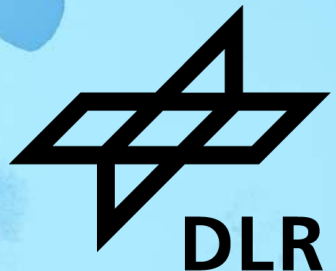


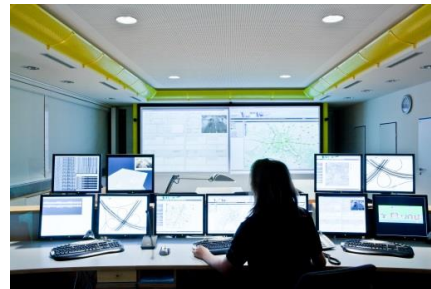
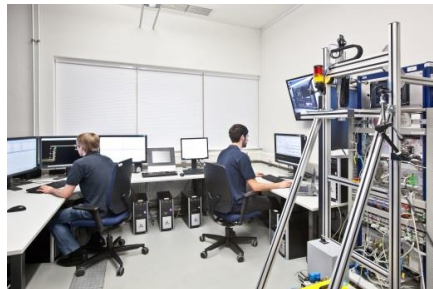
OpenDRIVE-HD-Karten mittels GDAL ins GIS bringen

FOSSGIS, 21.03.2024, Hamburg

Michael Scholz



Forschungsinfrastruktur



- OpenDRIVE-Anwendungsfelder
- OpenDRIVE-Struktur
- GDAL-Treiberimplementierung
- Weitere Tools für OpenDRIVE

STADTBELEUCHTUNG 902945

Source: BS | Energy

x: 605 168.6 r: 15
y: 577 306.24 (UTM)

LICHTSIGNALANLAGE 25139

Source: BELLIS

x: 605 162.71 r: 15
y: 577 297.43 (UTM)

VORFAHRT 51236

Source: BELLIS

x: 605 156.88 r: 30
y: 577 298.07 (UTM)

Fahrbahnmarkierung 85736A

Source: Geoinformation Braunschweig

BÄUDE

7267839

Source: Geoinformation Braunschweig

x: 605 153.39 r: 0
y: 577 302.98 (UTM)

GELÄNDEMÖDELL

Source: Geoinformation Braunschweig

OpenDRIVE-Anwendungsfelder

Anwendung in Fahrsimulation





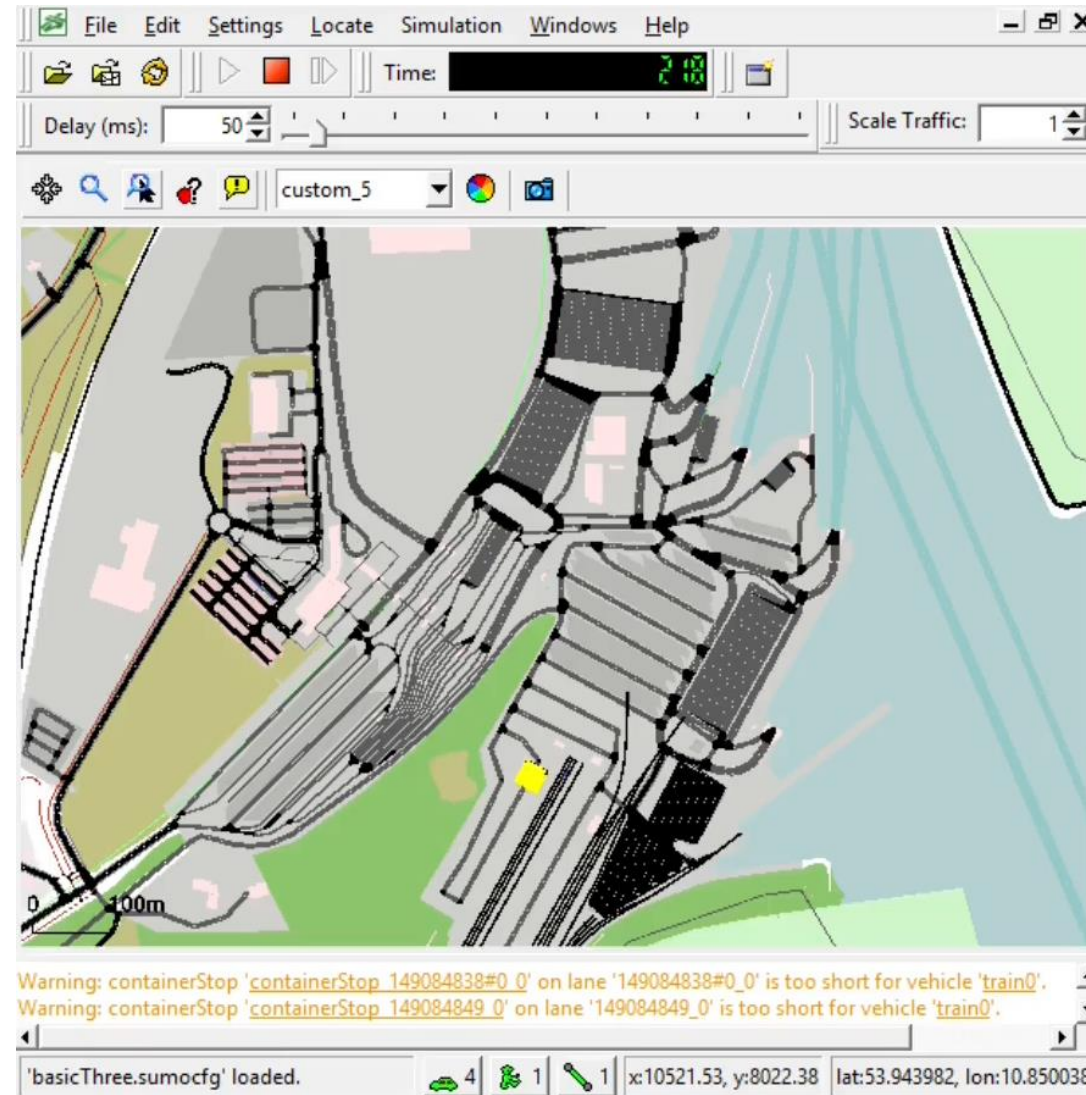
Anwendung in autonomem Fahren



© HOCHBAHN

Anwendung in Verkehrssimulation

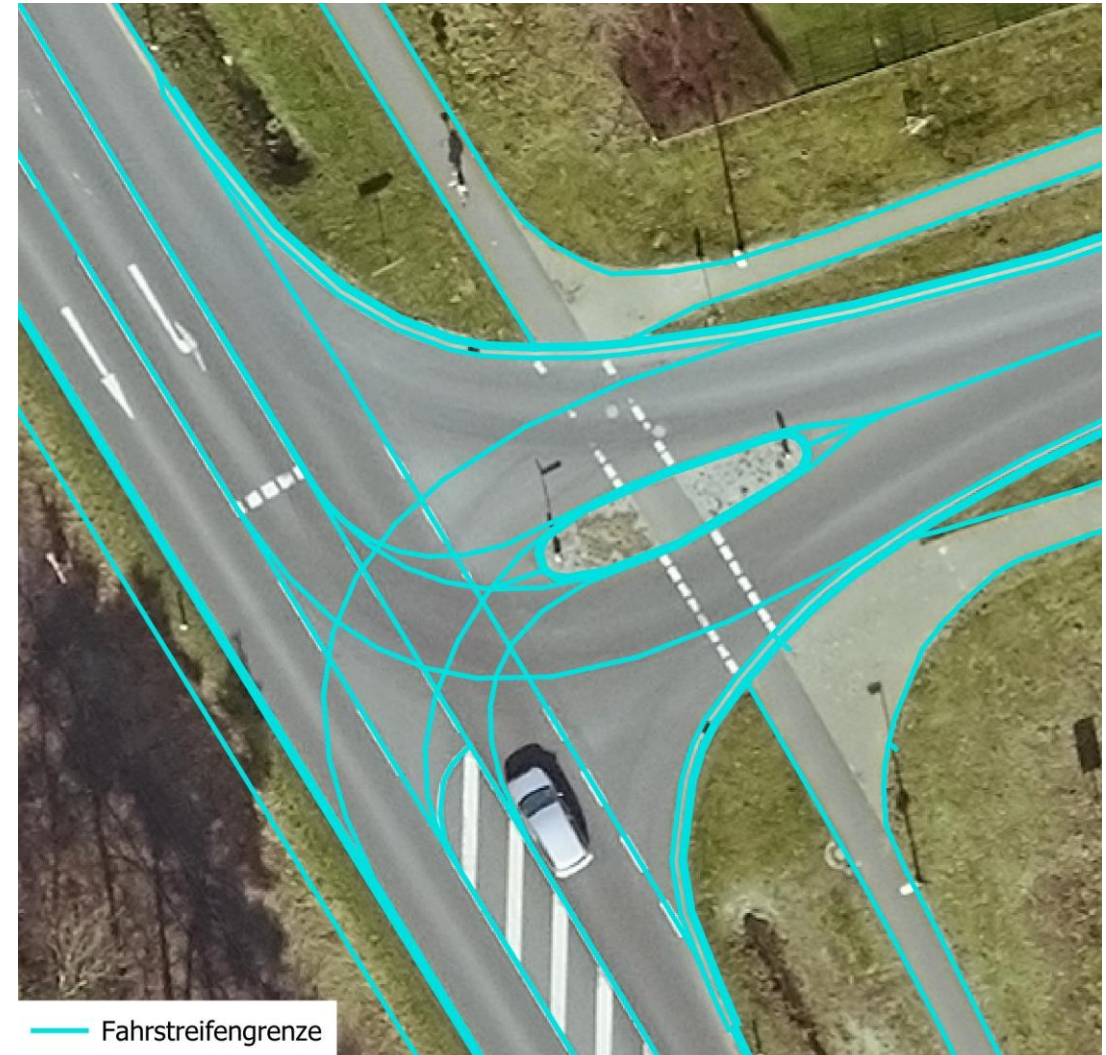
→ [SUMO](#)



Was bedeutet „HD“?

Streifengenaue Verkehrsraummodellierung

- Fahrstreifen
- Radwege
- Fußwege
- Grünstreifen



— Fahrstreifengrenze

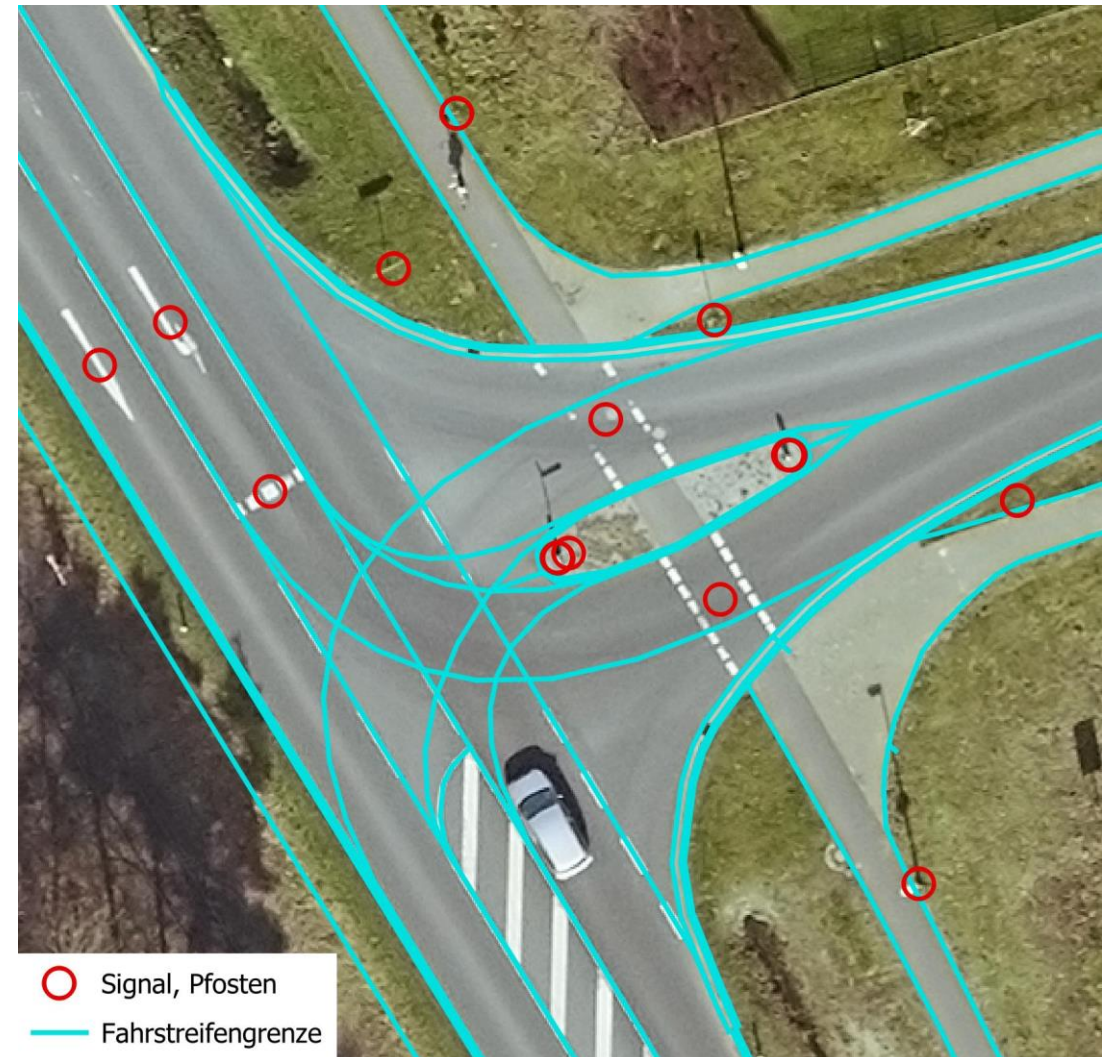
Was bedeutet „HD“?

Streifengenaue Verkehrsraummodellierung

- Fahrstreifen
- Radwege
- Fußwege
- Grünstreifen

Mit Verkehrsinfrastruktur

- Markierungen
- Signale und Schilder
- Pfosten und Masten



Was bedeutet „HD“?

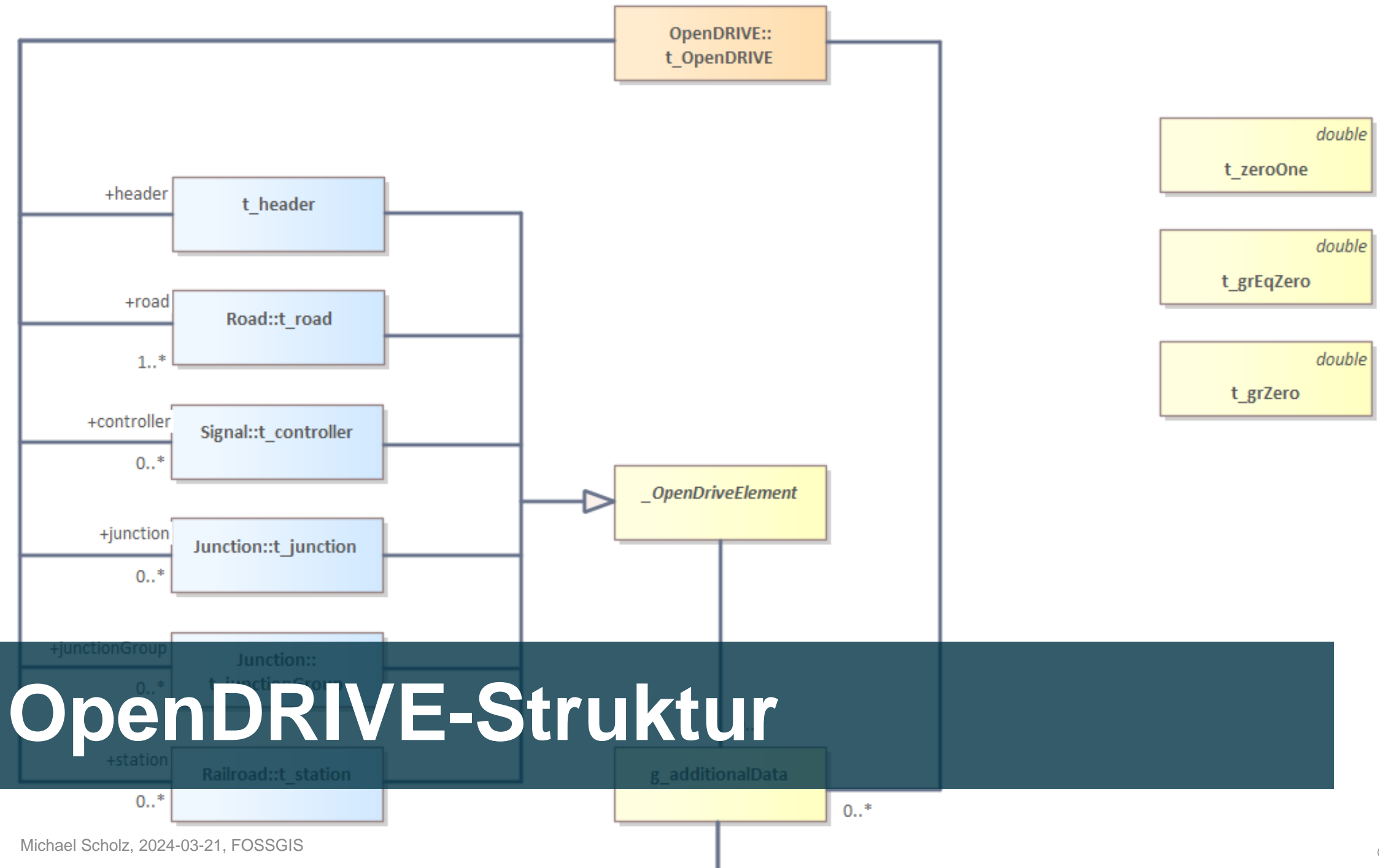


Genauigkeiten

- Anwendungsabhängig 😊
 - Absoluter GNSS-Koordinatenfehler < 20 cm?
 - Relativer Koordinatenfehler < 5 cm?

Datenakquise

- Mobile-Mapping-Dienstleister
- Vorwiegend manuelle Annotation
 - Teuer
 - Langsam



OpenDRIVE-Struktur

Räumliches Koordinatensystem



<geoReference>

<![CDATA[+proj=utm +zone=32 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0 +units=m +no_defs]]>

</geoReference>

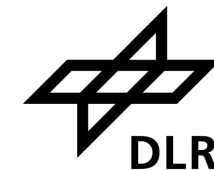
Hierarchisches Datenmodell



```
<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>
```


Hierarchisches Datenmodell

Mit vielen Querverweisen



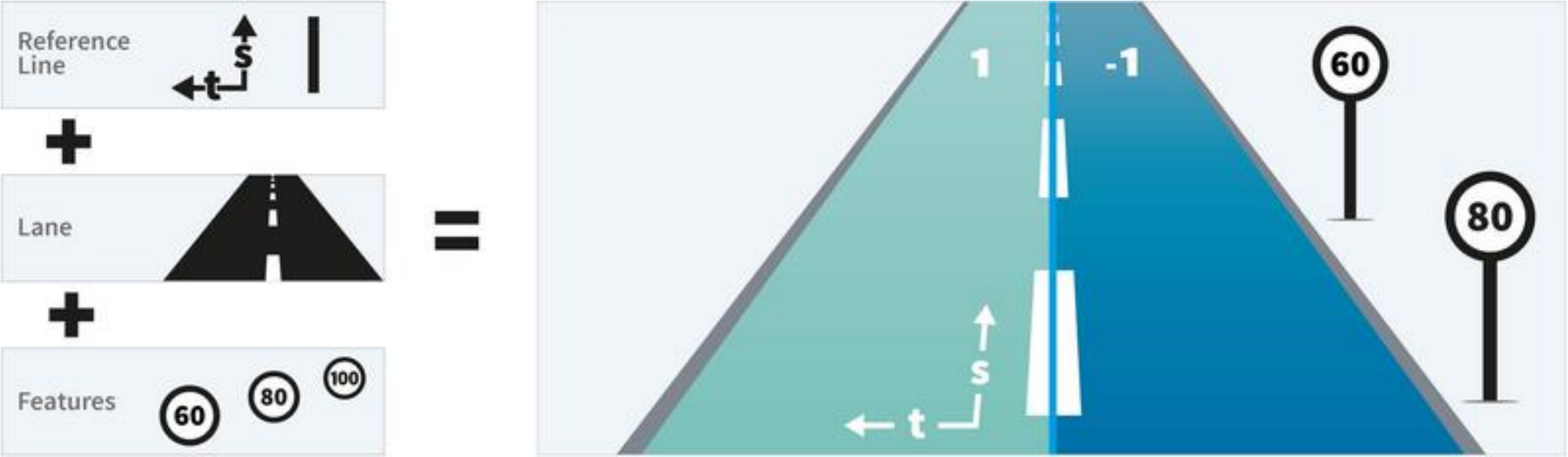
```
<road name="Boulevard of Rock" length="66.6">
  <link>
    <predecessor elementType="junction" id="1234"/>
    <successor elementType="junction" id="5678"/>
  </link>
</road>
```

```
<signal s="0" t="0" id="1337">
  country="LV-426" subtype="-1"
  <laneValidity fromLane="1" toLane="2"/>
</signal>
```

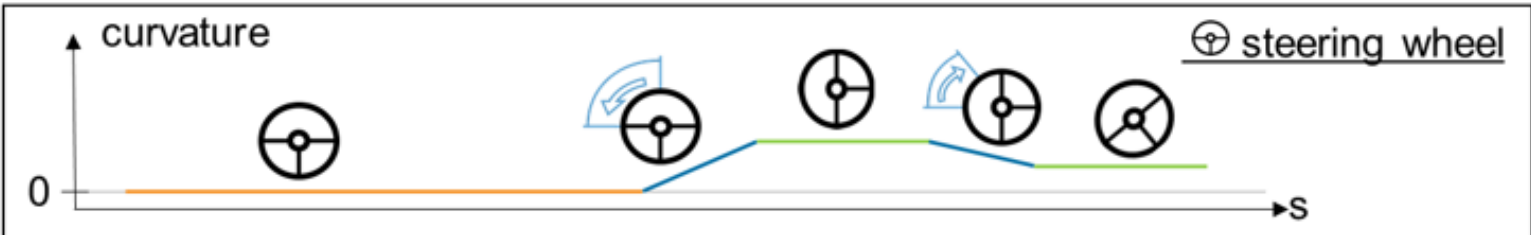
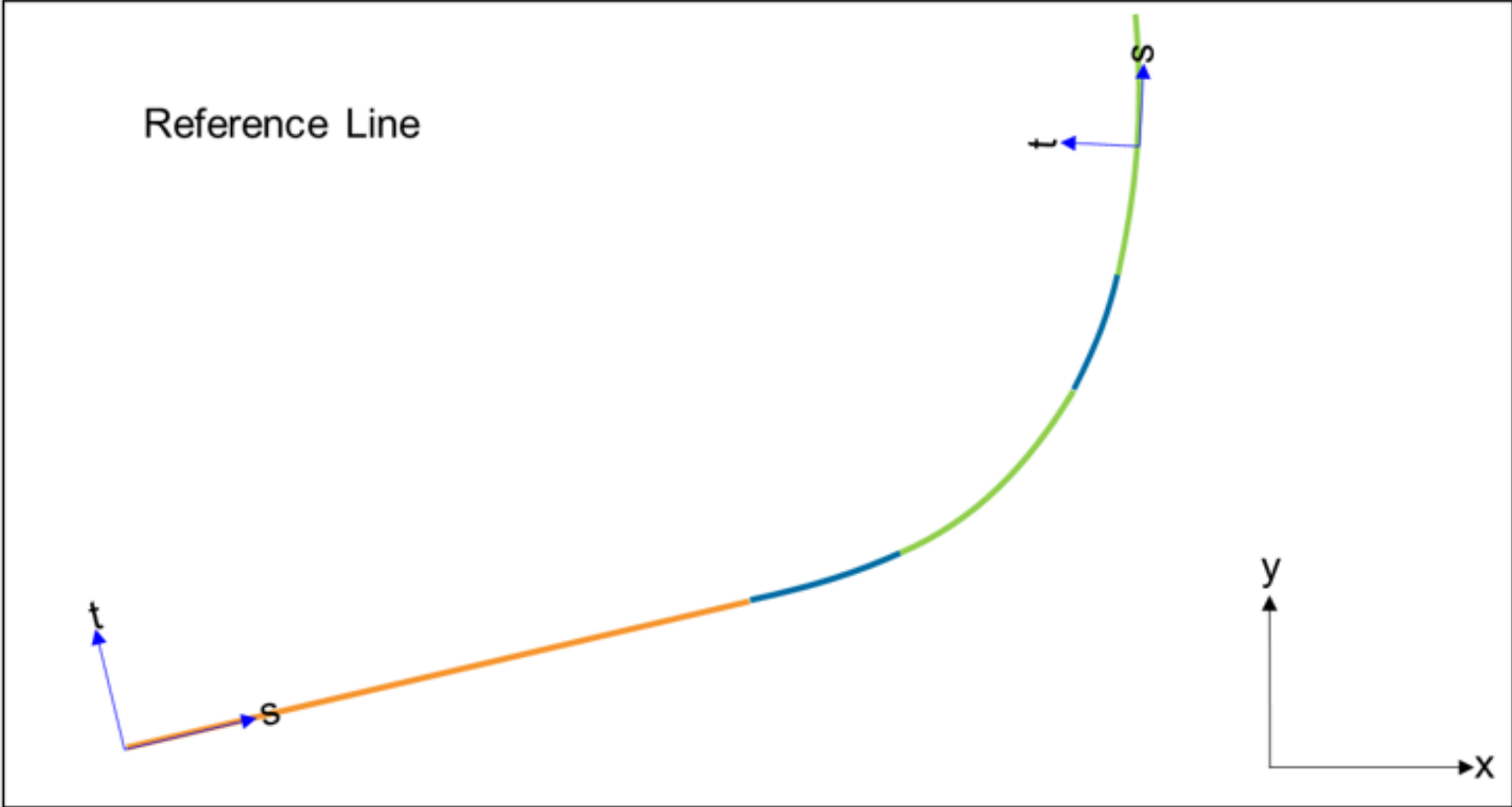
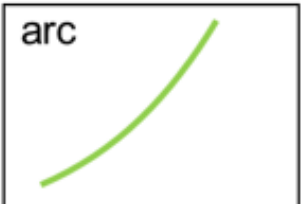
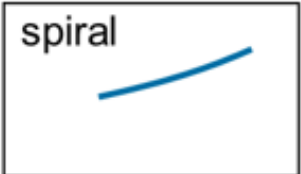
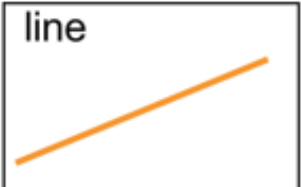
```
<lanes>
  <laneSection s="0">
    <left>
      <lane id="3" type="border">
        <link>
          <successor id="3"/>
        </link>
      </lane>
    </left>
  </laneSection>
</lanes>
```

```
<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"/>
  </connection>
</junction>
```

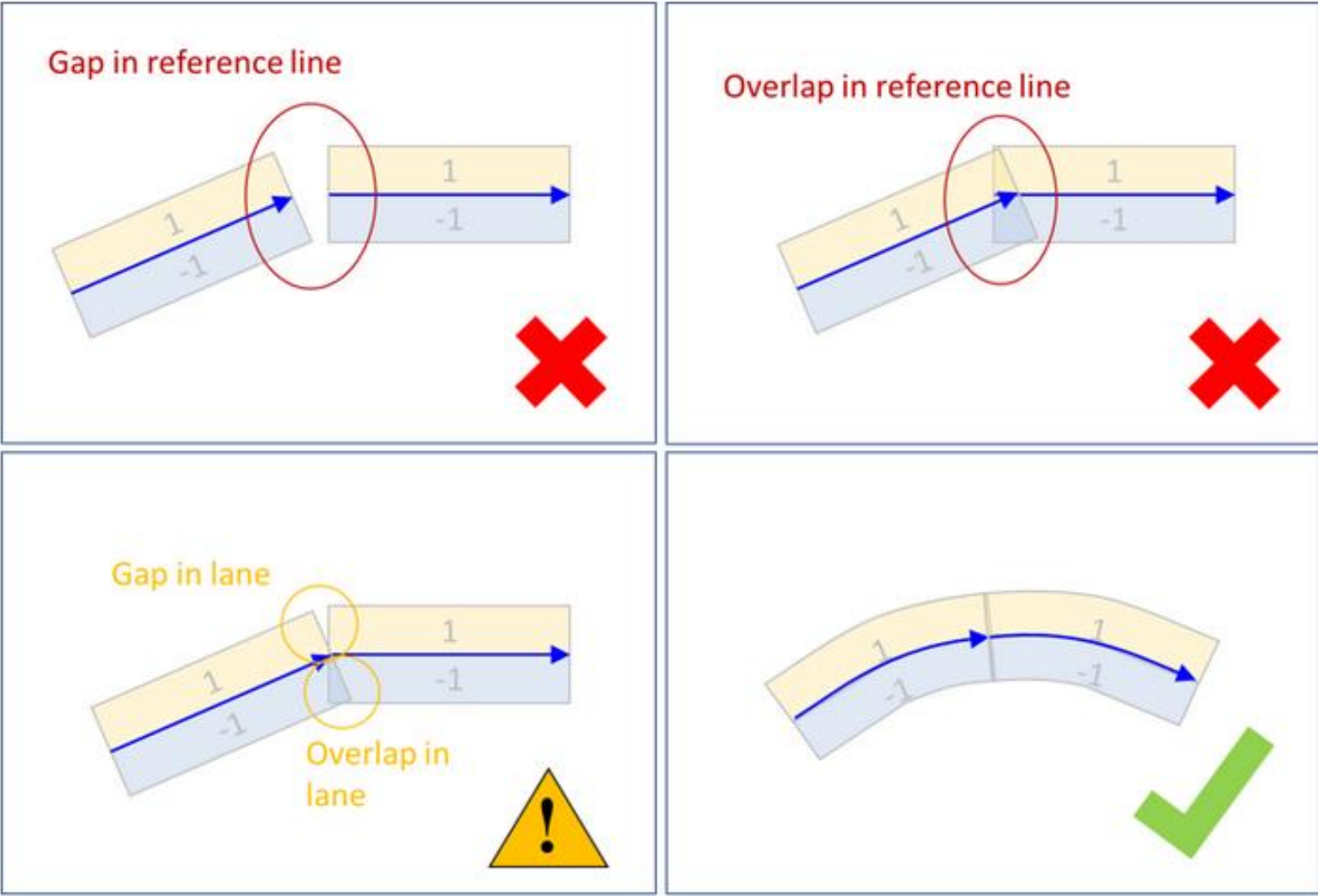
Geometrisch linear referenziert



© ASAM e. V.



Modellierungsbedingungen





GDAL-Treiberimplementierung

- Wikipedia:
 - „Neben den gängigen Formaten für Rasterdaten [..] kann GDAL noch **über 60** weitere [Raster-]Datenformate lesen [..]“
 - „[..] OGR unterstützt **über 20** Vektordatenformate [..]“
- Viele freie und kommerzielle GIS nutzen GDAL im Hintergrund!
- GDAL nutzt OGC Simple Features als Vektormodell

OpenDRIVE-Geometrien GISbar machen

Diskrete Ankerpunkte



```
<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-Geometrien GISbar machen

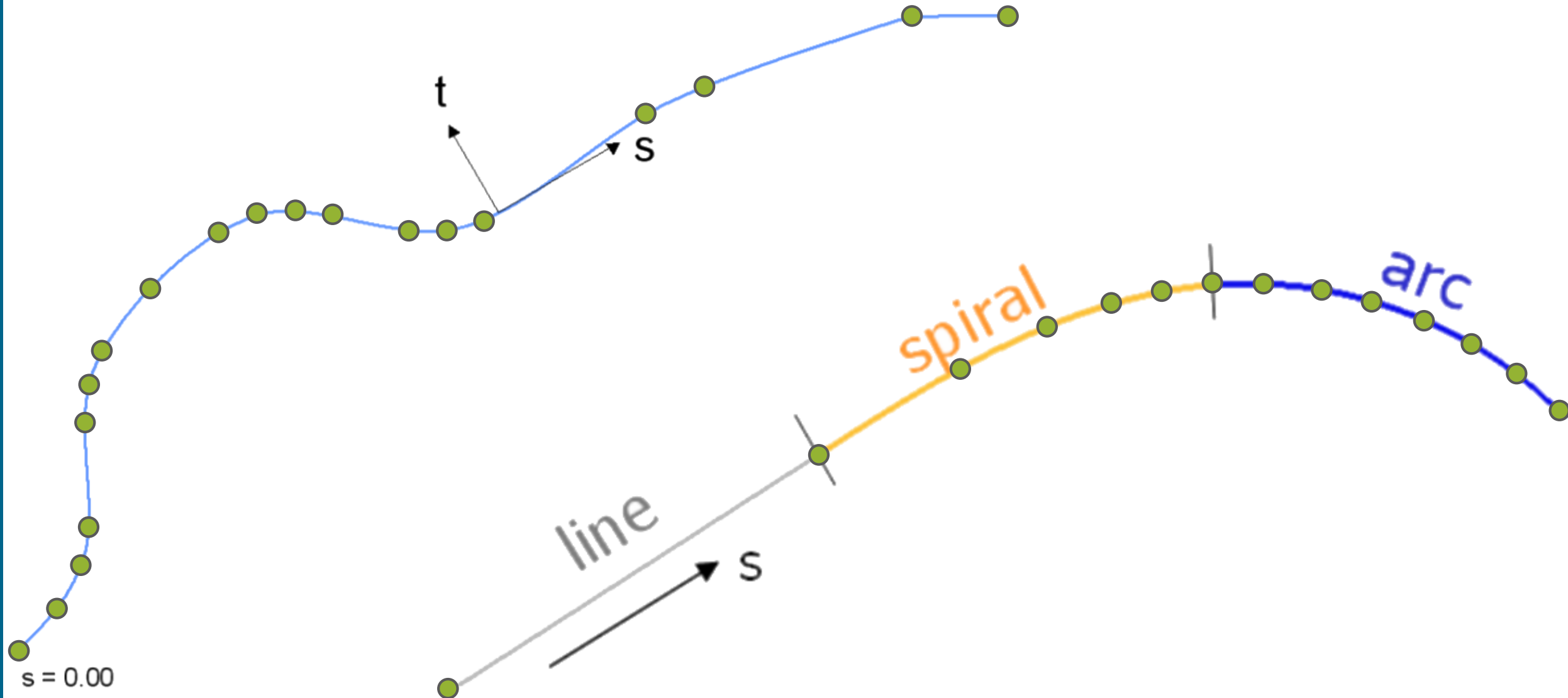
Entfaltungsparmeter



```
<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>
```

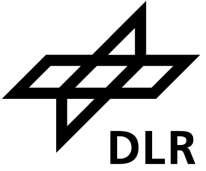

OpenDRIVE-Geometrien GISbar machen

Diskretisierung (sampling)

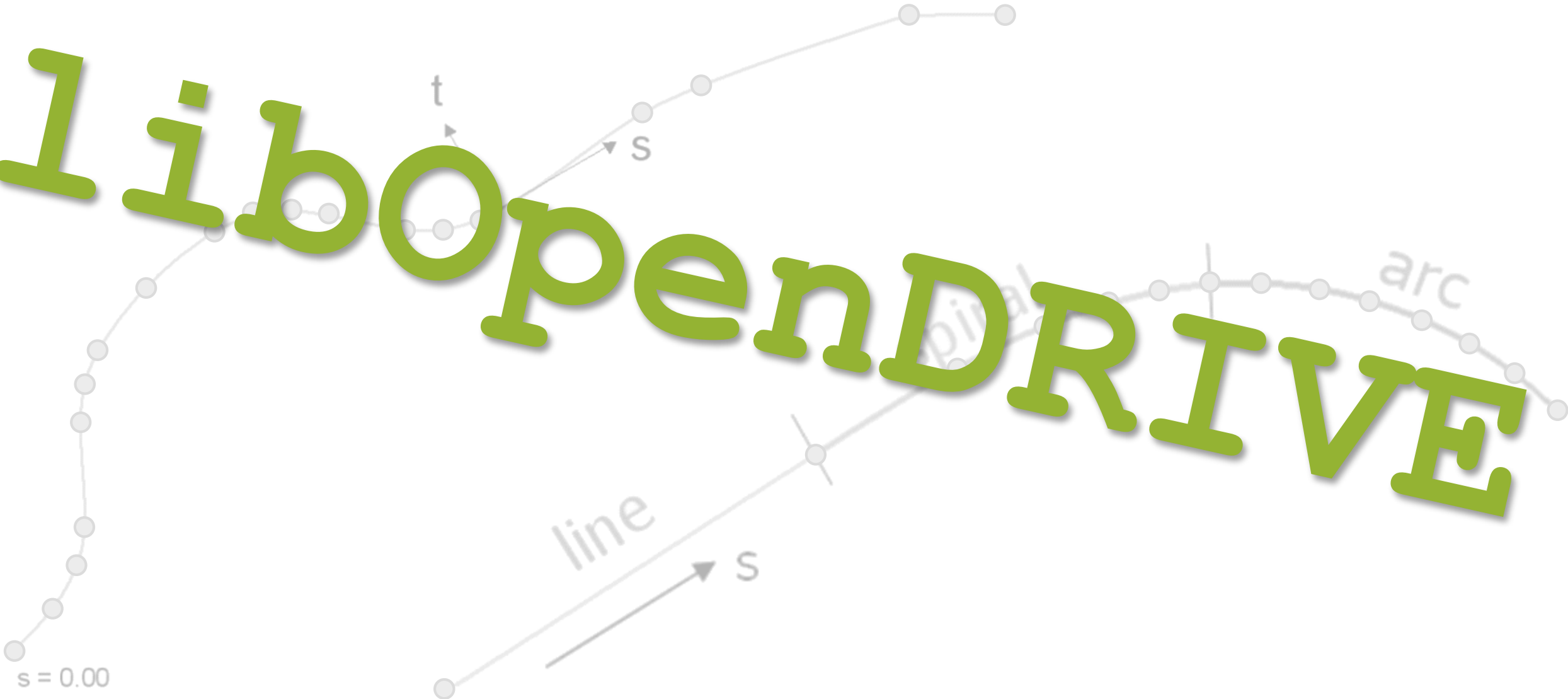


OpenDRIVE-Geometrien GISbar machen

Diskretisierung (sampling)



libOpenDRIVE



OpenDRIVE-Geometrien GISbar machen

Mit 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 main branch is `master`. The repository contains three folders: `include`, `src`, and `thirdparty`. The `include` folder was renamed from `Signal t...` 6 months ago. The `src` folder was added with a `std prefix...` 4 months ago. The `thirdparty` folder was renamed from `Thirdpa...` last year. The repository has 527 commits. The `About` section describes it as a "Small, lightweight C++ library for handling OpenDRIVE files" and lists tags: `library`, `cpp`, `opendrive`, and `xodr`. It also includes a `Readme` link and mentions the `Apache-2.0 license`.

pageldev / libOpenDRIVE

Code Issues 16 Pull requests 3 Actions Projects Security

libOpenDRIVE Public Watch 19 Fork 129 Starred 345

master Go to file + <> Code

pageldev i... 9a0437f · 4 months ago 527 Commits

include	Rename Signal t...	6 months ago
src	added std prefix...	4 months ago
thirdparty	rename Thirdpa...	last year

About

Small, lightweight C++ library for handling OpenDRIVE files

library cpp opendrive xodr

Readme

Apache-2.0 license

OpenDRIVE-Geometrien GISbar machen

Konvertieren zu OGC Simple Features



```
<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>
```

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

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

OpenDRIVE-Geometrien GISbar machen

Konvertieren zu OGC Simple Features



Simple Features type	OpenDRIVE element
Point	signal
LineString	referenceLine laneBorder
Polygon	lane roadMark roadObject

OpenDRIVE-Geometrien GISbar machen

GDAL-Treiber schreiben



```
user@machine:/dev/gdal$ ogrinfo --formats
```


OpenDRIVE-Geometrien GISbar machen

GDAL-Treiber schreiben



```
user@machine:/dev/gdal$ ogrinfo --formats
```

Supported Formats:

PCIDSK -raster,vector- (rw+v): PCIDSK Database File

CSV -vector- (rw+v): Comma Separated Value (.csv)

GML -vector- (rw+v): Geography Markup Language (GML)

KML -vector- (rw+v): Keyhole Markup Language (KML)

GeoJSON -vector- (rw+v): GeoJSON

... many more ...

MBTiles -raster,vector- (rw+v): MBTiles

OGCAPI -raster,vector- (rov): OGCAPI

ESRI Shapefile -vector- (rw+v): ESRI Shapefile

SQLite -vector- (rw+v): SQLite / Spatialite

TIGER -vector- (rov): U.S. Census TIGER/Line

OpenDRIVE-Geometrien GISbar machen

GDAL-Treiber schreiben



```
user@machine:/dev/gdal$ ogrinfo --formats
```

Supported Formats:

PCIDSK -raster,vector- (rw+v): PCIDSK Database File

CSV -vector- (rw+v): Comma Separated Value (.csv)

GML -vector- (rw+v): Geography Markup Language (GML)

KML -vector- (rw+v): Keyhole Markup Language (KML)

GeoJSON -vector- (rw+v): GeoJSON

... many more ...

MBTiles -raster,vector- (rw+v): MBTiles

OGCAPI -raster,vector- (rov): OGCAPI

ESRI Shapefile -vector- (rw+v): ESRI Shapefile

SQLite -vector- (rw+v): SQLite / Spatialite

TIGER -vector- (rov): U.S. Census TIGER/Line

XODR -vector- (rov): OpenDRIVE - Open Dynamic Road Information for Vehicle Environment

läuft ...

OpenDRIVE-Geometrien GISbar machen

GDAL-Treiber veröffentlichen



- github.com/DLR-TS/gdal/tree/libopendrive
- [Dokumentation](#)
- [Dockerfile](#) zum Selberbauen

OpenDRIVE-Geometrien GISbar machen

Pull-Request auf GitHub abschicken



OSGeo / gdal

Code

Issues 431

Pull requests 21

Actions

Projects

Wiki

Security

[WIP] Add new OGR driver for OpenDRIVE (XODR)
#9504

Edit

Code

Open

michikommader wants to merge 2 commits into `OSGeo:master` from `DLR-TS:libopendrive-pr`

Conversation 40

Commits 2

Checks 31

Files changed 18

+9,589

-0

michikommader commented yesterday

Contributor

What does this PR do?

This adds a read-only vector driver for the road description format [OpenDRIVE](#). OpenDRIVE is an open industry standard in the automotive

Reviewers

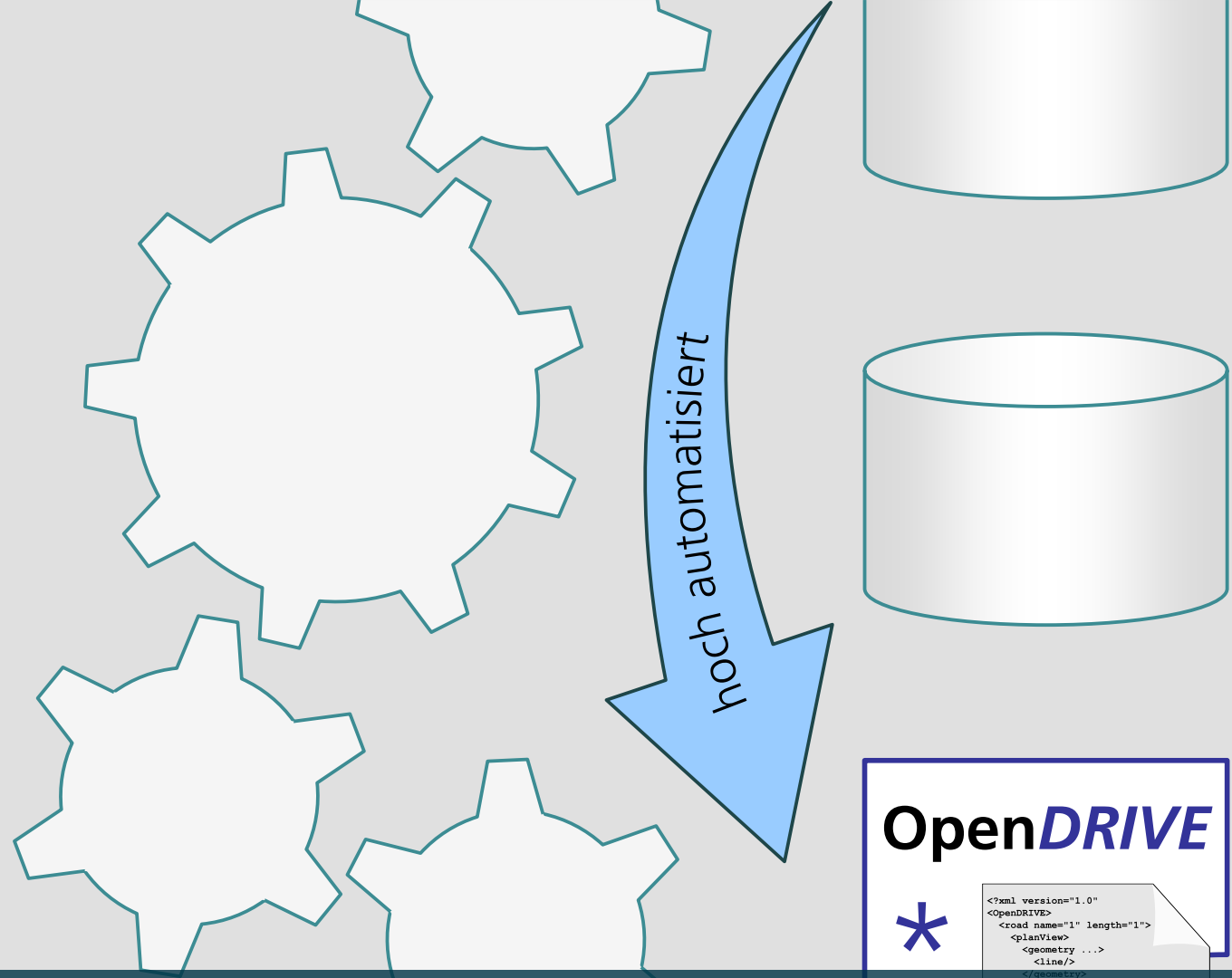
rouault

Still in progress? [Convert to draft](#)

OpenDRIVE-Geometrien GISbar machen



QGIS-Demo



Weitere Tools für OpenDRIVE

```
<?xml version="1.0"
<OpenDRIVE>
  <road name="1" length="1">
    <planView>
      <geometry ...>
        <line/>
      </geometry>
      <geometry ...>
        <spiral curvStart .../>
      </geometry>
    </planView>
    <lanes>
      <laneSection s="0.0">
        <left/>
        <center/>
        <right/>
      </laneSection>
    </lanes>
  </road>
</OpenDRIVE>
```

XML

Tools für OpenDRIVE



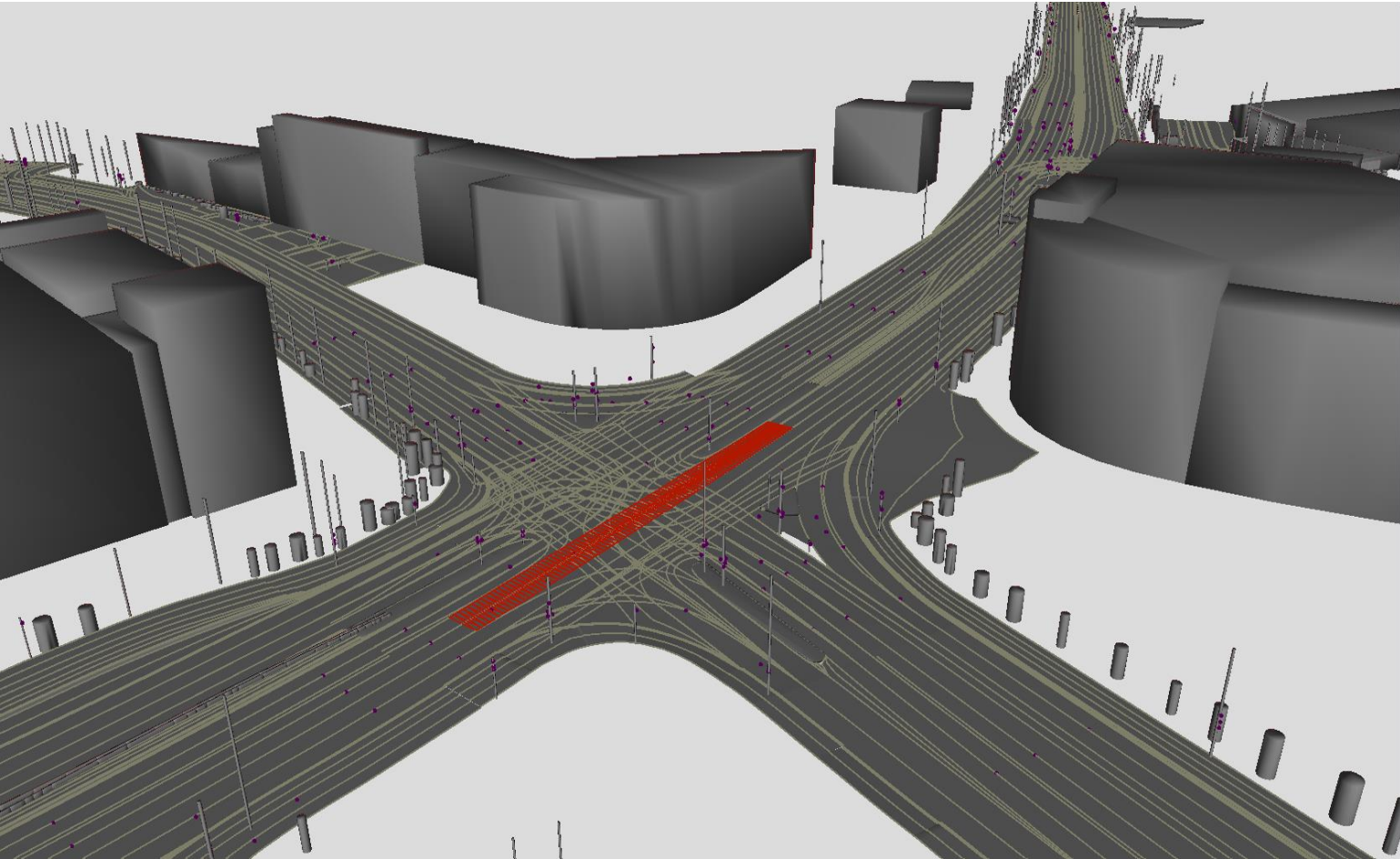
- Wachsende Community: [Awesome OpenX](#) 

- Wachsende Community: [Awesome OpenX](#) The logo for the "Awesome OpenX" community, consisting of a pink square with a white GitHub Octocat icon and a dark blue rectangle with the word "awesome" in white lowercase letters.



Tools für OpenDRIVE

r:trân



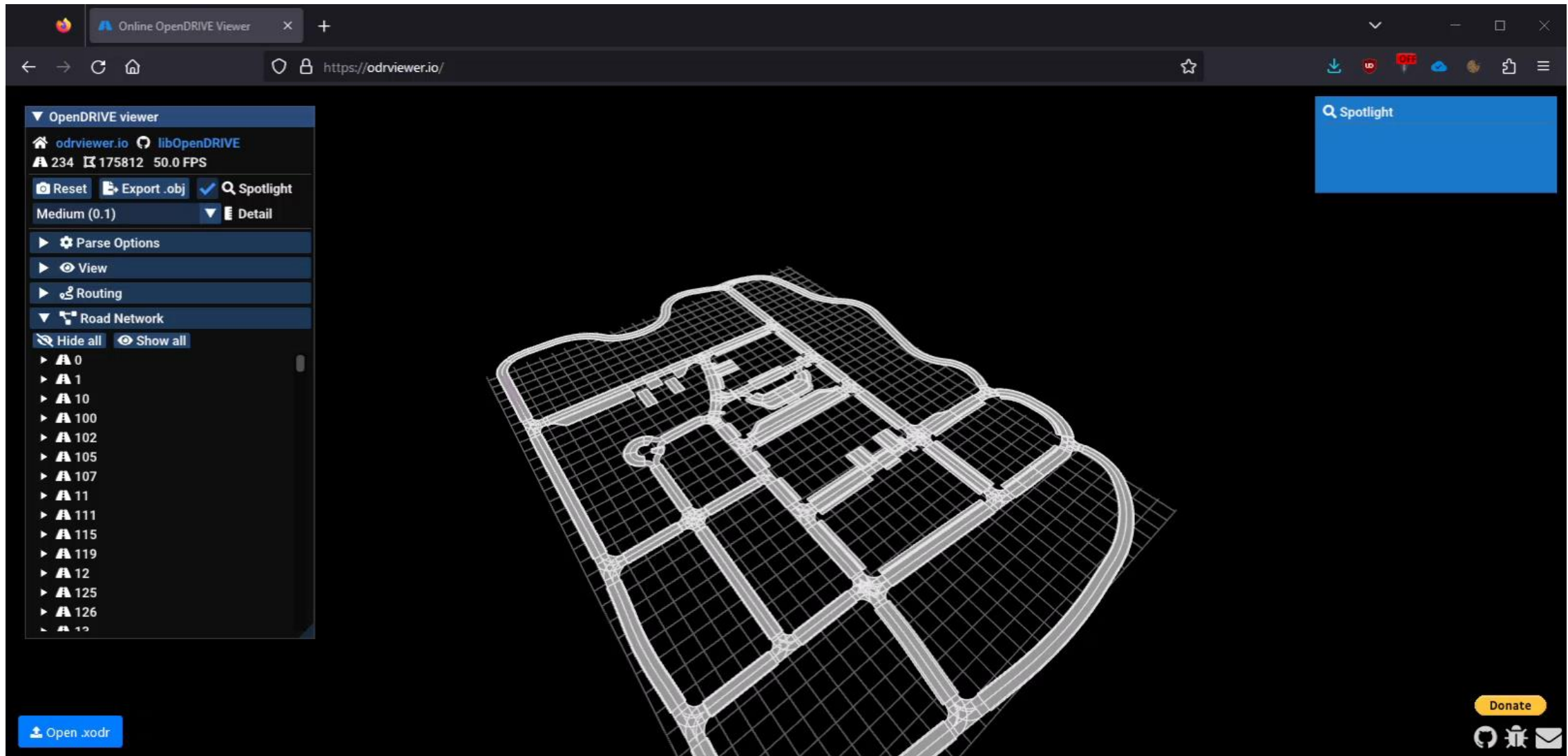
Property	Value
Feature Type	Road
Coordinate System	EPSG:32632
Dimension	3D
Number of Vertices	768
Min Extents	678819.6072548759, 5405772.029156608, 418.7514057725761
Max Extents	678866.4587420645, 5405787.700486677, 418.97760792542...
▼ Attributes (60)	
citygmL_feature_role (encoded: UTF-16LE)	cityObjectMember
citygmL_level_of_detail(0) (encoded: UTF-16LE)	2
citygmL_target_uri (encoded: UTF-16LE)	http://www.opengis.net/citygm/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
opendrive_identifier_laneId (encoded: UTF-16LE)	-1
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
opendrive_identifier_sourceFileHashSha256 (encoded: UTF-16LE)	75f5186976d879be2bb8e9dc8b3c4c9d1384cc55ac51547e01...
opendrive_identifier_sourceFileName (encoded: UTF-16LE)	2019-01-25_SAVE_Ingolstadt_Prio1
opendrive_lane_level (encoded: UTF-16LE)	false
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)	6.9048
opendrive_lane_roadMark_curvePositionStart_2 (encoded: UTF-16LE)	9.952
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)	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

Tools für OpenDRIVE

odrviewer.io

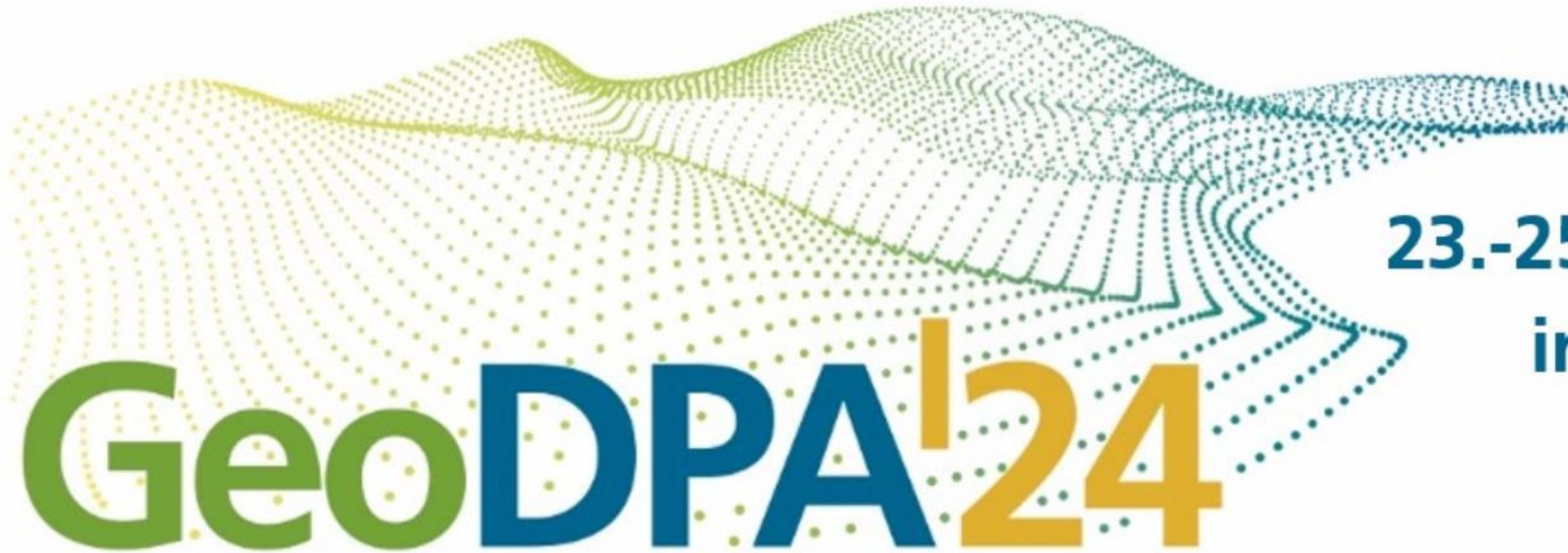


Wie geht es weiter?



- Ursprungsidee von 2017: elib.dlr.de/110123
- OpenDRIVE ist offener Industriestandard vom [ASAM e. V.](#)
- Stärkere Integration von OpenDRIVE in CityGML 3.0 mit dem ASAM
- OGC plant neue „Transportation and Mobility Domain Working Group“
- Ähnlicher GDAL-Treiber für railML? ...

Danke!



23.-25. April 2024
in Oldenburg

International Conference on **Geo**information, **Data**, **P**rocessing and **A**pplications

Thema: **OpenDRIVE-HD-Karten mittels GDAL ins GIS bringen**
FOSSGIS, Hamburg

Datum: 21.03.2024

Autor: Michael Scholz

Institut: Verkehrssystemtechnik

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sofern nicht anders angegeben