Making OpenDRIVE HD map data easily accessible in GIS

Geospatial World Forum, Tech Session: HD Mapping

2024-05-16, Rotterdam

Michael Scholz

DLR

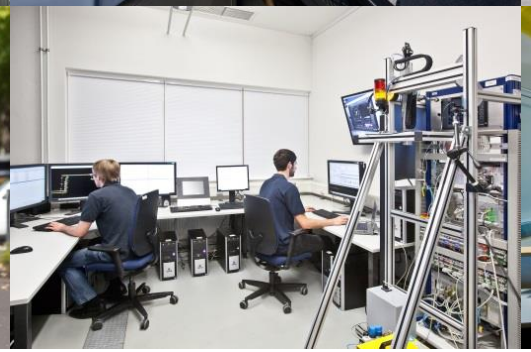
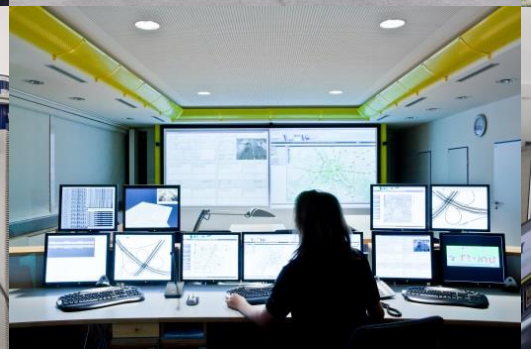
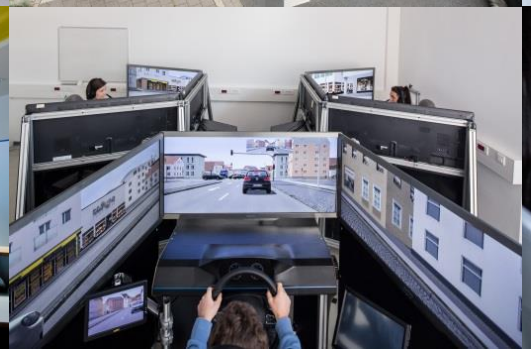
Institute of Transportation Systems
Our research infrastructure

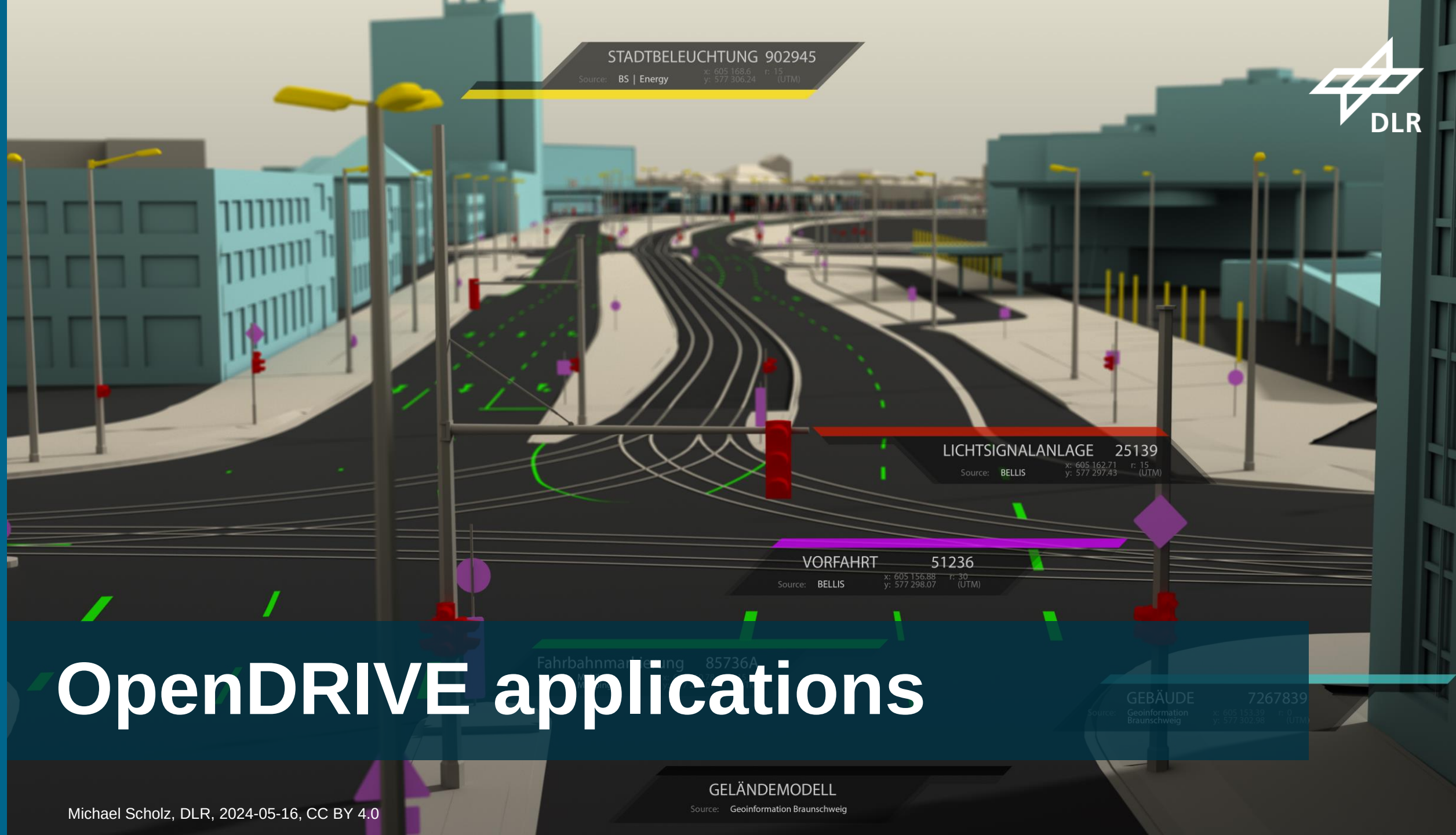








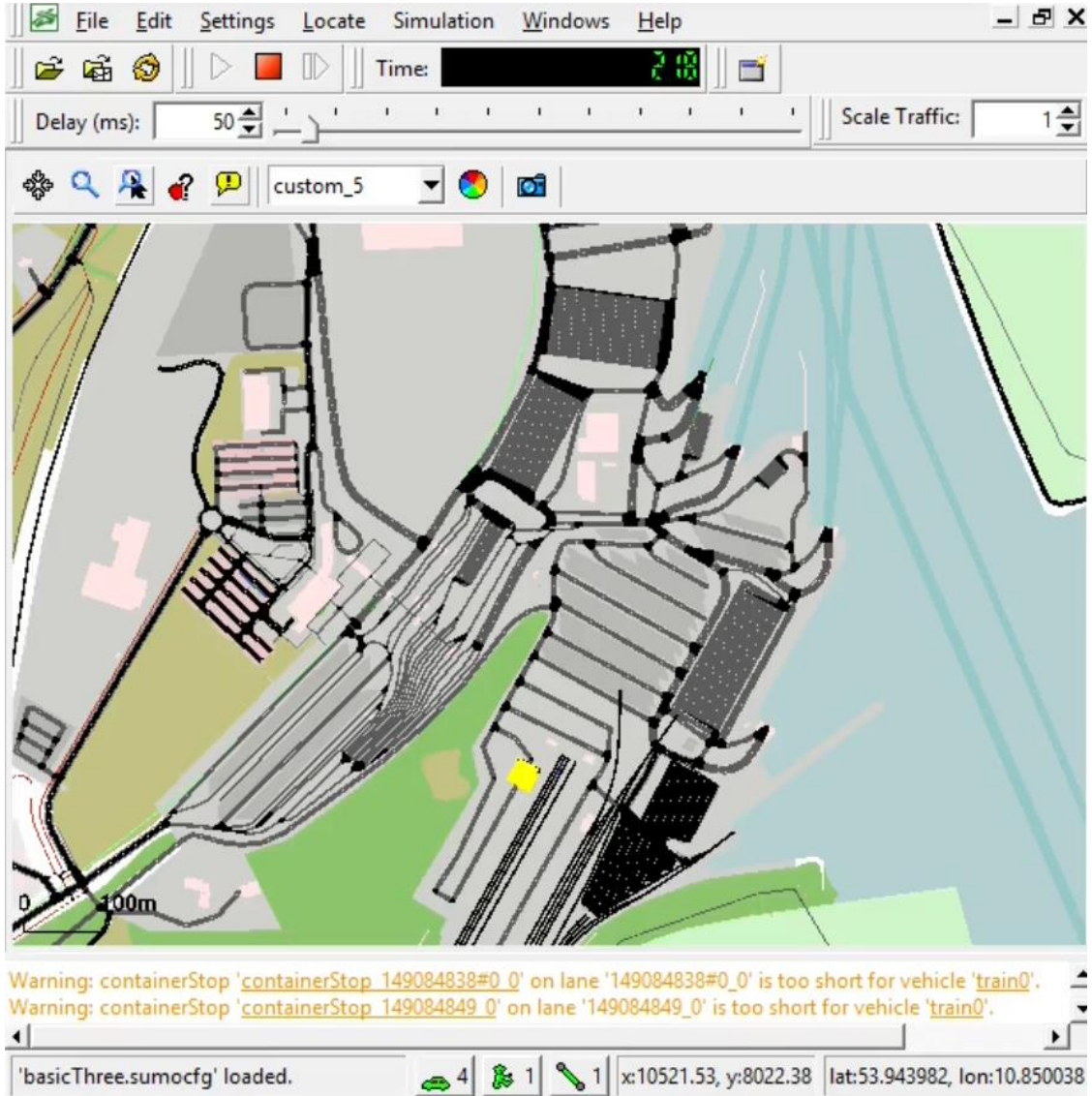



OpenDRIVE applications

OpenDRIVE applications
Urban digital twin for simulation

https://youtu.be/LDSvDEsvnig

OpenDRIVE applications
Microscopic traffic simulation → SUMO



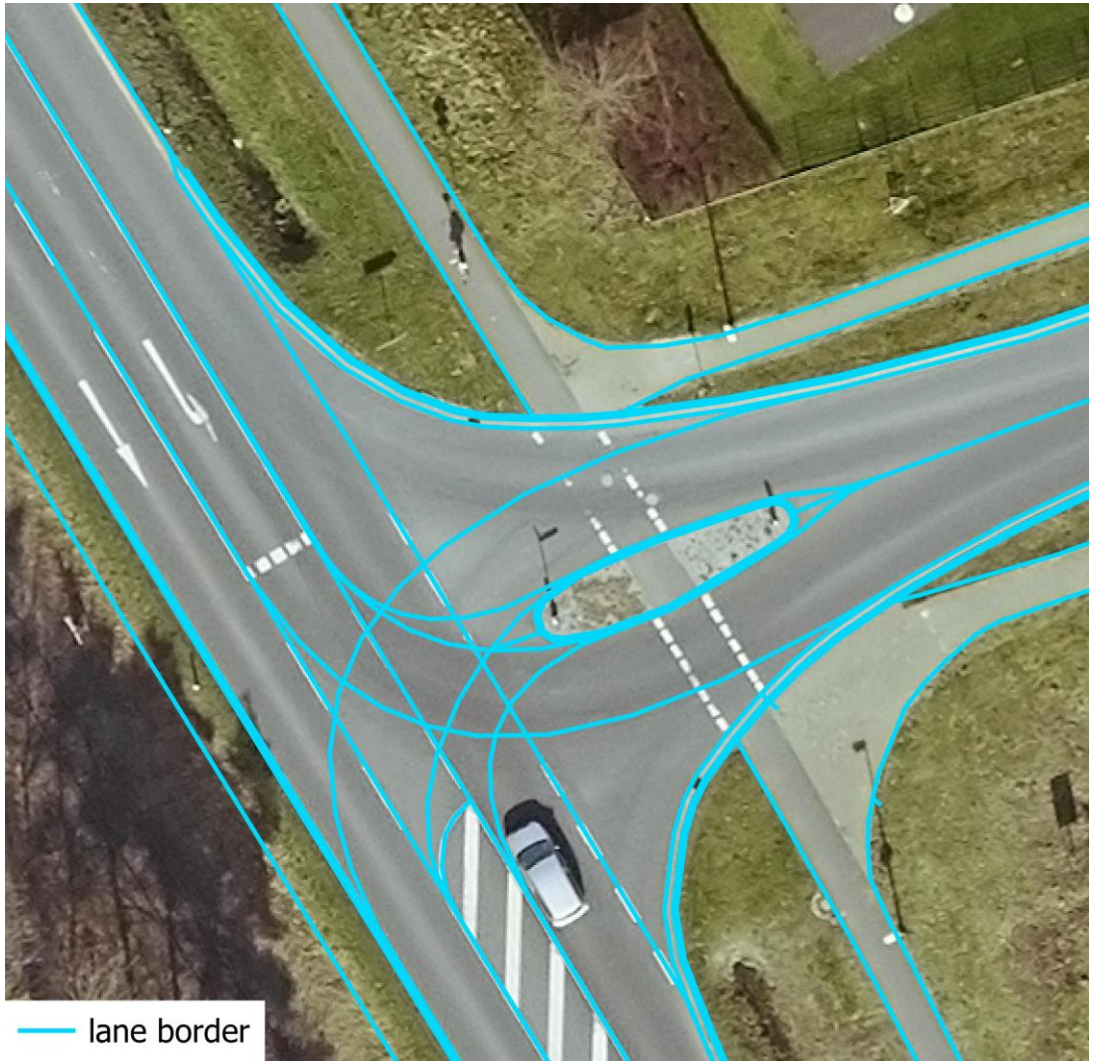
OpenDRIVE applications
Automated driving

https://youtu.be/RDXXBqL42W8

What does “HD” mean?

Modelling of road space on lane level

- Driving lanes
- Cycle ways
- Pedestrian ways
- Vegetation strips



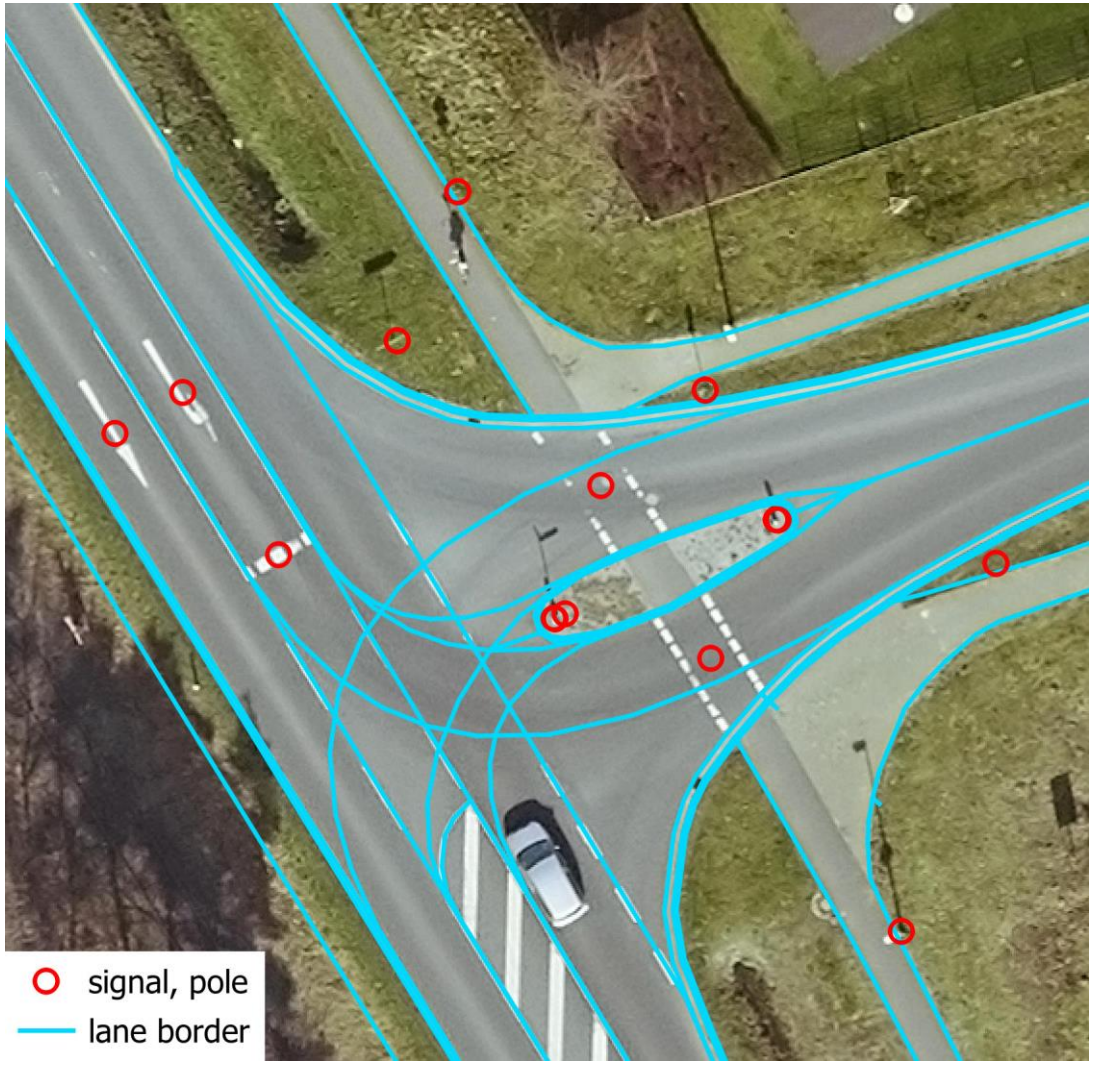
What does “HD” mean?

Modelling of road space on lane level

- Driving lanes
- Cycle ways
- Pedestrian ways
- Vegetation strips

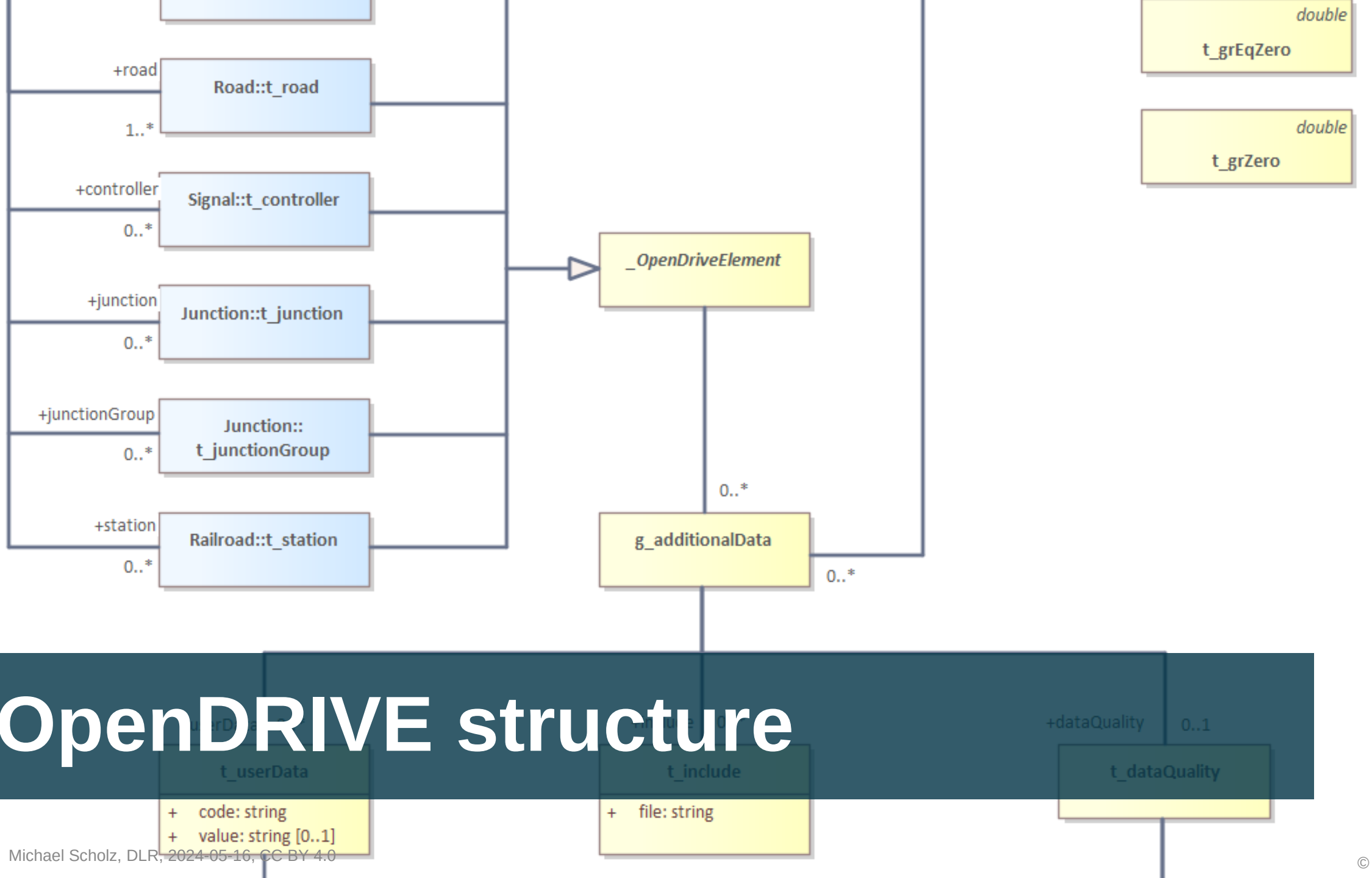
Including traffic infrastructure

- Road markings
- Signals and signs
- Poles, bollards



A “problem” with different perspectives

- Public authorities acquire OpenDRIVE data from industrial partners …
  - … and cannot use it in common GIS workflows.
- Public authorities want to export cadastral data into OpenDRIVE …
  - … and are missing appropriate tools.
- Let’s extend open-source software to bridge OpenDRIVE with GIS!



OpenDRIVE structure

Hierarchical data model

```
<road length="1000.0" id="0">
  <link>
    <successor elementType="road"
      elementId="1" contactPoint="start"/>
  </link>
  <type s="0.0" type="motorway"/>
  <planView>
    <geometry x="0.0" y="0.0" hdg="0.0"
      length="1000.0">
      <arc curvature="0.004"/>
  <elevationProfile>
  <lateralProfile/>
  <lanes>
    <laneSection>
      <left>
        <lane id="7" type="border">
        <lane id="6" type="shoulder">
        <lane id="5" type="stop">
        <lane id="4" type="driving">
          <link>
            <successor id="4"/>
          </link>
          <width a="3.75"/>
          <roadMark type="solid" weight="bold"
            color="white" width="0.3">
            <type>
              <line length="1.0" space="0.0"
                width="0.3"/>
            </type>
          </roadMark>
```

Hierarchical data model
With many cross-references

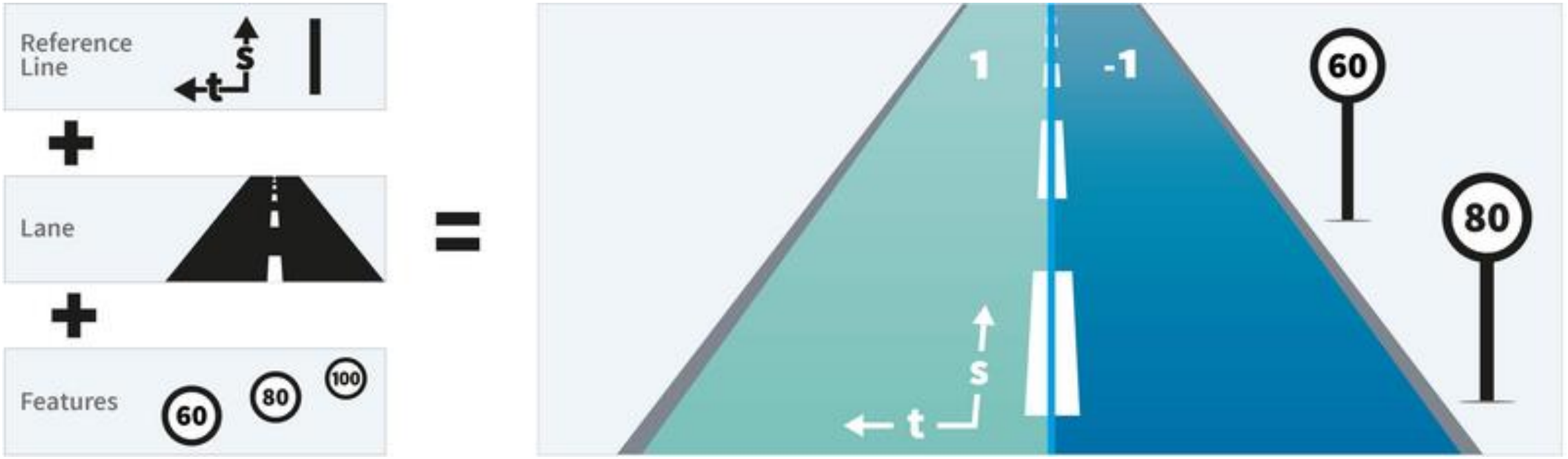
```
<road name="Boulevard of Rock" length="66.6"
    <link>
        <predecessor elementType="junction"
        <successor elementType="junction" el
    </link>
```

```
<signal s="0" t="0" id="1337"
 country="LV-426" subtype="-1"
    <laneValidity fromLane="1"
</signal>
```

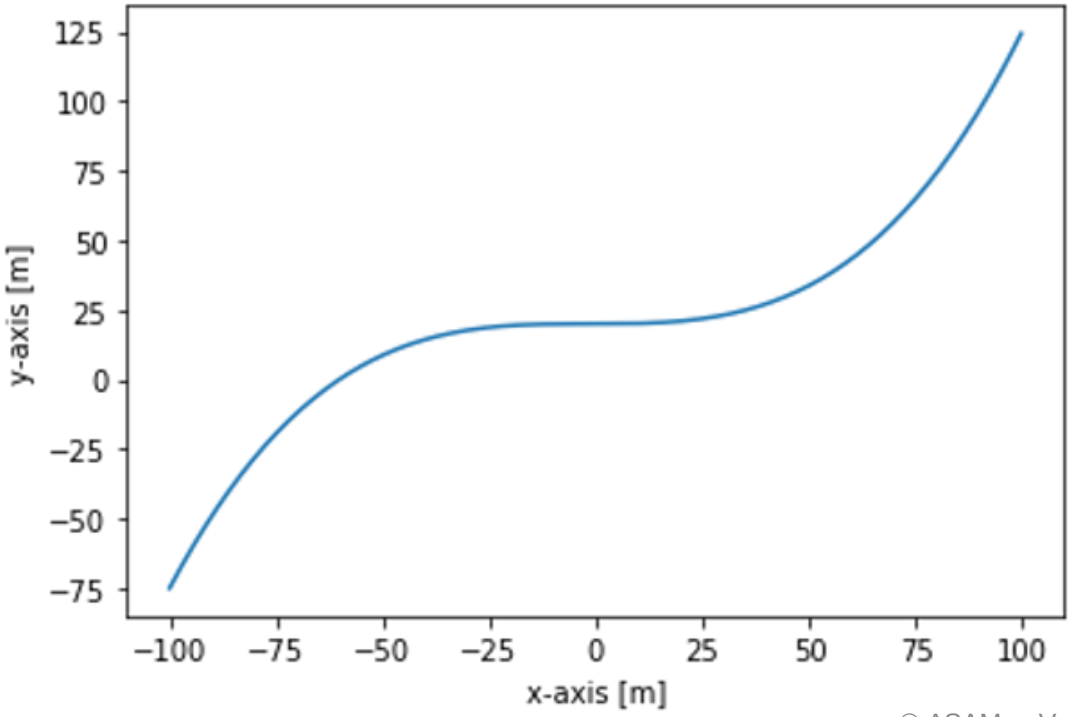
```
<lanes>
    <laneSection s="0">
        <left>
            <lane id="3" type="border"
                <link>
                    <successor id="3"/>
                </link>
```

```
<junction name="ne Kreuzung halt" id="1234">
    <connection id="0" incomingRoad="1" connectingRoad="2"
        <laneLink from="-7" to="-7"/>
        <laneLink from="-6" to="-6"/>
        <laneLink from="-5" to="-5"/>
        <laneLink from="-4" to="-4"/>
```

Linearly referenced geometries



Parametric geometries
Cubic polynomials




```
<geometry
        s="0.000000000000e+00"
        x="6.804539427645e+05"
        y="5.422483642942e+06"
        hdg="5.287405485081e+00"
        length="6.565893957370e+01">
        <paramPoly3
                aU="0.000000000000e+00"
                bU="1.000000000000e+00"
                cU="-4.666602734948e-09"
                dU="-2.629787927644e-08"
                aV="0.000000000000e+00"
                bV="1.665334536938e-16"
                cV="-1.987729787588e-04"
                dV="-1.317158625579e-09"
                pRange="arcLength">
        </paramPoly3>
</geometry>
```

GDAL driver implementation

Geospatial Data Abstraction Library (GDAL)

- Wikipedia:
  - “GDAL/OGR provides at least partial support for 154 raster and **93 vector geospatial data formats**”

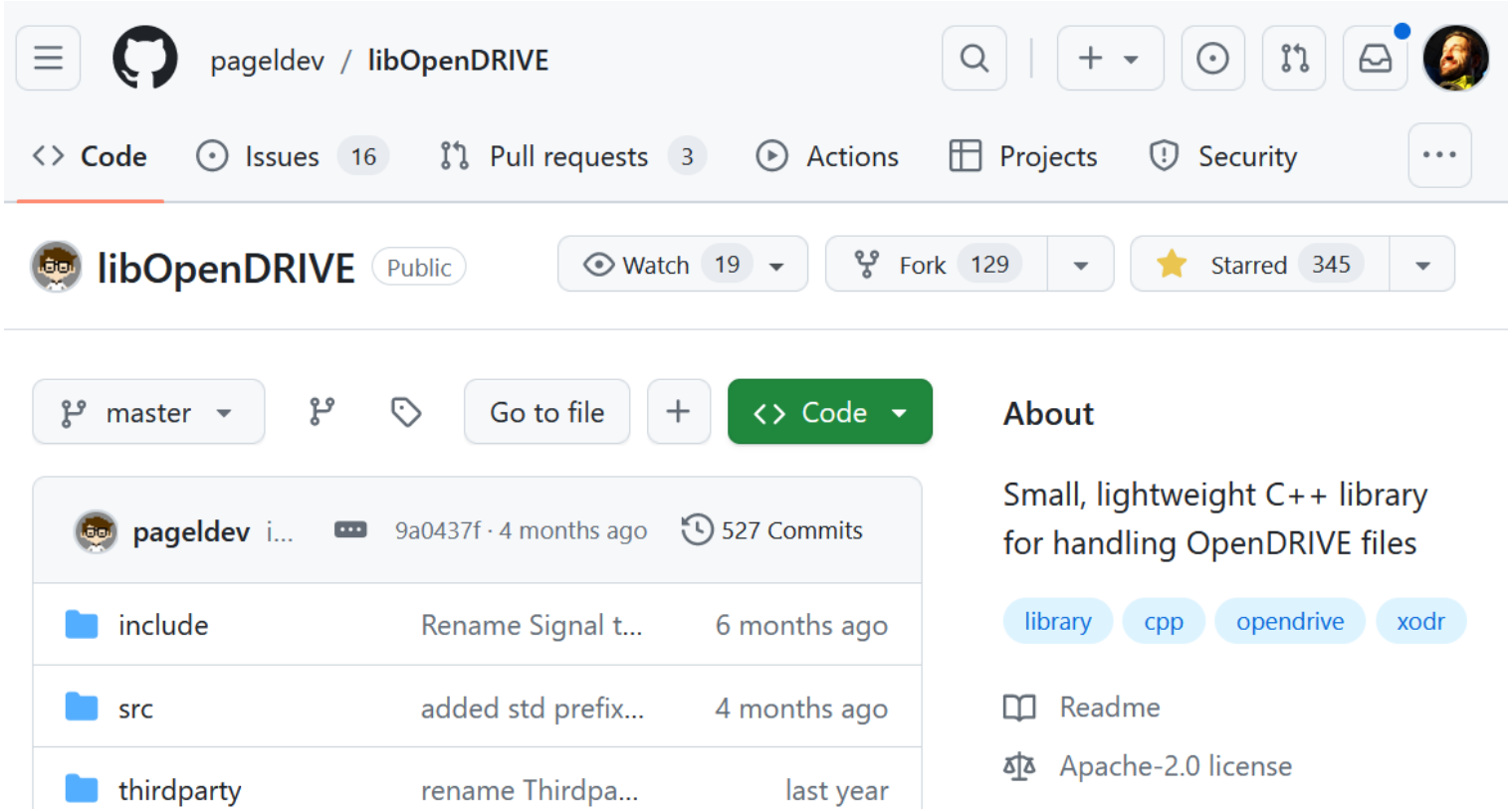
- Most open and commercial (desktop) GIS depend on GDAL!

- GDAL implements OGC Simple Features as vector model

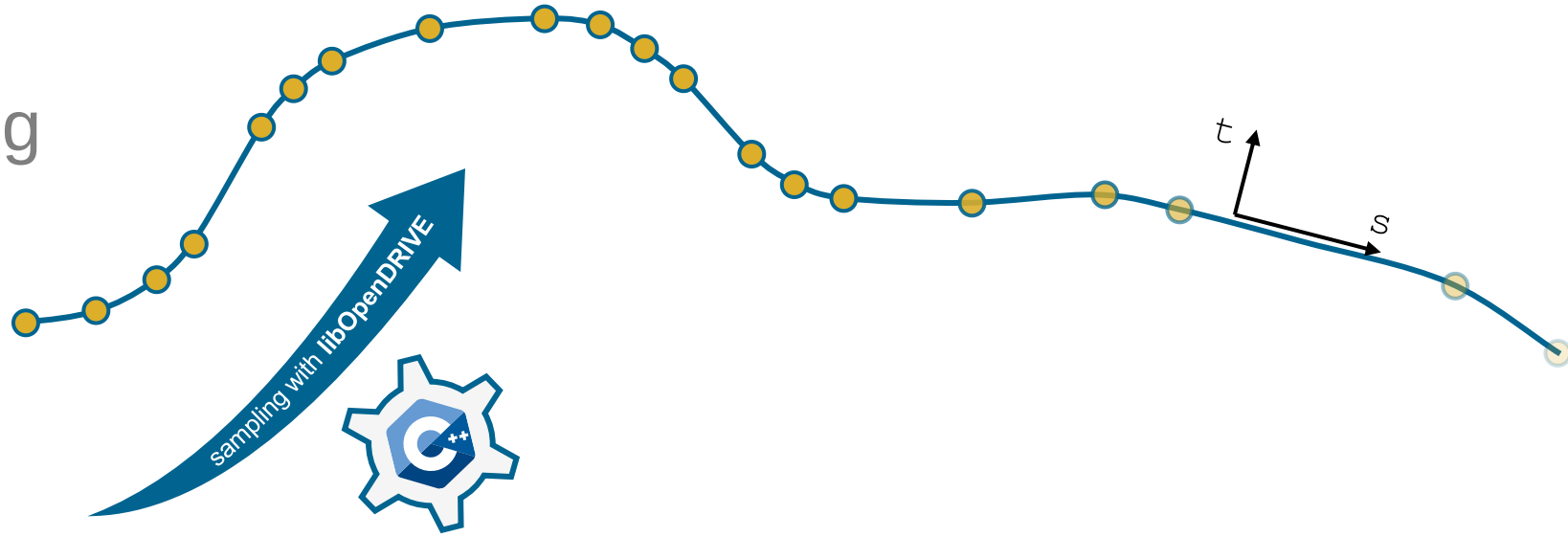
Make OpenDRIVE geometries GISable
Sampling with libOpenDRIVE

- github.com/pageldev/libOpenDRIVE

DOI 10.5281/zenodo.7771708



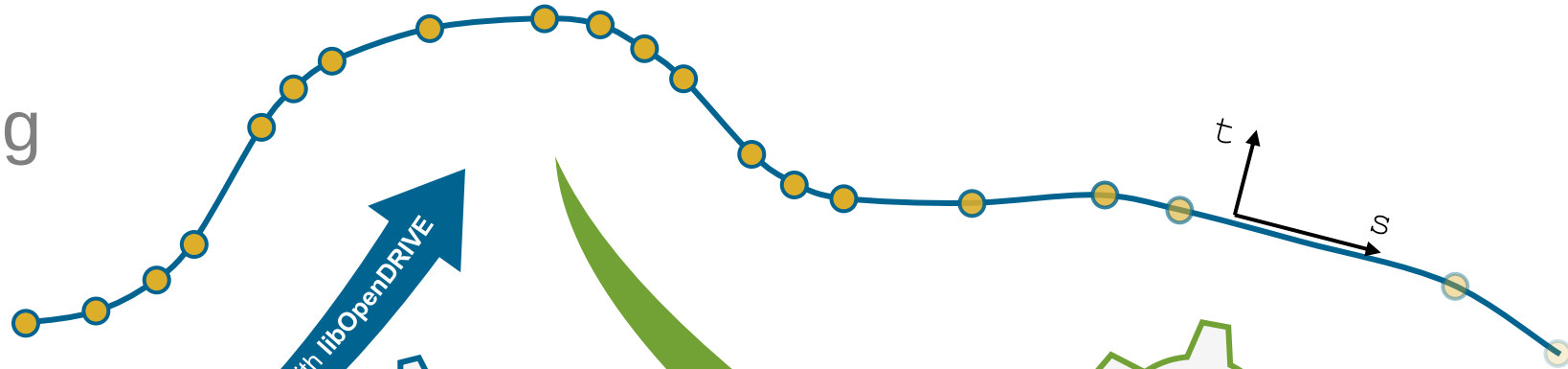
Sampling




```
<planView>
  <geometry s="0.0" x="604944.1037"
            y="5792860.1272"
            hdg="3.5148"
            length="9.7589">
    <arc curvature="9.0884E-4"/>
  </geometry>
  <geometry s="9.7589" x="604935.03"
            y="5792856.5285"
            hdg="3.5237"
            length="12.0">
    <line/>
  </geometry>
</planView>
```

OpenDRIVE Model

Sampling



sampling with **libOpenDRIVE**

translation with **GDAL**

straight into **GIS**

```
<planView>
  <geometry s="0.0" x="604944.1037"
            y="5792860.1272"
            hdg="3.5148"
            length="9.7589">
    <arc curvature="9.0884E-4"/>
  </geometry>
  <geometry s="9.7589" x="604935.03"
            y="5792856.5285"
            hdg="3.5237"
            length="12.0">
    <line/>
  </geometry>
</planView>
```

OpenDRIVE Model

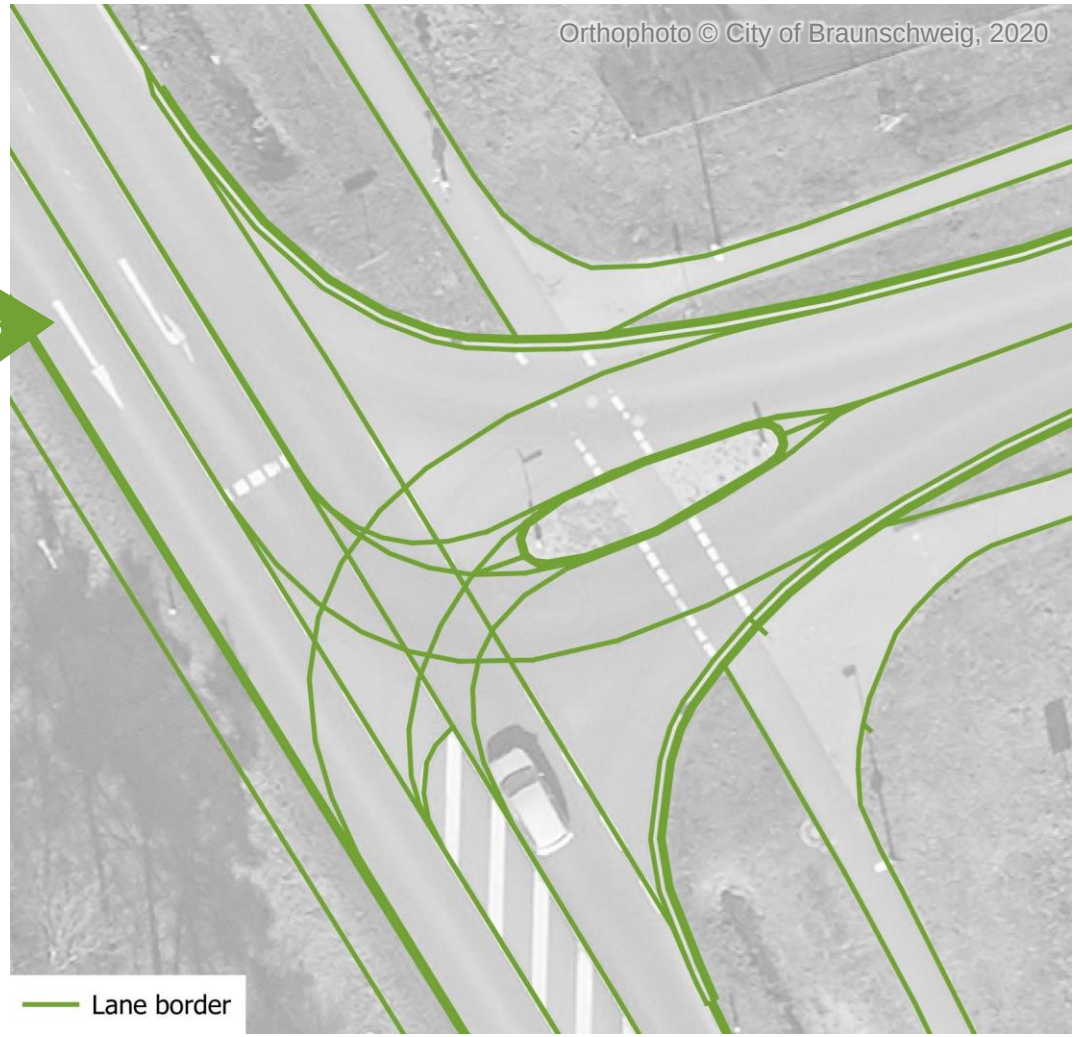
```
LineString(
   604944.1037 5792860.1272,
   604752.81 5792819.10, ...)

LineString(
  604935.03 5792856.5285,
  604754.39 5792810.73, ...)
```

Simple Features Model

Make OpenDRIVE geometries GISable
Voilà

straight into **GIS**



Simple Feature type	OpenDRIVE element
`Point`	`signal`
`LineString`	`referenceLine` `laneBorder`

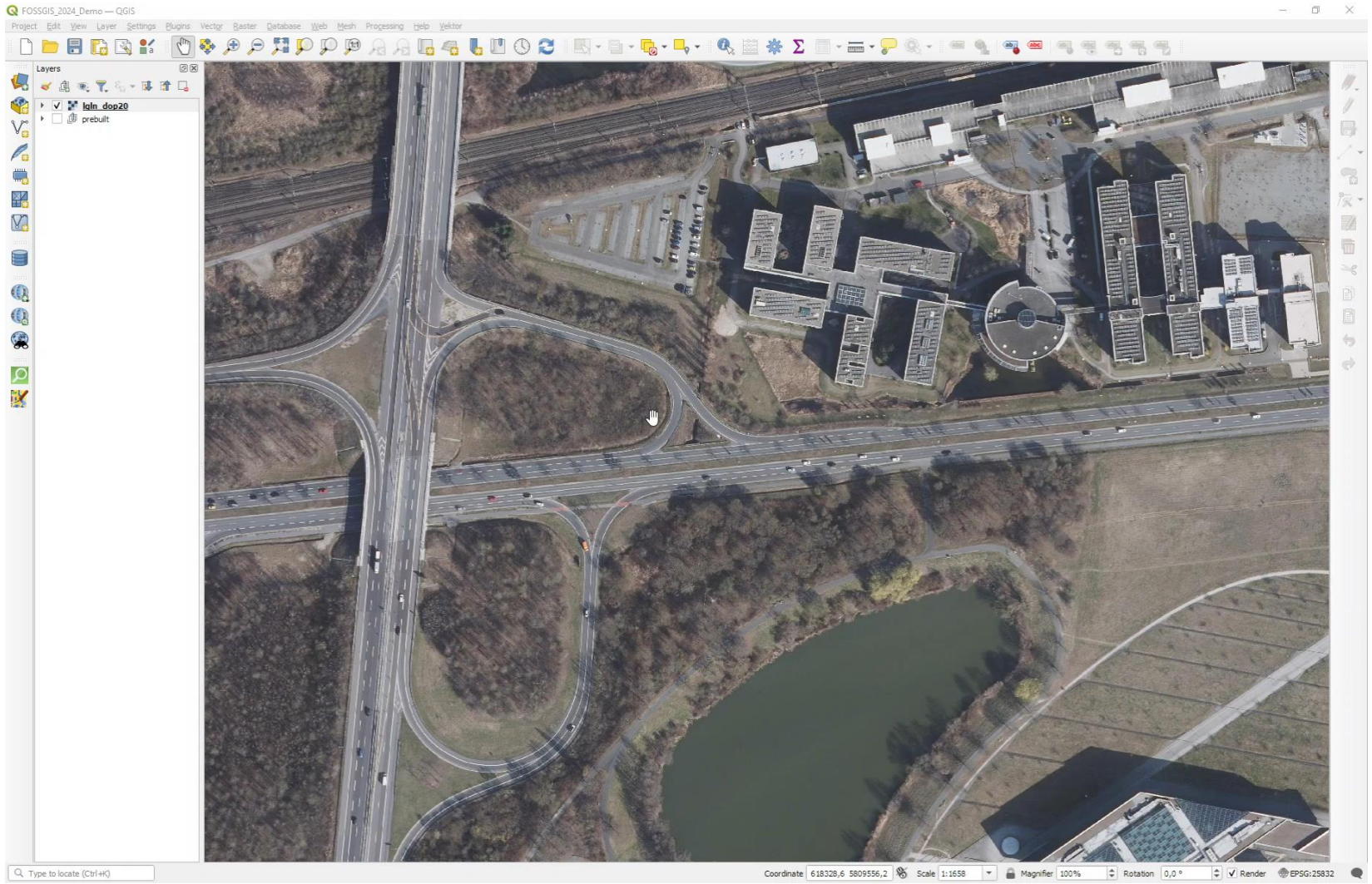
`Polygon`	`lane`
	`roadMark`
	`roadObject`

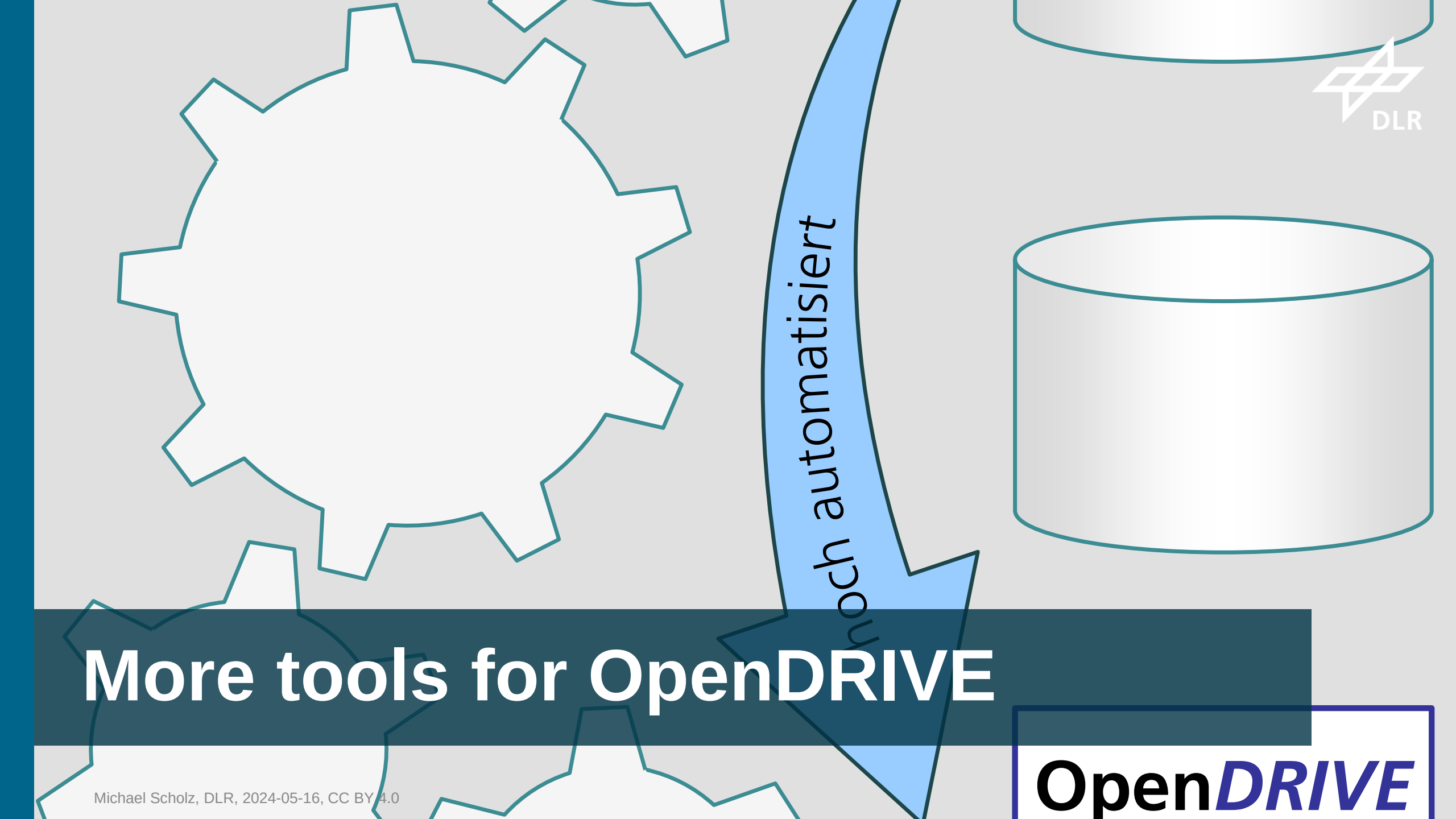
Make OpenDRIVE geometries GISable

Try it out!

dlr-ts.github.io/gdal-opendrive-how-to

Make OpenDRIVE geometries GISable
QGIS demo





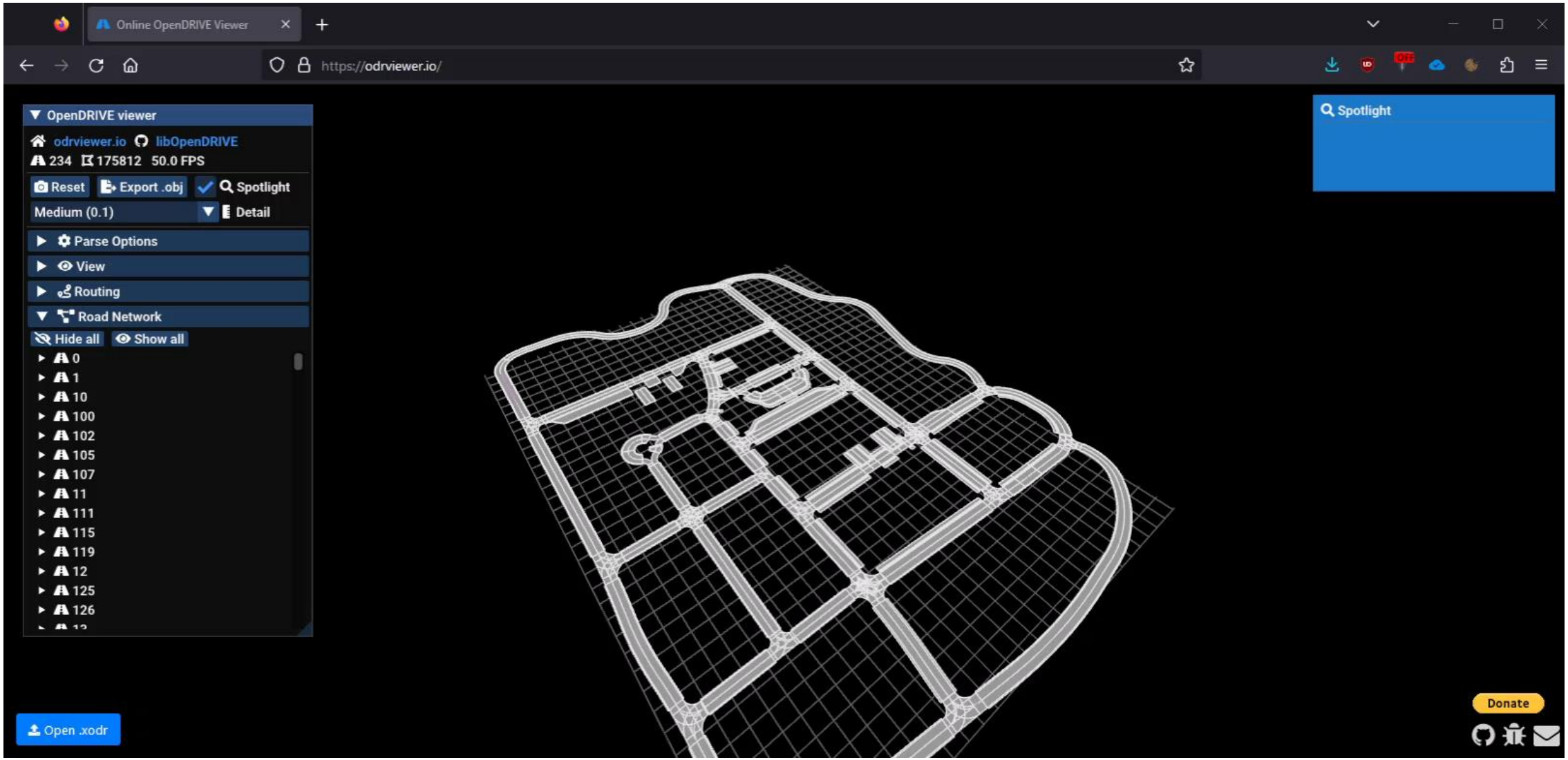
More tools for OpenDRIVE

OpenDRIVE

Tools for OpenDRIVE

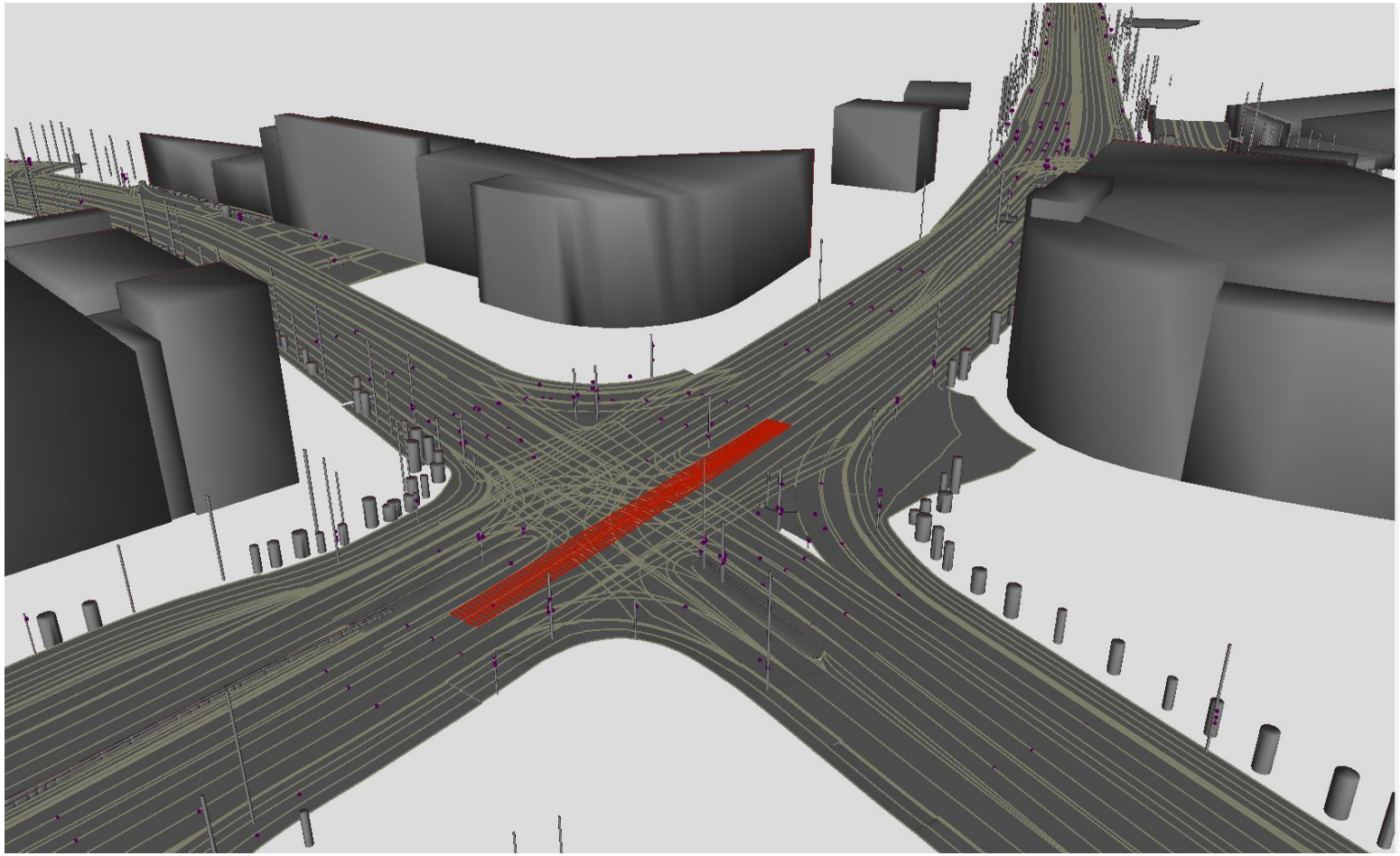
- Growing community: github.com/beneschwab/awesome-openx 

Tools for OpenDRIVE
odrviewer.io, also using libOpenDRIVE



Tools for OpenDRIVE

r:trån, conversion to CityGML with comprehensive validation



Property	Value
Feature Type	Road
Coordinate System	EPSG:32632
Dimension	3D
Number of Vertices	768
Min Extents	678819.6072548759, 5405772.029156608, 418.7514057725761
Max Extents	678866.4587420645, 5405787.700486677, 418.97760792542…
Attributes (60)	
citygml_feature_role (encoded: UTF-16LE)	cityObjectMember
citygml_level_of_detail{0} (encoded: UTF-16LE)	2
citygml_target_uri (encoded: UTF-16LE)	http://www.opengis.net/citygml/transportation/2.0
fme_geometry (string)	fme_aggregate
fme_type (string)	fme_surface
gml_id (encoded: UTF-16LE)	UUID_065ce01e-2791-4eb6-8cb0-63f208c85e16
gml_name (encoded: UTF-16LE)	LaneSurface
gml_parent_id (encoded: UTF-16LE)	fme-gen-1527720d-ec1a-409c-8b71-8184256fc0a4
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opendrive_identifier_laneSectionId (encoded: UTF-16LE)	3
opendrive_identifier_modelDate (encoded: UTF-16LE)	13-06-18
opendrive_identifier_modelName (encoded: UTF-16LE)	SAVe_Ingolstadt
opendrive_identifier_modelVendor (encoded: UTF-16LE)	3D Mapping Solutions
opendrive_identifier_roadId (encoded: UTF-16LE)	3124021
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opendrive_lane_roadMark_color_3 (encoded: UTF-16LE)	STANDARD
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opendrive_lane_roadMark_color_5 (encoded: UTF-16LE)	STANDARD
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opendrive_lane_roadMark_material_3 (encoded: UTF-16LE)	standard
opendrive_lane_roadMark_material_4 (encoded: UTF-16LE)	standard
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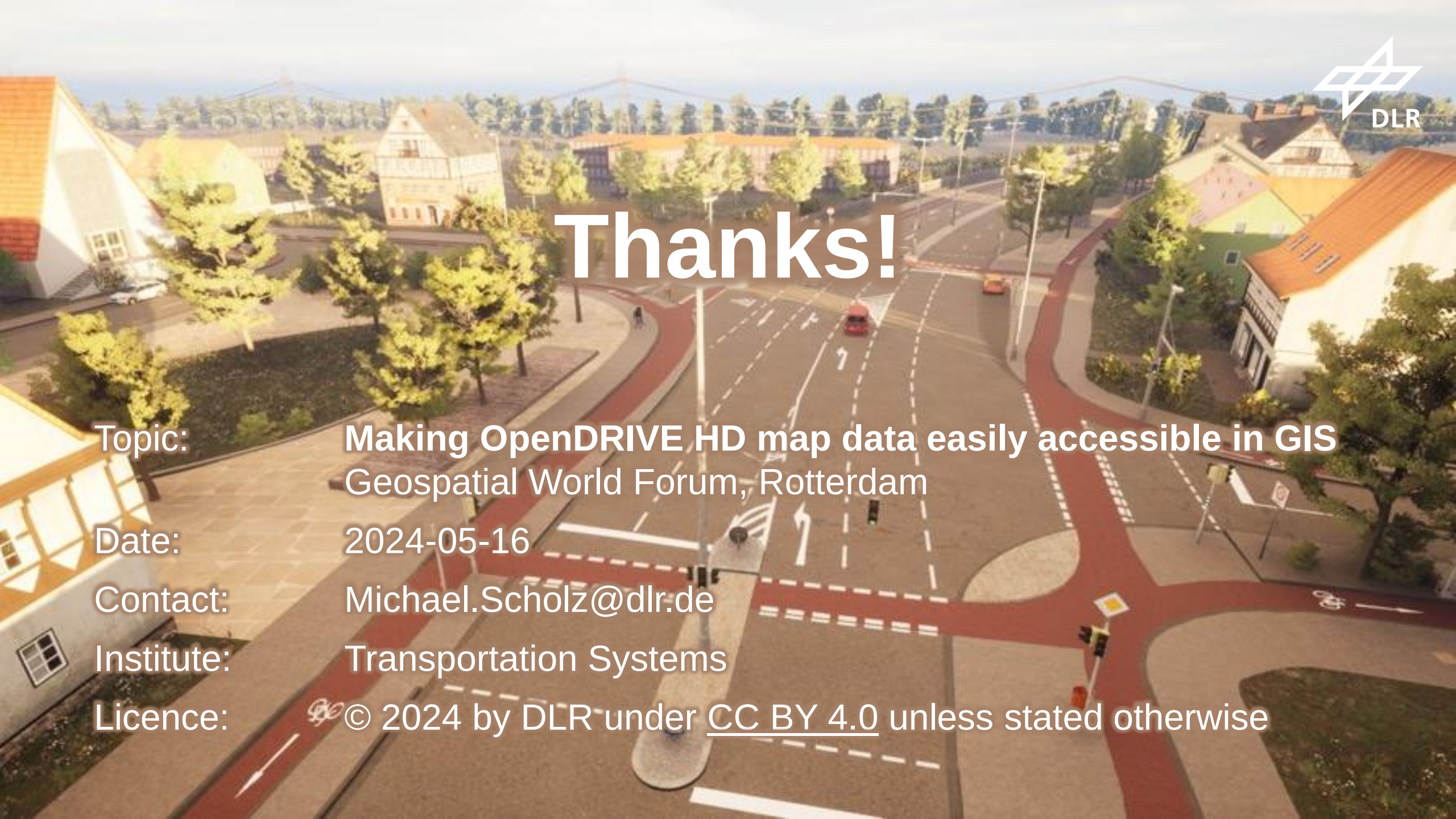
opendrive_lane_roadMark_type_1 (encoded: UTF-16LE)	BROKEN
opendrive_lane_roadMark_type_2 (encoded: UTF-16LE)	NONE
opendrive_lane_roadMark_type_3 (encoded: UTF-16LE)	BROKEN
opendrive_lane_roadMark_type_4 (encoded: UTF-16LE)	NONE
opendrive_lane_roadMark_type_5 (encoded: UTF-16LE)	BROKEN
opendrive_lane_roadMark_weight_0 (encoded: UTF-16LE)	STANDARD

Features Selected: 1 of 1

DOI 10.5281/zenodo.7702313

What’s next?

- Initial idea originated in 2017: elib.dlr.de/110123
- Stronger coupling of OpenDRIVE with CityGML 3.0 together with ASAM
- Subject in new OGC “Transportation and Mobility Domain Working Group“?
- Similar GDAL driver for railML and other domain-specific models? …



Thanks!

Topic: **Making OpenDRIVE HD map data easily accessible in GIS**
Geospatial World Forum, Rotterdam

Date: 2024-05-16

Contact: Michael.Scholz@dlr.de

Institute: Transportation Systems