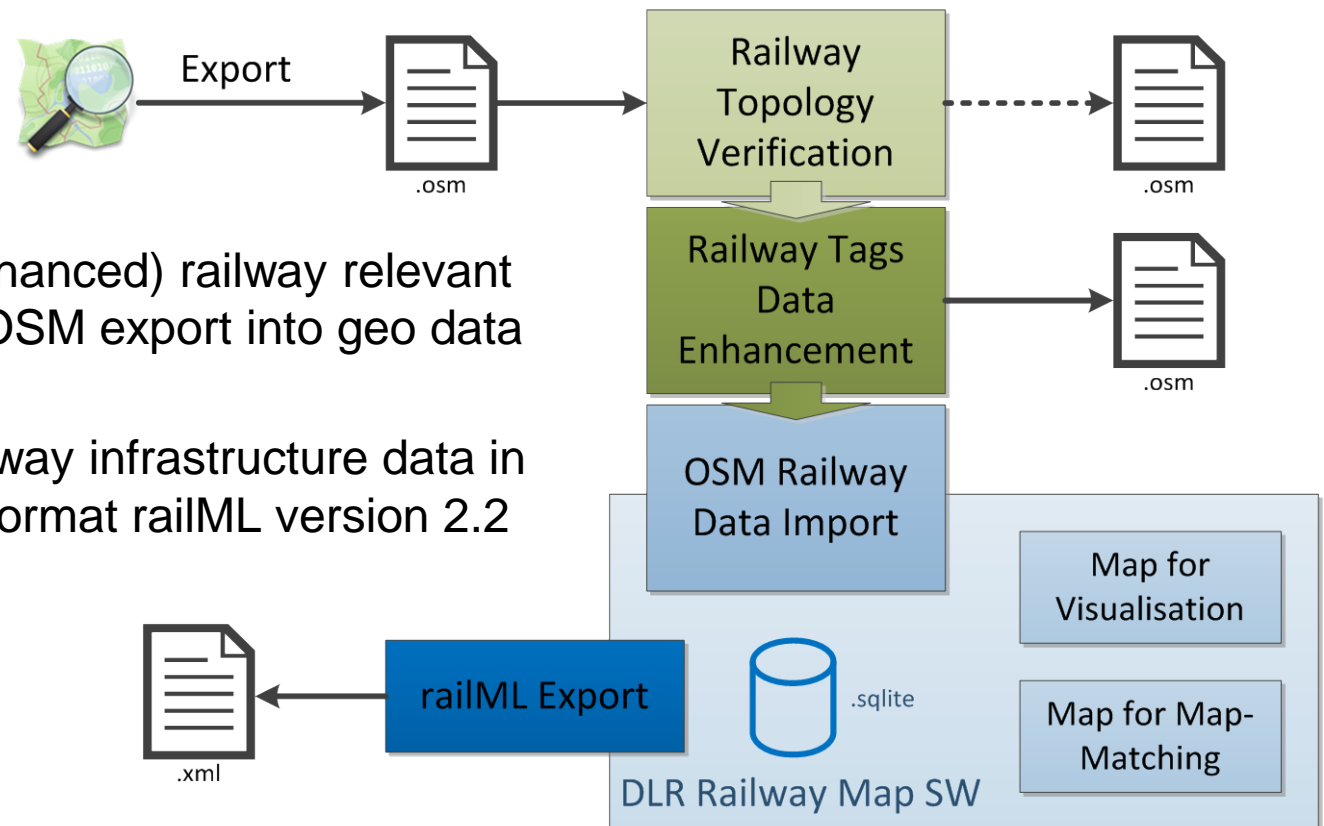
The OSM-4-Railway Tool Chain



- **Topology Verification** ...extract railway network and verify its topology (node edge 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
- **Export** railway infrastructure data in exchange format railML version 2.2

Excursus

railML®

railMLtimetable common
rollingstock
infrastructure

- Railway Markup Language
- XML-Schema-based description language
- Generic data exchange format for better communication between different IT applications in railways
- railML.org-Initiative
 - European railways (infrastructure managers and undertakers)
 - Software and consulting companies
 - Research facilities (universities, institutes)
- Sub-schemas:
 - Infrastructure
 - Timetable
 - Rollingstock

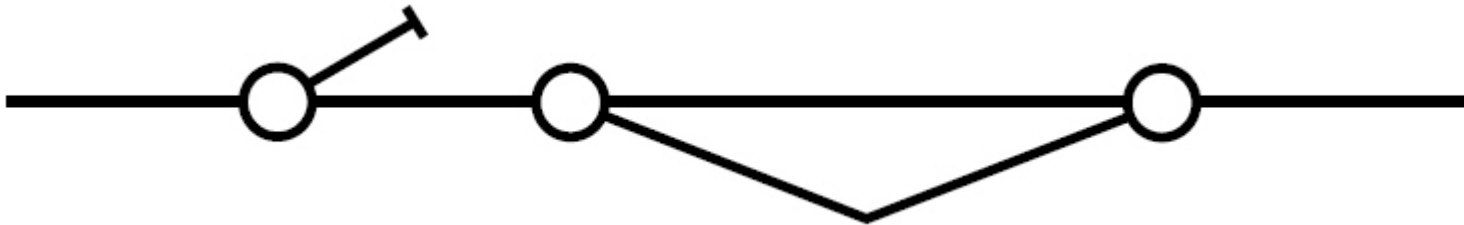
www.railML.org



Excursus: railML®

What is railML® Infrastructure?

- **Track Topology**
- Track Geometry
- Track Topography and railway service-relevant data

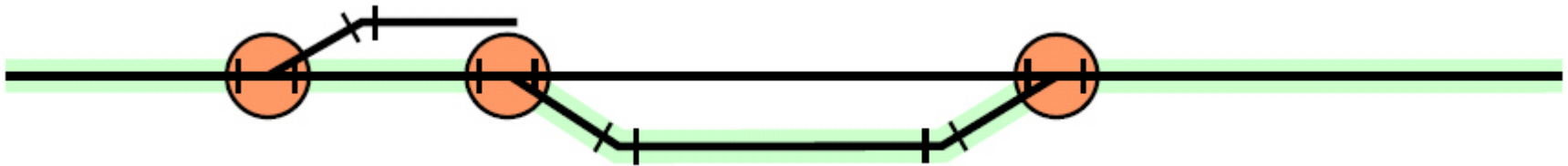


... Graph with Nodes and Edges

Excursus: railML®

What is railML® Infrastructure?

- Track Topology
- **Track Geometry**
- Track Topography and railway service-relevant data

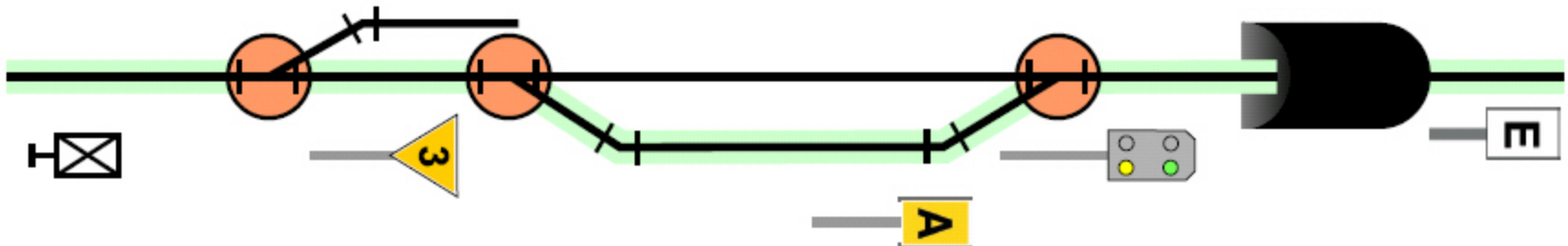


... straight lines, curves, increasing/decreasing slope

Excursus: railML®

What is railML® Infrastructure?

- Track Topology
- Track Geometry
- **Track Topography and railway service-relevant data**



... signals, platforms, tunnels, electrification etc.



Approach

SimWorld / Virtual World

➤ Goal of project “Virtual World”:

- Create a *Digital Atlas* capable to describe multimodal metropolitan areas (road, rail, development, environment, infrastructure, ...)
 - The *Digital Atlas* in the context of the project *Virtual World* will contain data about Braunschweig as a demonstration area as virtual test site (see also *AIM*) and will keep growing during project duration...
- Create a *tool chain*, that is able to generate automatically virtual worlds and logical road descriptions for driving and traffic simulations.

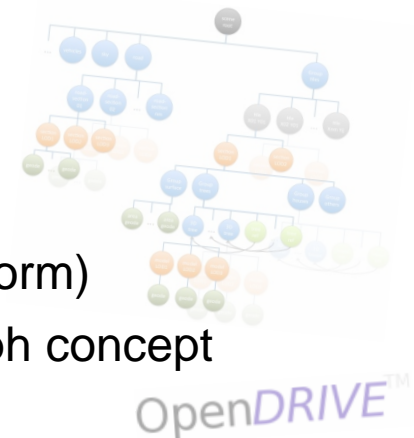
Source: „*Virtual World – Digital Atlas of Multimodal Metropolitan Areas*“ by Andreas Richter (WAW 2013)



Approach

The SimWorld database

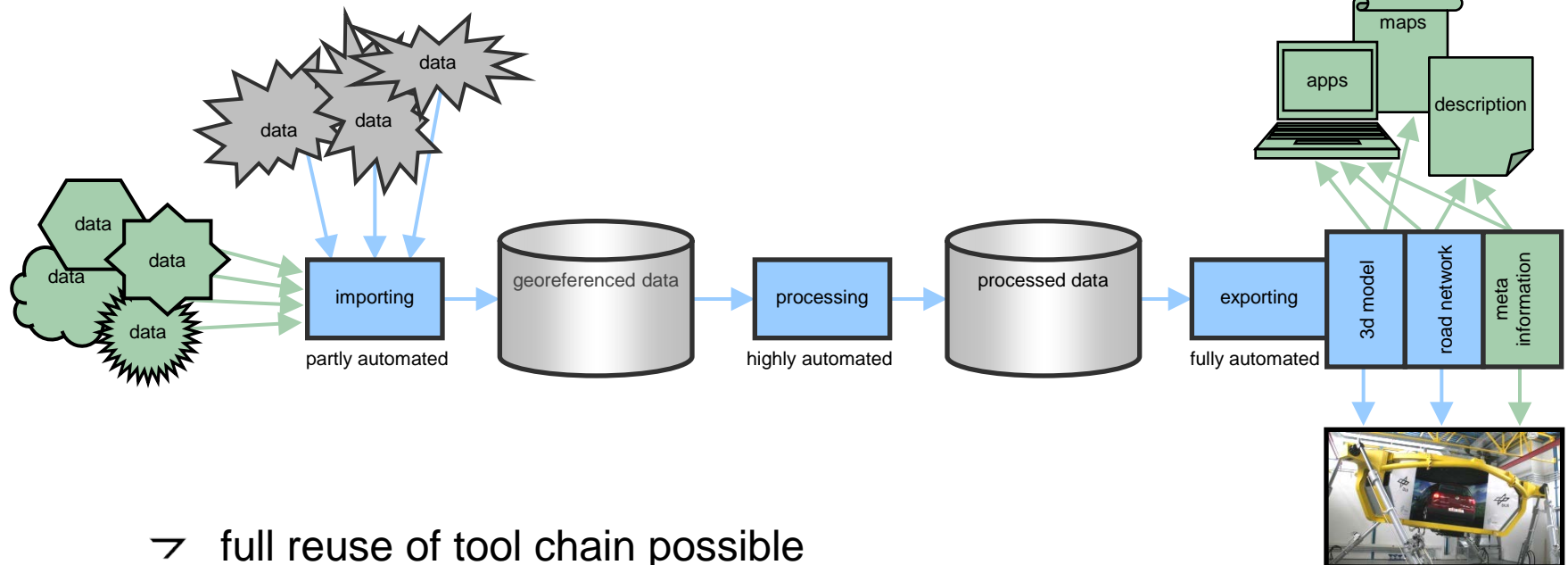
- database design (central component of integration platform)
 - designing database structure based of scene graph concept and OpenDRIVE
 - design of data interfaces for data import form various sources and for data export for applications using or refining this data
- database implementing
 - realising database in PostgreSQL / PostGIS
 - realising the exporters with OpenSceneGraph
- concept and prototype about integration and realising (including high grade of automation)



Approach

The SimWorld Tool Chain

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

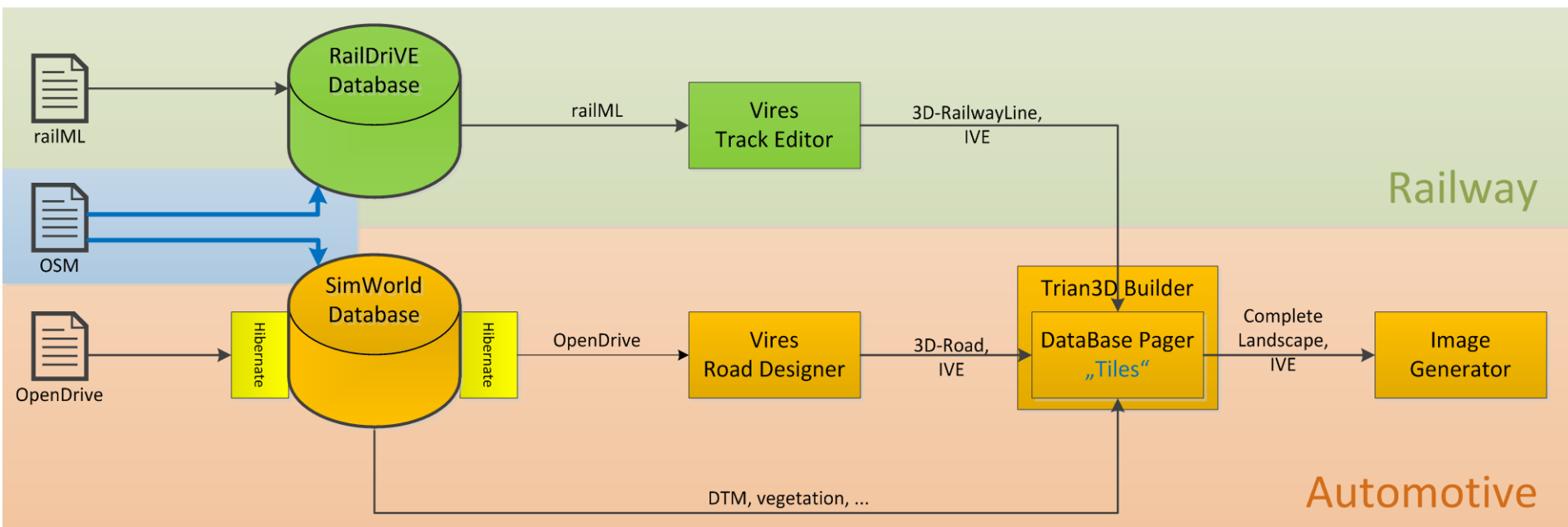


- full reuse of tool chain possible
- additional data in driving simulation available

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



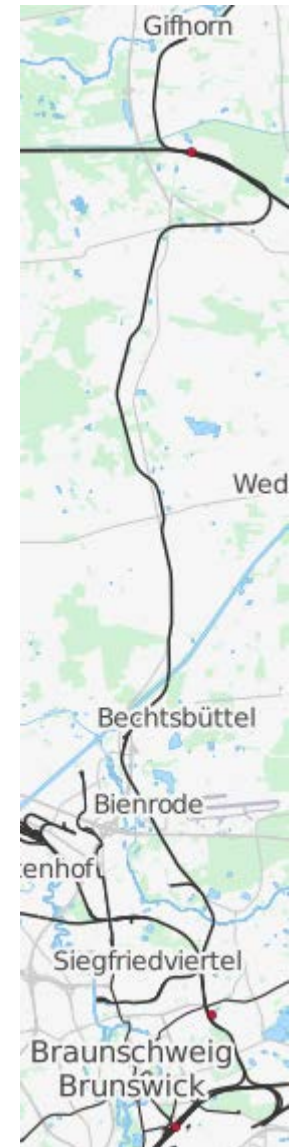
Source: www.vires.com

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

Implementation

OSM-4-Railway tool chain

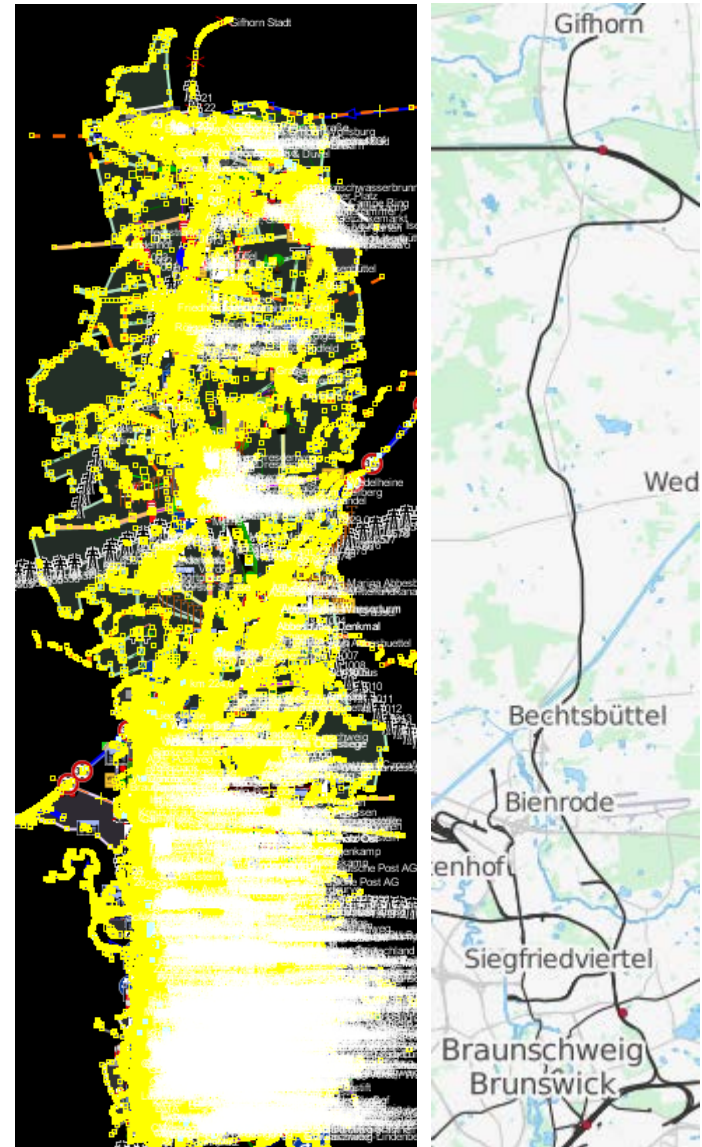
- The railway line from Braunschweig to Gifhorn has been selected for testing the tool chain implementation
- Additionally, Vires built the railway reference line Braunschweig-Gifhorn within the AIM project for being used in the RailSET laboratory environment → can be used as reference



Implementation

OSM-4-Railway tool chain

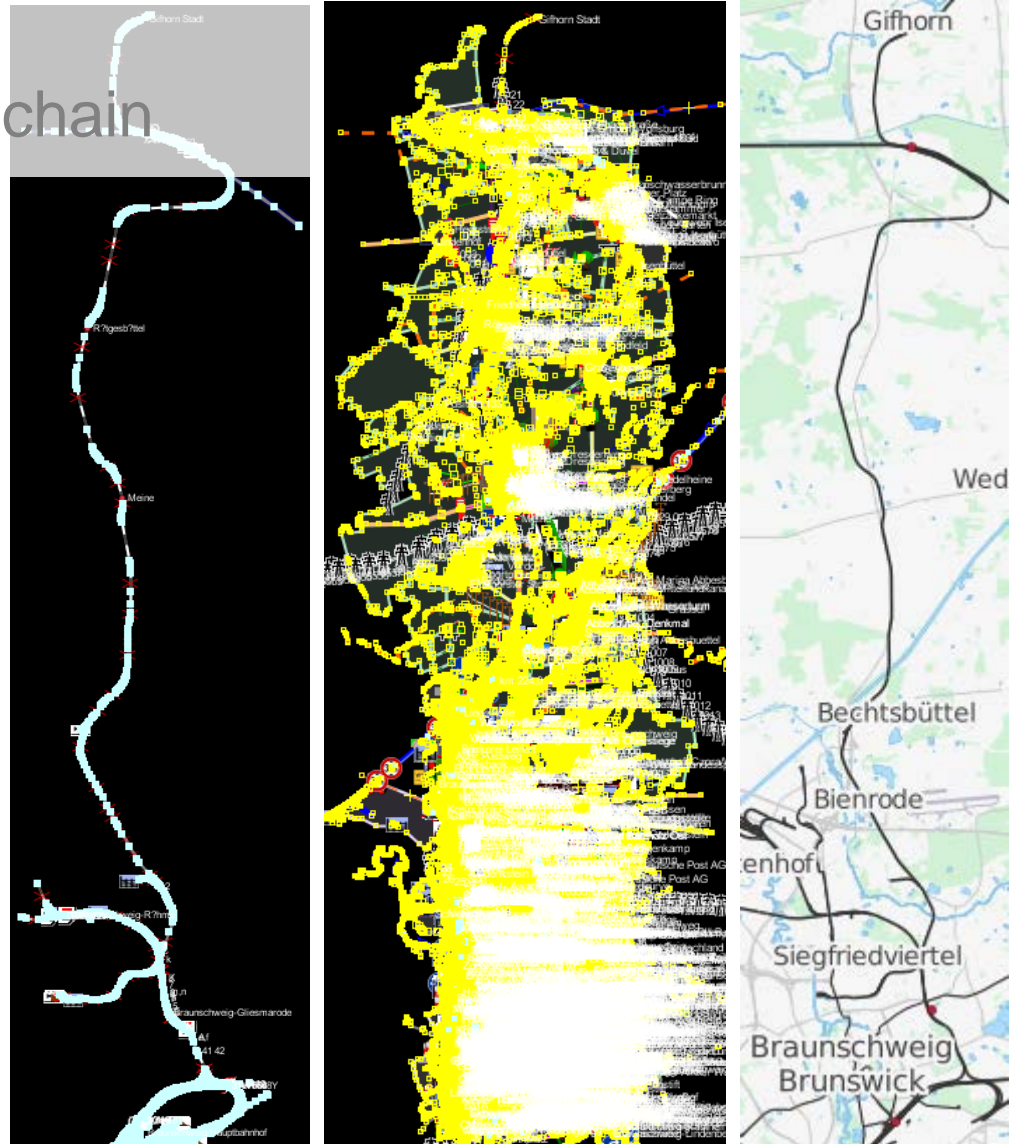
➤ Export OSM data



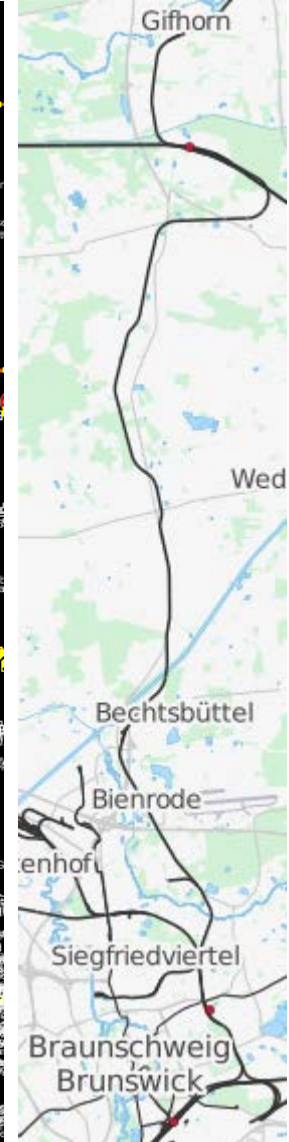
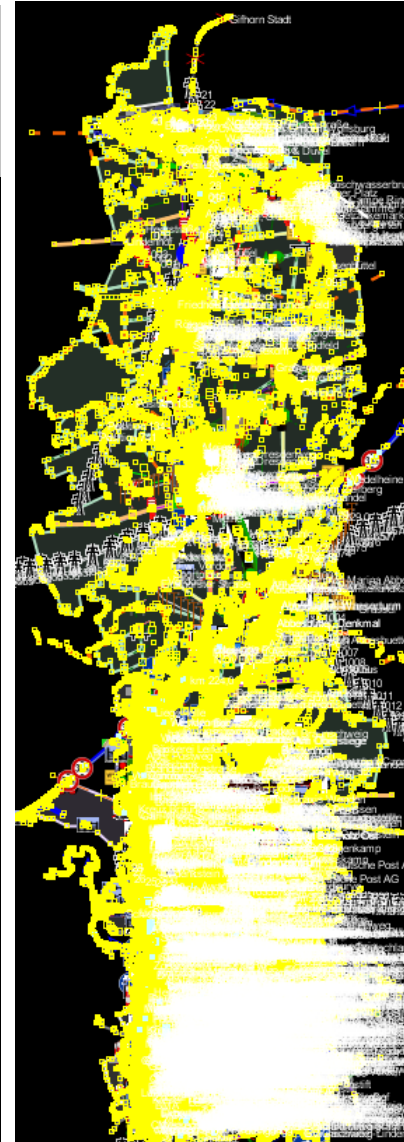
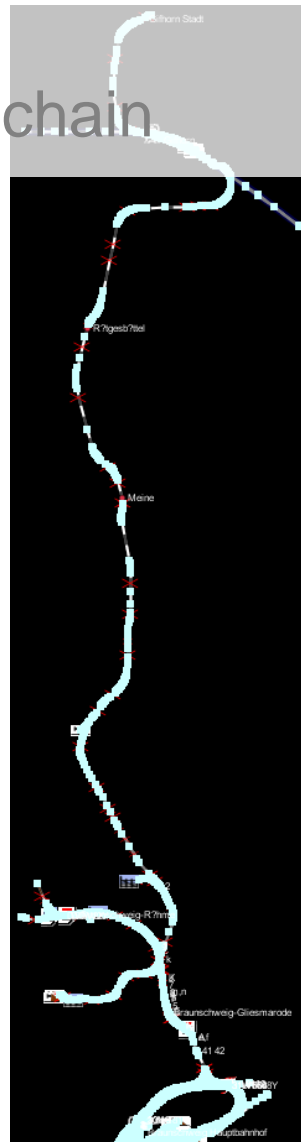
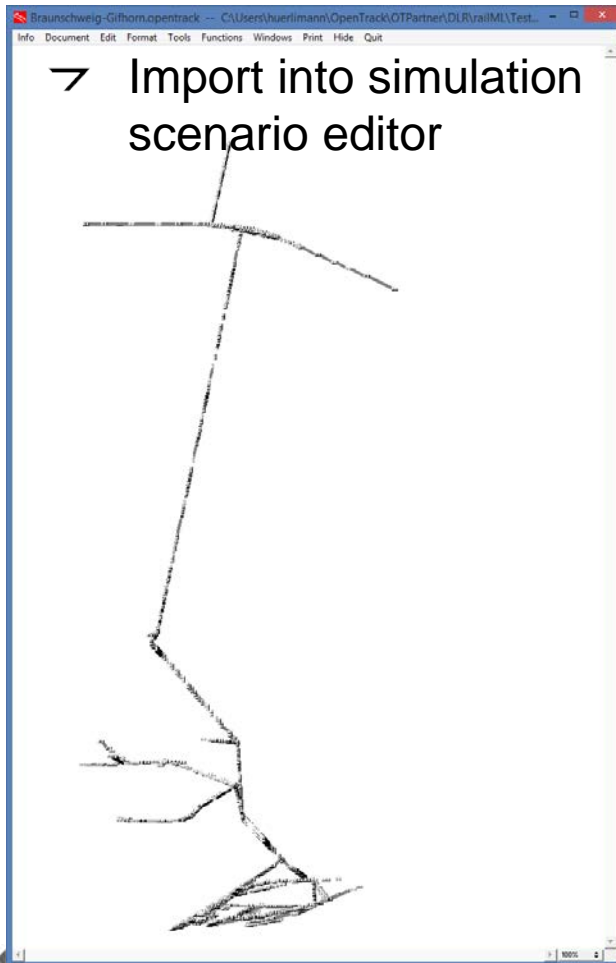
Implementation

OSM-4-Railway tool chain

- OSM-4-Railway data verification and enhancement



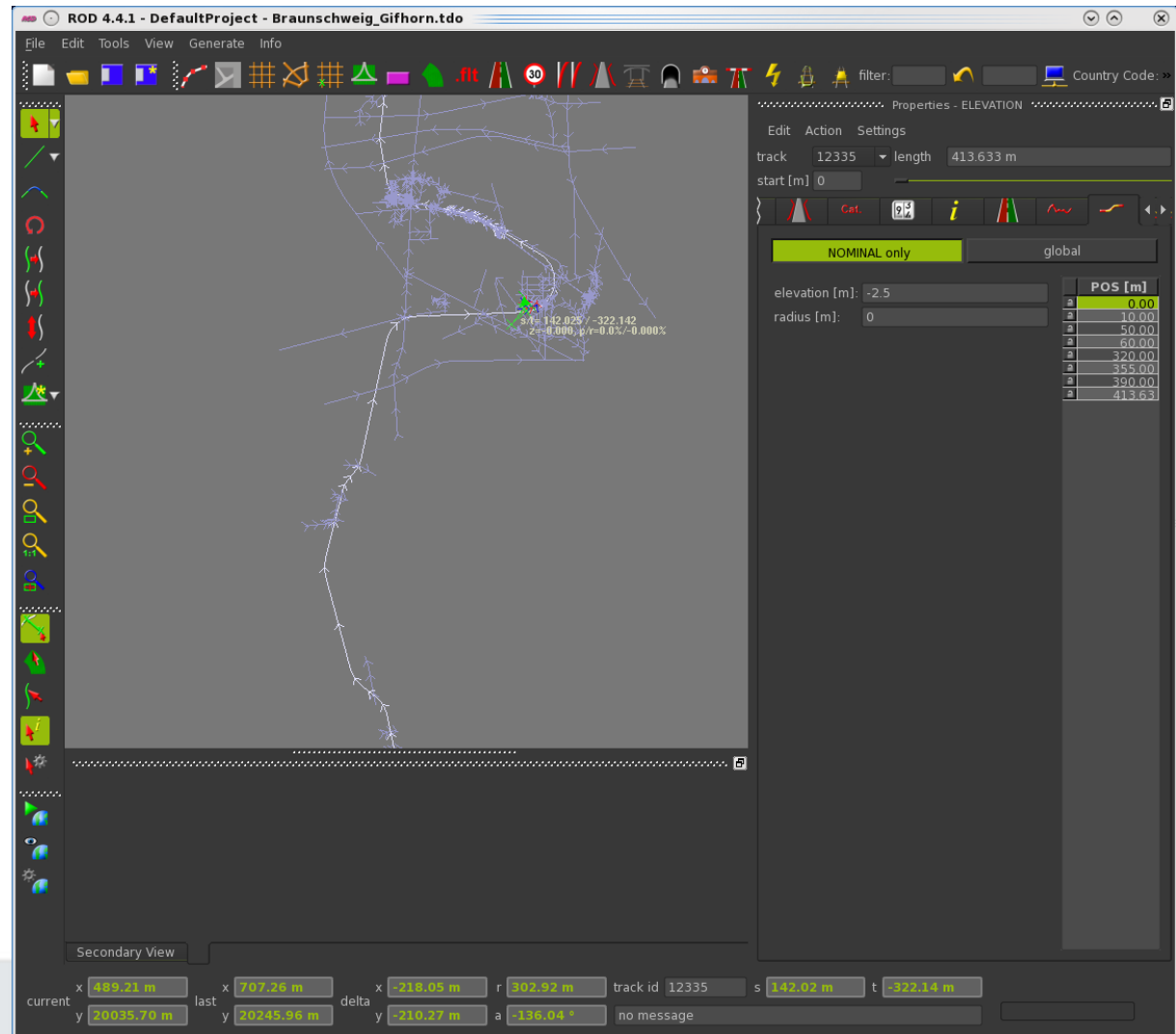
Implementation OSM-4-Railway tool chain



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 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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