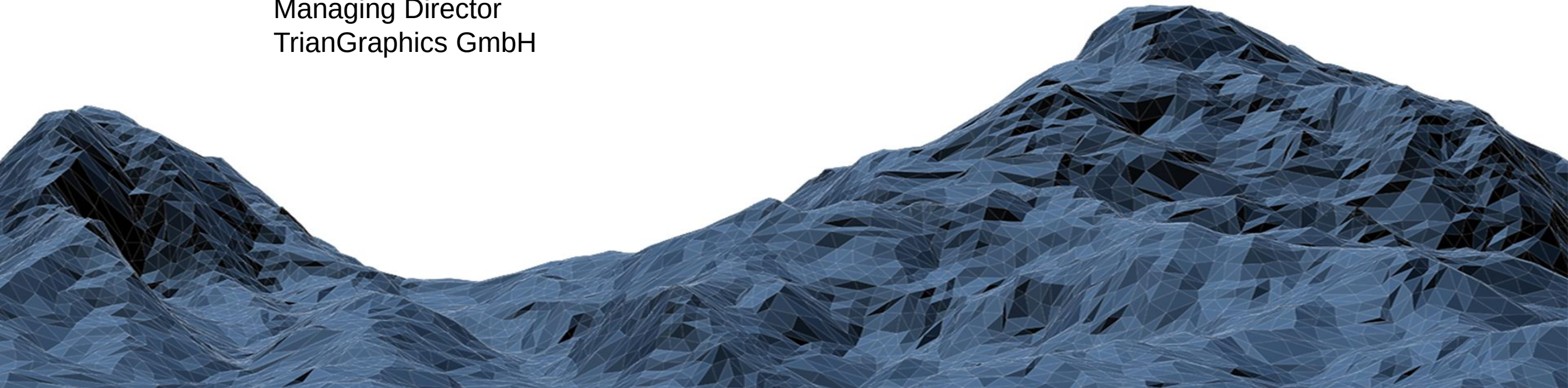




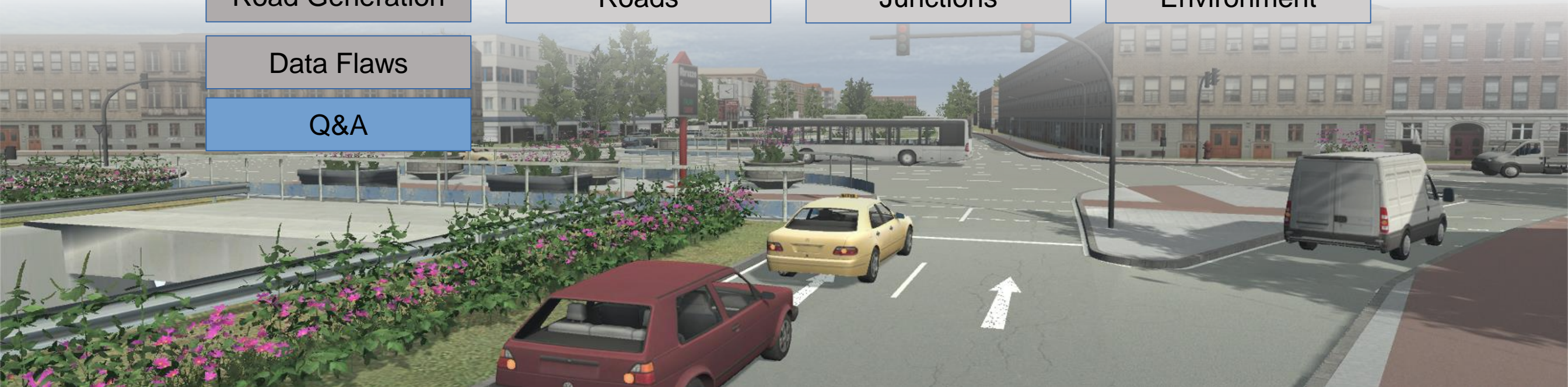
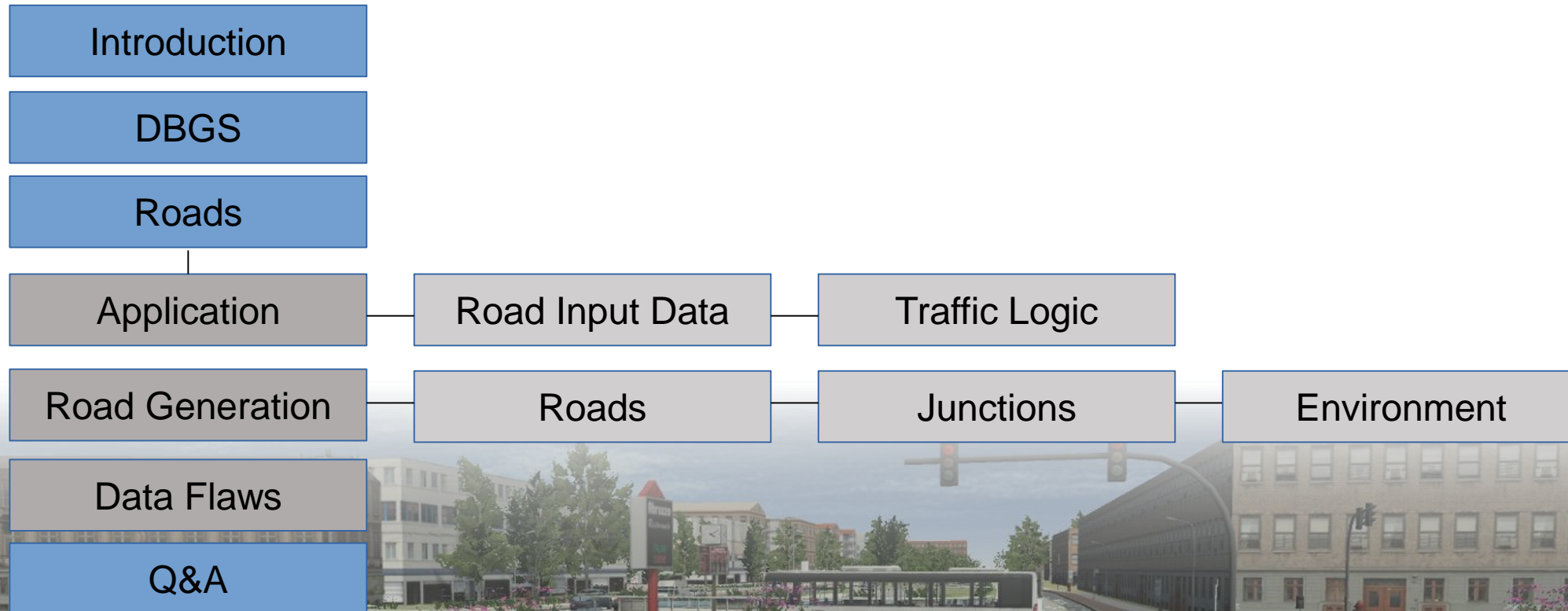
# ROADS FOR SIMULATION

ITEC 15.05.2019, Stockholm  
Stephan Kussmaul  
Managing Director  
TrianGraphics GmbH





## OVERVIEW







## TRIANGRAPHICS



### GROUND

High-detailed open world environments optimized for real-time rendering



### AUTOMOTIVE

Complex road networks for autonomous driving tests & other applications



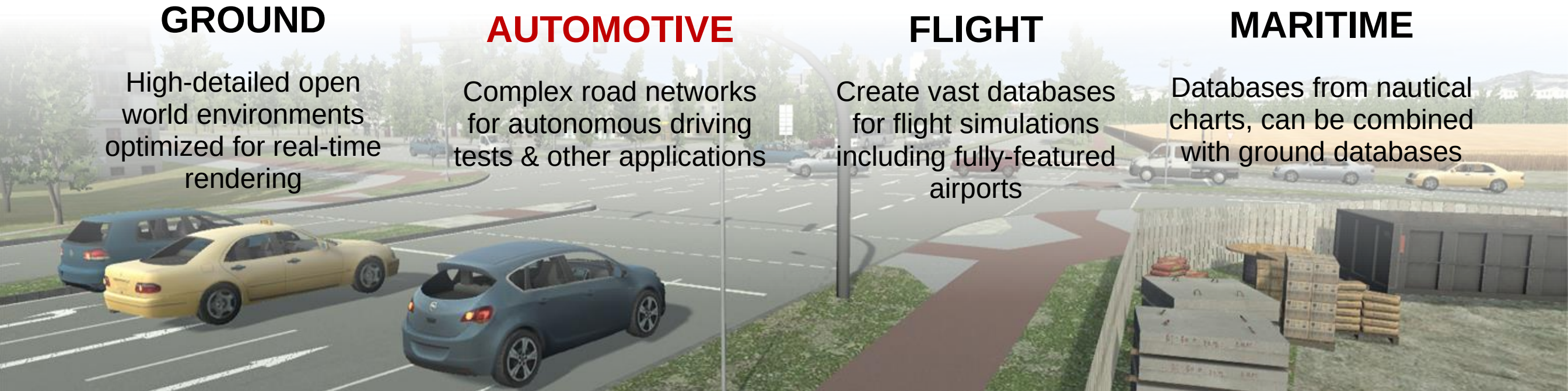
### FLIGHT

Create vast databases for flight simulations including fully-featured airports



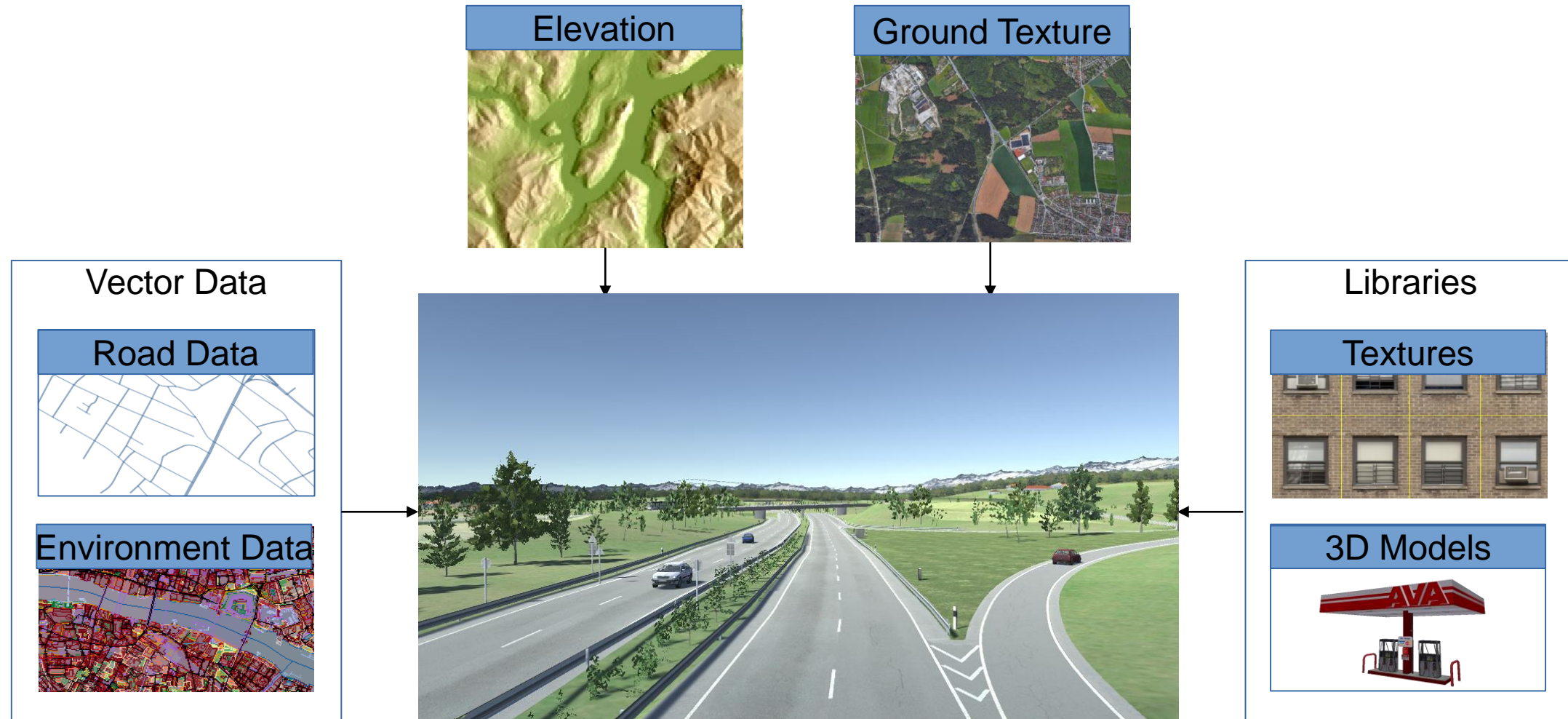
### MARITIME

Databases from nautical charts, can be combined with ground databases



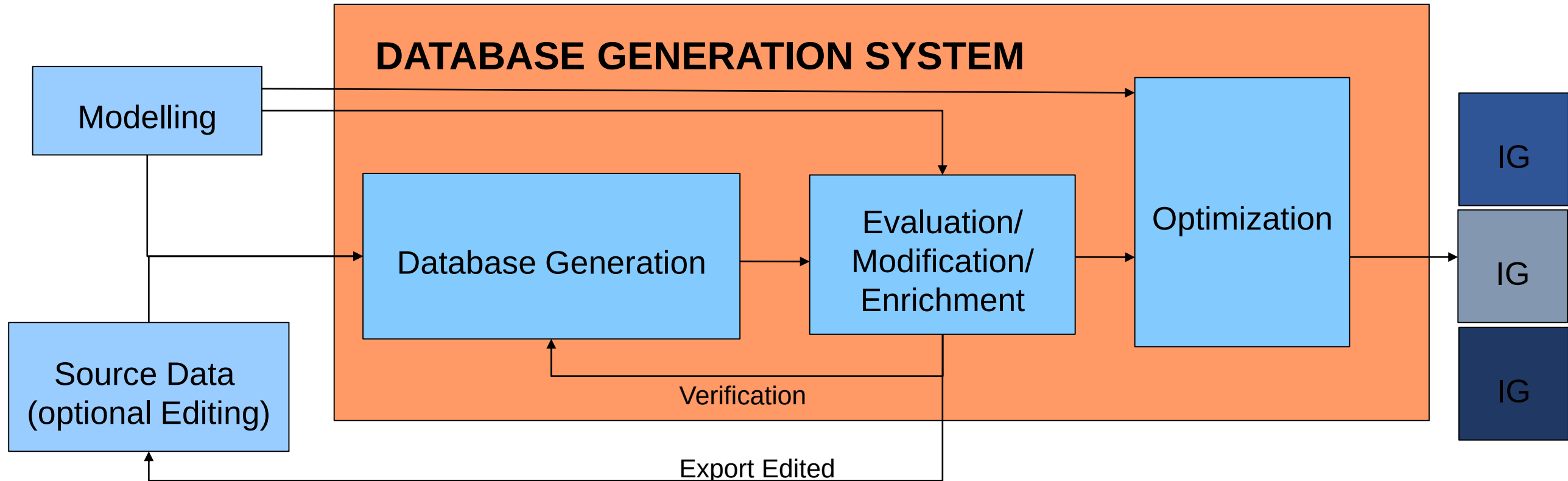


## DATABASE GENERATION SYSTEM





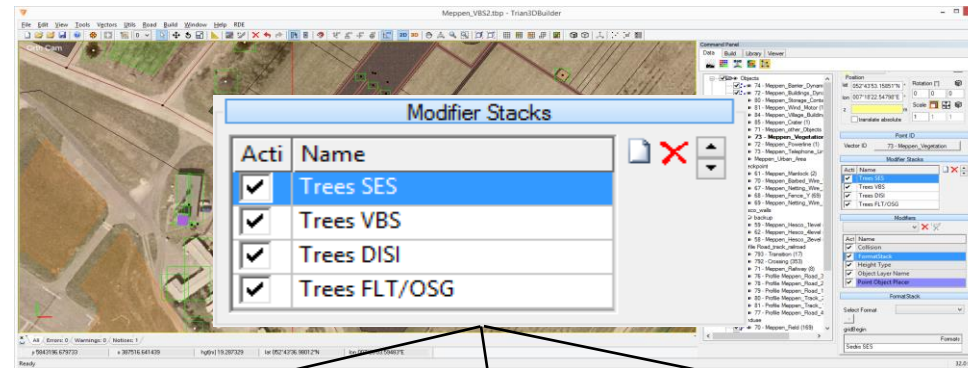
## DATABASE GENERATION SYSTEM





## Correlated Data

- Parallel exporters
- Format specific generation rules



DISI XTREME

OpenFlight

OpenSceneGraph

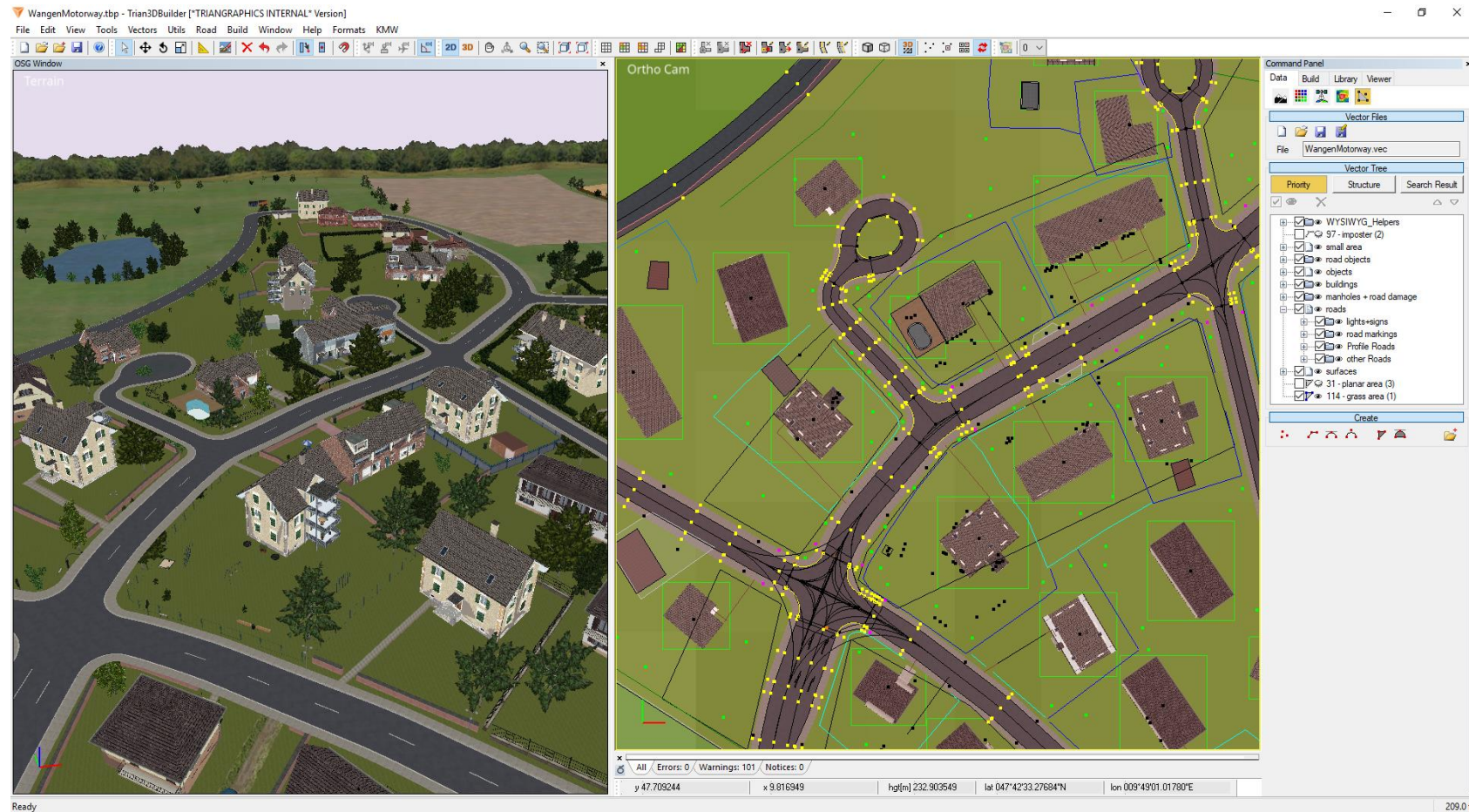
VBS



ENHANCE, EDIT, VERIFY

# TRIAN**3DBUILDER**

Database Generation System





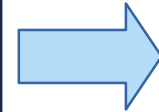
## APPLICATIONS

STATIC

### Map & Traffic Detection



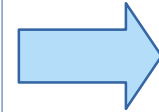
- Road Scan
- Static Ground Truth
- Environment Data



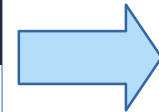
### Environment Simulation



Road Traffic Logic



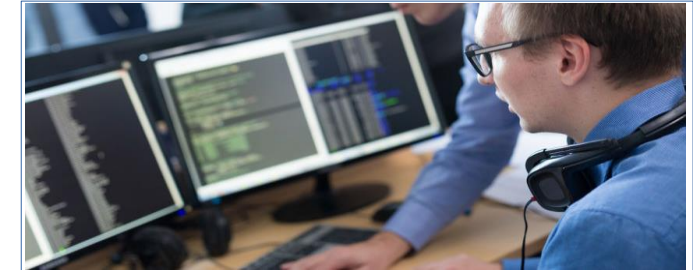
Visual 3D Scenario



Digitized Traffic



### Test Execution



MIL / SIL



HIL / DIL



VIL

DYNAMIC

- Vehicle Data
- Dynamic Ground Truth





## FORMATS

### Center Line Based

- OpenStreetMap
- HERE RDF/ ADAS  
RP
- ESRI Shapefile





## FORMATS

### Center Line Based

Geometry based on:

- Road Type
- Lane Count

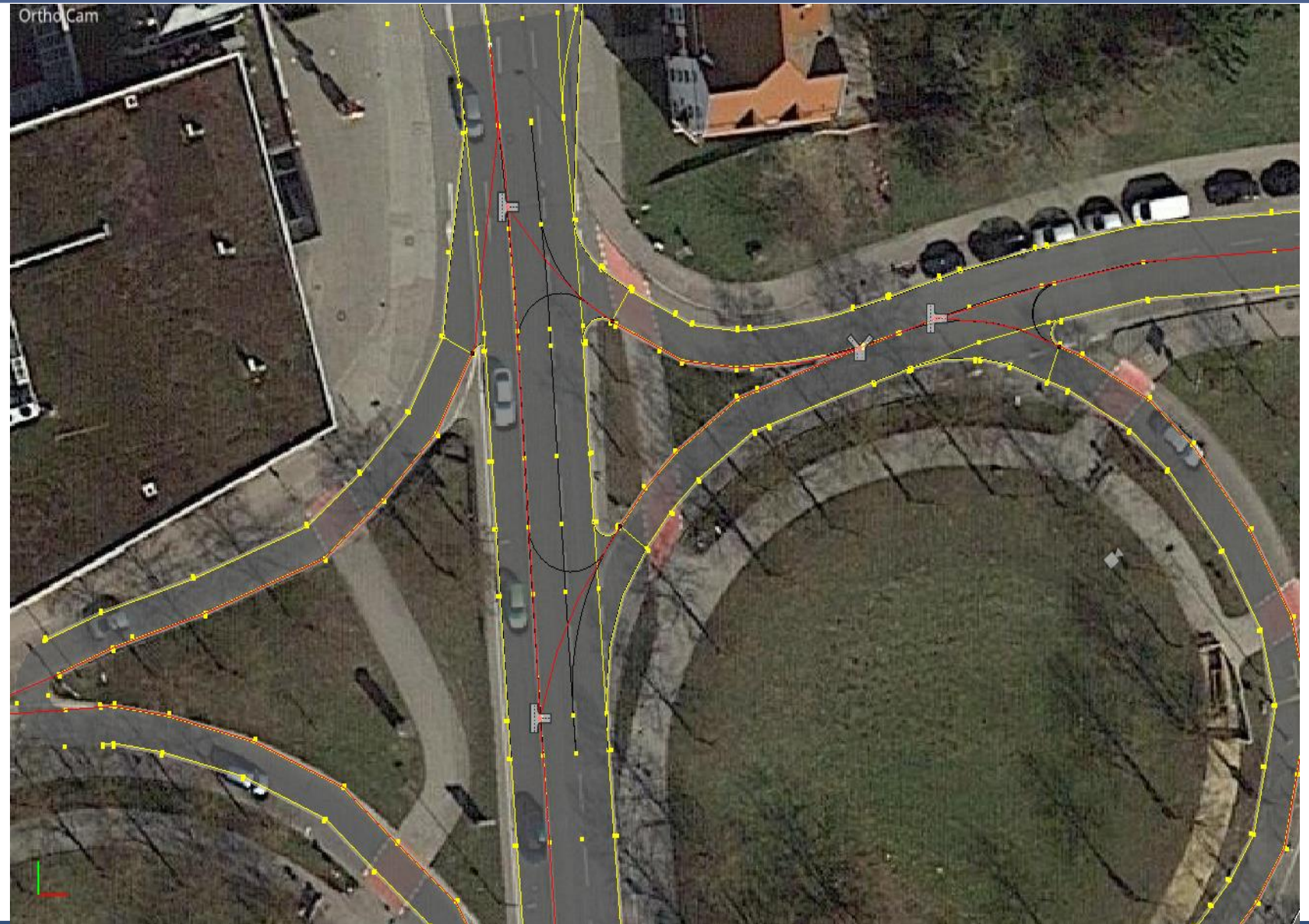


Pro:

- Availability
- Easy to use

Contra:

- Uncertain data quality
- Partly without elevation
- Procedural look





## FORMATS

### Lane based

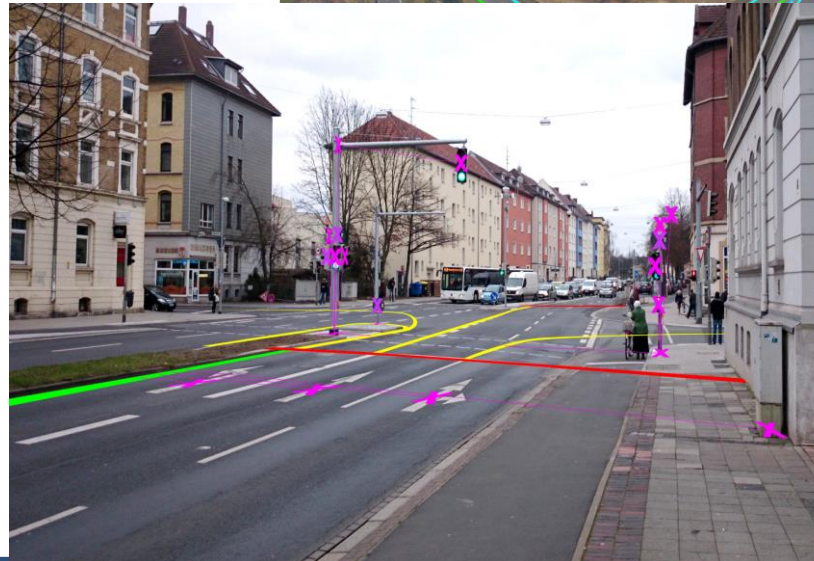
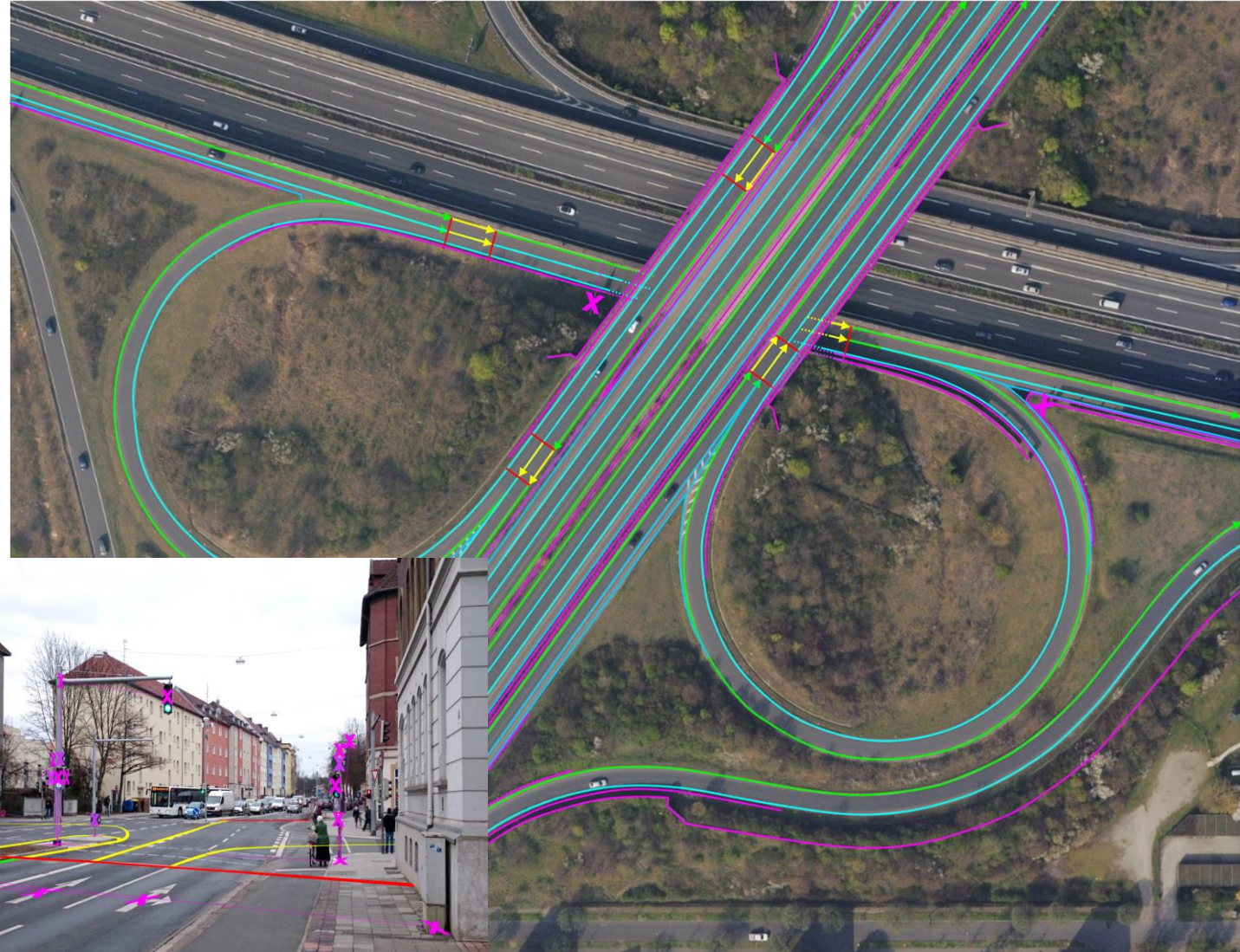
- HERE HD Live Maps
- OpenDrive
- Lane based shapefile data
- Customer formats

#### Pro:

- Exact lines
- Exact turn directions

#### Contra:

- Not yet comprehensive availability

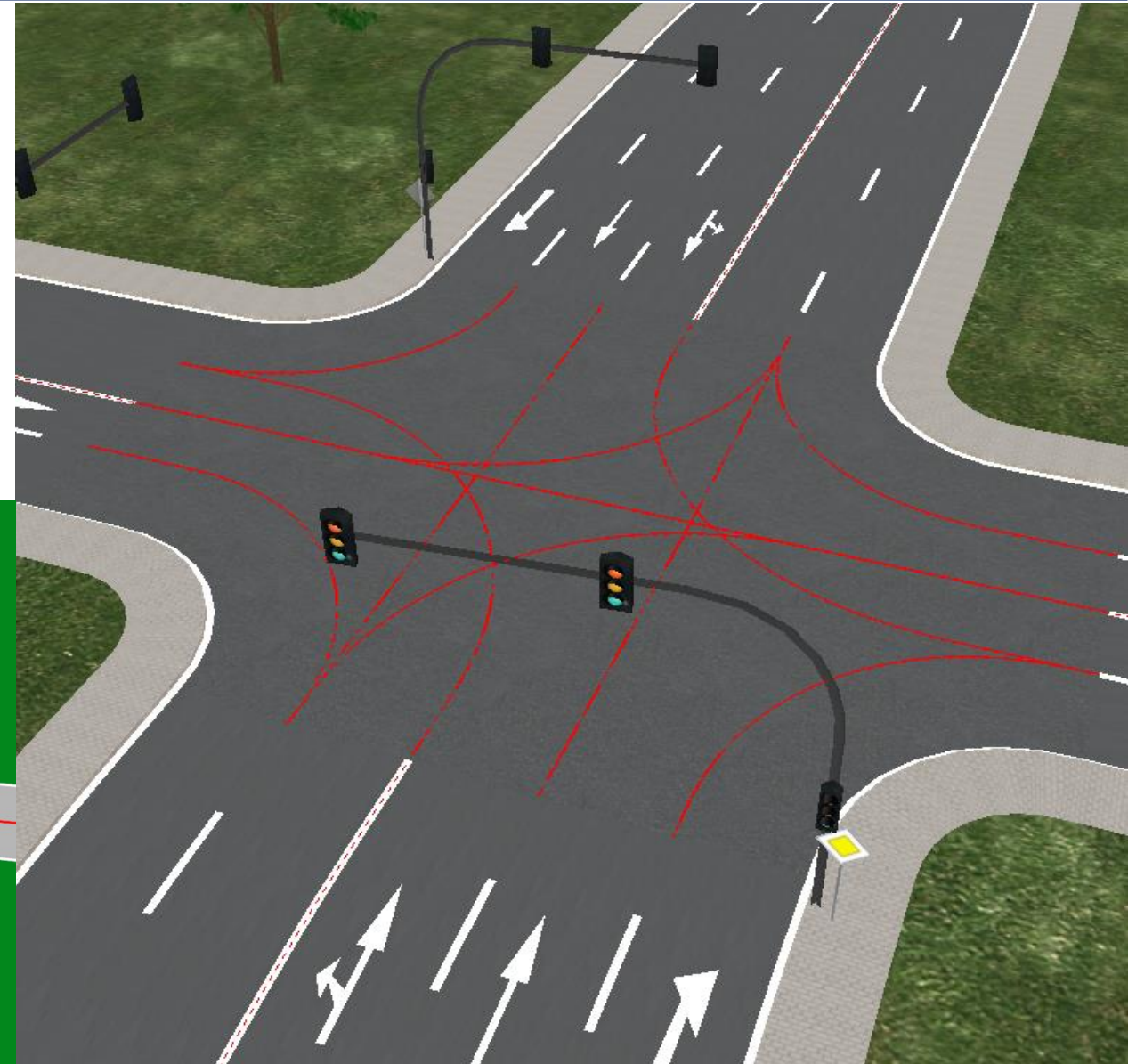
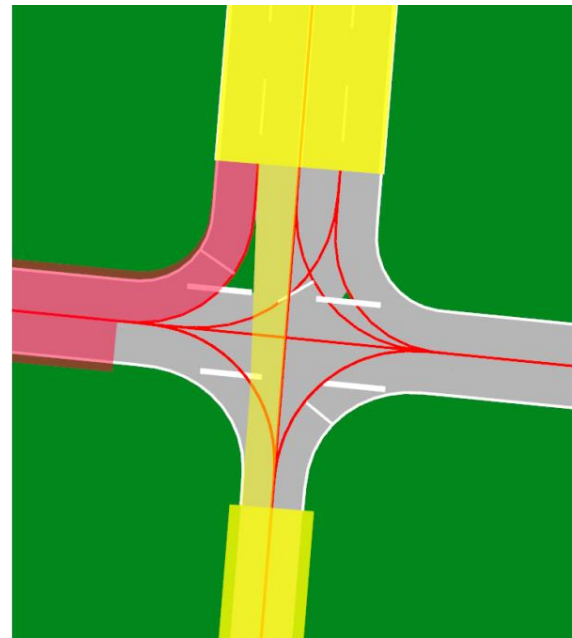




## FORMATS

### Logical Formats

- OpenDrive (.xodr)
- IPG Road5,...
- Vector formats (shp, kml, kmz, etc.)
- OpenCRG
- OpenScenario

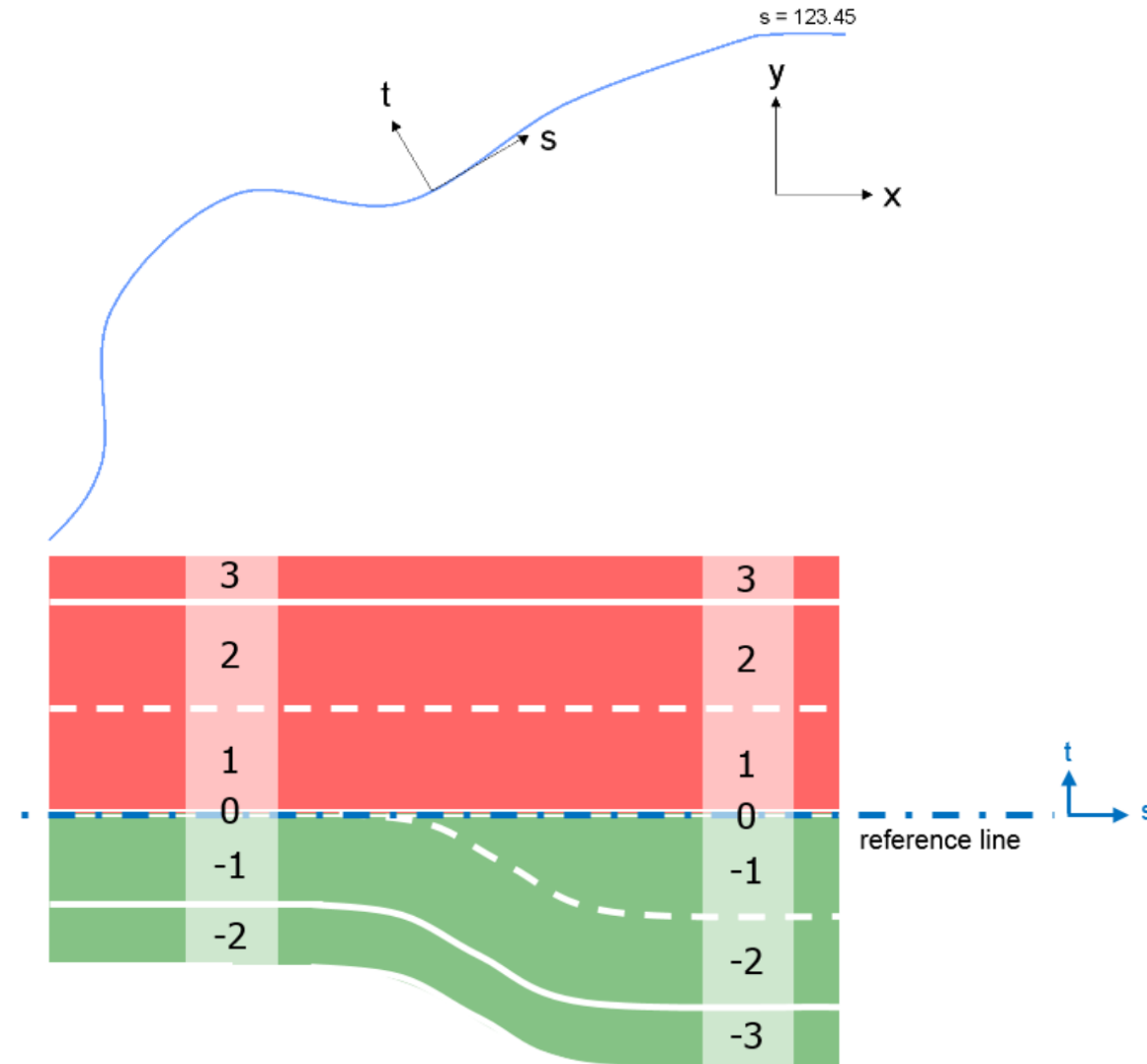




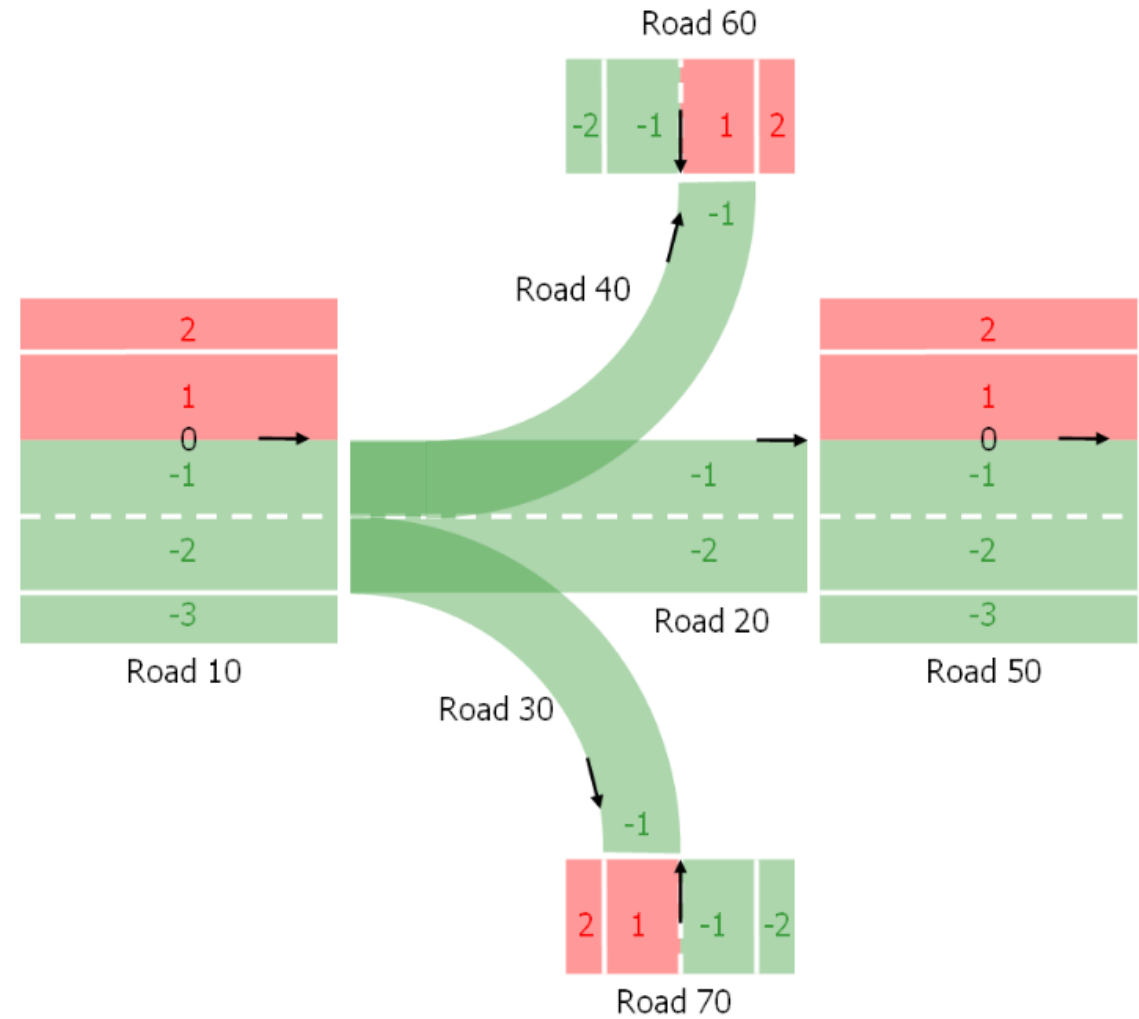
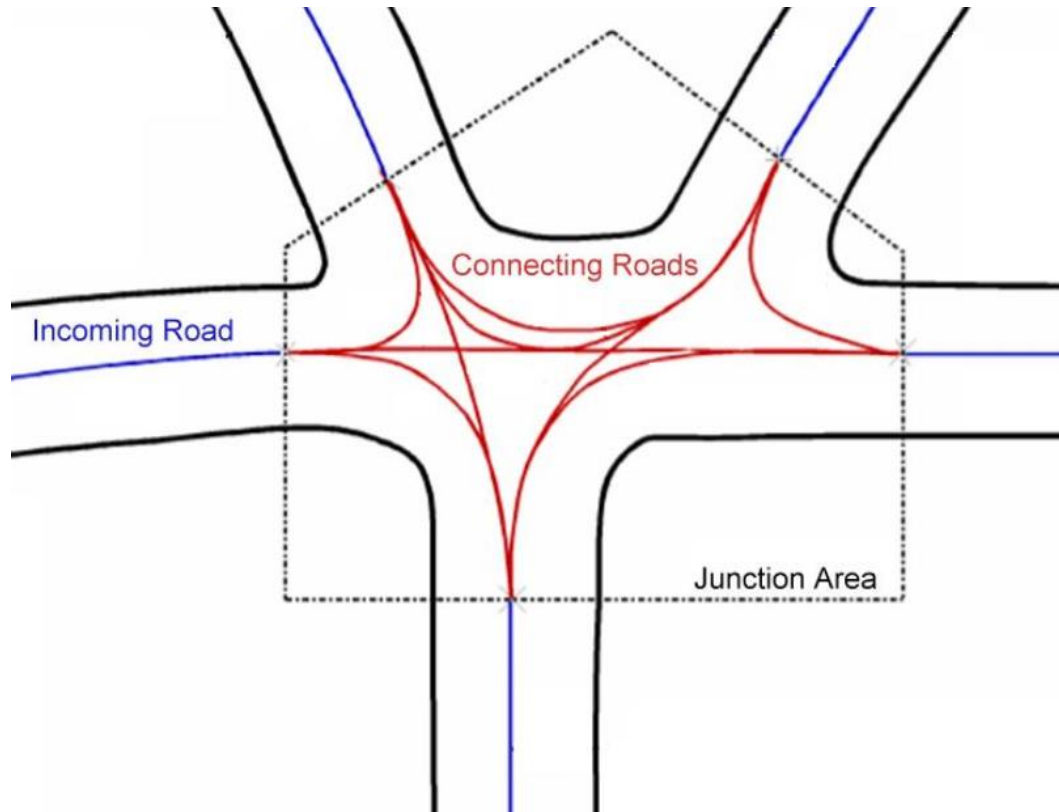
## OPENDRIVE

### OpenDRIVE

- Traffic logic description
- Open Format: <http://www.opendrive.org>
- XML-Format, Version 1.4
- Width  $t$  at line position  $s$
- Reference line as linear, polynom, clothoid
- Width described as polynomial



# OPENDRIVE

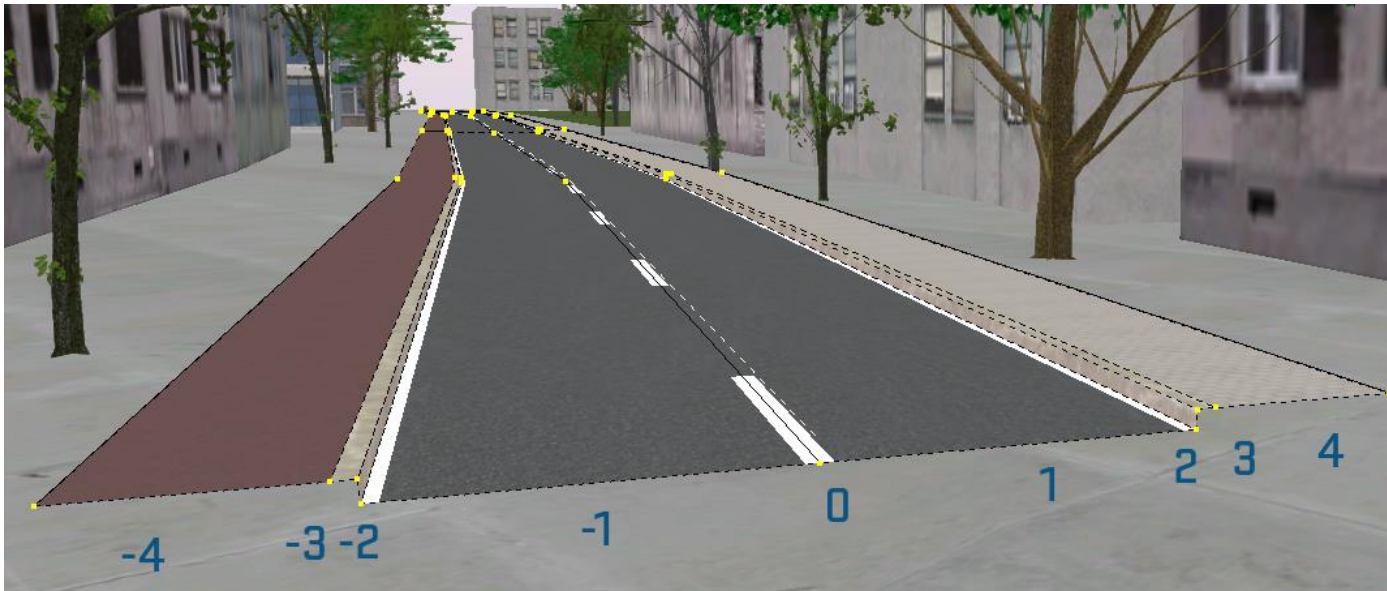




## ROADS

### Roads with 3D Profile

- Different lane types
- Individual height for each lane
- Lane markings
- Driving direction and speed limit for AI traffic



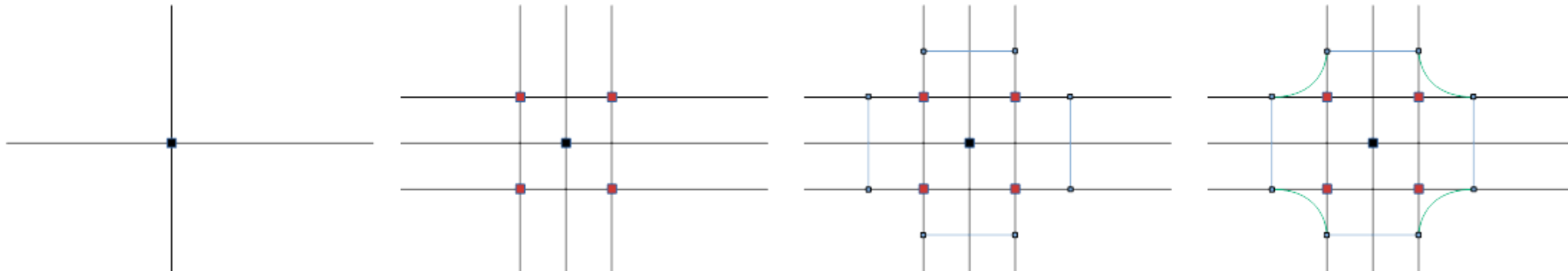
Profiler	
Road Type	Motorway
Profiler Type	Normal Road
<input type="checkbox"/> Crossing Internal Road	
Max Superelevation	0
Radius	80
Curve Length	100 m
Lanes	+ Left + Right - Selected
	-4 -3 -2 -1 0 1 2 3 4

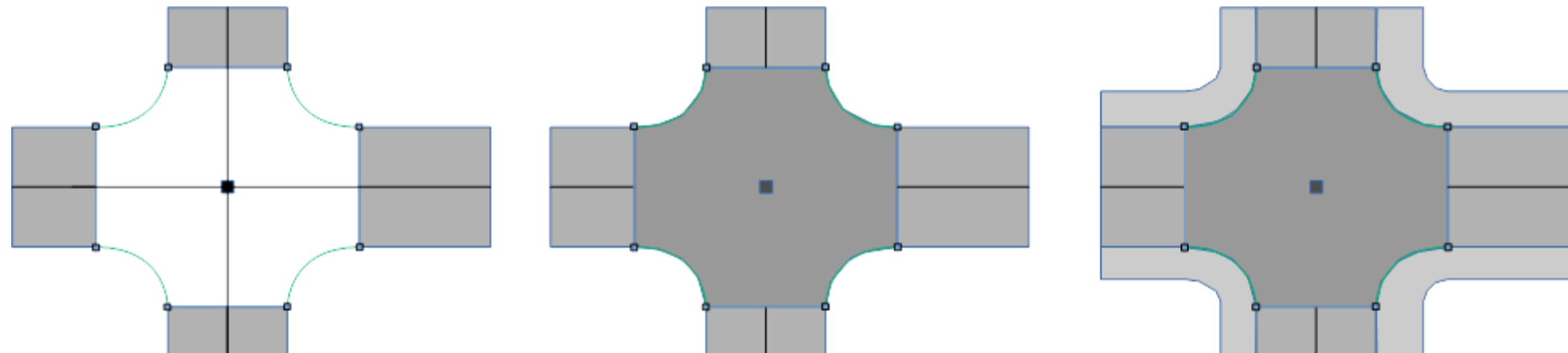
Lane	
UniqueID	18295
Height	0 m
Width	1.5 m
HighPrio	<input type="checkbox"/> front <input type="checkbox"/> back
Speed limit	50
Type	Biking
Turn	
Texture	asphal...cle.png
--- Marking ---	
Type	none
Width	0.1 m
Marking Texture	mark_solid.rgb

## INTERSECTIONS (SD DATA)

### Intersect Outlines



### Geometry Generation

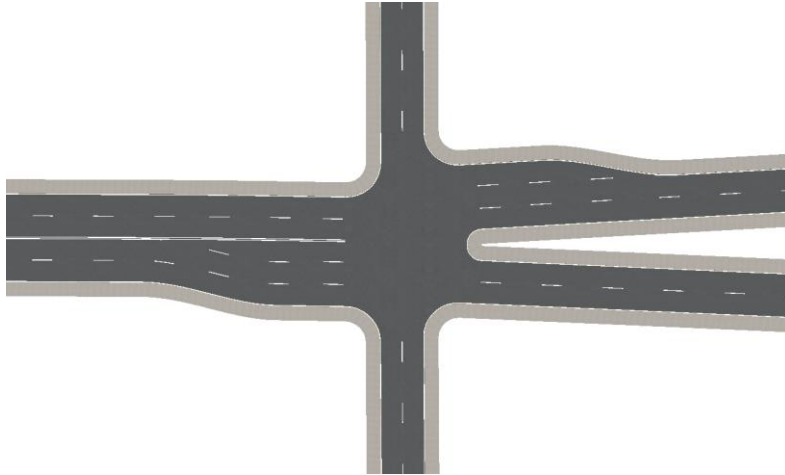




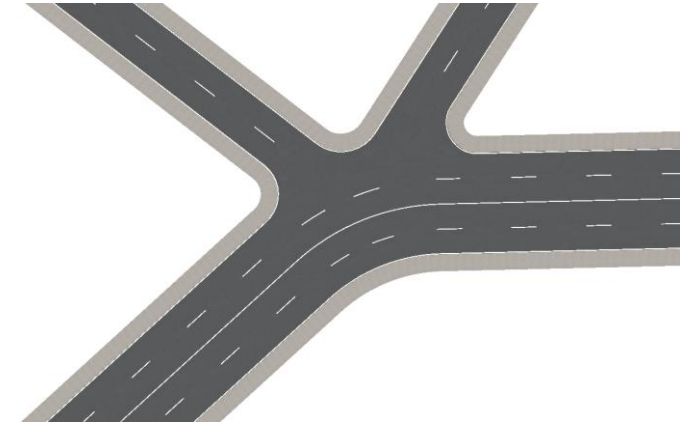


## INTERSECTION TYPES

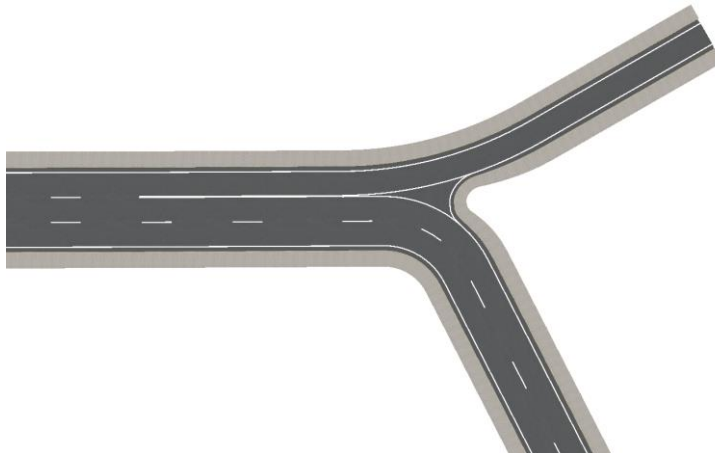
Crossing



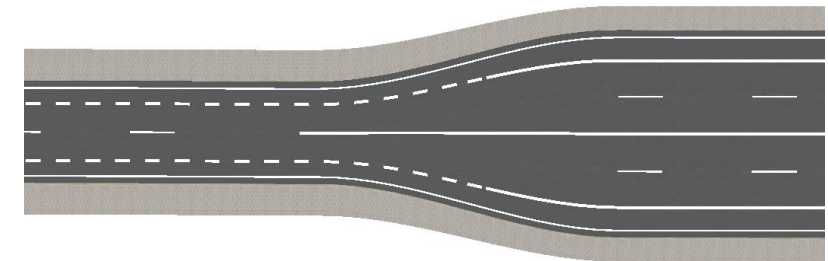
Drive-up



Forking

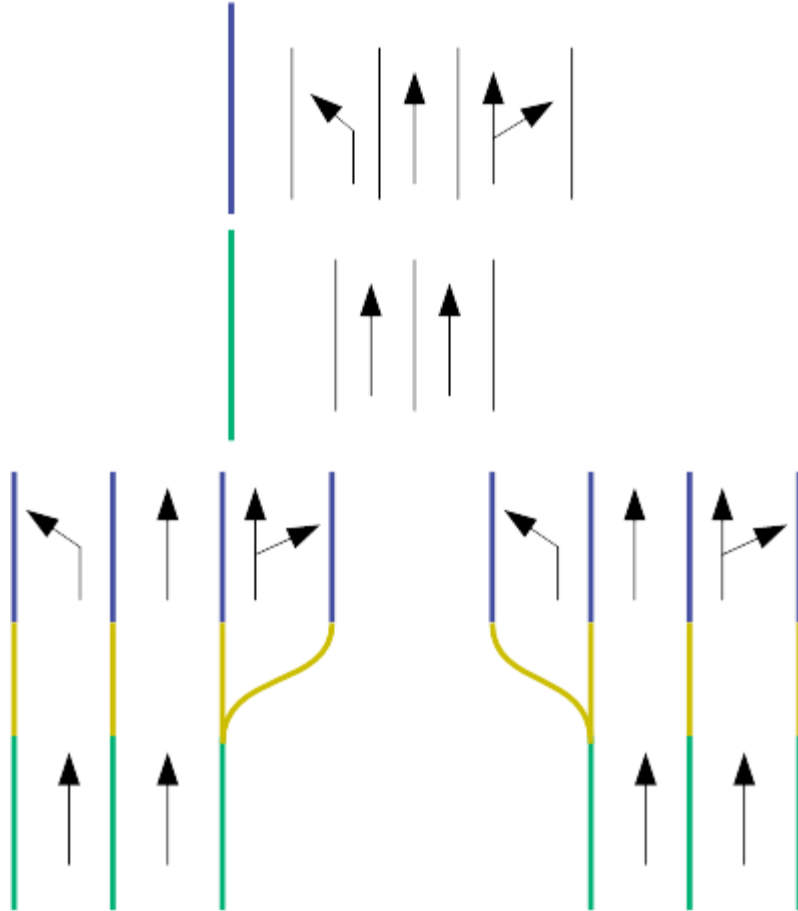


Transition

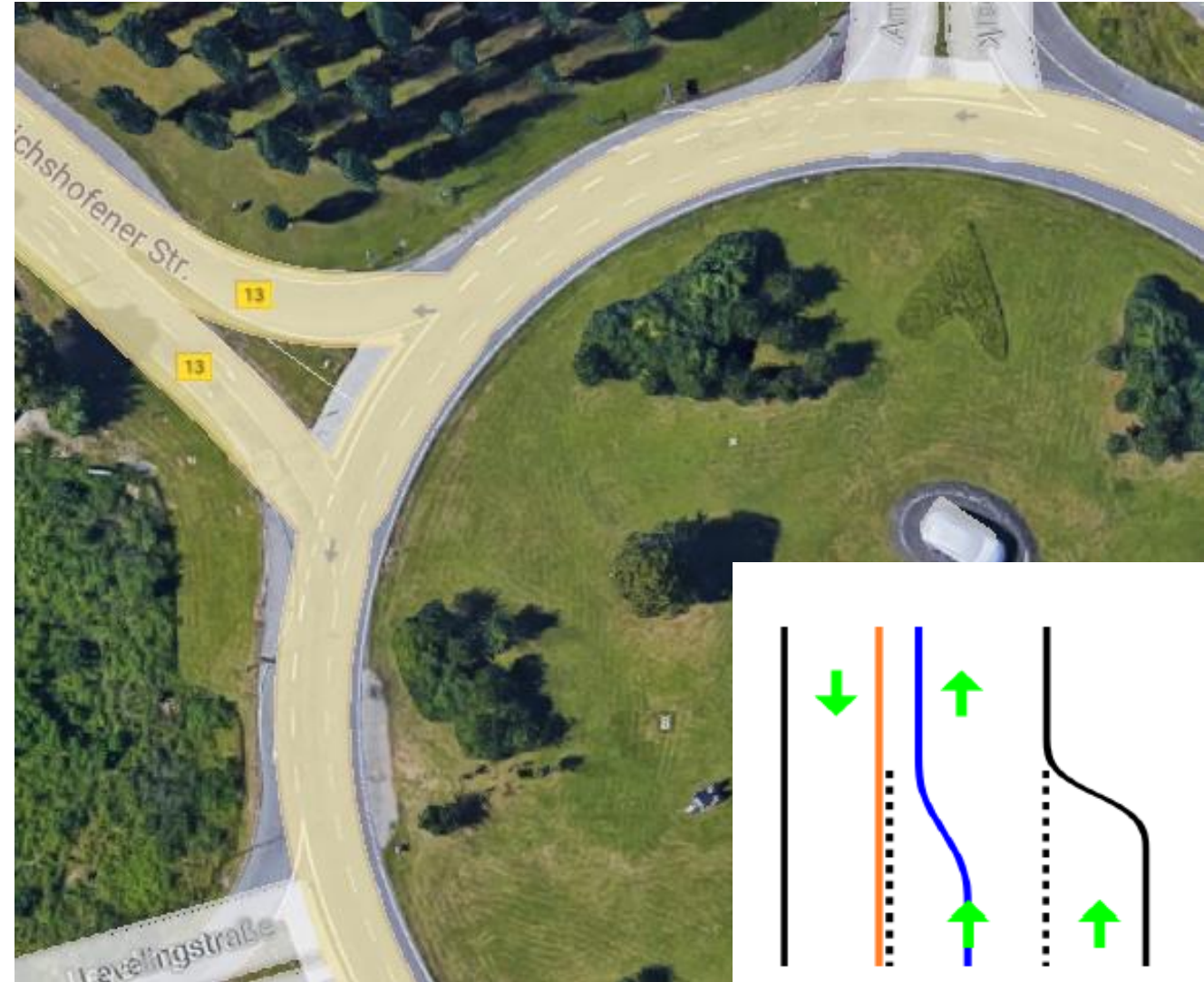


## SD DATA FLAWS

### Ambiguous Lane Change

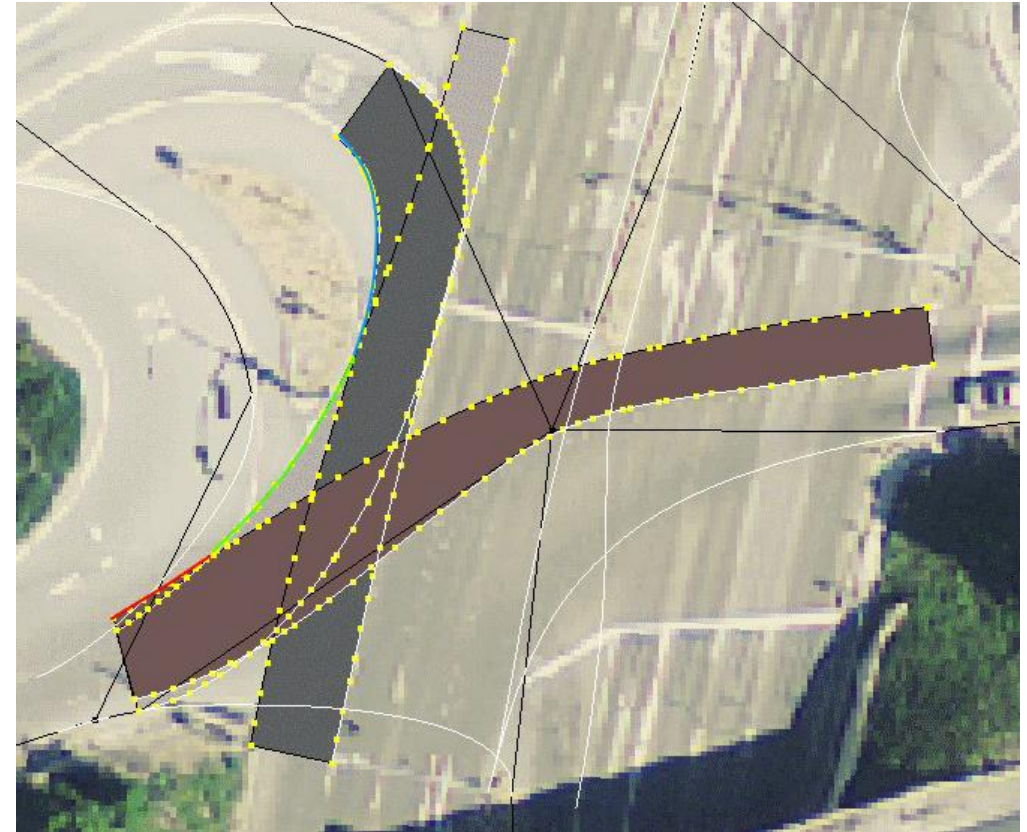
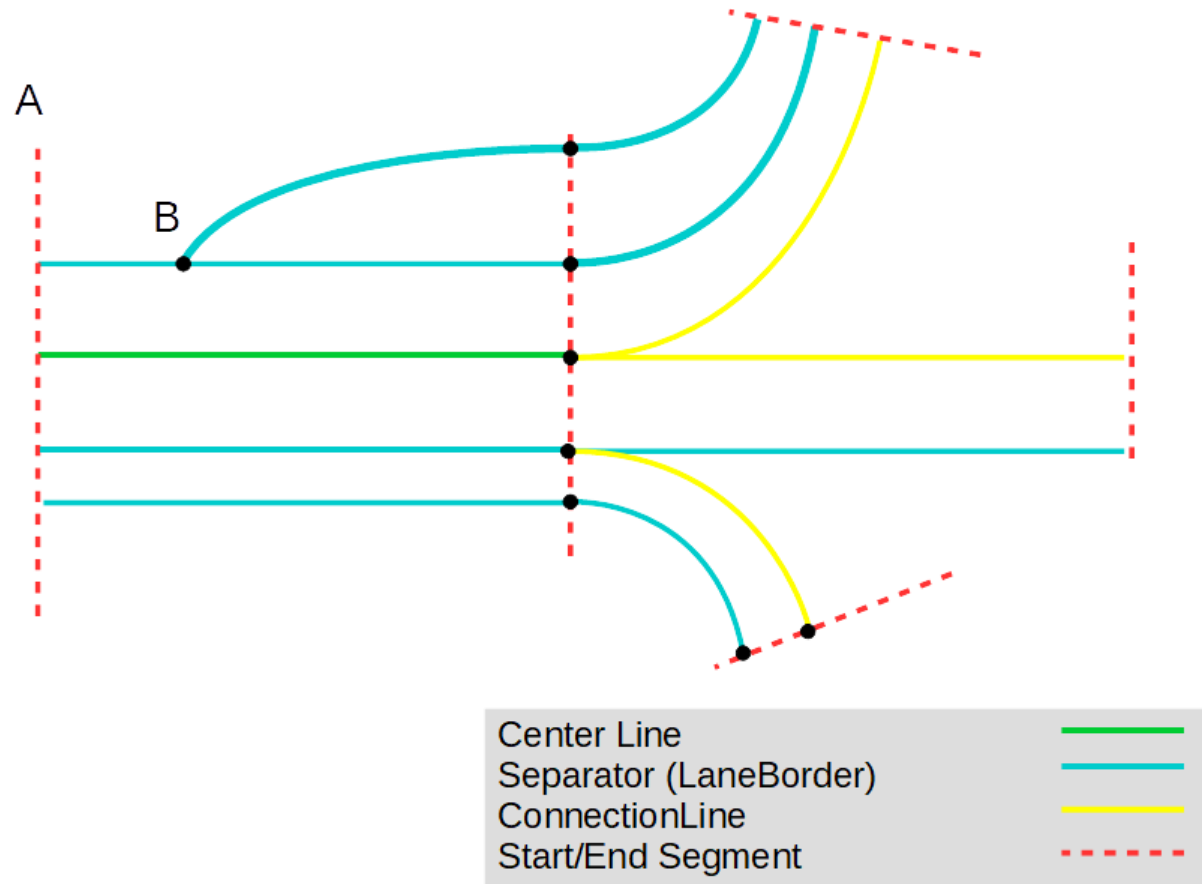


### Position Center Line (One Way Roads etc.)

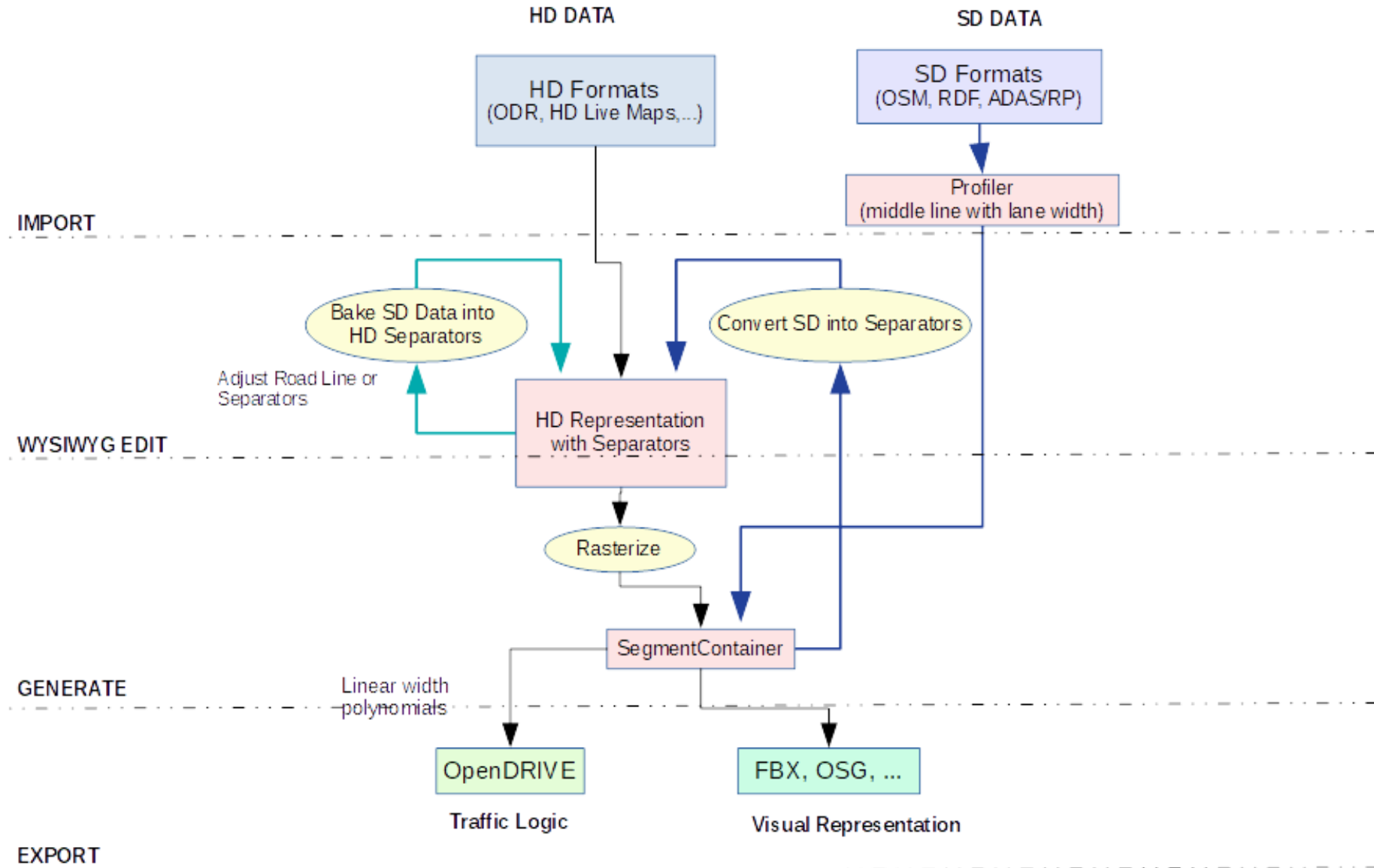




# HD DATA REQUIREMENTS



# GENERATION PIPELINE







## MARKINGS

### Markings

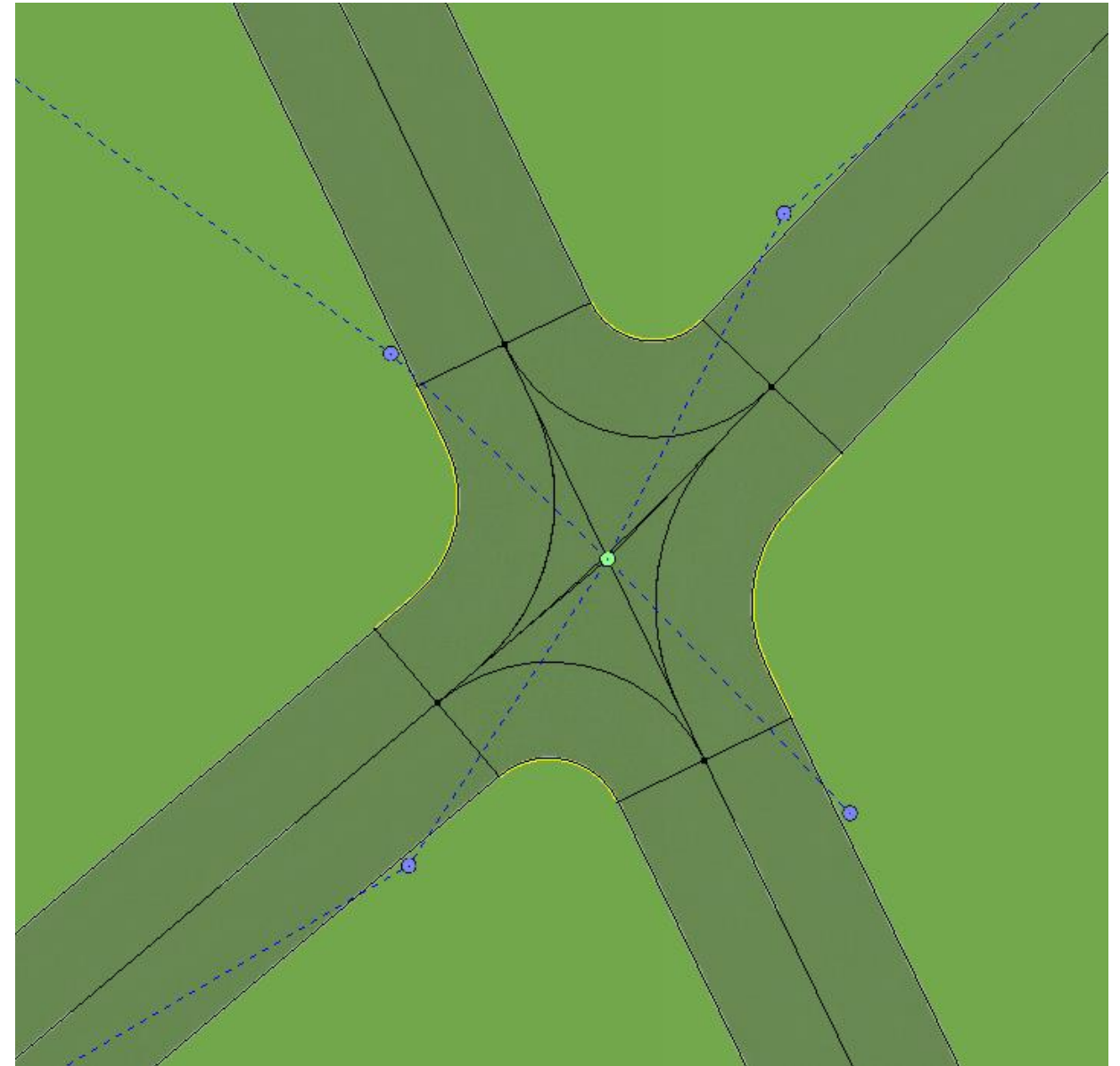
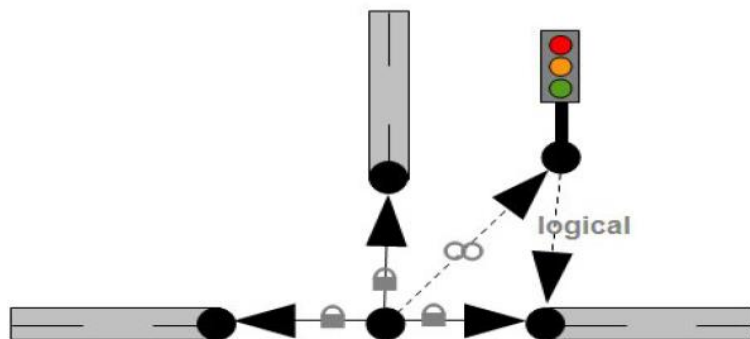
- Individual Markings
- Inside crossings
- Clip on road surface
- Restricted areas, stop lines, arrows



## SIGNALS

### Signs & Signals

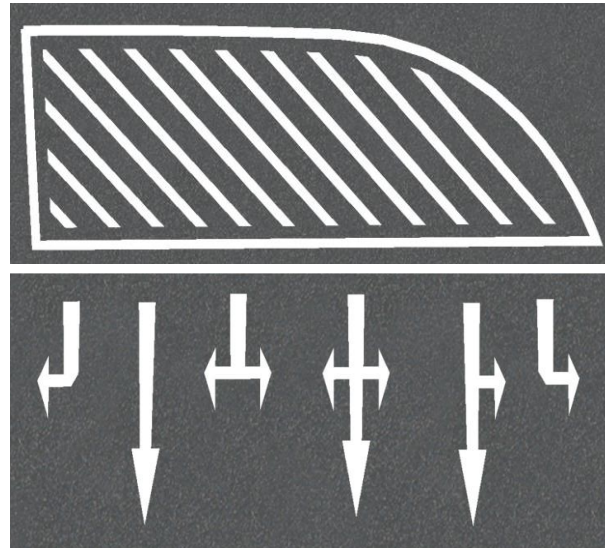
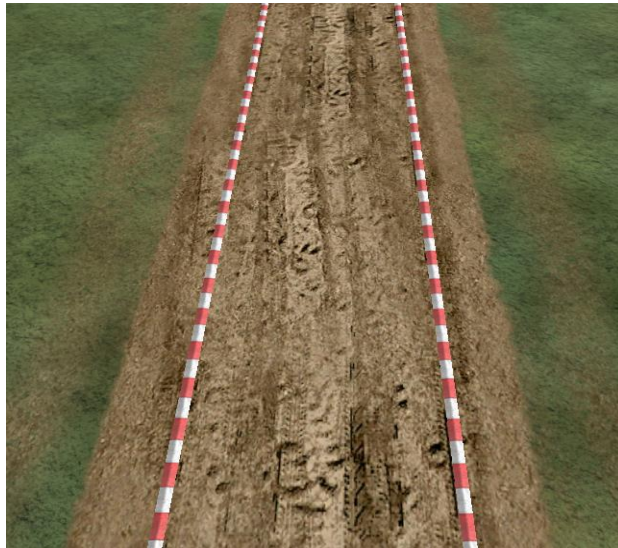
- Model Placement
- Signal Definition
- Controller if applicable
- Logical link to Road/Crossing
- OpenDrive Settings





## ADDITIONAL DEMANDS

- Smooth transitions and height adjustment
- Multitexturing and PBR material support
- Extruded guard rails, barriers,...
- Bridges, Tunnels

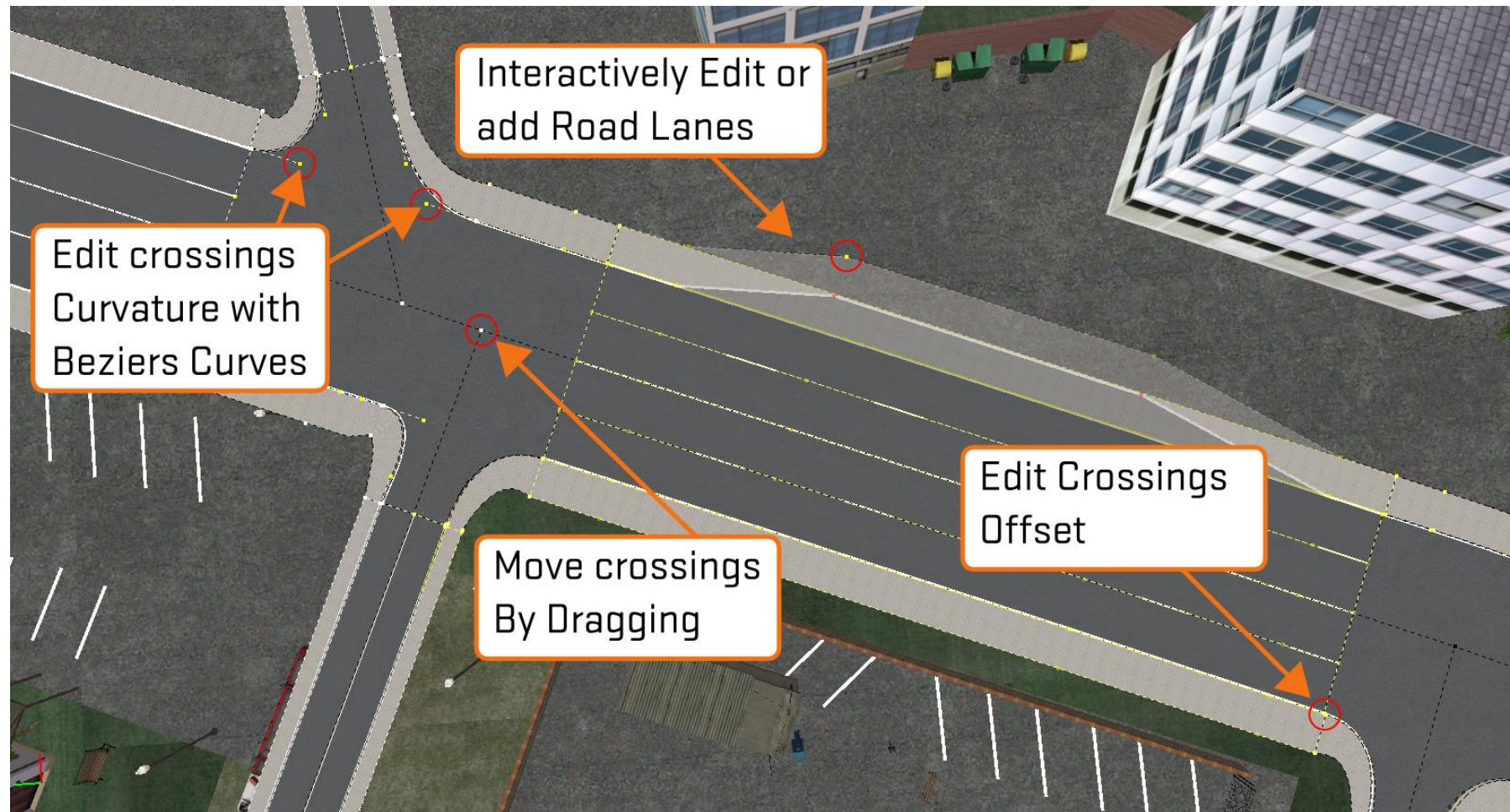






## EDITING

### Edit Roads & Crossings in 2D or 3D View

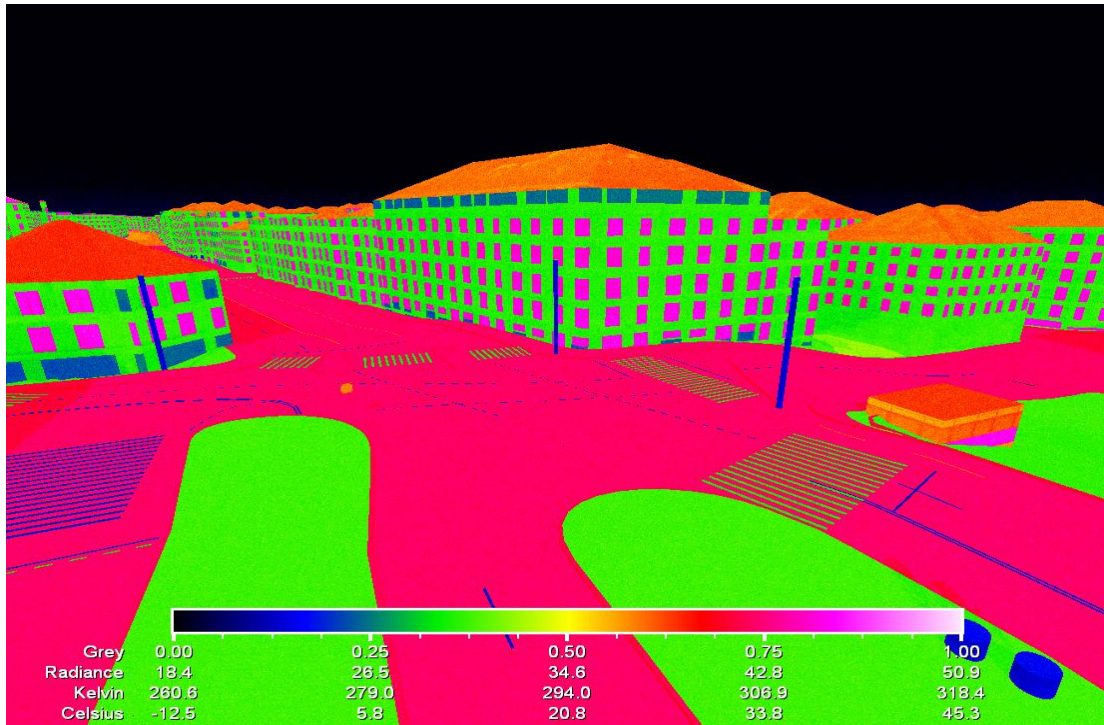




## METADATA & SENSOR

### Sensor Data

- Definition of physical surface attributes
- Flexible generation of sensor images with reference to attributes
- Support of night vision, material classification, ...



**Sensor Global Settings**

☒ Sensor Active

ClassSet Values

Max classes in class set:

Min class weight:  %

Encoding

☒ 8 bit ☐ 16 bit

Write

☒ File ☐ Description

File name:

Texture format read:

Texture format write:

Generation mode:

☐ Add Texture Layer

**Class List File**

File:

**Class List**

Name:

ID	Name	Co
0	Grassland	
1	Scrubland	
2	Ded. Forest	
3	Field - Ploughed	
4	Water	
5	Roads	
6	Urban / Concrete	
7	Field - dry	
8	Sand	
9	Fields - Crops	

**Class Attributes**

Template:

Attributes:

name	value
brightness	0.1
weighting	40
SB_ID	10
SB_isWater	FALSE
SB_isWadi	FALSE
SB_isSnow	FALSE
SB_Drag	0.12
SB_Traction	1
SB_Hardness	1
SB_WetDrag	0.15
SB_WetTraction	0.7
SB_WetHardness	1
SB_Bumpiness	0.2
SB_Dustiness	0
SB_Obj1	Grass-002.flt
SB_Obj1_Density	80
SB_Obj1_Height	0.3
SB_Obj2	Grass-004.flt
SB_Obj2_Density	80
SB_Obj2_Height	0.3
SB_Texture_Hi	grass4.jpg
SB_Texture_Lo	medGrass2.jpg
IR	Sand



## EXPORT

### Common Target Platforms

- OpenSceneGraph (ive, osgb)
- Unreal (Datasmith) & Unity3D (fbx)
  - Define PBR materials
  - Place prefabs/assets
- OpenFlight (flt)
- Various serious game engines







## GAME QUALITY







## Road Networks



THANKS FOR YOUR INTEREST