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Making OpenDRIVE HD map data easily accessible in GIS

Geospatial World Forum, Tech Session: HD Mapping

2024-05-16, Rotterdam

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Institute of Transportation Systems

Our research infrastructure



STADTBELEUCHTUNG 902945

Source: BS | Energy

LICHTSIGNALANLAGE 25139

Source: BELLIS

VORFAHRT 51236

Source: BELLIS

Fahrbahnmarkierung 85736A

GEBÄUDE 7267839

Source: Geoinformation Braunschweig

GELÄNDEMDELL

Source: Geoinformation Braunschweig

OpenDRIVE applications

OpenDRIVE applications

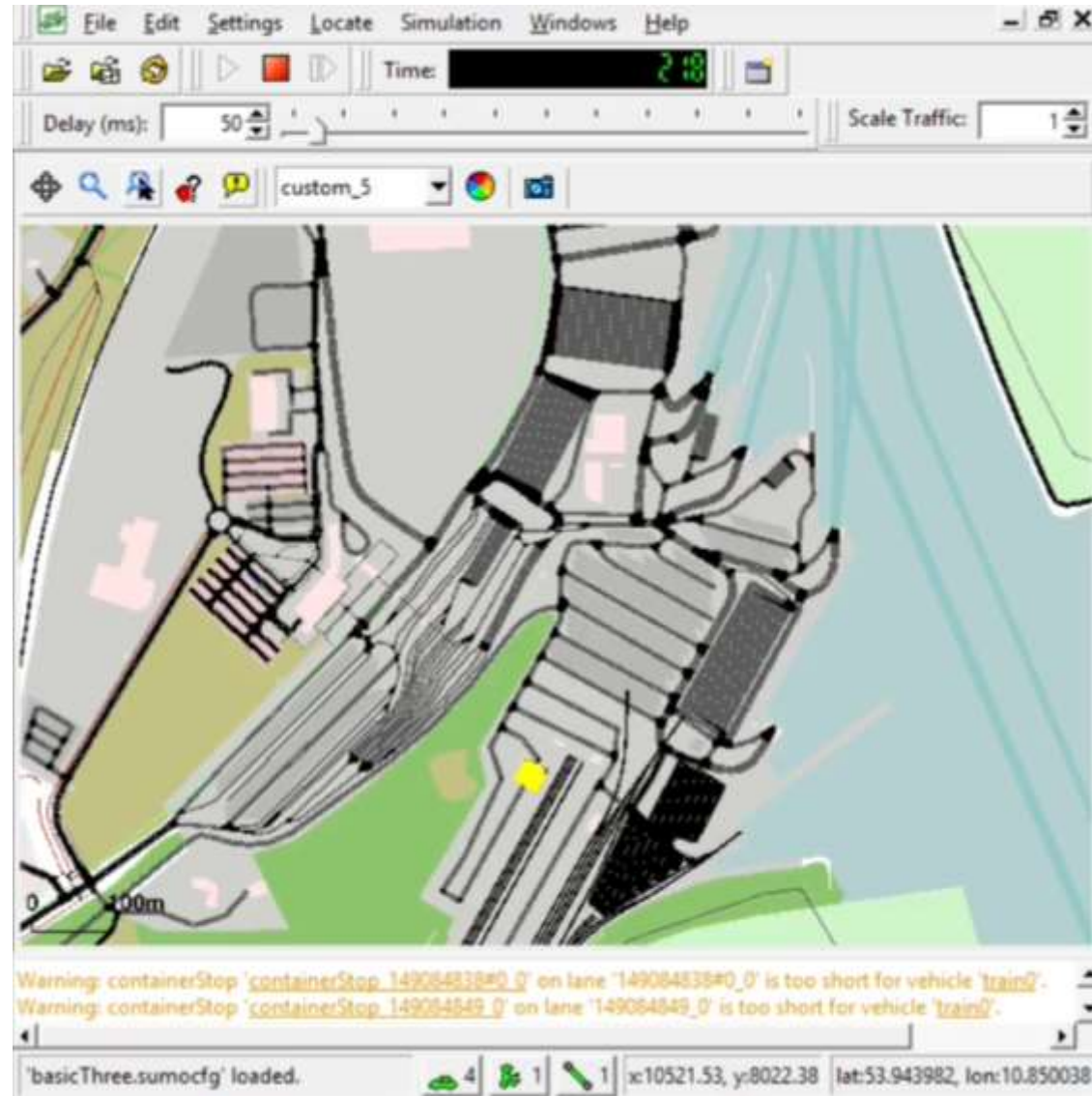
Urban digital twin for simulation



<https://youtu.be/LDSvDEsvnig>

OpenDRIVE applications

Microscopic traffic simulation → SUMO



OpenDRIVE applications

Automated driving

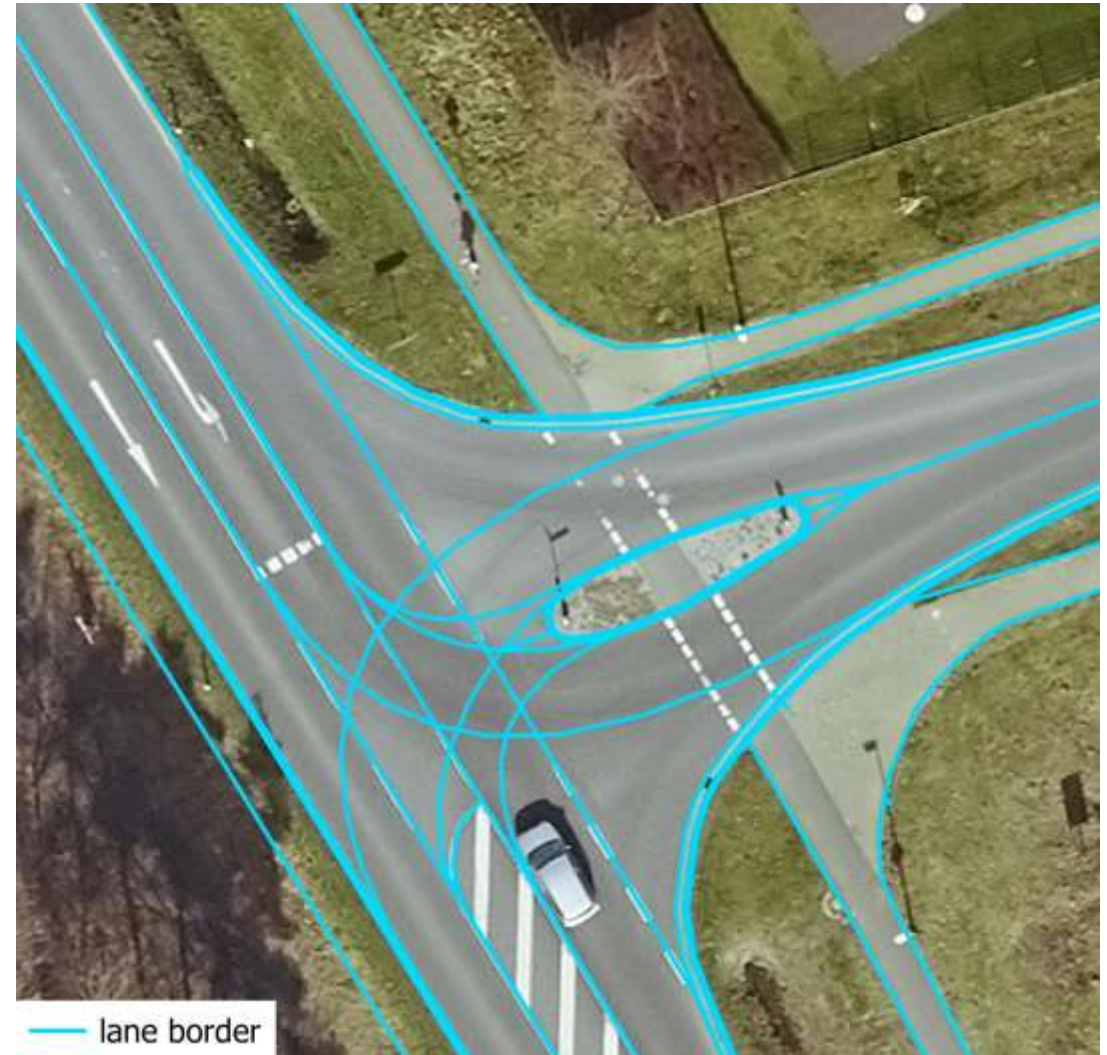


<https://youtu.be/RDXXBqL42W8>

What does “HD” mean?

Modelling of road space on lane level

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



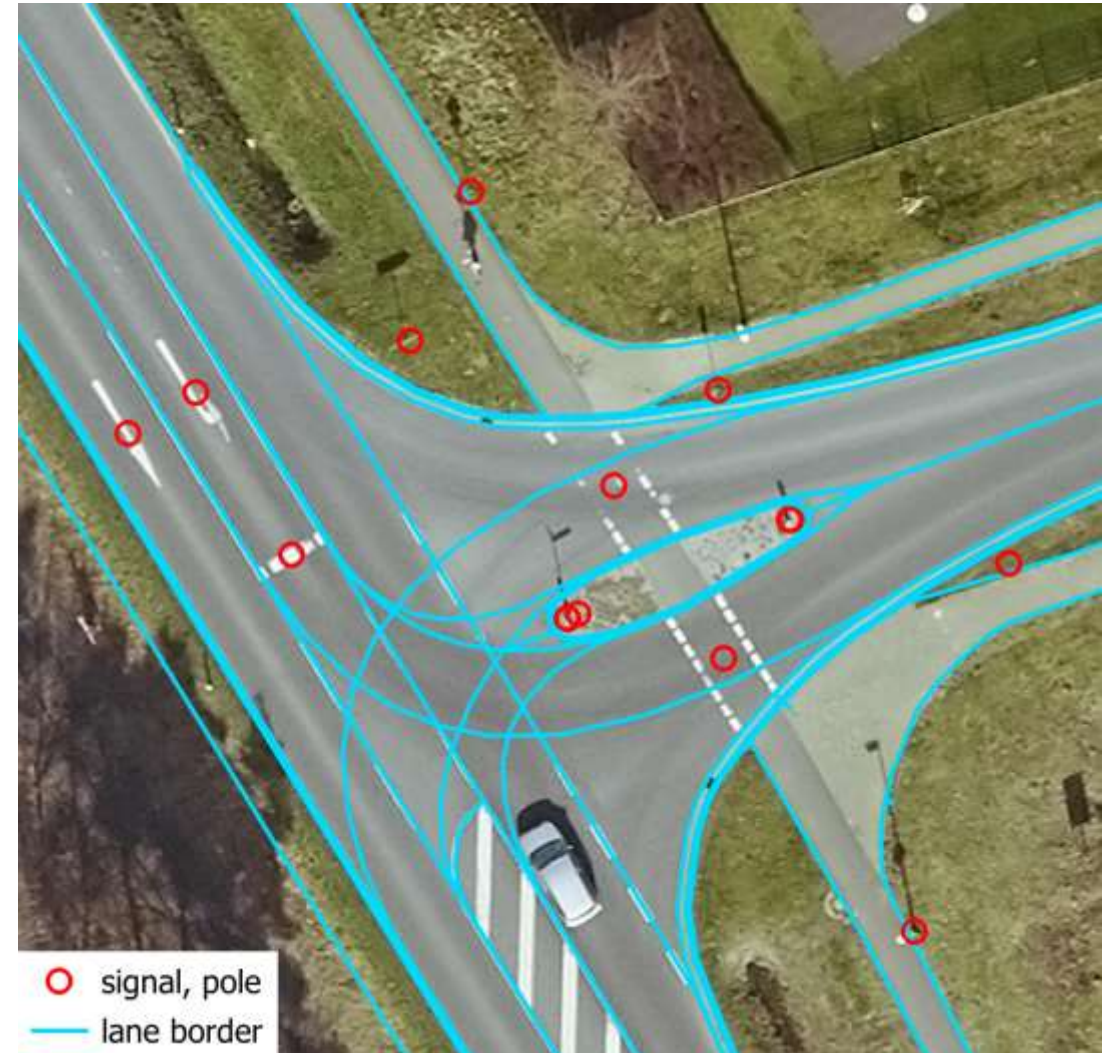
What does “HD” mean?

Modelling of road space on lane level

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

Including traffic infrastructure

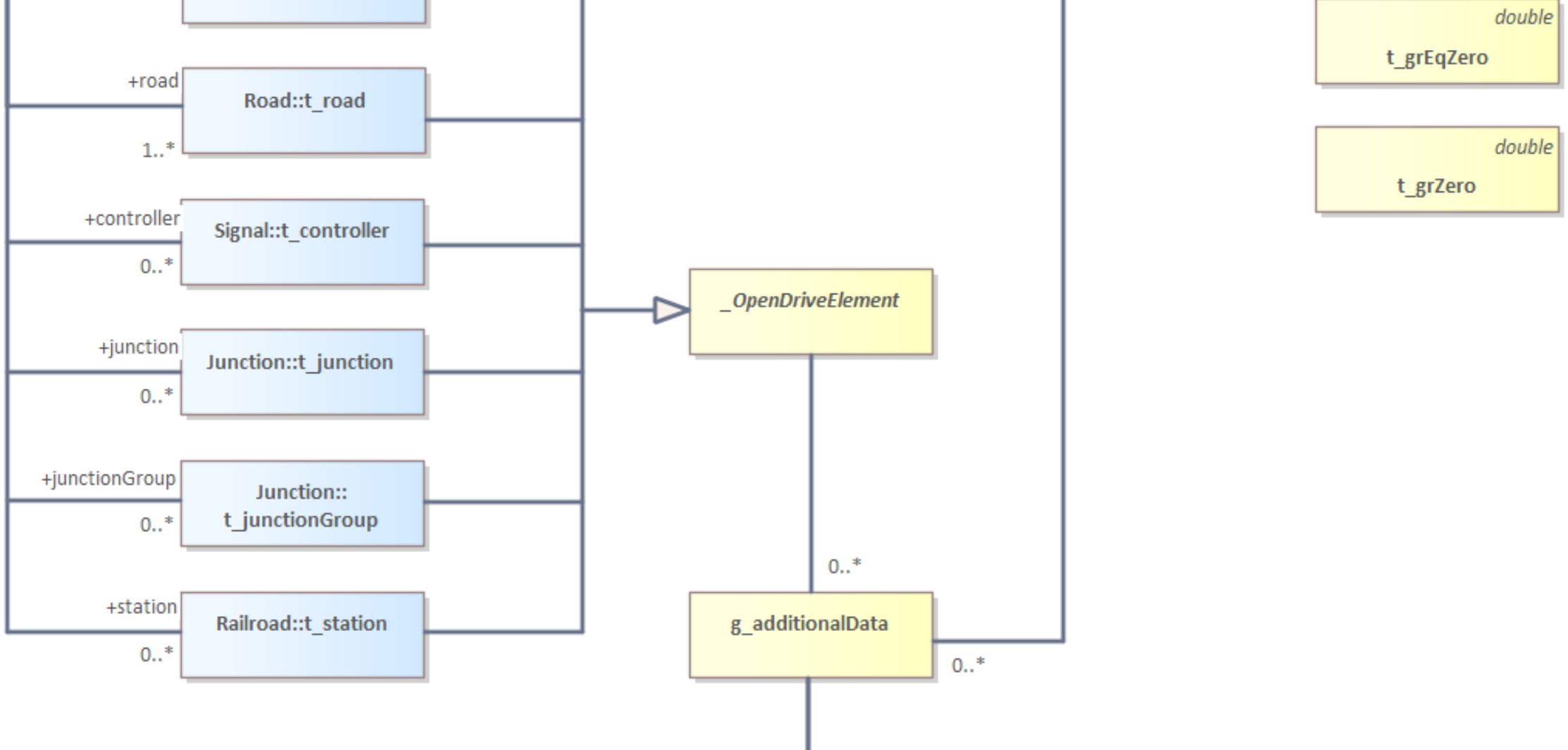
- Road markings
- Signals and signs
- Poles, bollards



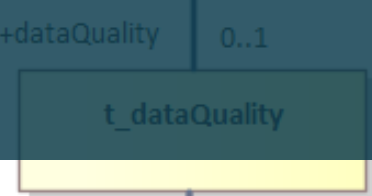
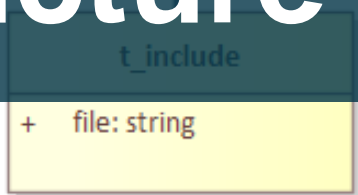
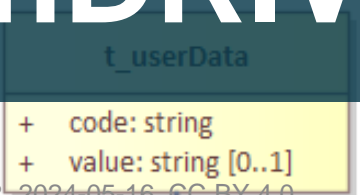
A “problem” with different perspectives



- 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"/>
    </geometry>
  </planView>
  <elevationProfile>
  </elevationProfile>
  <lateralProfile/>
  <lanes>
    <laneSection>
      <left>
        <lane id="7" type="border">
        </lane>
        <lane id="6" type="shoulder">
        </lane>
        <lane id="5" type="stop">
        </lane>
        <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>
        </lane>
      </left>
    </laneSection>
  </lanes>
</road>
```

Hierarchical data model

With many cross-references



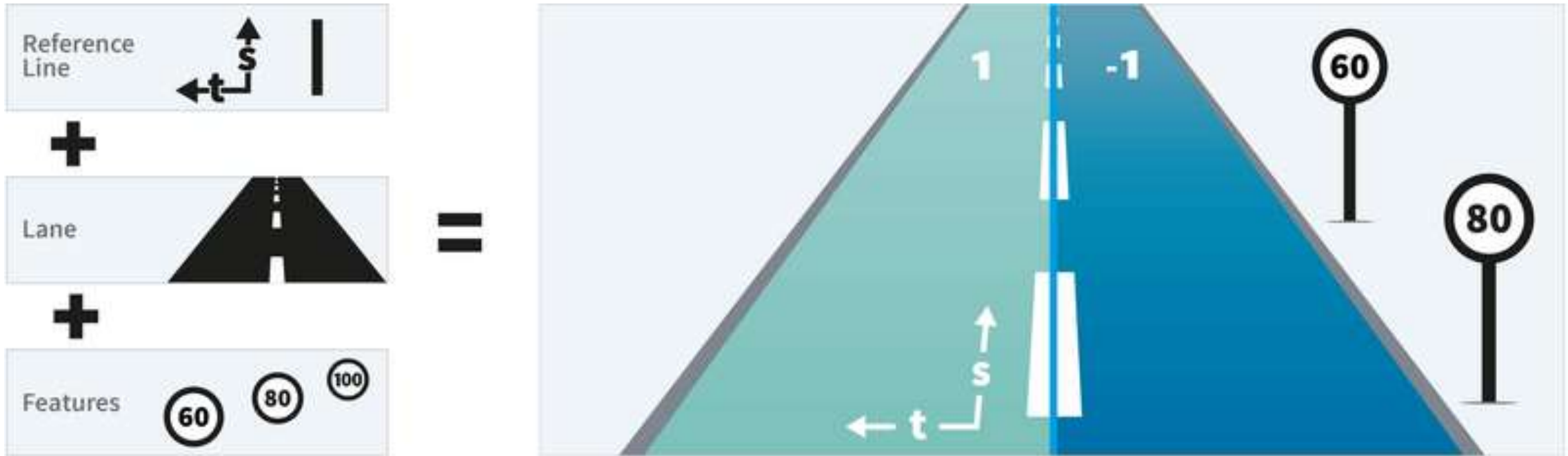
```
<road name="Boulevard of Rock" length="66.6"  
  <link>  
    <predecessor elementType="junction" e  
    <successor elementType="junction" ele  
  </link>
```

```
<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"/>
```

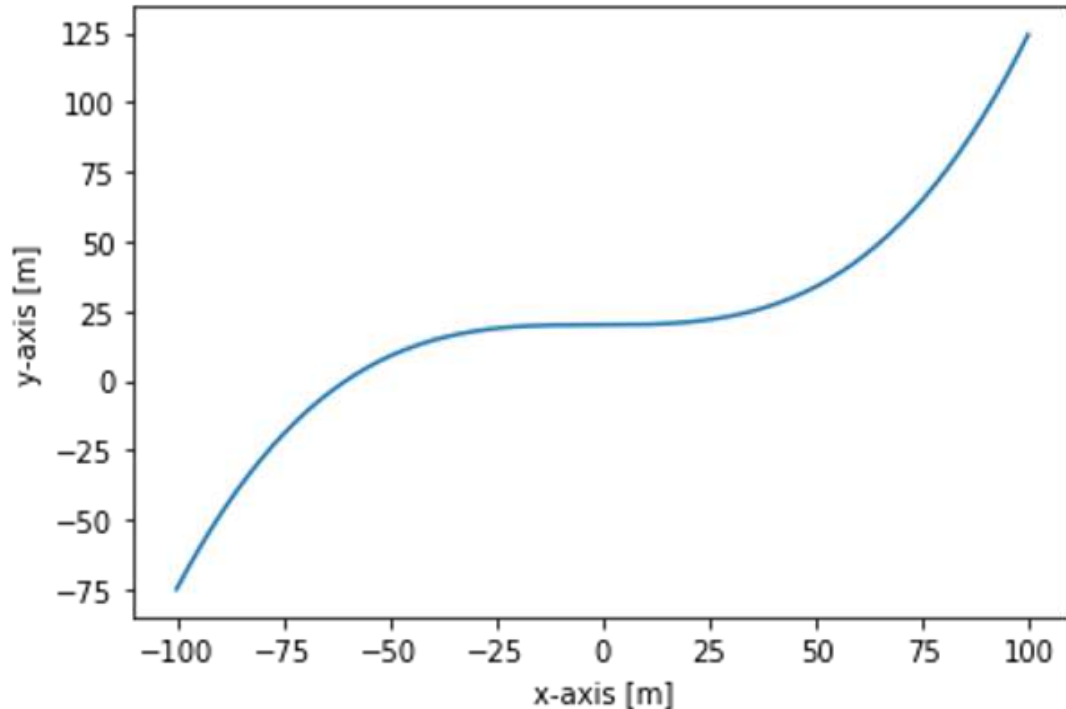
Linearly referenced geometries



© ASAM e. V.

Parametric geometries

Cubic polynomials



© ASAM e. V.

```
<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

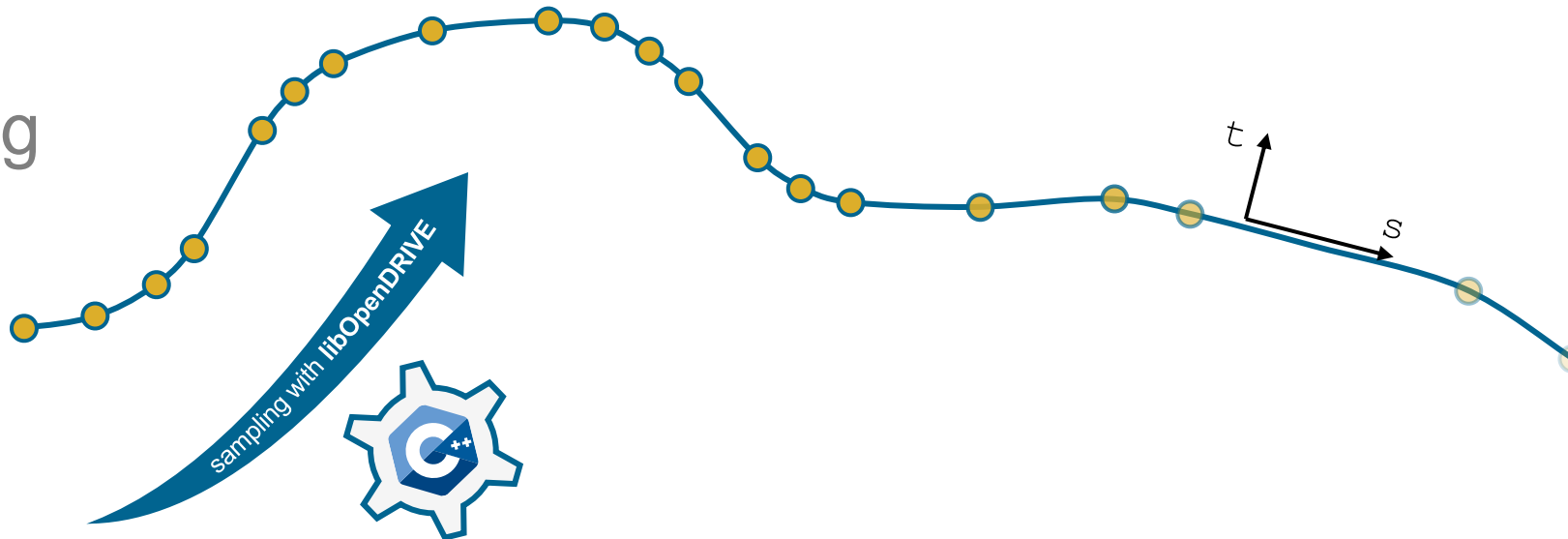
DOI 10.5281/zenodo.7771708

The screenshot shows the GitHub repository page for `pageldev / libOpenDRIVE`. The repository is public and has 19 watchers, 129 forks, and 345 stars. The repository description is "Small, lightweight C++ library for handling OpenDRIVE files". The repository includes tags for `library`, `cpp`, `opendrive`, and `xodr`. The repository also has a README and is licensed under Apache-2.0.

The repository page shows the following details:

- Repository name: `libOpenDRIVE` (Public)
- Watchers: 19
- Forks: 129
- Stars: 345
- Repository description: Small, lightweight C++ library for handling OpenDRIVE files
- Tags: `library`, `cpp`, `opendrive`, `xodr`
- Repository actions: `Code`, `Issues` (16), `Pull requests` (3), `Actions`, `Projects`, `Security`
- Repository files: `include` (Rename Signal t... 6 months ago), `src` (added std prefix... 4 months ago), `thirdparty` (rename Thirdpa... last year)

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">
```

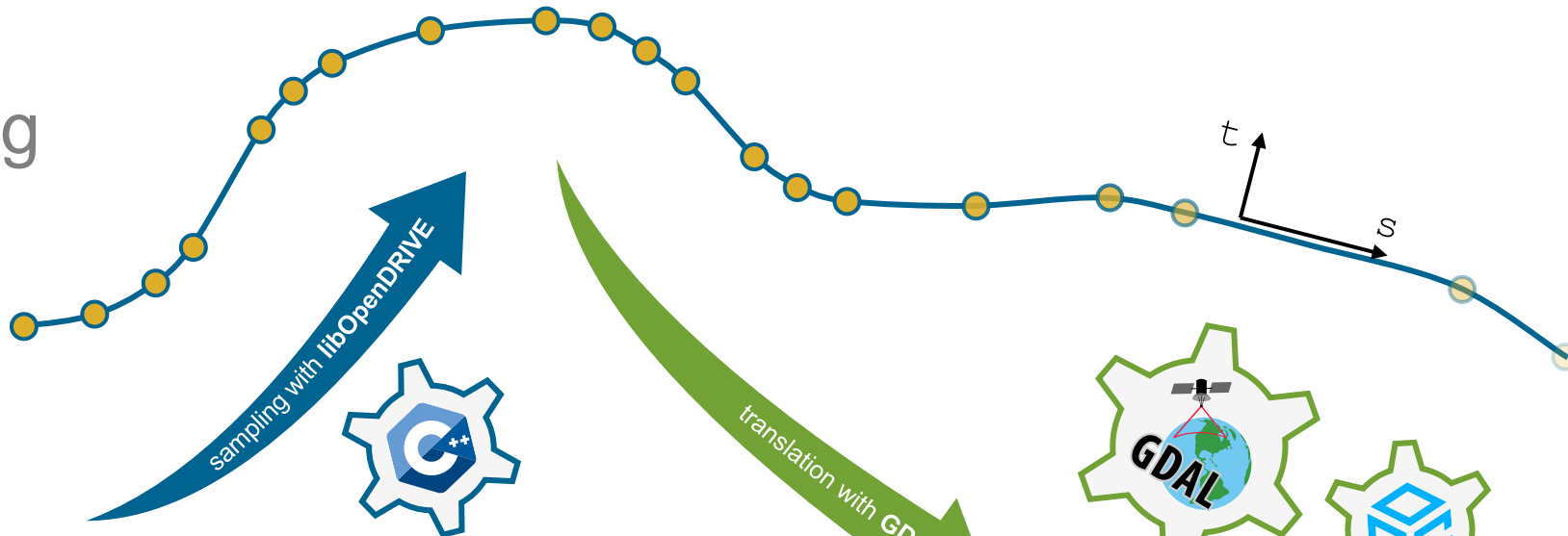
```
</line/>
```

```
</geometry>
```

```
</planView>
```

OpenDRIVE Model

Sampling



```

<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">
  </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

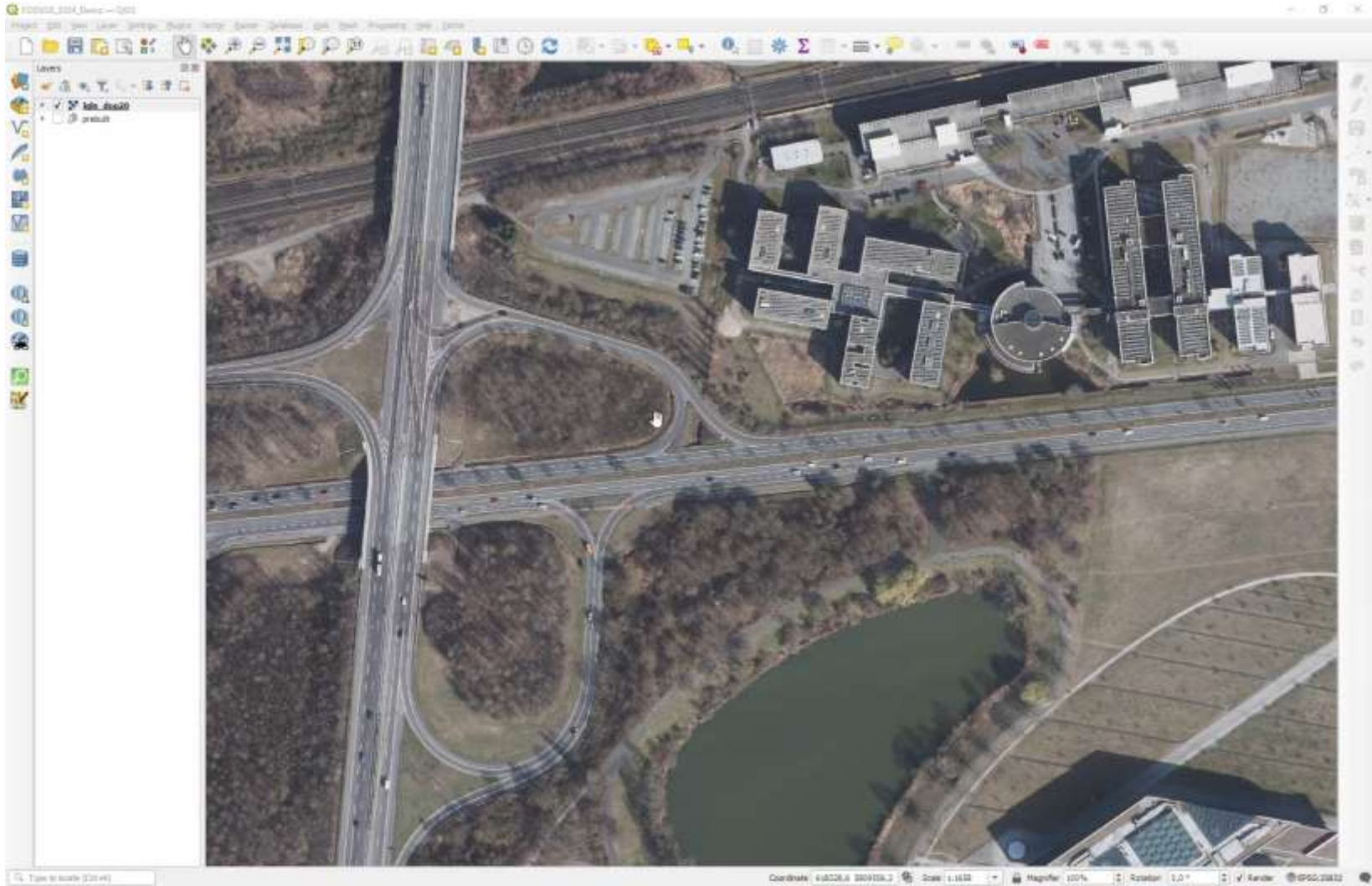
Try it out!



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

Make OpenDRIVE geometries GISable

QGIS demo



noch automatisiert

More tools for OpenDRIVE

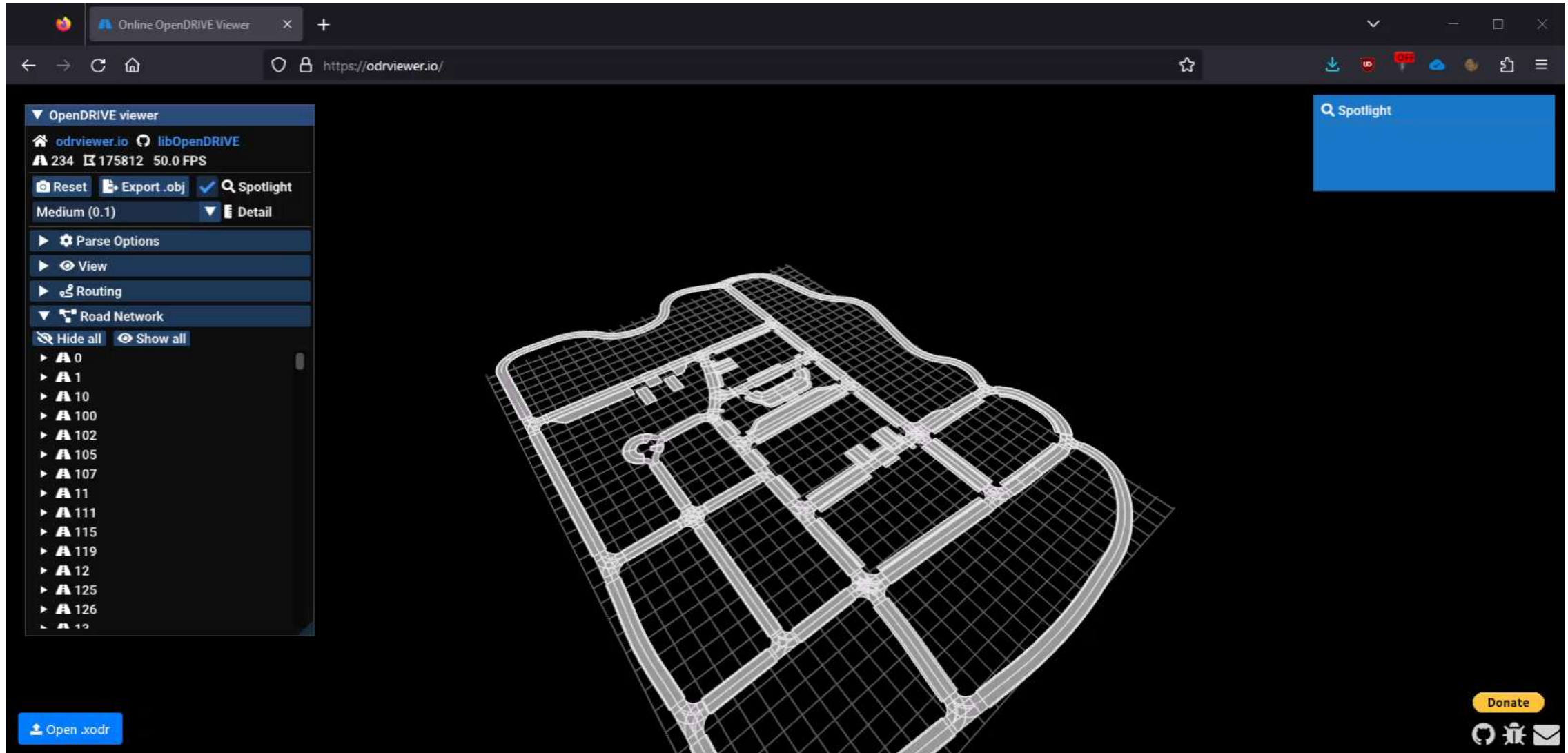
Tools for OpenDRIVE



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

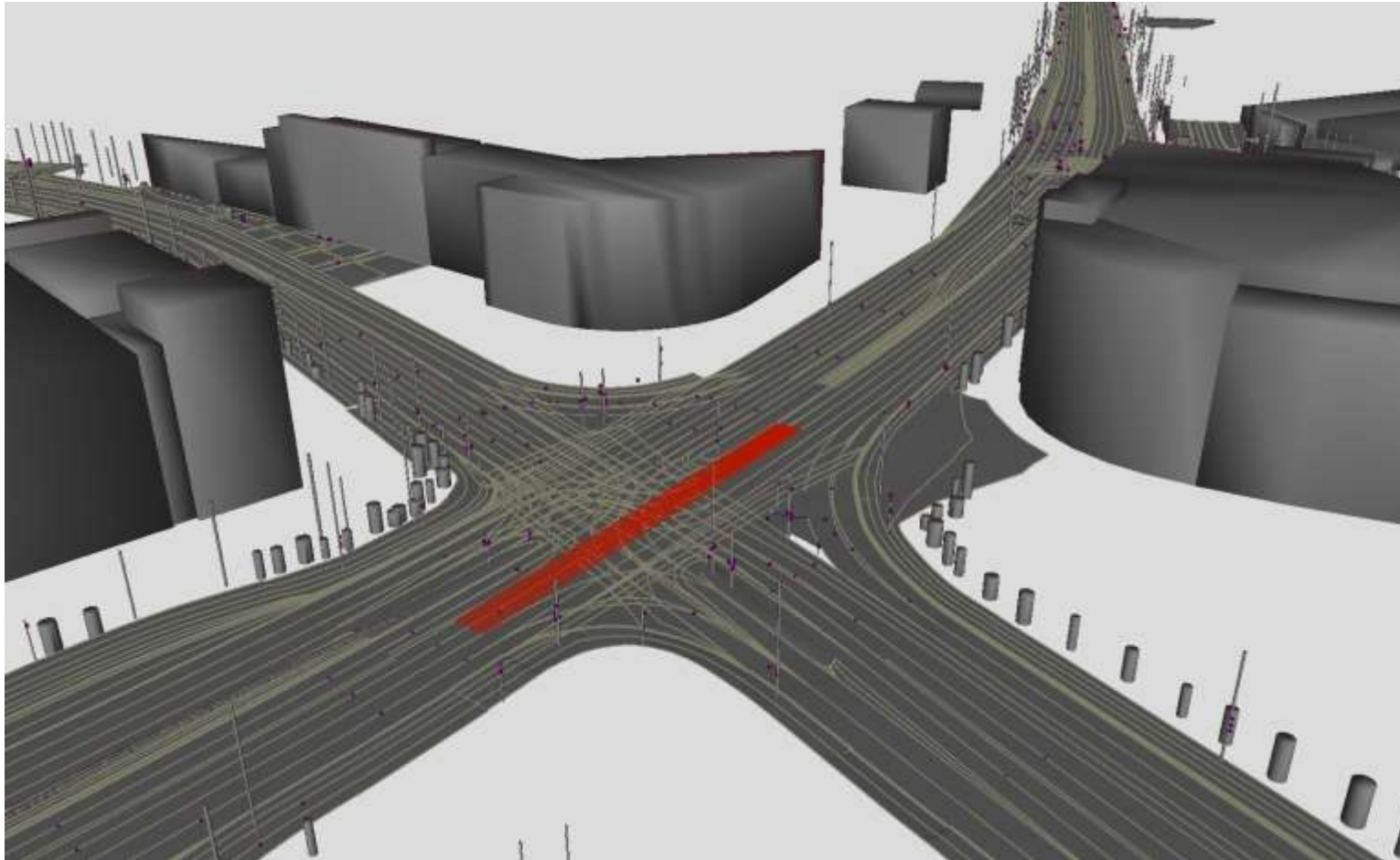
Tools for OpenDRIVE

odrviewer.io, also using libOpenDRIVE



Tools for OpenDRIVE

r:trân, conversion to CityGML with comprehensive validation



Property	Value
Feature Type	Road
Coordinate System	EPSG:32632
Dimension	3D
Number of Vertices	768
Min Extents	878819.5072548758, 5405772.029155808, 418.7514057225761
Max Extents	678886.4587420645, 5405787.700486677, 218.97760792342...
Attributes (60)	
citygml_feature_role (encoded: UTF-16LE)	cityObjectName
citygml_level_of_detail (encoded: UTF-16LE)	3
citygml_target_url (encoded: UTF-16LE)	https://www.openh.net/citygml/transportation/2.0
file_geometry (string)	file_surface
file_type (string)	file_surface
gml_id (encoded: UTF-16LE)	UJAD_065m01e-2791-4e56-8cd0-63f208c9e18
gml_name (encoded: UTF-16LE)	LaneSurface
gml_srsName (encoded: UTF-16LE)	urn:ogc:1.3:2008-06-01:4386-8B71-81842586c04
opendrive_idenfur_laneid (encoded: UTF-16LE)	-1
opendrive_idenfur_laneSectionid (encoded: UTF-16LE)	3
opendrive_idenfur_modelData (encoded: UTF-16LE)	13-06-18
opendrive_idenfur_modelName (encoded: UTF-16LE)	3D Mapping Solutions
opendrive_idenfur_modelVendor (encoded: UTF-16LE)	3D Mapping Solutions
opendrive_idenfur_roadid (encoded: UTF-16LE)	3124021
opendrive_idenfur_sourceFilename (encoded: UTF-16LE)	3124021
opendrive_idenfur_sourceFilename (encoded: UTF-16LE)	3124021
opendrive_lane_level (encoded: UTF-16LE)	3
opendrive_lane_material_curvePositionStart_0 (encoded: UTF-16LE)	0.0
opendrive_lane_material_friction_0 (encoded: UTF-16LE)	1.0
opendrive_lane_material_roughness_0 (encoded: UTF-16LE)	0.0
opendrive_lane_material_surface_0 (encoded: UTF-16LE)	asphalt
opendrive_lane_roadMark_color_0 (encoded: UTF-16LE)	STANDARD
opendrive_lane_roadMark_color_1 (encoded: UTF-16LE)	STANDARD
opendrive_lane_roadMark_color_2 (encoded: UTF-16LE)	STANDARD
opendrive_lane_roadMark_color_3 (encoded: UTF-16LE)	STANDARD
opendrive_lane_roadMark_color_4 (encoded: UTF-16LE)	STANDARD
opendrive_lane_roadMark_color_5 (encoded: UTF-16LE)	STANDARD
opendrive_lane_roadMark_curvePositionStart_0 (encoded: UTF-16LE)	0.0
opendrive_lane_roadMark_curvePositionStart_1 (encoded: UTF-16LE)	4.9348
opendrive_lane_roadMark_curvePositionStart_2 (encoded: UTF-16LE)	9.912
opendrive_lane_roadMark_curvePositionStart_3 (encoded: UTF-16LE)	15.8268
opendrive_lane_roadMark_curvePositionStart_4 (encoded: UTF-16LE)	24.9801
opendrive_lane_roadMark_curvePositionStart_5 (encoded: UTF-16LE)	34.0587
opendrive_lane_roadMark_material_0 (encoded: UTF-16LE)	standard
opendrive_lane_roadMark_material_1 (encoded: UTF-16LE)	standard
opendrive_lane_roadMark_material_2 (encoded: UTF-16LE)	standard
opendrive_lane_roadMark_material_3 (encoded: UTF-16LE)	standard
opendrive_lane_roadMark_material_4 (encoded: UTF-16LE)	standard
opendrive_lane_roadMark_material_5 (encoded: UTF-16LE)	standard
opendrive_lane_roadMark_type_0 (encoded: UTF-16LE)	NONE
opendrive_lane_roadMark_type_1 (encoded: UTF-16LE)	NONE
opendrive_lane_roadMark_type_2 (encoded: UTF-16LE)	NONE
opendrive_lane_roadMark_type_3 (encoded: UTF-16LE)	NONE
opendrive_lane_roadMark_type_4 (encoded: UTF-16LE)	NONE
opendrive_lane_roadMark_type_5 (encoded: UTF-16LE)	NONE
opendrive_lane_roadMark_weight_0 (encoded: UTF-16LE)	STANDARD

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

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