Chair of Geoinformatics
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CityGML 3.0

Examples for modelling object parts shared by multiple features

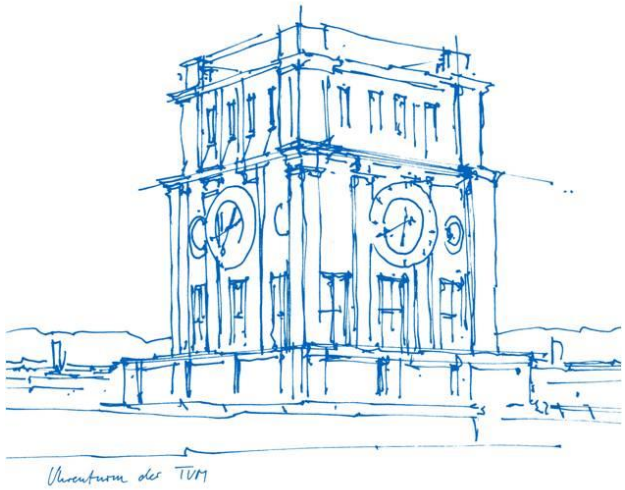
(using CityObjectRelations or XLinks)

Shared surfaces by

(1) Roads and Bridges

(2) Buildings and Roads

(3) two Roads (Intersection)



CityGML 3.0 – Modelling shared object parts

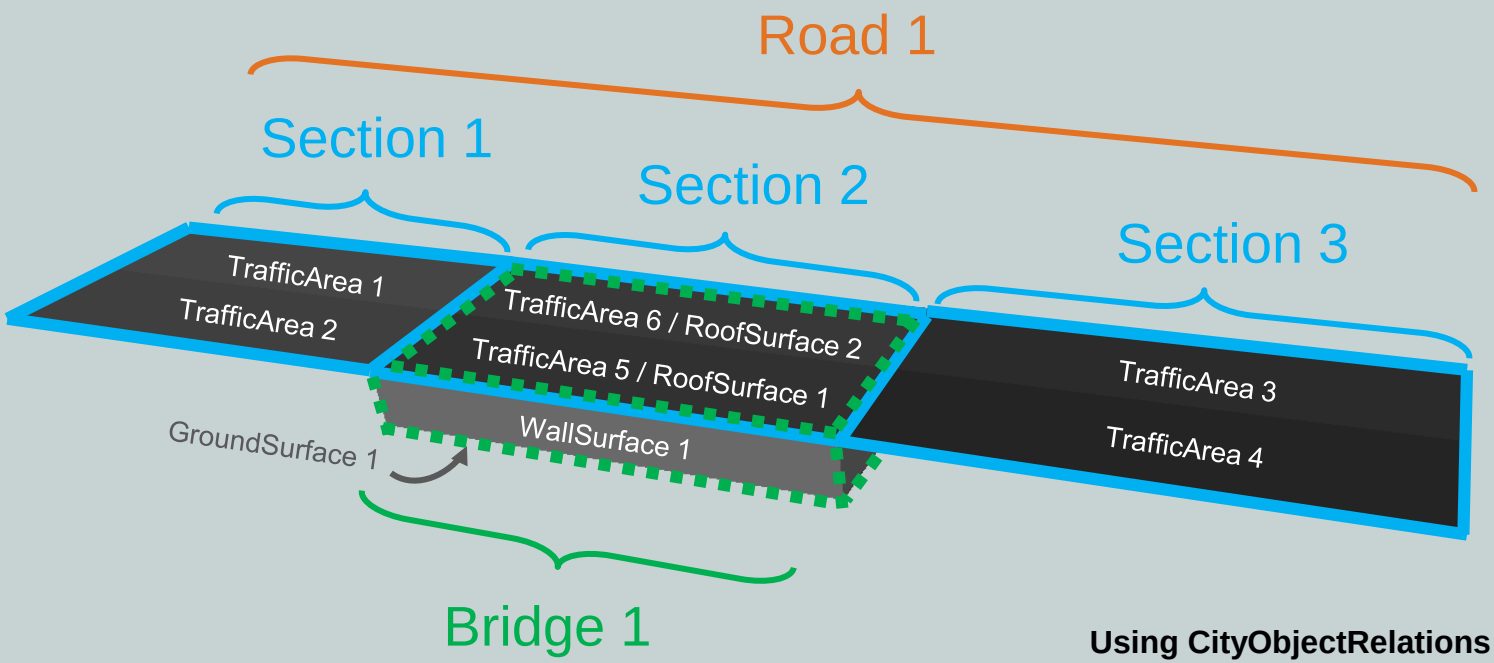
- **Geometrically identical** surfaces can be part of **semantically different** objects.
- E.g. **Road** surfaces on a **Bridge** could be modelled as **TrafficAreas** (as part of a Road) and **RoofSurfaces** (as part of a Bridge) at the same time.
- Transportation networks and **Roads** can reach into **Buildings** (e.g. within a parking garage). In this case **TrafficAreas** are also **Floor-** or **RoofSurfaces**.
- **Intersections** can be part of **multiple Roads**.
- The following examples illustrate how this could be modelled using **CityObjectRelations or XLinks**, with a proposal for when to use which concept

https://github.com/opengeospatial/CityGML-3.0Encodings/tree/master/CityGML/Examples/Transportation/Basic%20examples

Different concepts for modelling shared parts

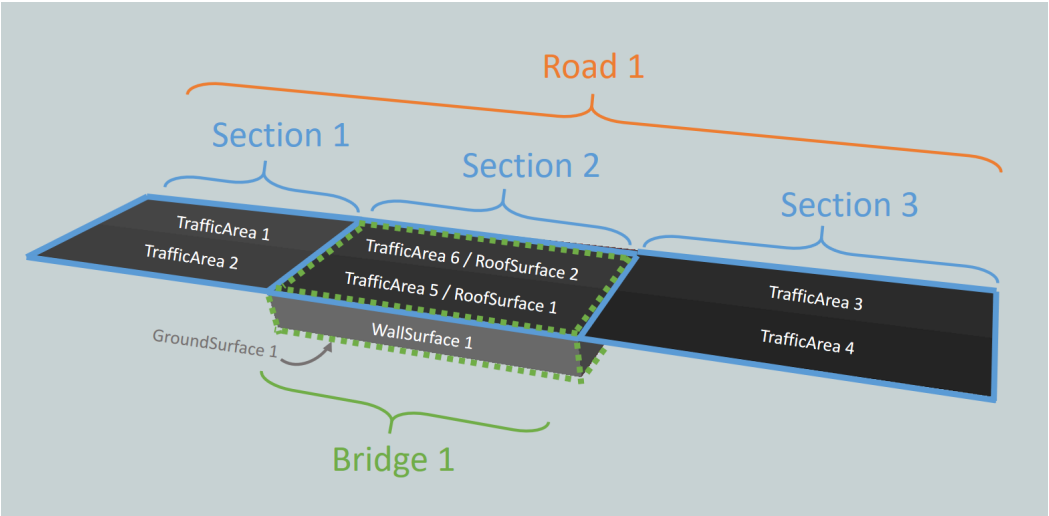
- Shared geometry: XLinks between geometries
  - Disadvantage: In large files, linked geometries may be stored very far apart → not feasible for different top level features
- Shared features: XLinks to features with identical semantics
  - Disadvantage: In large files, linked objects may be stored very far apart
  - Advantage: Semantically and geometrically identical objects do not need to be represented multiple times
- Explicit linking of related features: CityObjectRelations
  - Disadvantage: Geometry of objects / surfaces needs to be represented redundantly
  - Advantage: Geometry of each object is stored directly with the object. Information on identical (geometrically equal) surfaces is available

Shared surfaces by Roads and Bridges

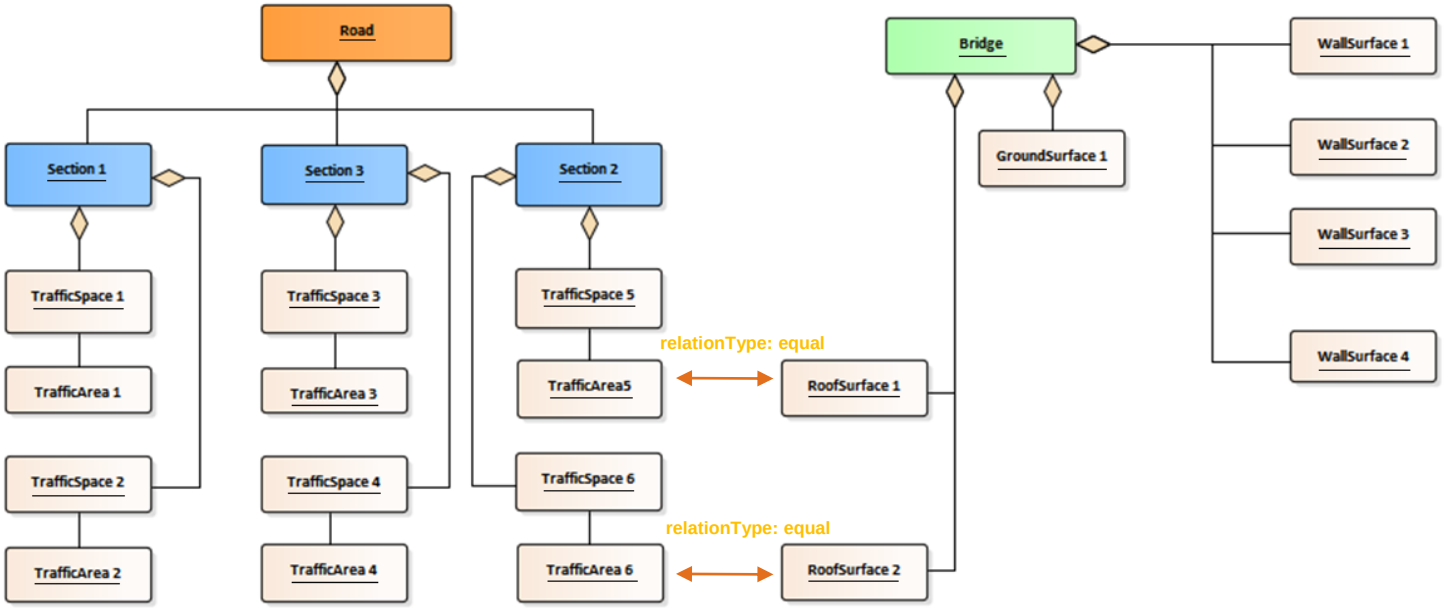


Using CityObjectRelations makes sense for linking semantically different but geometrically identical surfaces / objects.

e.g. TrafficArea 5 and RoofSurface 1 represent the same (geometric) surface but are part of different (semantic) objects.

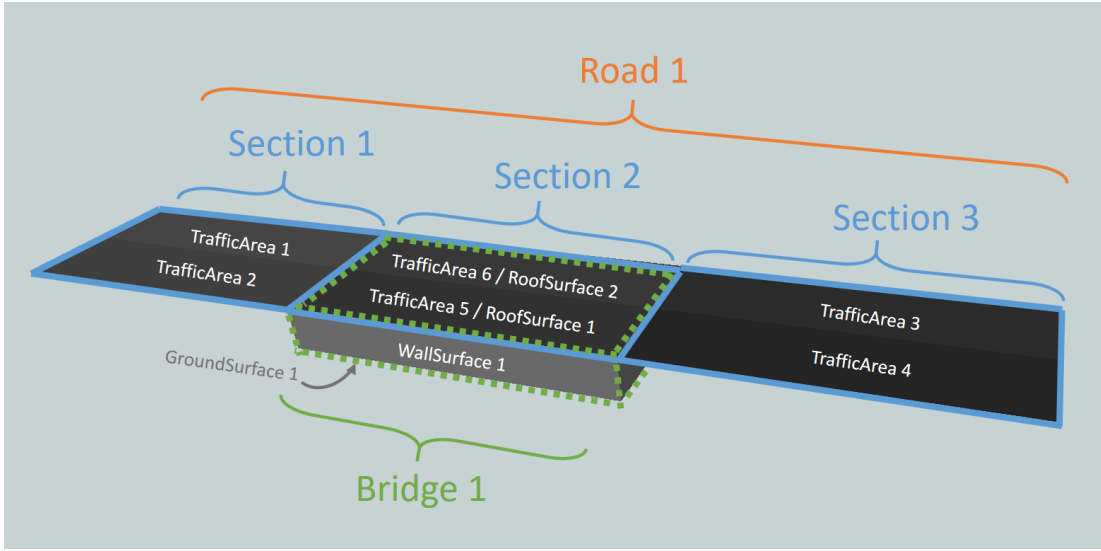


Instance diagram of this example



Surfaces that represent the exact same area but are semantically different can be connected via CityObjectRelations (= equal)

relationType: equal

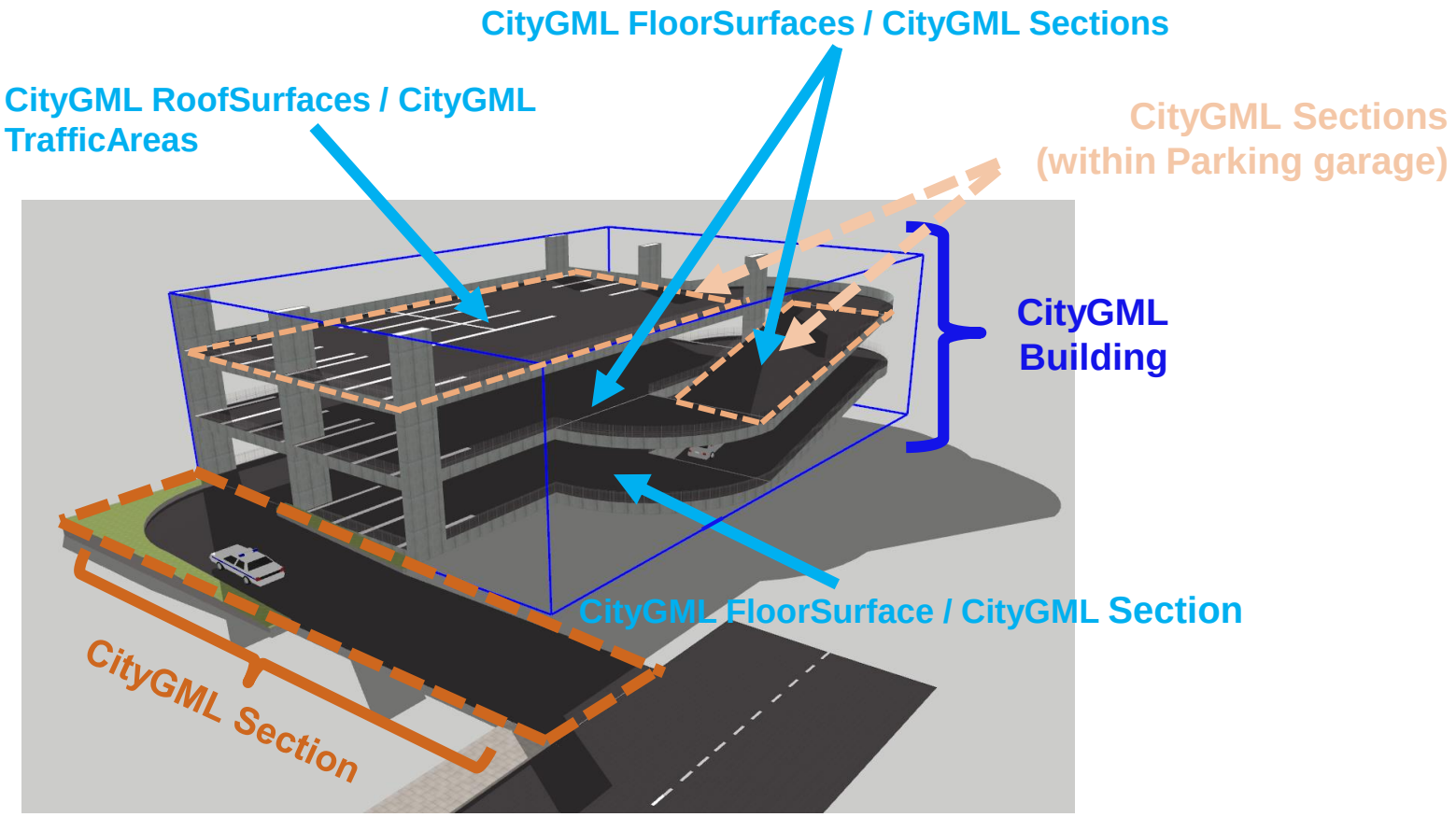


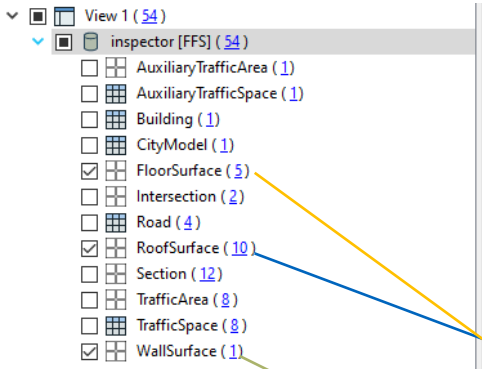
The CityObjectRelation (= equal) should be available in both directions.

```
<con:RoofSurface gml:id="id_roofsurface2">
    <core:relatedTo>
        <core:CityObjectRelation>
            <core:relationType>equal</core:relationType>
            <core:relatedTo xlink:href="id_trafficarea6"/>
        </core:CityObjectRelation>
    </core:relatedTo>
```

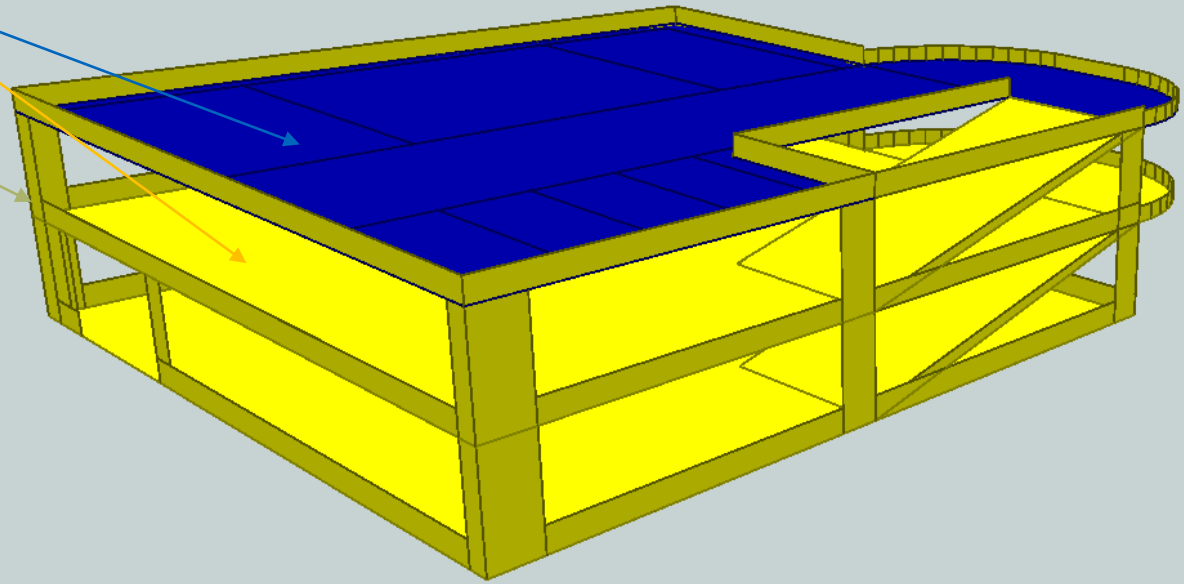
```
<tran:TrafficSpace gml:id="id_trafficspace6">
    <core:boundary>
        <tran:TrafficArea gml:id="id_trafficarea6">
            <core:relatedTo>
                <core:CityObjectRelation>
                    <core:relationType>equal</core:relationType>
                    <core:relatedTo xlink:href="id_roofSurface2"/>
                </core:CityObjectRelation>
            </core:relatedTo>
            <core:lod2MultiSurface>
                <gml:MultiSurface gml:id="id_trafficarea6-0" srsDimension="3">
            </core:lod2MultiSurface>
        </tran:TrafficArea>
    </core:boundary>
    <tran:granularity>lane</tran:granularity>
</tran:TrafficSpace>
```

Modelling shared surfaces by Buildings and Roads (e.g. within a parking garage) using CityObjectRelations

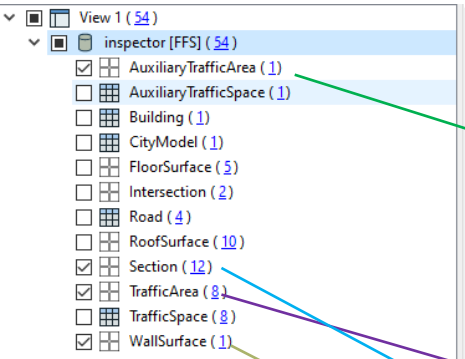




Parking garage as „classic“ CityGML Building consisting of Floor-, Wall-, and RoofSurfaces.

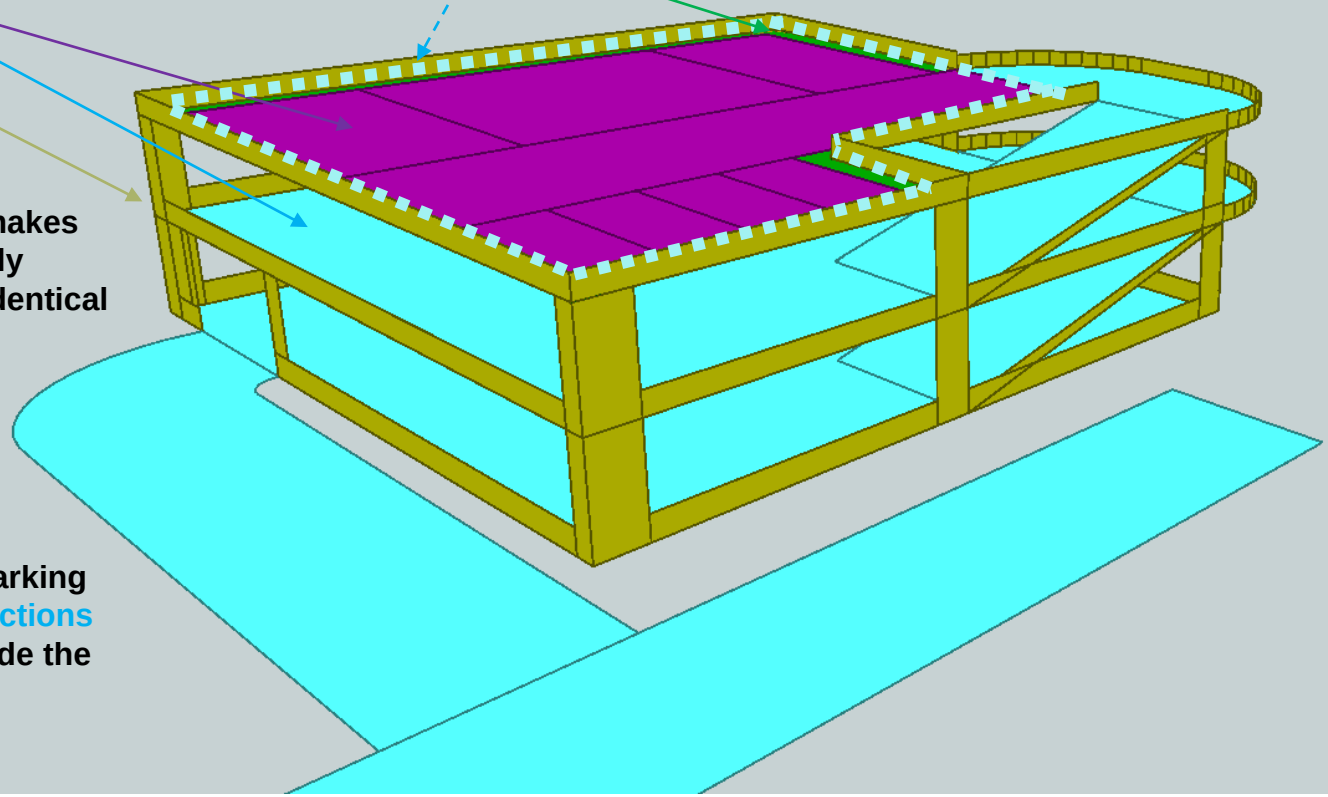


Each Floor- and RoofSurface is connected to corresponding Sections / (Auxiliary)TrafficAreas via CityObjectRealations (type: equal)



At the same time modelled as CityGML Road Object consisting of Sections. (e.g. one Section per level / ramp)

The top level of the parking garage in this example is modelled as a Section that is further divided into individual (Auxiliary)TrafficSpaces, bounded by TrafficAreas and AuxiliaryTrafficAreas.

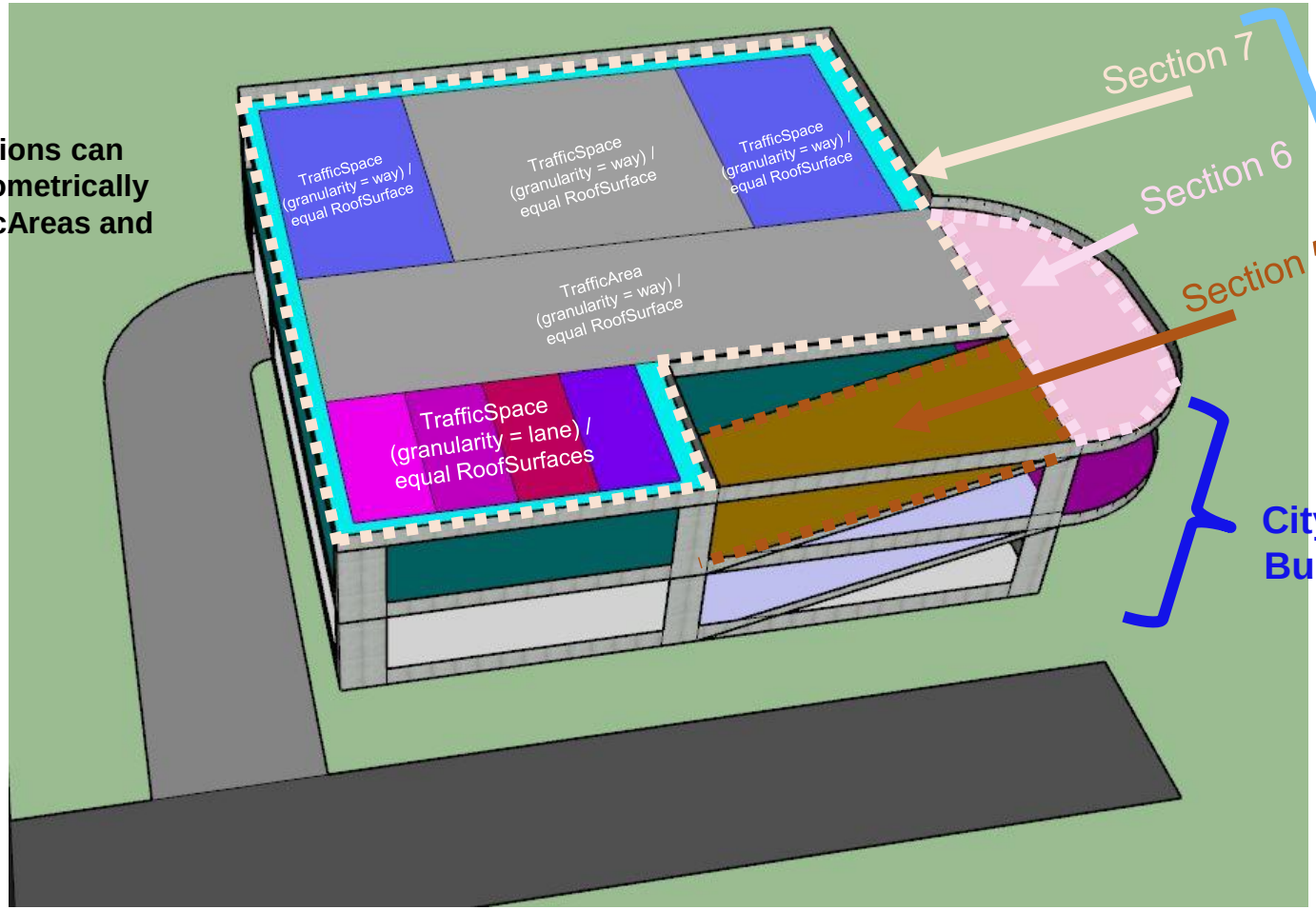


Using CityObjectRelations makes sense for linking semantically different but geometrically identical surfaces / objects.

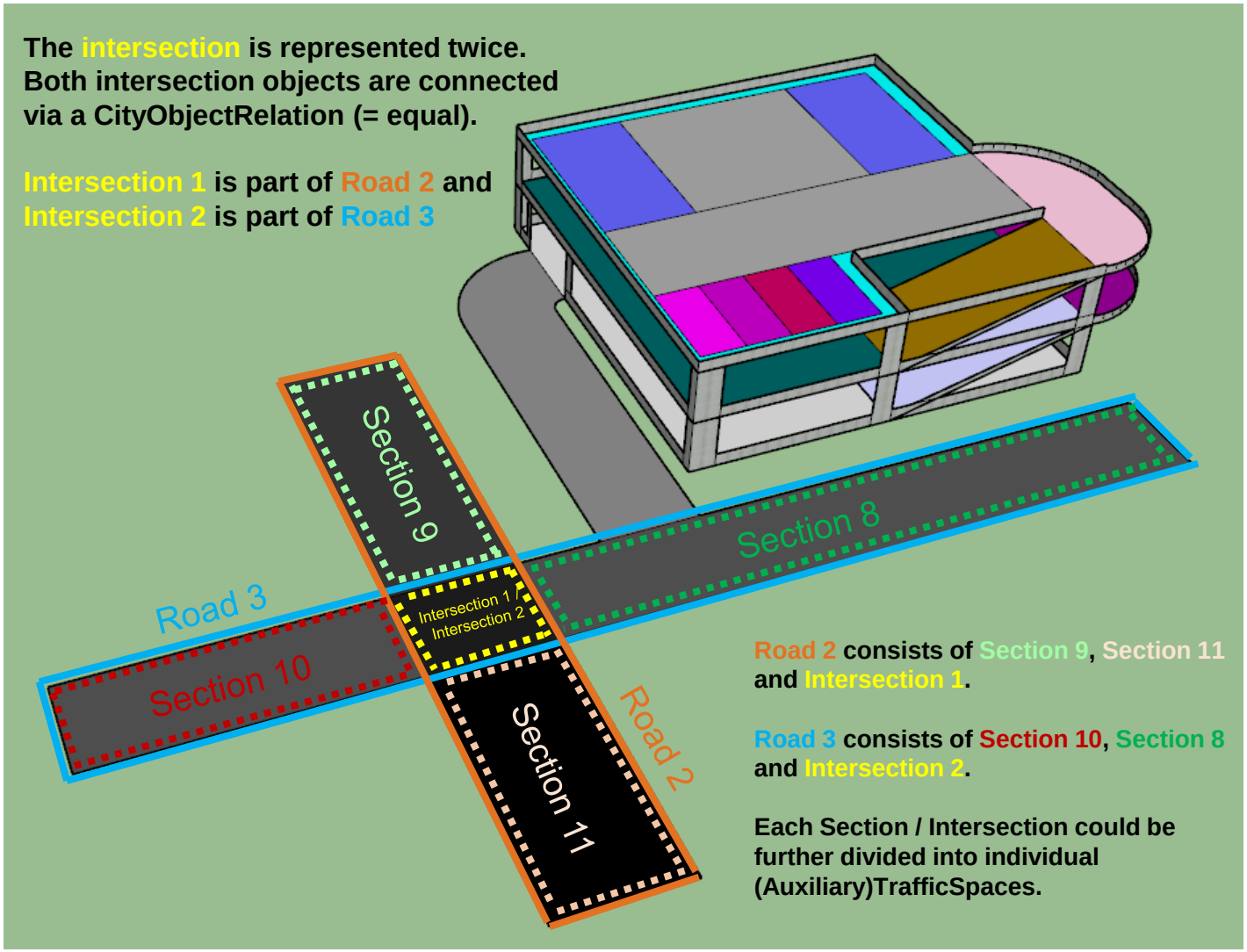
Road Sections within the parking garage are connected to Sections that are part of Roads outside the parking garage.

Entire parking areas are modelled as CityGML TrafficSpaces in granularity „way“ and individual parking lots are modelled as CityGML TrafficSpaces in granularity „lane“. Sections within a parking garage could be part of a separate Road Object.

CityObjectRelations can link related (geometrically identical) TrafficAreas and RoofSurfaces.



Modelling surfaces of an Intersection that is part of two Roads (Option 1) using CityObjectRelations

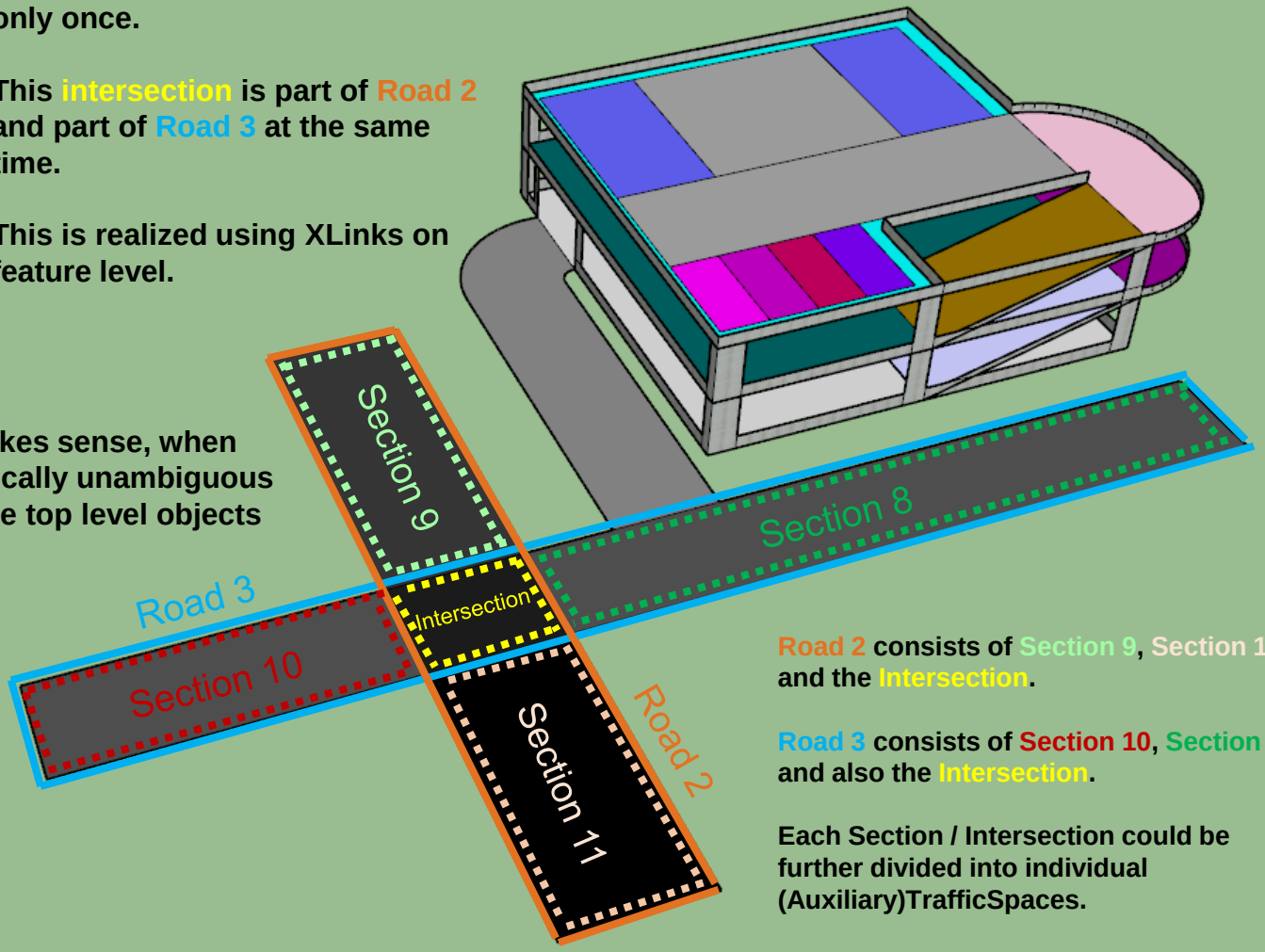


Modelling surfaces of an Intersection part of two Roads (Option 2) using XLinks on feature level

The intersection is represented only once.

This intersection is part of Road 2 and part of Road 3 at the same time.

This is realized using XLinks on feature level.



Using XLinks makes sense, when linking a semantically unambiguous feature to multiple top level objects of the same type.

Road 2 consists of Section 9, Section 11 and the Intersection.

Road 3 consists of Section 10, Section 8 and also the Intersection.

Each Section / Intersection could be further divided into individual (Auxiliary)TrafficSpaces.

Comparison of both options

Modelling surfaces of an Intersection that is part of two Roads (Option 1) using CityObjectRelations

Modelling surfaces of an Intersection part of two Roads (Option 2) using XLinks on feature level

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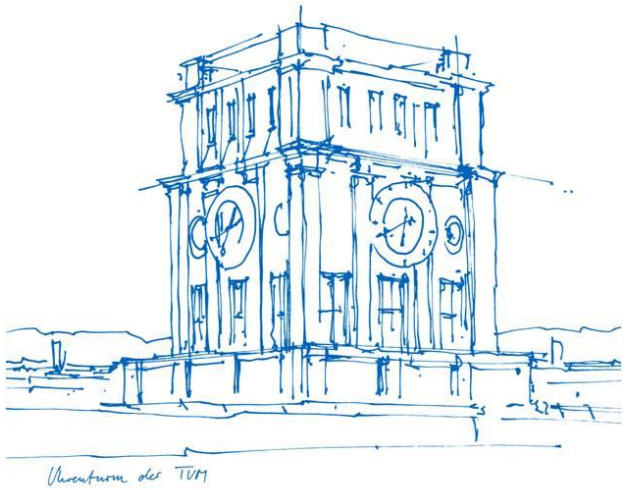
CityGML 3.0 Transportation Objects

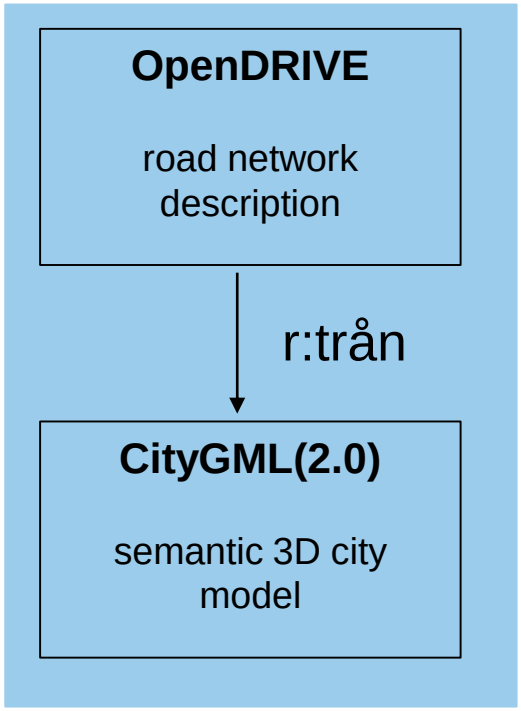
generated from **OpenDRIVE** data using the OpenSource tool **r:trån**

Real word example for an intersection in Ingolstadt



CityGML 3.0 – Transportation from OpenDRIVE

- Open Source tool for OpenDRIVE→CityGML conversion: https://rtron.io
- https://github.com/tum-gis/rtron



OpenDRIVE: commonly used format in the automotive industry

→ **Parametric representation**

CityGML: commonly used format for semantic 3D city and landscape modelling

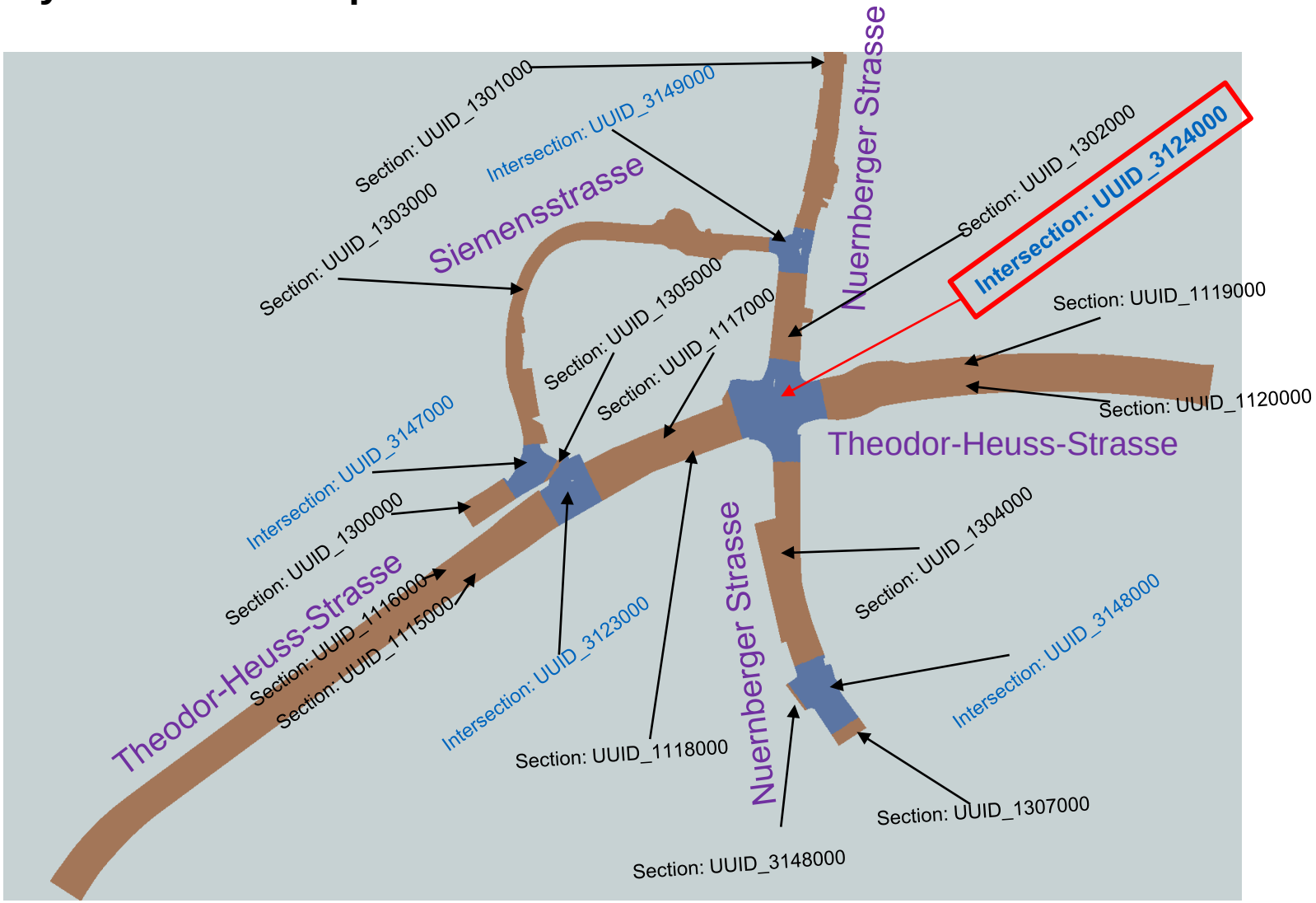
→ **Explicit geometries**

- Resulting data is further transformed to CityGML3.0 compliant data using FME (ongoing development of r:trån for direct CityGML3.0 support)

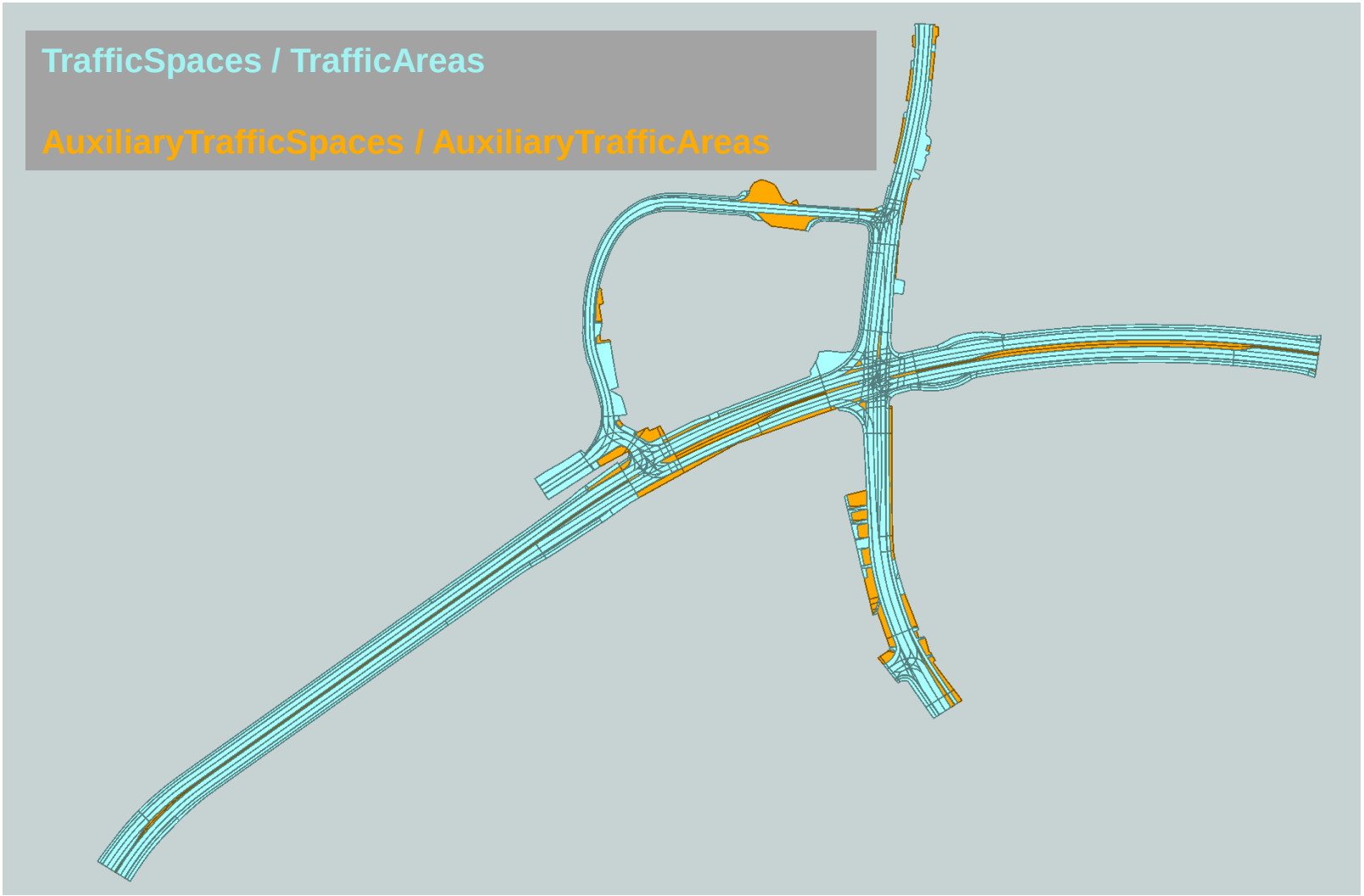
“Markkaufkreuzung” in Ingolstadt (Bavaria, Germany)

Resulting CityGML 3.0 data will be made available in the near future.

CityGML3.0 Streetspace Model – Roads / Sections / Intersections



Each Section / Intersection is further divided into individual (Auxiliary)TrafficSpaces (granularity = lane)

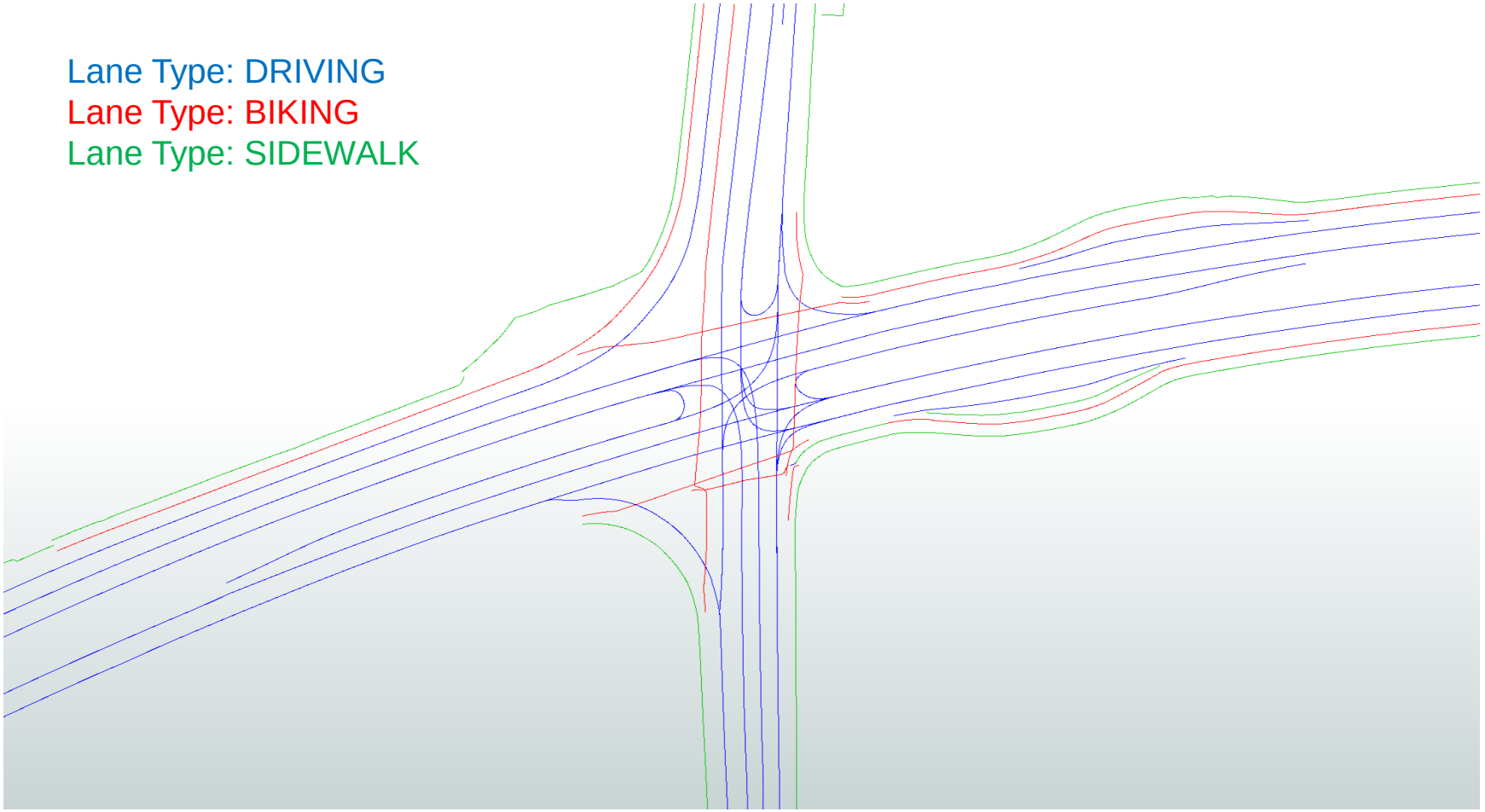


Link to interactive Online Demo (Blender + 3DCityDB Web-Map Client visualization)
https://wiki.tum.de/display/gisproject/Online+Demo+Collection

Including CityFurniture, Vegetation etc.
(the visualization is currently based on CityGML2.0)

CityGML3.0 linear representations of TrafficSpaces derived from OpenDRIVE Center Lanes (granularity = lane)

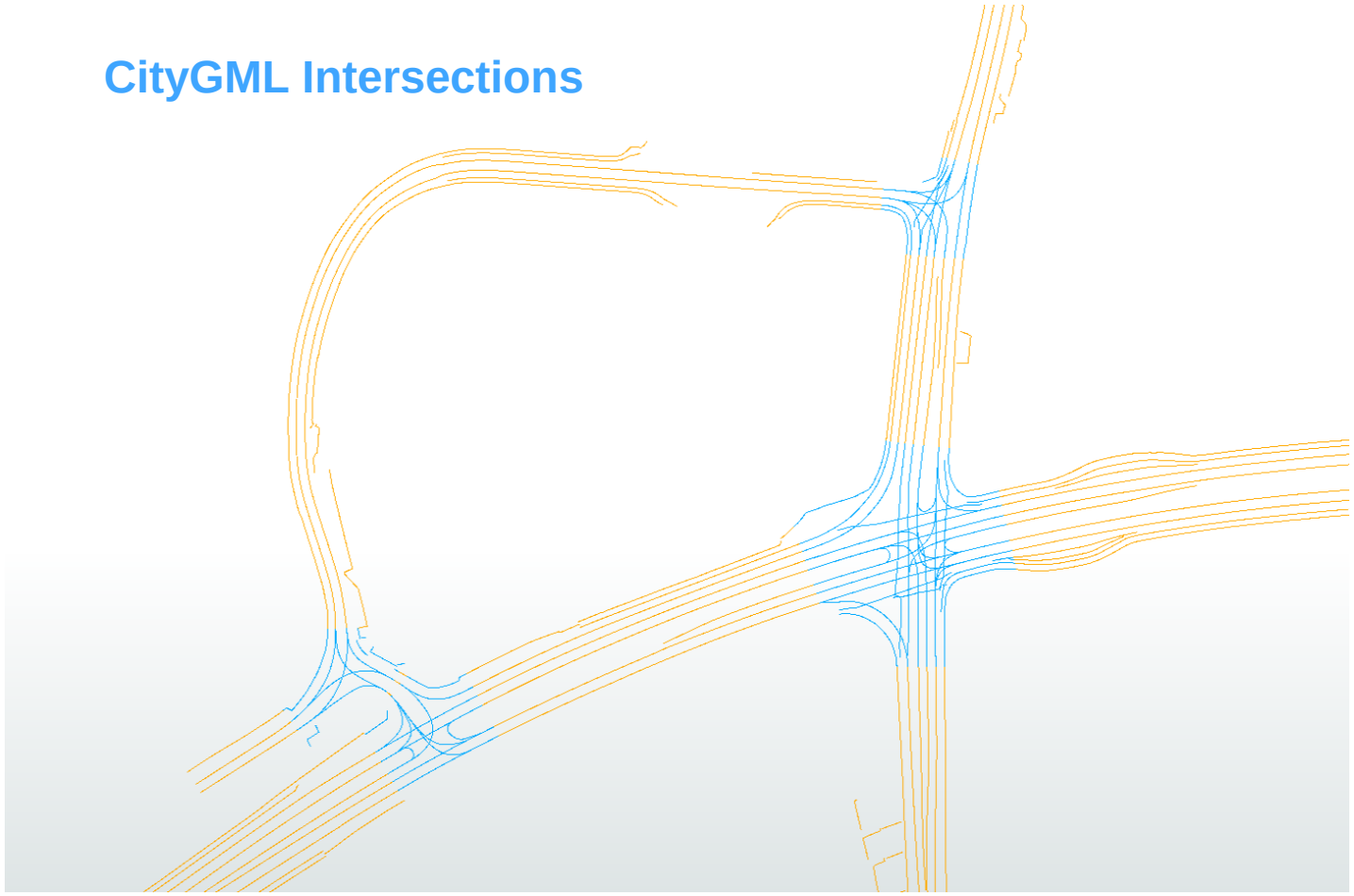
Lane Type: DRIVING
Lane Type: BIKING
Lane Type: SIDEWALK



Each linear TrafficSpace is assigned to a Section / Intersection

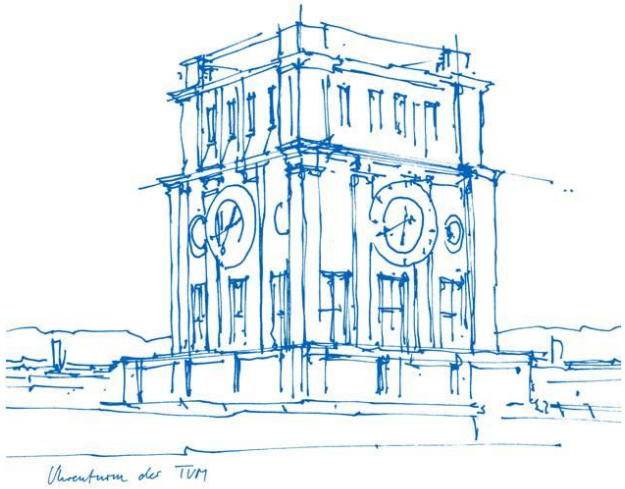
CityGML Sections

CityGML Intersections



CityGML 3.0 Transportation Objects

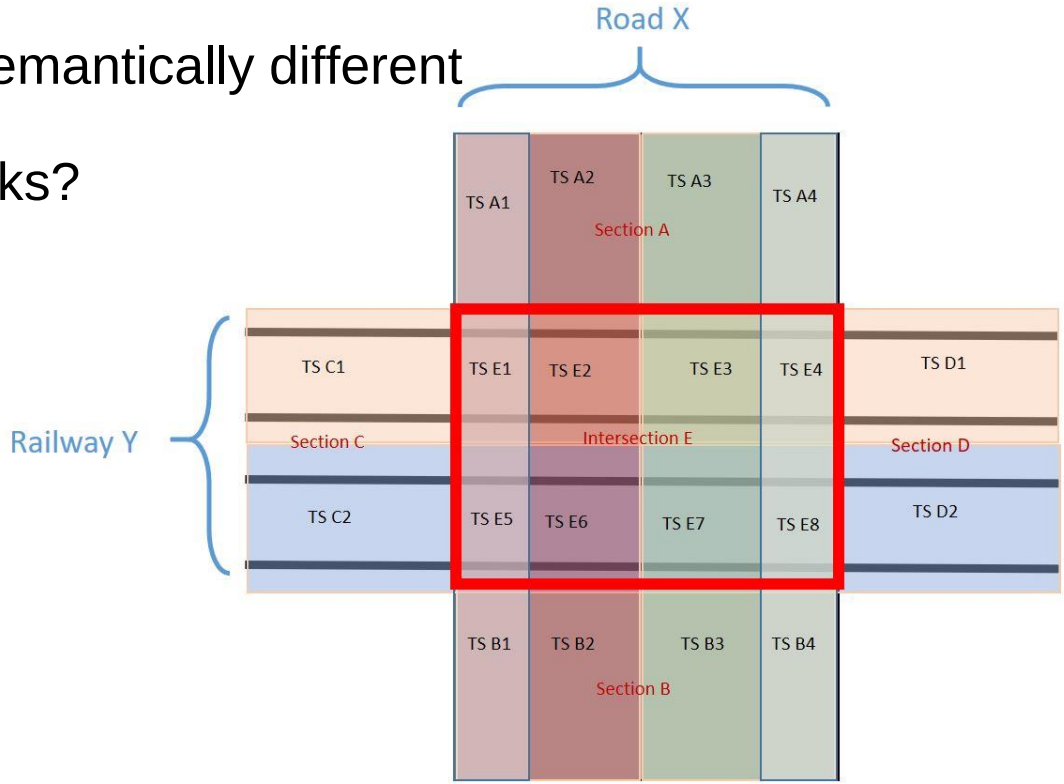
other examples for shared object parts / surfaces



Railway level crossing

- Granularity = lane
- Different functions could also be represented with multiple function attributes (e.g. TrafficSpace with attributes *driving lane* + *railway lane*)
- Geometrically identical but semantically different

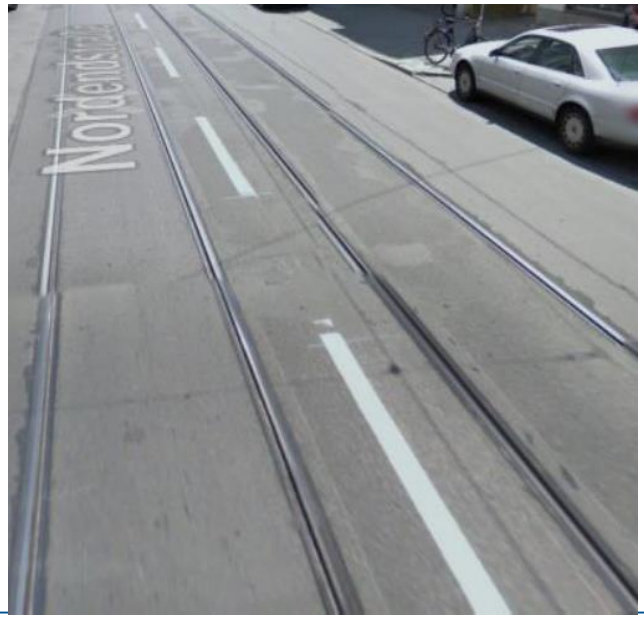
→ CityObjectRelation or XLinks?

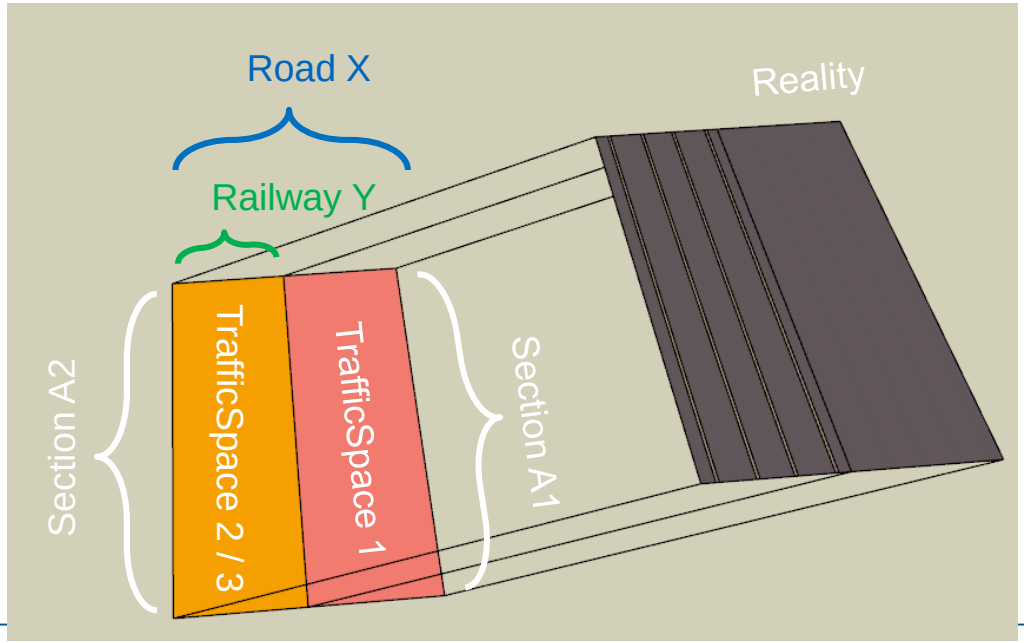


Tramways within a Road

- TrafficSpace 2 / 3 is represented twice and linked via a CityObjectRelation
- TrafficSpace 1 and 2 are part of Section A1 → Part of Road X
- TrafficSpace 3 is part of Section A2 → Part of Railway Y
- Geometrically identical but semantically different

→ CityObjectRelation or XLinks?





Learnings / Discussion

- Advantages / Disadvantages to both concepts
- Using CityObjectRelations makes sense mainly for linking semantically different but geometrically identical surfaces / objects (e.g. TrafficArea <-> RoofSurface)
- Using XLinks makes sense, when linking a semantically unambiguous feature to multiple top level objects of the same type (e.g. Intersection part of multiple Roads)
- Dataset with both concepts available for direct comparison

https://github.com/opengeospatial/CityGML-3.0Encodings/tree/master/CityGML/Examples/Transportation/Basic%20examples

- For real world examples many (small) objects (e.g. TrafficSpaces within an Intersetion) would have to be represented redundantly when using CityObjectRelations for semantically and geometrically identical objects