Workshop

Generating detailed 3D Streetspace Models in CityGML 3.0 using the free OpenDRIVE data conversion tool r:trån

115th OGC Technical Committee (Virtual) – September 15 2021

Christof Beil, Benedikt Schwab, Thomas H. Kolbe

(christof.beil, benedikt.schwab, thomas.kolbe)@tum.de

Technical University of Munich

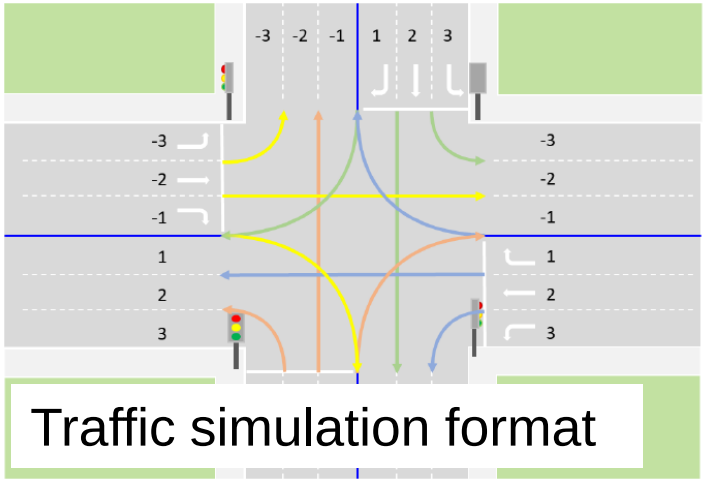
OGC®
Making location count.

Agenda

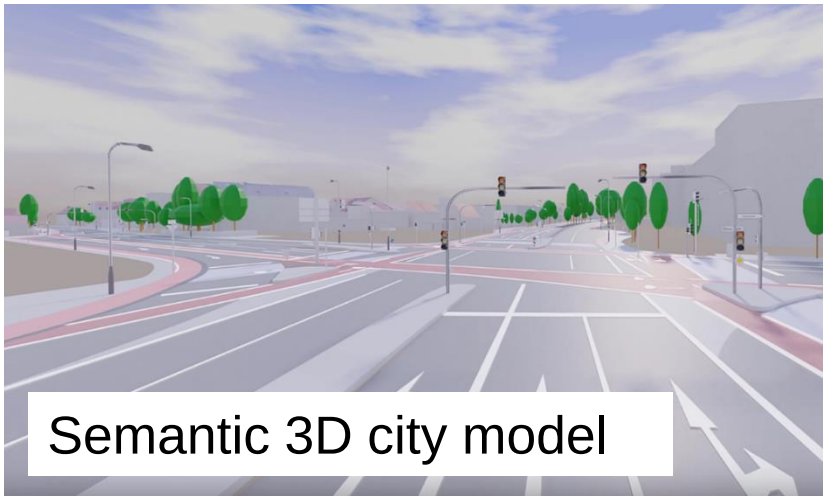
- Motivation
- Comparison of OpenDRIVE 1.6 and CityGML 3.0
- **r:trån** – Converting OpenDRIVE data to CityGML
  - Introduction to the software
  - Hands-on tutorial
- Visualizations using FME / 3DCityDB
- Try it yourself!

Motivation

- **OpenDRIVE** is a commonly used standard in the automotive industry
- Mostly commercial software for **driving simulations**
- Limited (free) software for visualizing the data
- **Difficult** to get 3D **visualization** from OpenDRIVE data (parametric representation)



Traffic simulation format

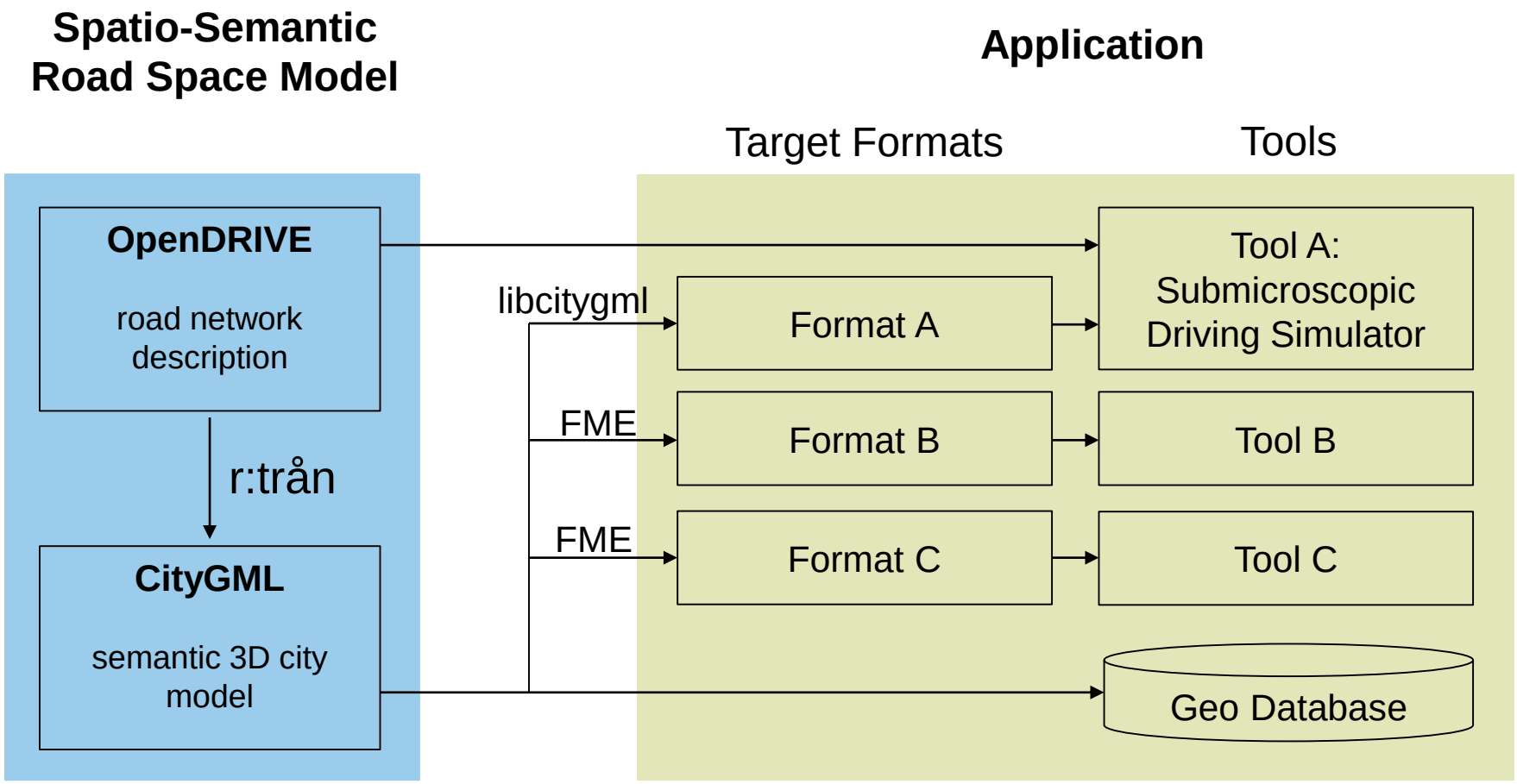


Semantic 3D city model

Motivation

- **Few options** to combine with other data (point clouds, BIM, city models etc.)
- Few possibilities for sub-setting data (**no WFS**, **no database storage**, file-based)
- Other applications need explicit geometrical representation
  - E.g. asset / facility management, spatial analyses / simulation
- **CityGML suitable** for these applications
- **Open tools** for storage, management and visualization of CityGML data available (e.g. **3DCityDB**)

Motivation

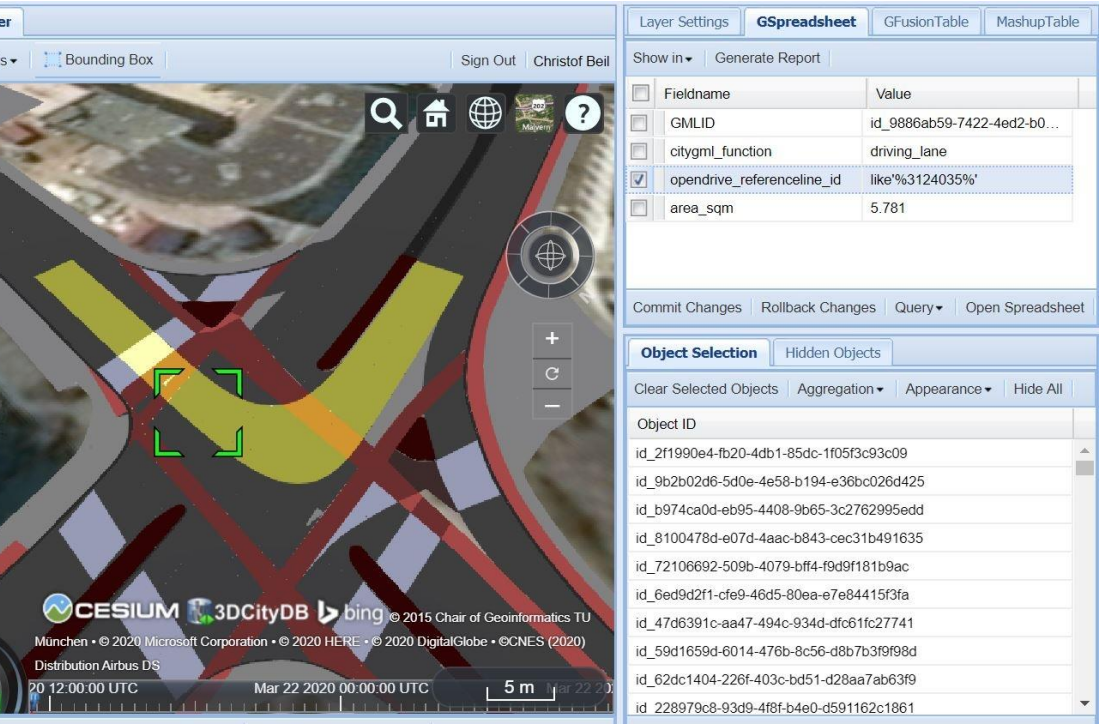


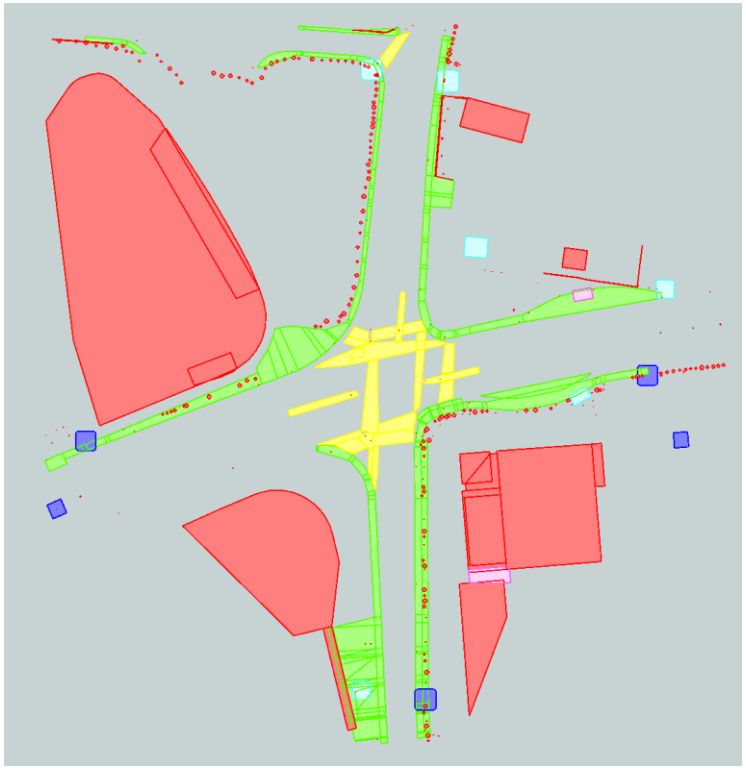
(Schwab, Beil, Kolbe, 2020)

Application of the OpenDRIVE data converted to CityGML

Spatial / semantic query

Map for pedestrian simulation tool “momenTUM”

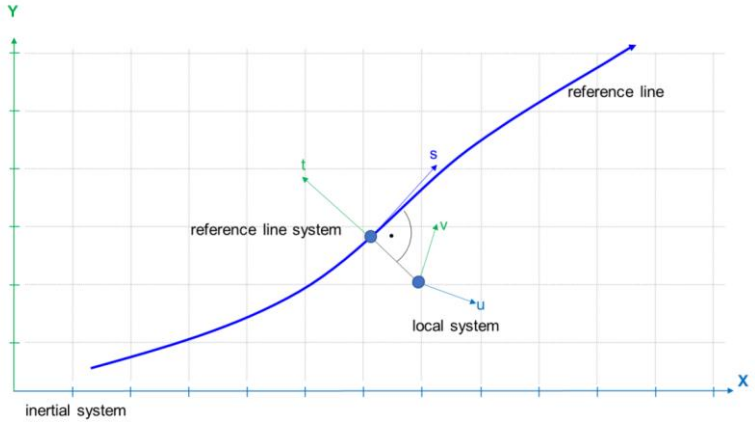


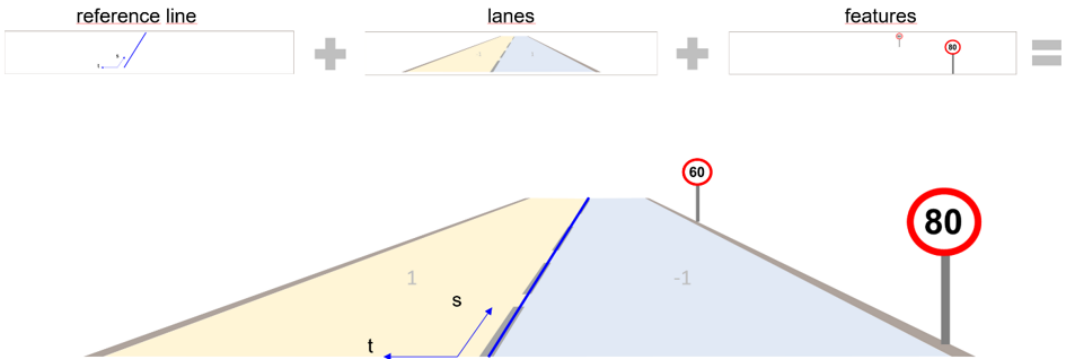


(Schwab, Beil, Kolbe, 2020)

OpenDRIVE

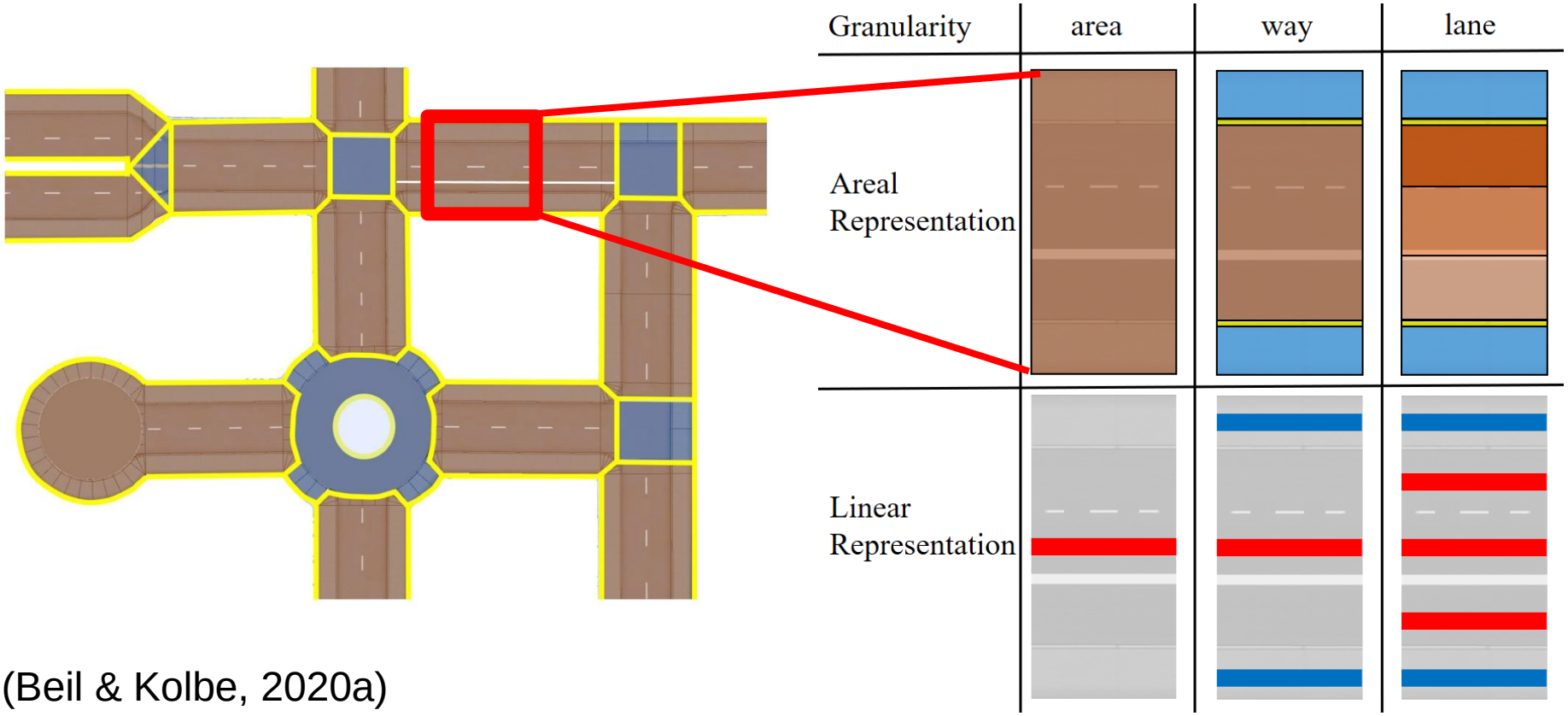
- Established standard in the automotive industry
- Analytical description of road networks for
  - driving simulation
  - georeferencing with PROJ string
- Modelling concept
  - Reference line based (parametric representations)
  - Multiple affine transformations
  - Automotive-specific





CityGML 3.0 Transportation Module

- **Sections:** Segments belonging to one Road
- **Intersections:** Belonging to multiple Roads

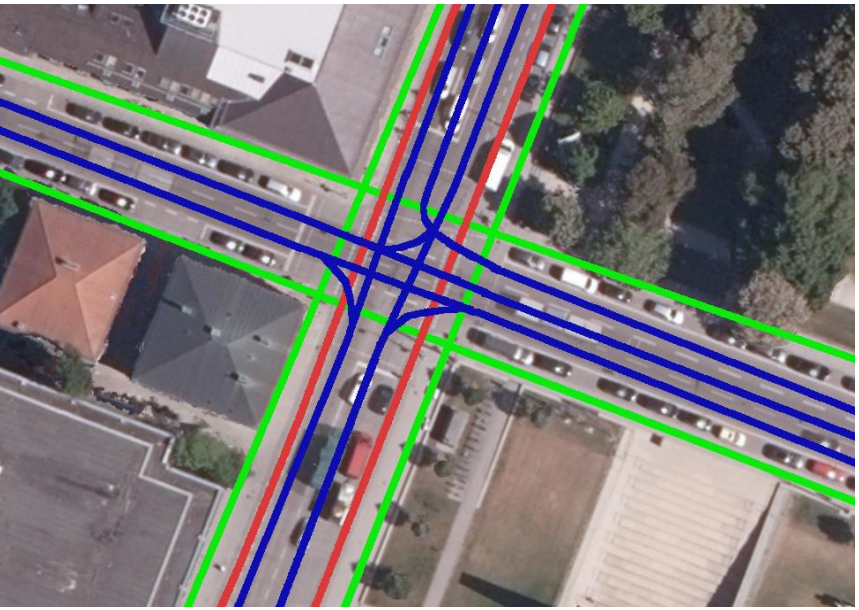


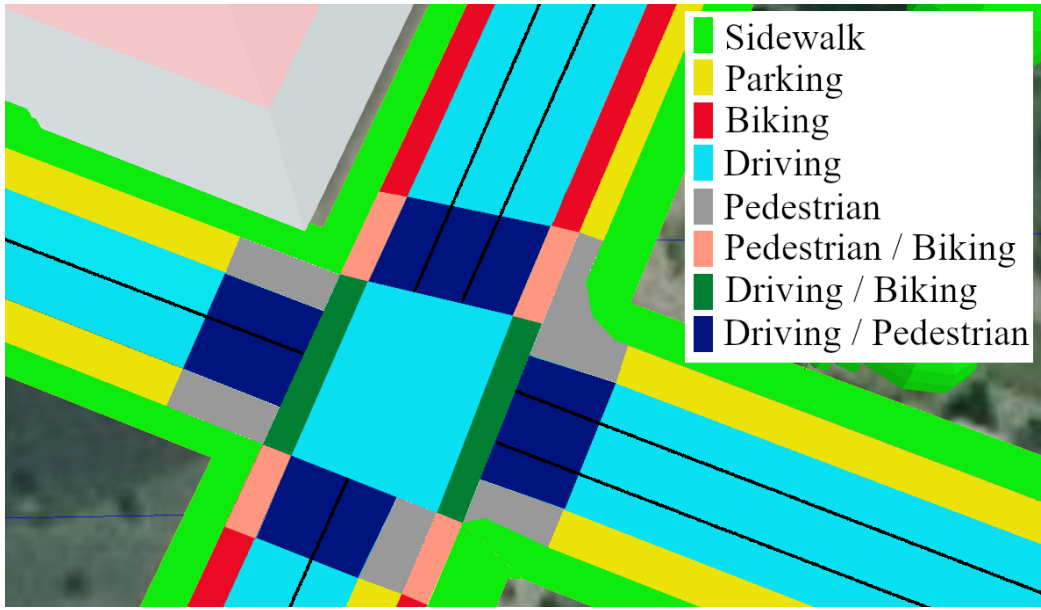
(Beil & Kolbe, 2020a)

CityGML 3.0 Transportation Module

- **Combined Road, Track, Railway, Waterway representations**
- **CityGML** module supports representation of multiple transportation types in a **consistent**, **standardized** and **integrated** way

(Beil & Kolbe, 2020b)





Comparison of OpenDRIVE 1.6 and CityGML 3.0

- Application Domain

CityGML3.0

Topographic model w.r.t. geometry, topology, semantics and appearance

- Core element: *"city object as* geographic feature with volumetric extent
- Application domains:
  - Geospatial simulations (flood, energy, …)
  - Urban planning
  - …

OpenDRIVE1.6

Model to describe static road space networks and objects along roads

- Central element: *"road"*

→ Main application domain:

Driving simulation

Comparison of OpenDRIVE 1.6 and CityGML 3.0

- Geometries

CityGML3.0

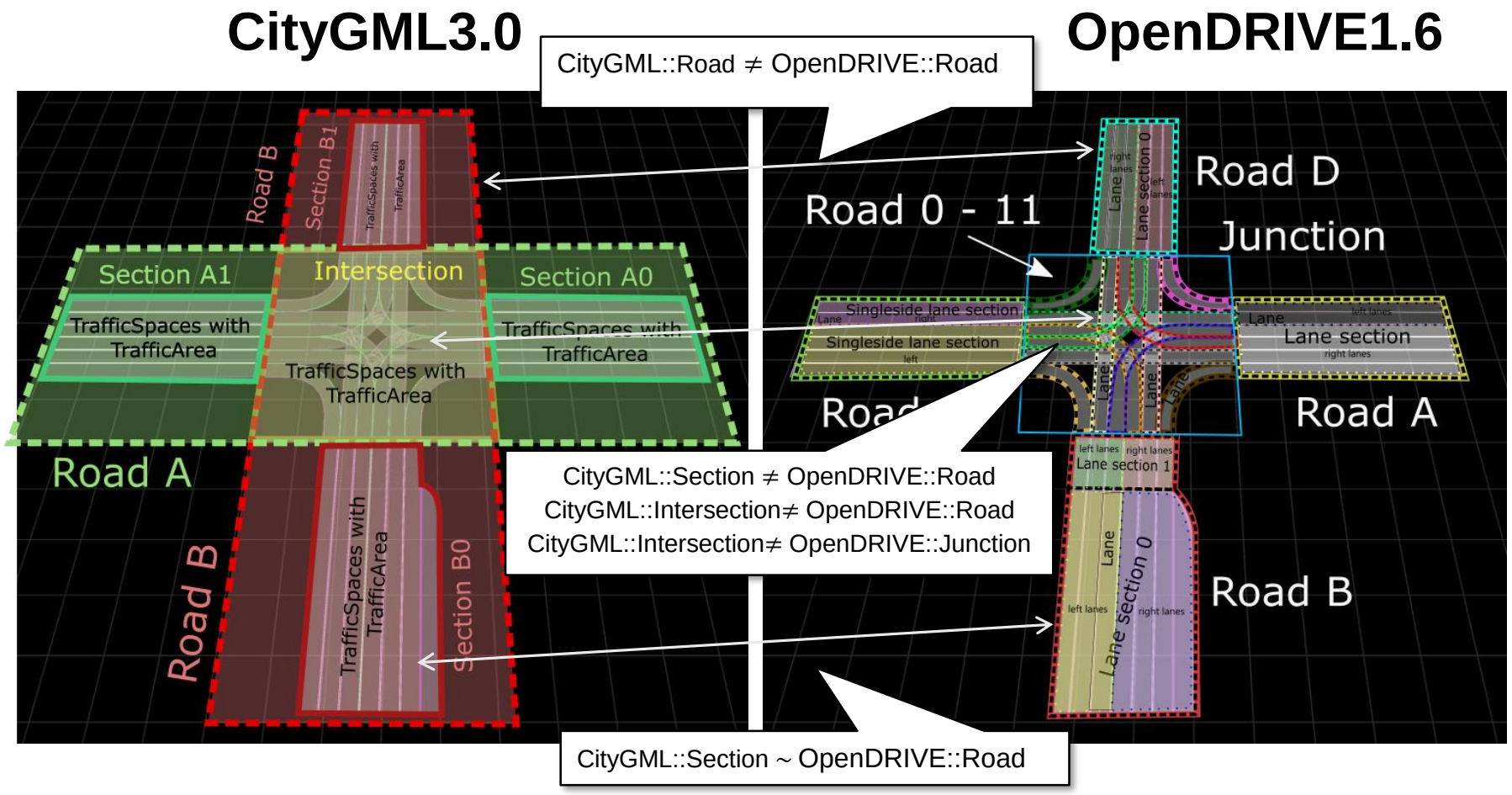
- Application schema of GML (ISO Standard)
- Conceptual model uses the spatial schema of ISO 19107
- Mainly explicit geometry (derivation of datasets from real-world measurement data)

OpenDRIVE1.6

- Standard-specific geometry
- Parametric geometry for road modeling
- Based on a reference line

Comparison of OpenDRIVE 1.6 and CityGML 3.0

- Semantic concepts



- r:trån is an
  - open library
  - for road space model transformations
  - steered by parameterizable recipes

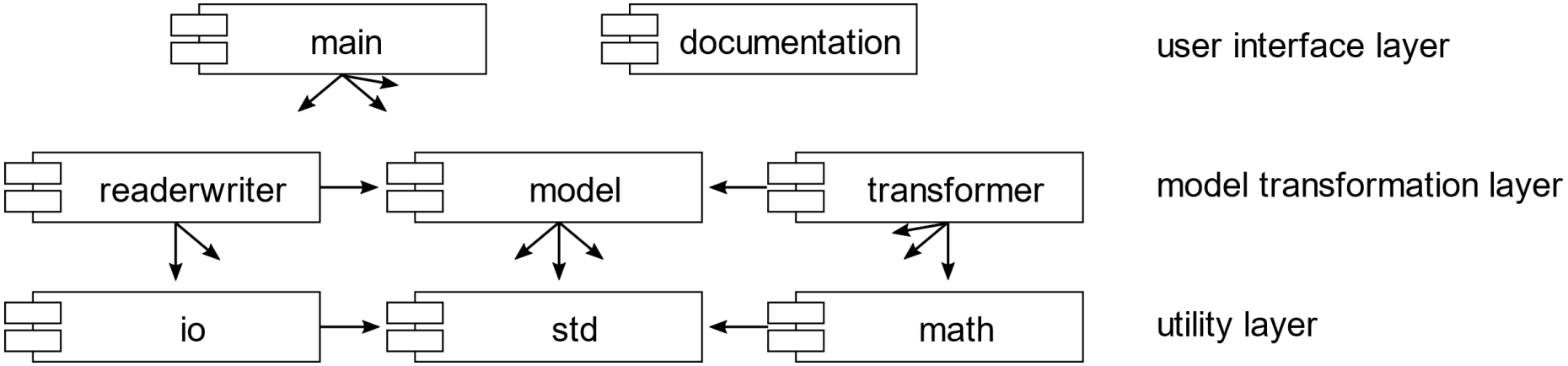
- Initial use cases
  - Conversion of OpenDRIVE → CityGML 2.0
  - Conversion of OpenDRIVE → CityGML 3.0

https://rtron.io
https://github.com/tum-gis/rtron

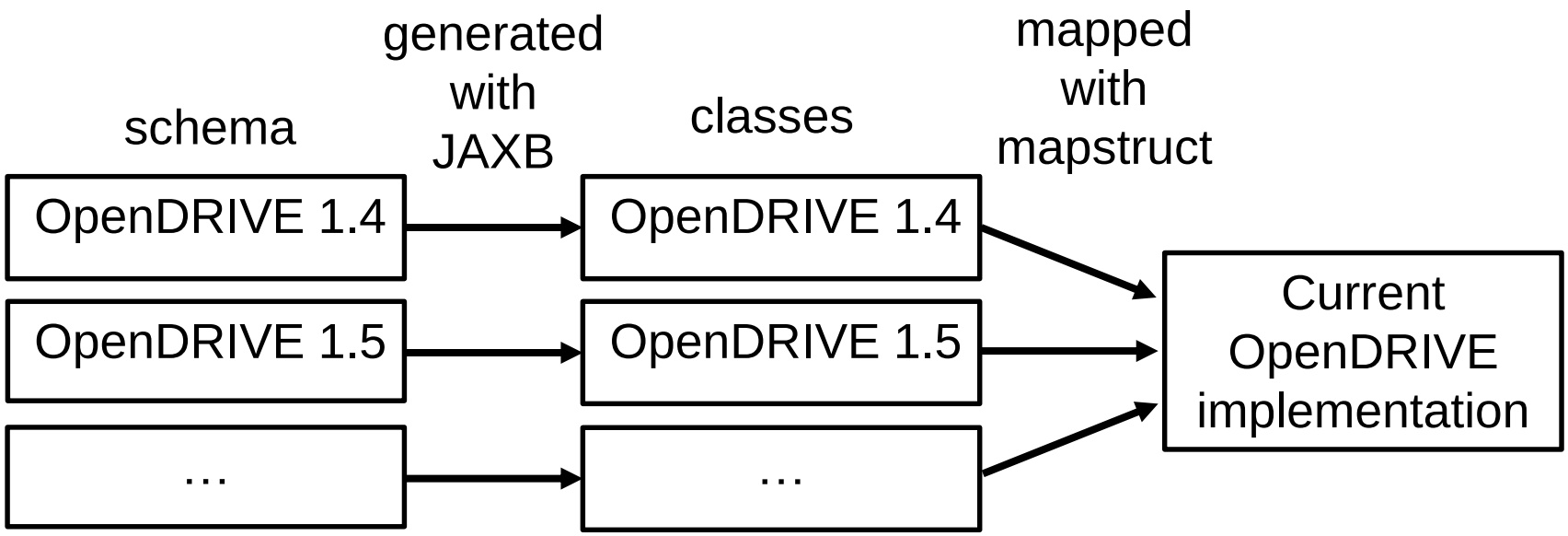
Architecture of r:trån

- Runs on the Java Virtual Machine (JVM)
- Implemented in Kotlin: Concise, safe, interoperable

- Separated into components



OpenDRIVE Reader

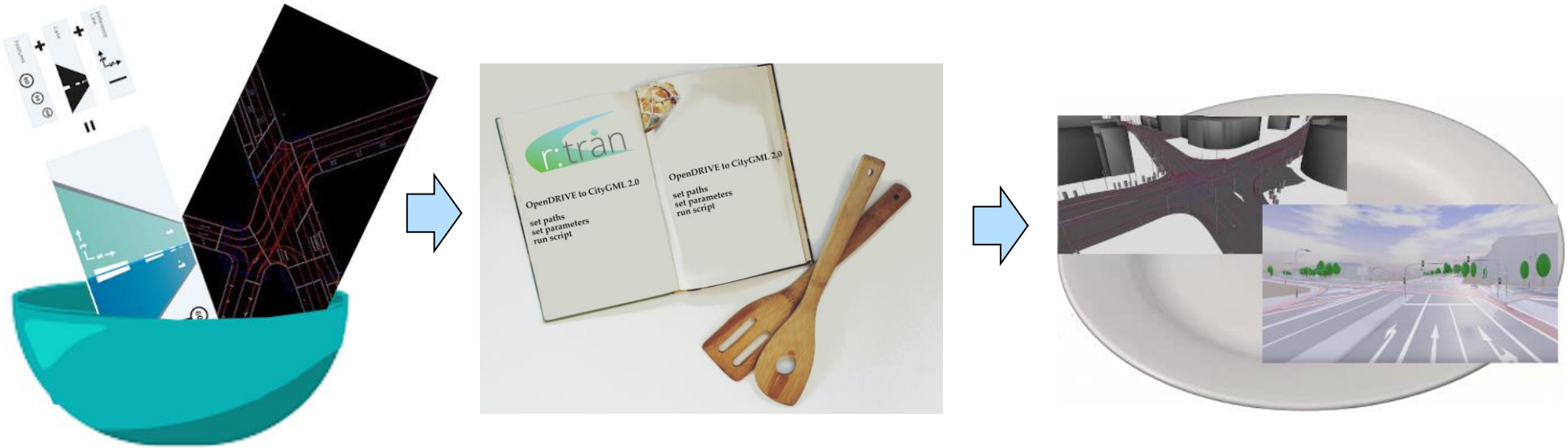


Mapstruct

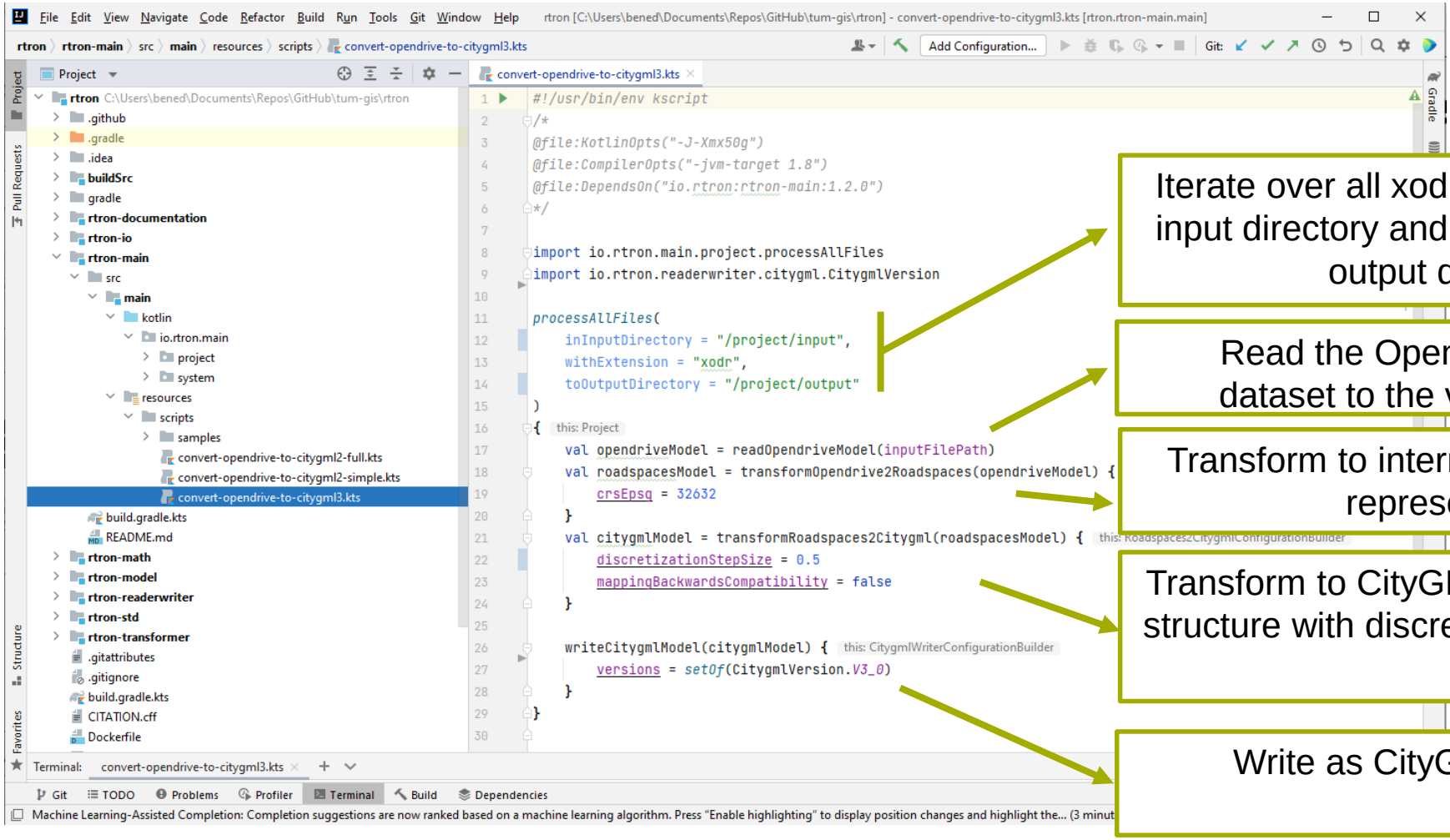
- Generation of mappings during compile time
- Annotations: OpenDRIVE 1.4 → 1.6 takes 300LoC
- Type-safe mapping, performant, inverse possible

Usage of r:trån – multiple options

- Recipe development in IDE
- Library for other projects
- Deployment via
  - kscript directly
  - **Docker**



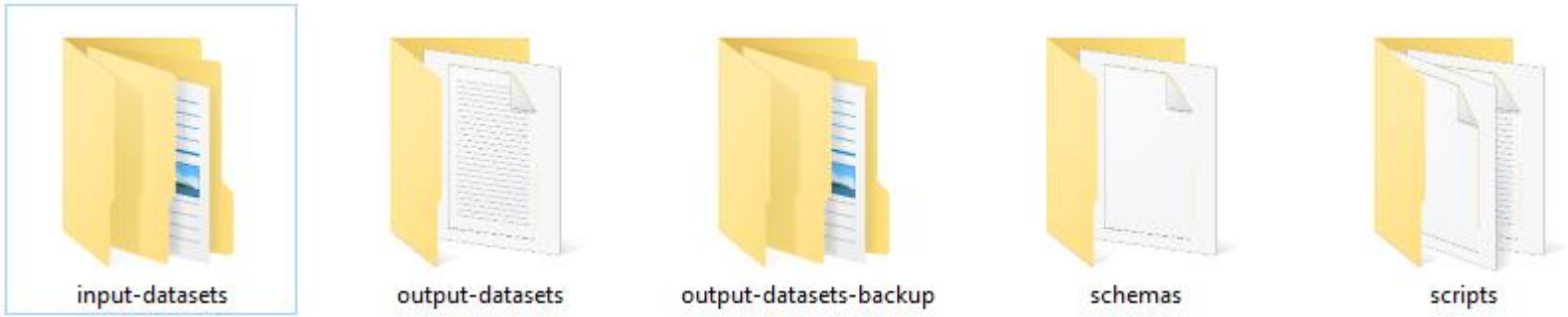
Recipe in IntelliJ IDEA



Hands-on Tutorial

- Prerequisite
  - Commands are based Windows OS
  - Docker installation
  - Data inspector of FME (Safe Software)
  - Optional 3DCityDB

- Downloaded sample data: https://syncandshare.lrz.de/getlink/fiCYHWPtetehc1TybqWRpeRy/sample-datasets.zip



Step 1: Unzip “sample-dataset” folder – Open “input-datasets” folder

- Info on the provided data
- KML visualization of OpenDRIVE reference lines (GoogleEarth)
- Light blue: standard line
- Orange: connection lines in junction areas

Step 2: Open “scripts” folder

- These are the recipes we will use
  - For creating CityGML2.0 or CityGML3.0 compliant data

Name	Änderungsdatum	Typ	Größe
opendrive-to-citygml2.kts	06.09.2021 16:15	KTS-Datei	1 KB
opendrive-to-citygml3.kts	25.08.2021 21:43	KTS-Datei	2 KB
readme	25.08.2021 21:45	Textdokument	1 KB

Step 3: Open e.g. “opendrive-to-citygml3.kts” in any text editor

- Here you can adjust e.g. discretization steps
- For now we will leave everything as it is

```
processAllFiles(
    inInputDirectory = "/project/input", // adjust path to directory of input datasets
    withExtension = "xodr",
    toOutputDirectory = "/project/output" // adjust path to output directory
)
{
    val opendriveModel = readOpendriveModel(inputFilePath)
    val roadspacesModel = transformOpendrive2Roadspaces(opendriveModel) {
        crsEpsg = 32632
    }
    val citygmlModel = transformRoadspaces2Citygml(roadspacesModel) {
        // if false, all classes according to CityGML3 are populated
        mappingBackwardsCompatibility = false

        // distance between each discretization step for curves and surfaces
        discretizationStepSize = 0.5

        // number of discretization points for a circle or cylinder
        circleSlices = 12
    }

    writeCitygmlModel(citygmlModel) {
        // write as CityGML dataset of version 3
        versions = setOf(CitygmlVersion.V3_0)
    }
}
```

Step 4: Open “readme.txt” (within scripts folder) in any text editor and adapt paths

```
Replace C:\adjust\path\to\ with the correct path to the sample data directory on your system:


docker run -i --name rtron --rm^
 -v C:\adjust\path\to\sample-datasets\input-datasets:/project/input^
 -v C:\adjust\path\to\sample-datasets\output-datasets:/project/output^
 rtron/rtron - < C:\adjust\path\to\sample-datasets\scripts\opendrive-to-citygml3.kts
```

- Path to the downloaded sample dataset directory
- Container internal path to project input & output directory (leave unchanged)
- Transformation recipe script (select desired .kts script)

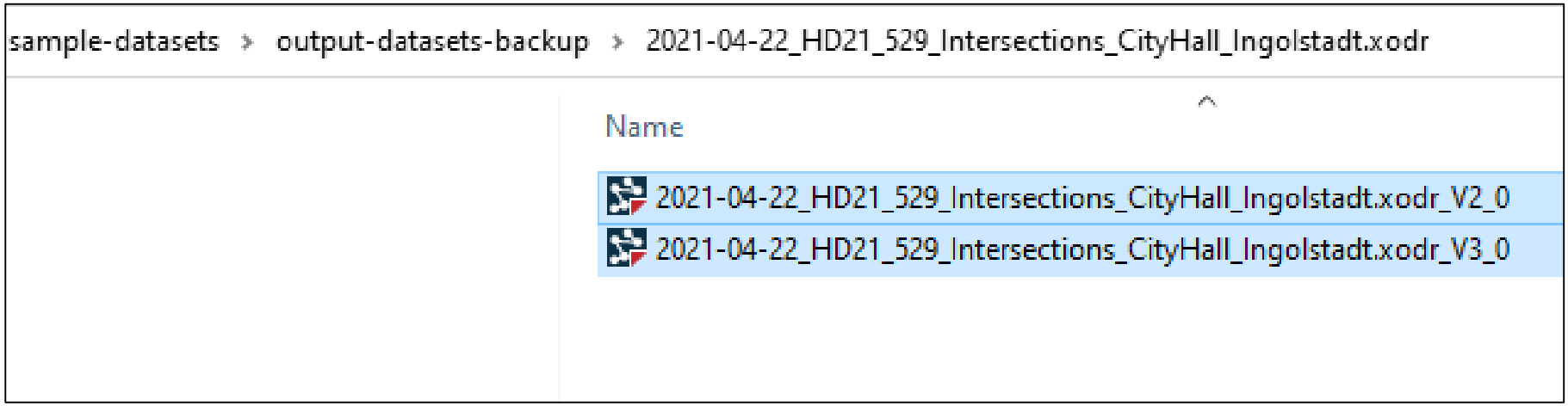
```
docker run -i --name rtron --rm^
  -v C:\adjust\path\to\sample-datasets\input-datasets:/project/input^
  -v C:\adjust\path\to\sample-datasets\output-datasets:/project/output^
  rtron/rtron - < C:\adjust\path\to\sample-datasets\scripts\opendrive-to-citygml3.kts
```

Step 5: Copy and run command

```
C:\Users\bened>docker run -i --name rtron --rm^ -v C:\Users\bened\sample-datasets\input-datase
ts:/project/input^ -v C:\Users\bened\sample-datasets\output-datasets:/project/output^ rtron/rt
ron - < C:\Users\bened\sample-datasets\scripts\opendrive-to-citygml3.kts
Unable to find image 'rtron/rtron:latest' locally
```

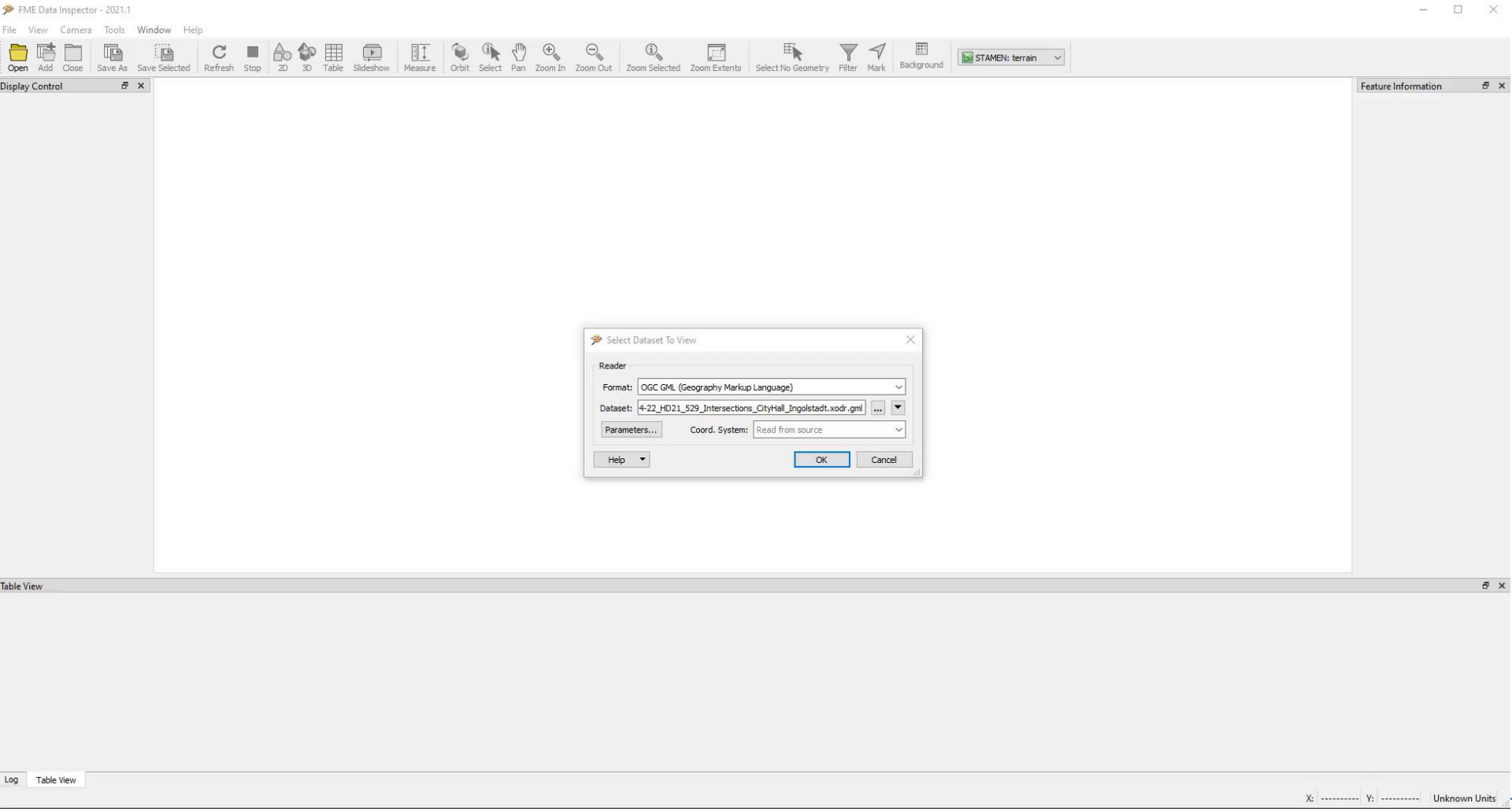
Step 6: Find result in “output-datasets” folder

- In case something didn‘t work we also provided the resulting datasets in the “output-datasets-backup” folder



Step 7: Inspection of CityGML 3.0 data using FME

- Applications schemas provided in schemas folder



Conversion using a different script and different parameters

Script:
opendrive-to-citygml2.kts

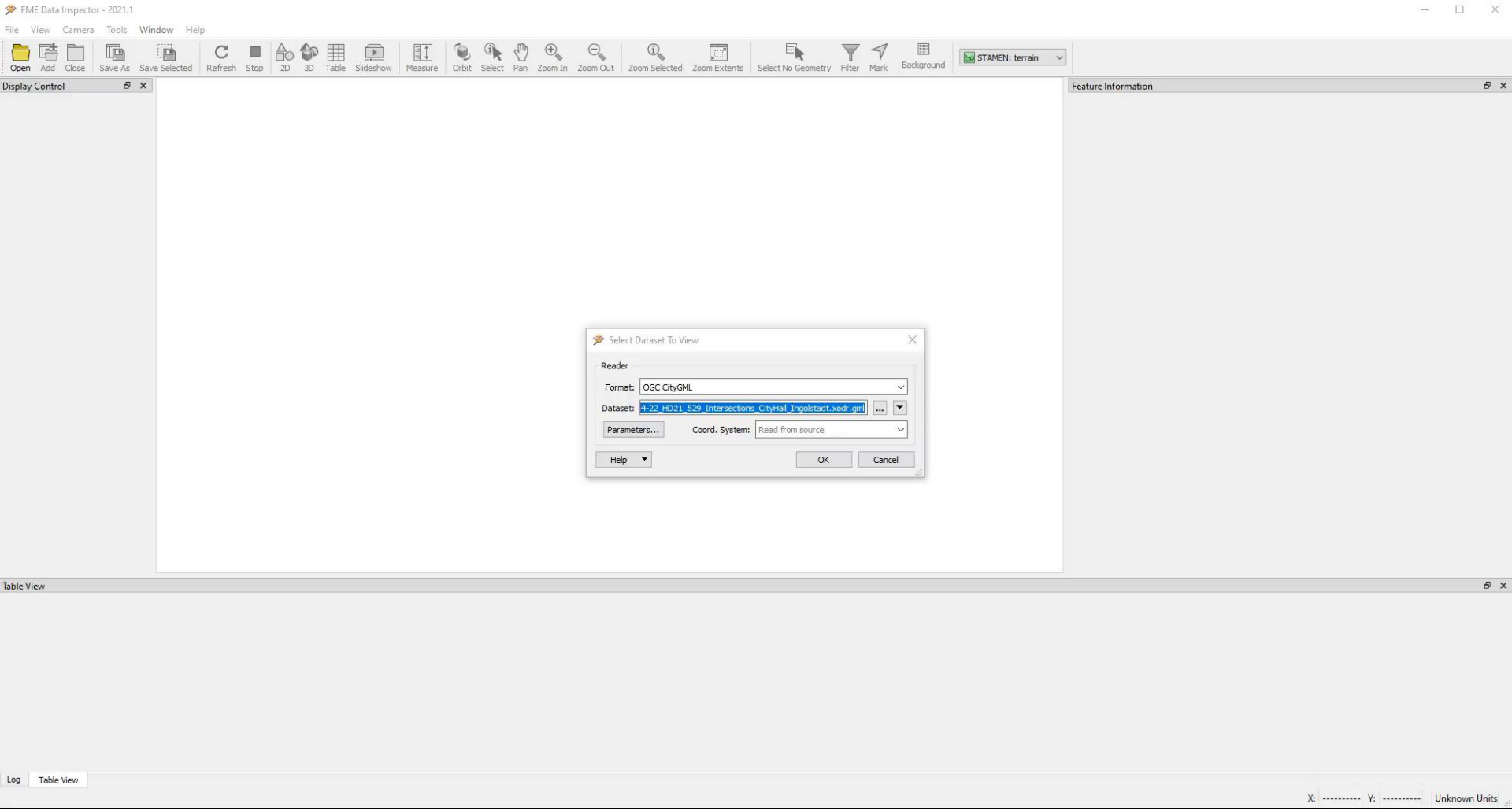
opendrive-to-citygml2.kts

```
#!/usr/bin/env kscript
/*
@file:KotlinOpts("-J-Xmx50g")
@file:CompilerOpts("-jvm-target 1.8")
@file:DependsOn("io.rtron:rtron-main:1.2.0")
*/

import io.rtron.main.project.processAllFiles
import io.rtron.readerwriter.citygml.CitygmlVersion

processAllFiles(
    inInputDirectory = "/project/input",
    withExtension = "xodr",
    toOutputDirectory = "/project/output"
)
{
    val opendriveModel = readOpendriveModel(inputFilePath)
    val roadspacesModel = transformOpendrive2Roadspaces(opendriveModel) {
        crsEpsg = 32632
    }
    val citygmlModel = transformRoadspaces2Citygml(roadspacesModel) {
        mappingBackwardsCompatibility = true
        discretizationStepSize = 10.0
        circleSlices = 3
    }
    writeCitygmlModel(citygmlModel) {
        versions = setOf(CitygmlVersion.V2_0)
    }
}
```

Step size for discretizing parametric geometries = 10m

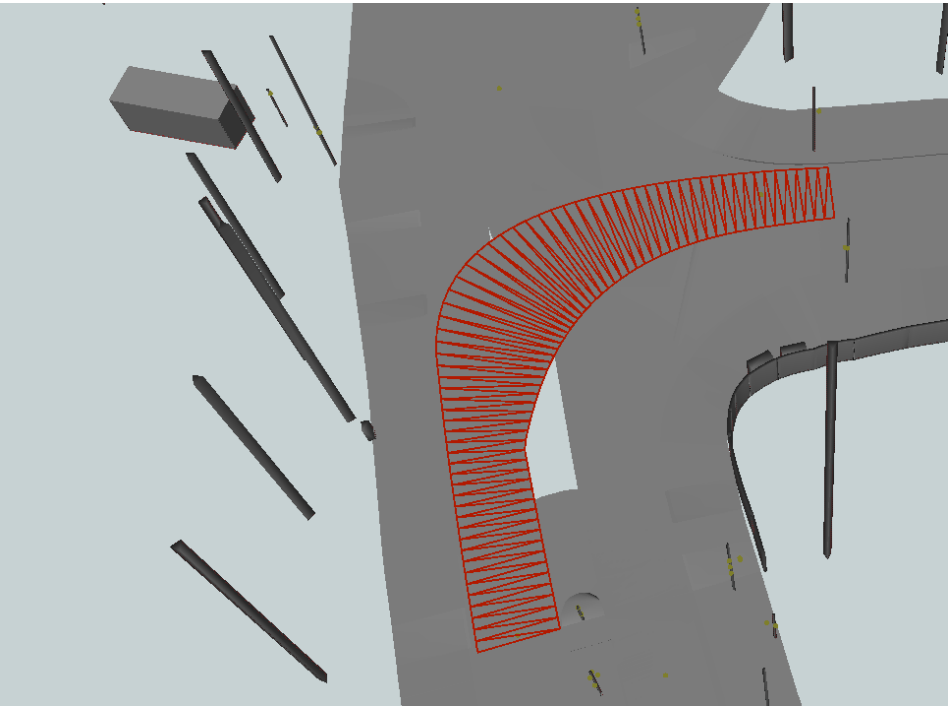
Circles and cylinders are discretized with 3 slices

Inspection CityGML 2.0 using FME

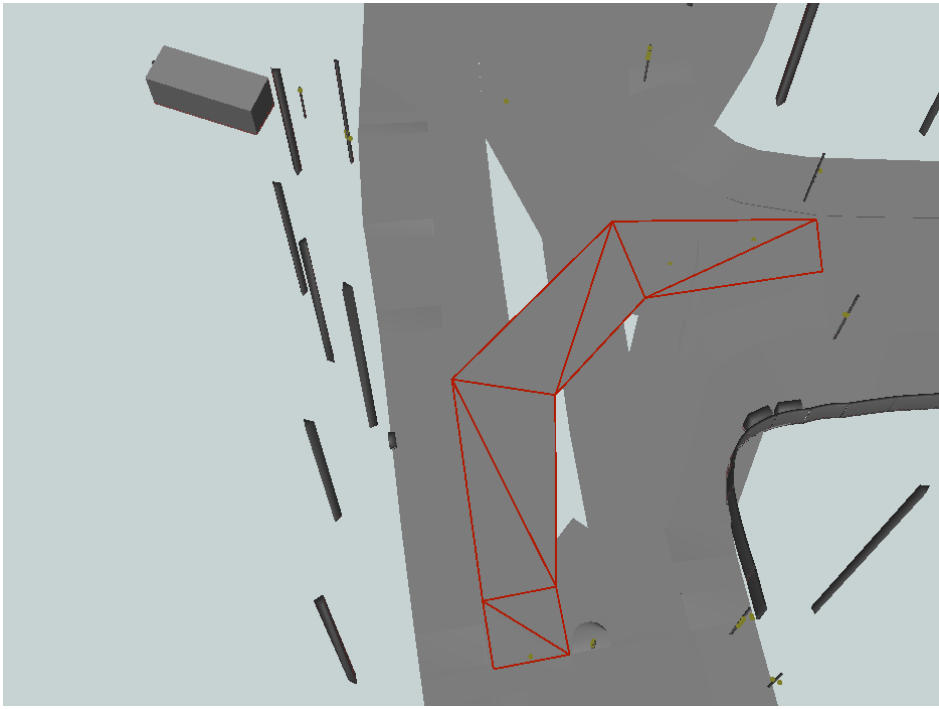


Effect of changed discretization step

Discretization step = 0.5 m

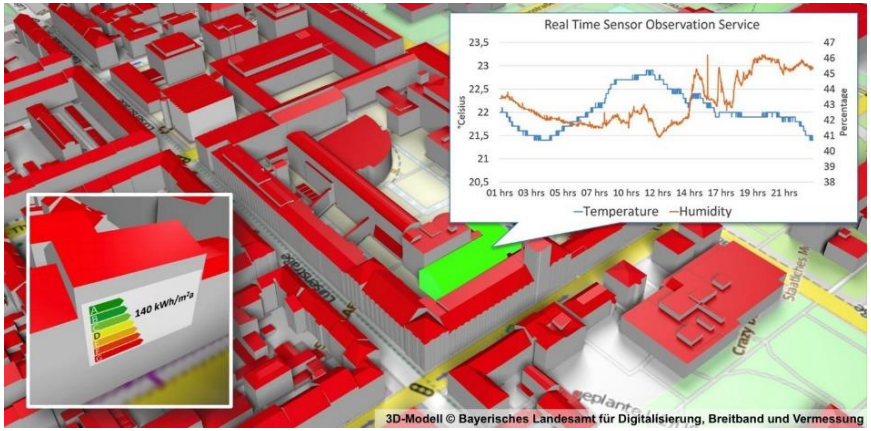


Discretization step = 10 m

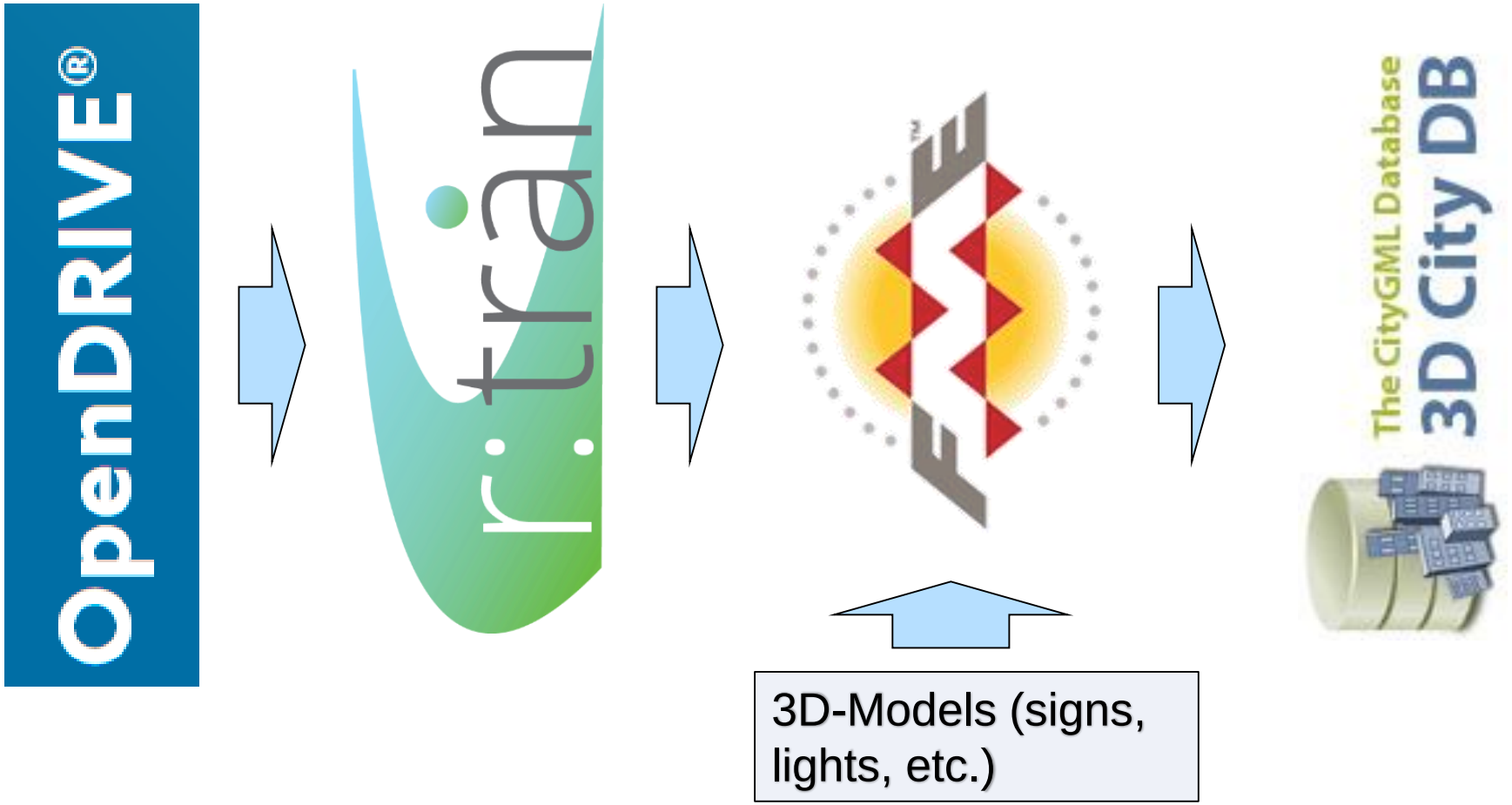


3D City Database

- **3DCityDB**:
  - Free 3D geo-database to store, represent, and manage virtual 3D city models https://www.3dcitydb.org/3dcitydb/
- **Importer / Exporter Tool**:
  - Import: CityGML data (currently version 2.0, soon: CityGML 3.0)
  - Export: CityGML, KML, COLLADA and glTF formats
- **Web Feature Service**
  - Web-based access to the 3D city objects
- **3DCityDB-Web-Map-Client**
  - Interactive 3D visualization based on Cesium virtual globe



Workflow: Generating a detailed 3D Streetspace model



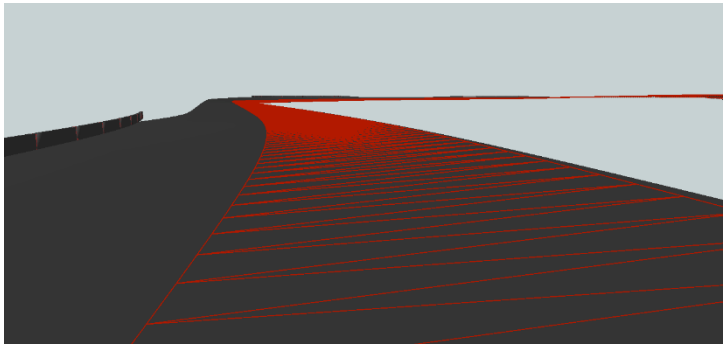
3DCityDB Web-Map-Client Visualization

- 3D streetspace model of Ingolstadt

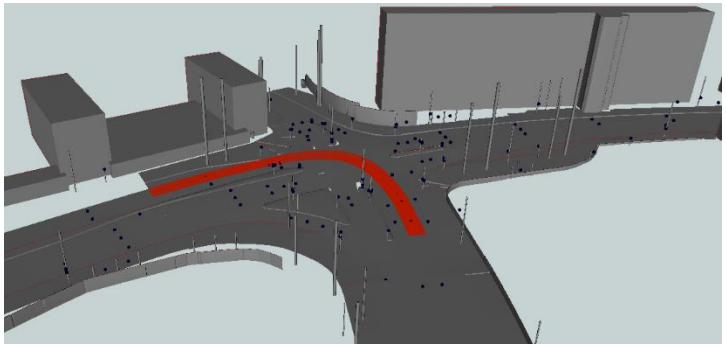
https://wiki.tum.de/display/gisproject/Online+Demo+Collection

Further OpenDRIVE Datasets

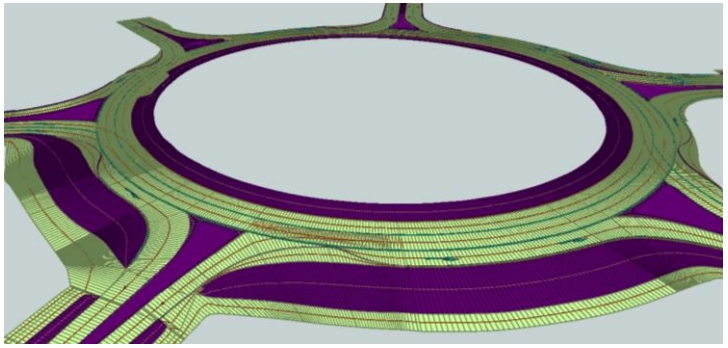
- 3D Mapping Solutions: https://www.3d-mapping.de/en/customer-area/
- Around 130 ready-to-use datasets



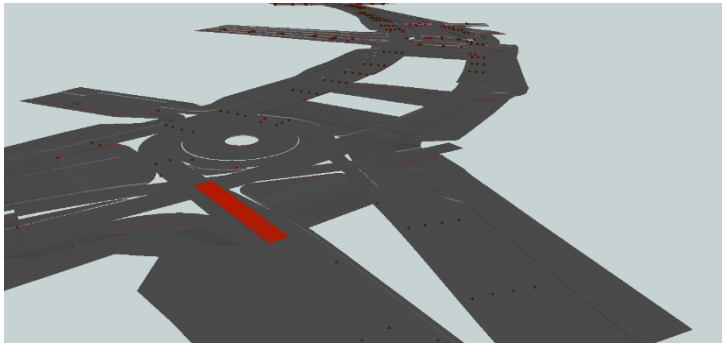
USA, CA: Highway Nr.1



Germany: Complex intersection



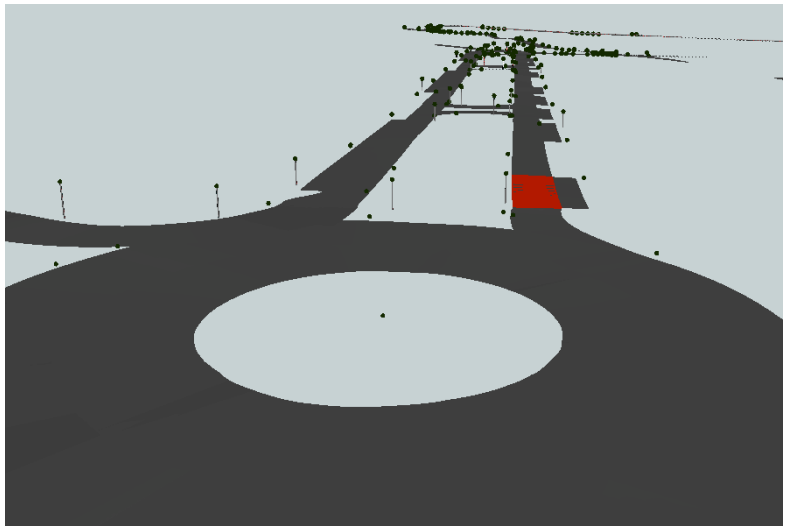
Germany: Roundabout



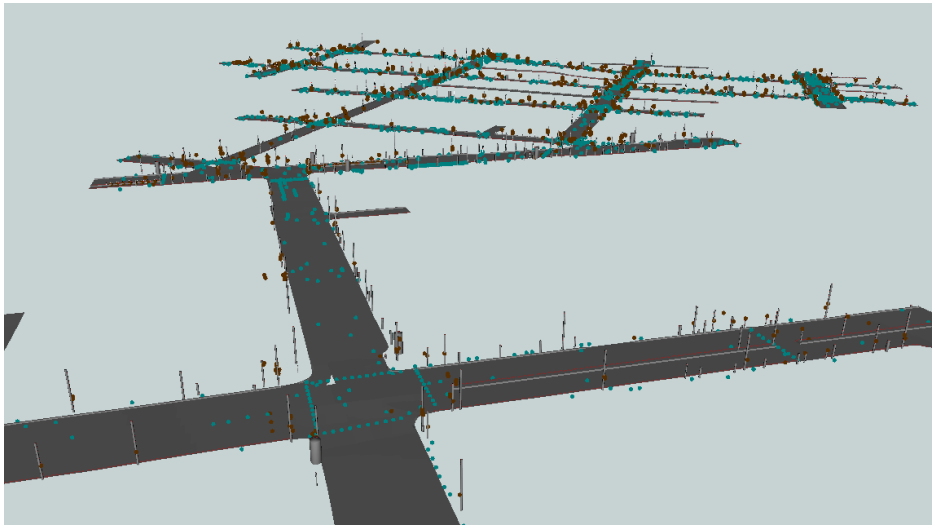
Germany: Complete inner city ring

Further OpenDRIVE Datasets

- Atlatec: https://atlatec.de/en/getsampledata.html
- For more: https://github.com/b-schwab/awesome-openx



Spain: El Vendrell



USA: San Francisco

Conclusion

- Questions?
  - Issue at https://github.com/tum-gis/rtron
- Contributions welcome
  - New OpenDRIVE dialects
  - E.g. new transformers/ writers
- Feature ideas
  - OpenDRIVE inconsistency report or fixing (beyond the schema)
  - OpenDRIVE version upmapping
  - Geodata to OpenDRIVE conversions
  - Implementation of OpenDRIVE-ADE for CityGML
- **Try converting OpenDRIVE data yourself! Following the steps on slide 20 – 29**

References

Beil, C.; Kolbe, T. H. (2017). CityGML and the streets of New York-A proposal for detailed street space modelling. In Proceedings of the 12th International 3D GeoInfo Conference 2017 (pp. 9-16). https://mediatum.ub.tum.de/doc/1368093/1368093.pdf

Beil, C.; Kolbe, T. H. (2020a). Combined modelling of multiple transportation infrastructure within 3D city models and its implementation in CityGML 3.0. Proceedings of the 15th International 3D GeoInfo Conference 2020 (ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences), ISPRS. http://mediatum.ub.tum.de/node?id=1554455

Beil C.; Kolbe, T.H. (2020b). Detailed Streetspace Modelling for Multiple Applications: Discussions on the Proposed CityGML 3.0 Transportation Model. ISPRS International Journal of Geo-Information **9** (10), 603. https://www.mdpi.com/2220-9964/9/10/603

Coduro, T. (2018). Straßenraummodellierung mittels Mobile Mapping in OpenDRIVE und CityGML sowie Entwicklung geeigneter Visualisierungsmethoden. Technical University of Munich, Chair of Geoinformatics, Master's Thesis (in German). 2018. https://mediatum.ub.tum.de/1451954

Kutzner,T.; Chaturvedi, K.; Kolbe, T.H. (2020). CityGML3.0 – New Functions open up new Applications. In: PFG - Journal of Photogrammetry, Remote Sensing and Geoinformation Science. http://mediatum.ub.tum.de/node?id=1539643

Ruhdorfer, R.; Willenborg, B.; Sindram, M. (2018). Coupling of Traffic Simulations and Semantic 3D City Models. *gis. Science*, 2018, Nr. 3/2018. https://mediatum.ub.tum.de/1454442

Schwab, B.; Beil, C.; Kolbe T. H. (2020). Spatio-Semantic Road Space Modeling for Vehicle–Pedestrian Simulation to Test Automated Driving Systems. Sustainability **12** (9), 3799. https://www.mdpi.com/2071-1050/12/9/3799

Schwab, B.; Kolbe T. H. (2019). Requirement Analysis of 3D Road Space Models for Automated Driving. ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, IV-4/W8, 99–106. https://mediatum.ub.tum.de/node?id=1507292