

The Surveyor's Guide to Automotive Simulation: Development and Evaluation of Guidelines for Straightforward Road Surveying for Driving Simulator Databases and Test Development of Driver Assistance and Automation Systems

Driving Simulator Conference 2016 VR

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Knowledge for Tomorrow

Development and Evaluation of Driver Assistance and Automation Systems using Driving Simulators



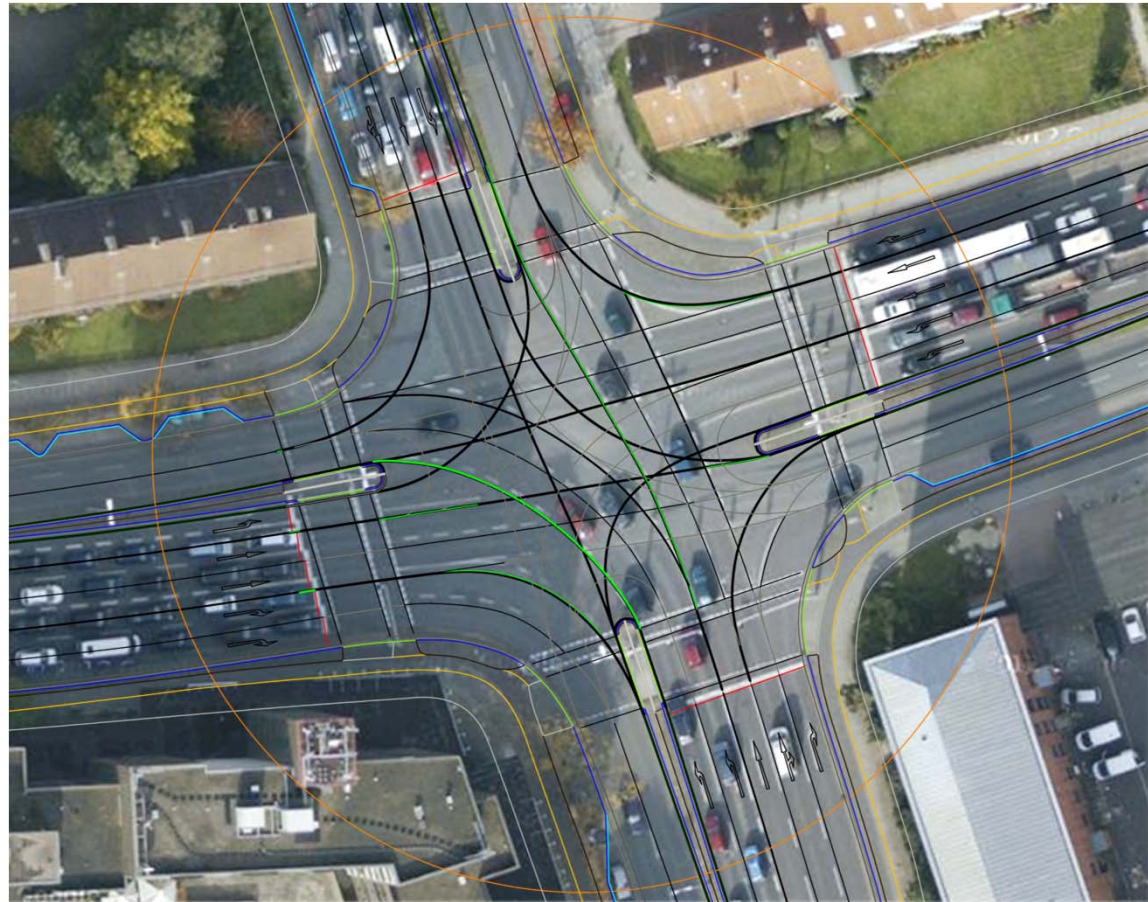
Need for Re-creation of Complex Urban Environments in Driving Simulators



Urban Road Networks in Driving Simulators: Solution 1

Surveying of the Original

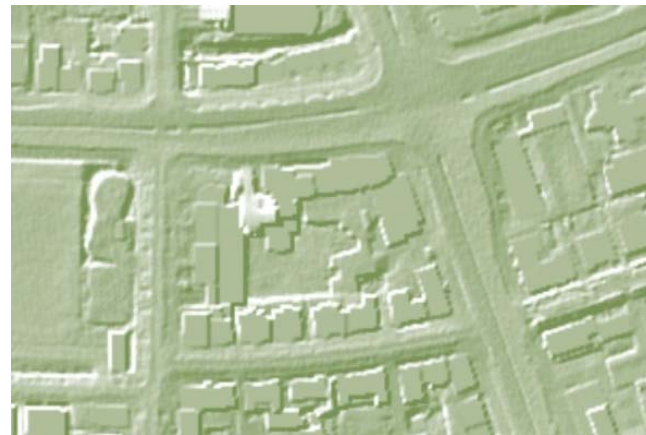
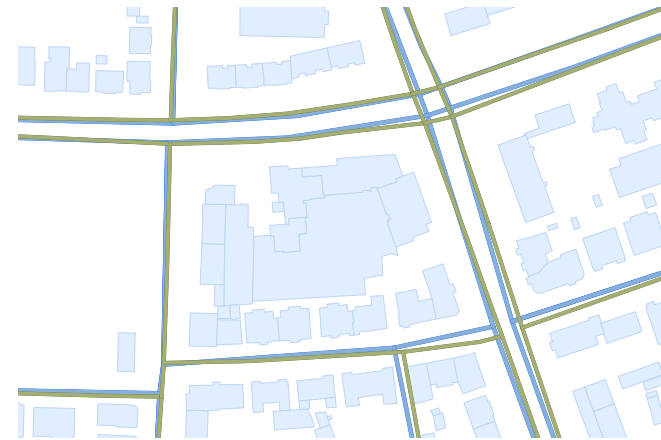
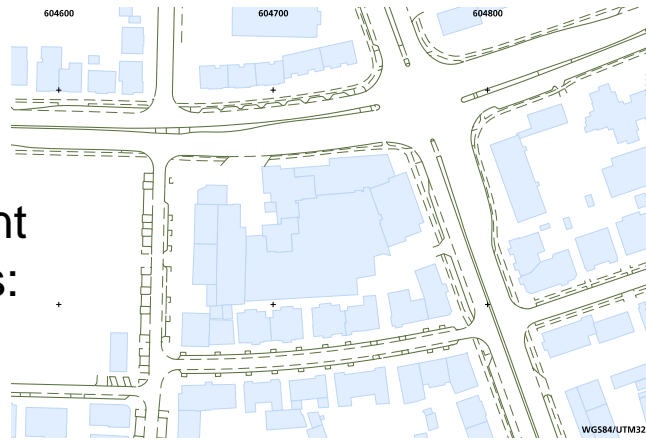
- by specialist companies (ResultOverlay)



Urban Road Networks in Driving Simulators: Solution 2a

Transforming of Cadastral GIS Data...

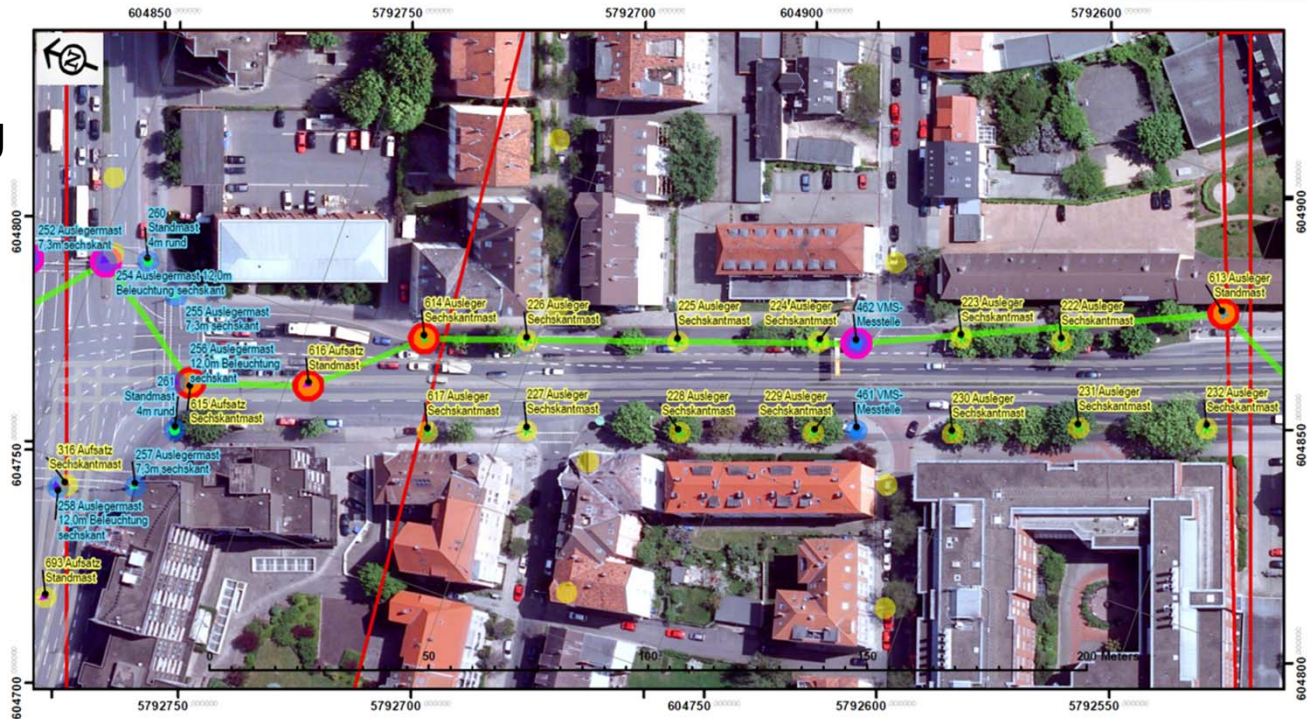
- fusion of different sources such as:
 - road topography
 - road axis
 - elevation model
 - land use
 - ...



Urban Road Networks in Driving Simulators: Solution 2b ...and fusion with Road Operator Data



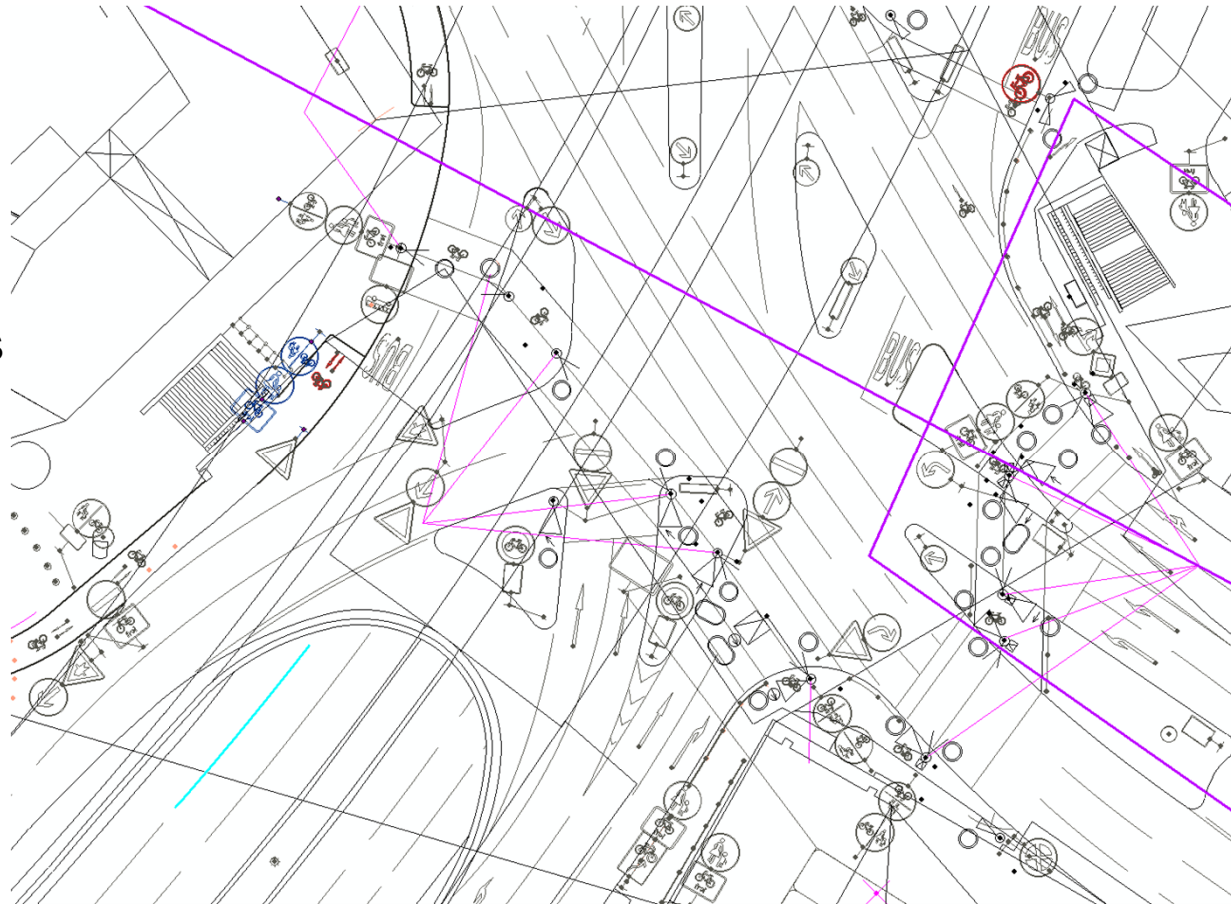
- fusion of different cadaster regarding location and orientation:
 - road signs
 - road signpost
 - traffic lights
 - street lighting
 - catenary
 - ...



Urban Road Networks in Driving Simulators: Solution 2c

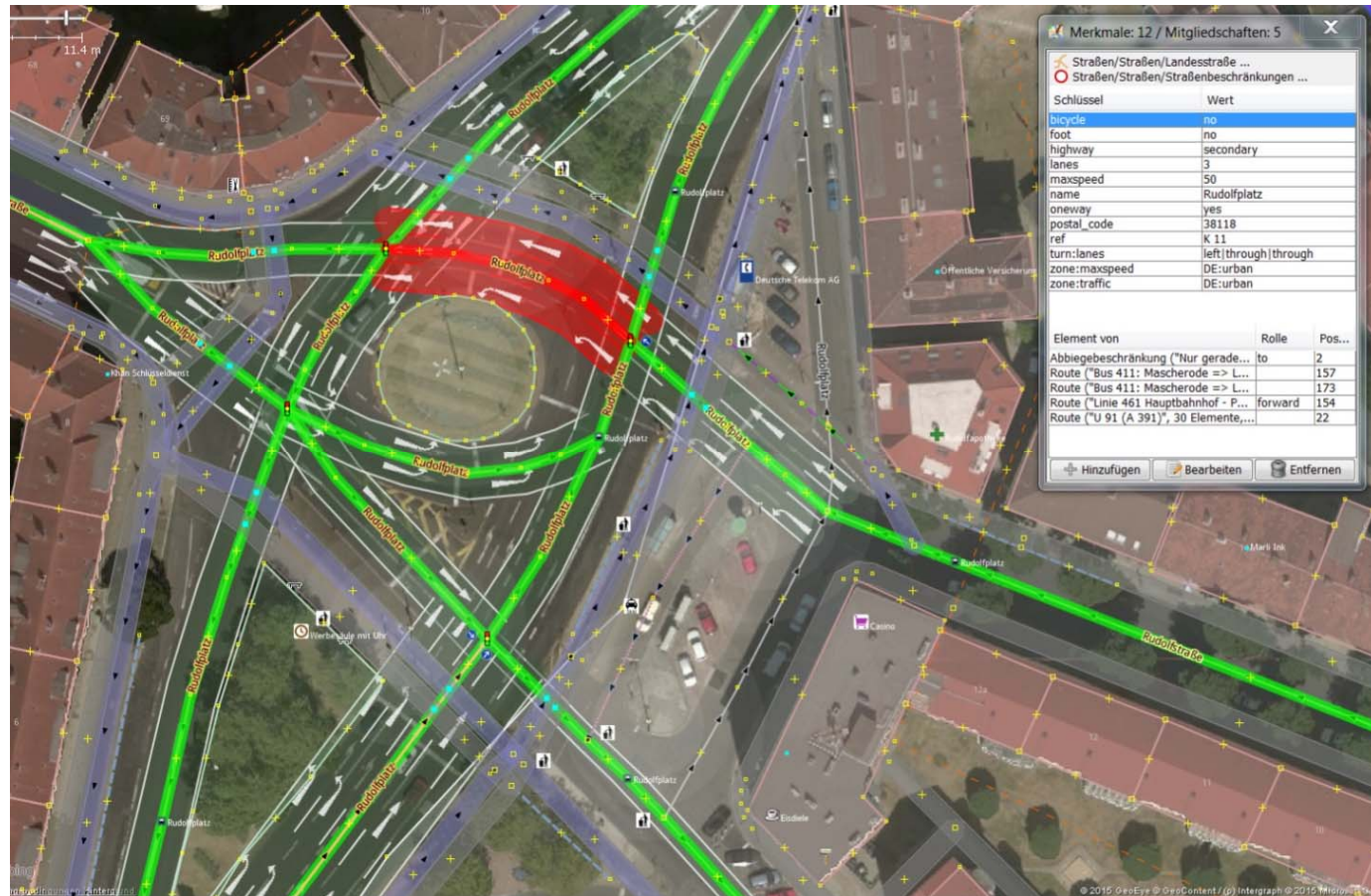
Transforming Cadastral CAD Data

- only visual database, road signs as images and no logical correlation



Urban Road Networks in Driving Simulators: Solution 3 Using Crowd-Sourced Data

- such as OSM, including:
 - lanes
 - traffic rules
 - traffics signs
 - street furniture
 - ...



Urban Road Networks in Driving Simulators

Summary

- **Solution 1:**

- high precision road survey can be conducted by specialist companies delivering the results in driving simulator formats
- Drawbacks are a high amount of time and cost for data transformation, not suitable for large-scale road networks

- **Solution 2:**

- automated generation of large-scale road networks based on GIS data using a combination of computer graphics GIS approach is possible (see “Virtual World” project – DOI: 10.1177/0037549716641201)
- Drawbacks are generalized intersection layouts and less accuracy, both depending on input data

- **Solution 3:**

- crowd-sourced data is (more or less) free to use and widely available
- Drawbacks are a lack of lane level details and heterogeneous data quality and a poor accuracy



Urban Road Networks in Driving Simulators

Goal

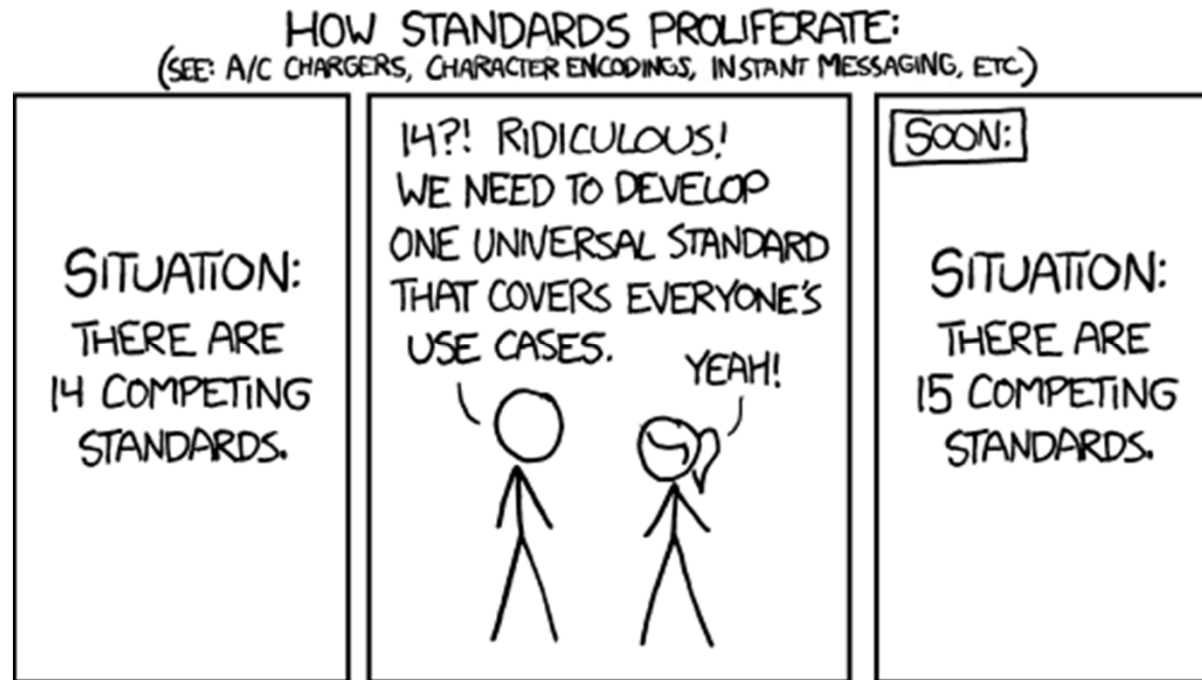
- Having a solution 1 + 2: high precision data that is widely available and automatically transformable (to reduce time and cost effort).
- Therefore:
 - cities should provide their data in a “machine-understandable” way
 - store information in a simplified way, thus everybody is able to gather the data with only few pre-processing effort
 - store the data in a way that requirements of public authorities and driving simulators are met
 - guidelines should support every surveyor how to pre-process the data
- Solution:
 - join forces in the project “Road2Simulation” to create and test such guidelines and disseminate them



Road2Simulation

Just a new “Standard”?

- <http://xkcd.com/927/>



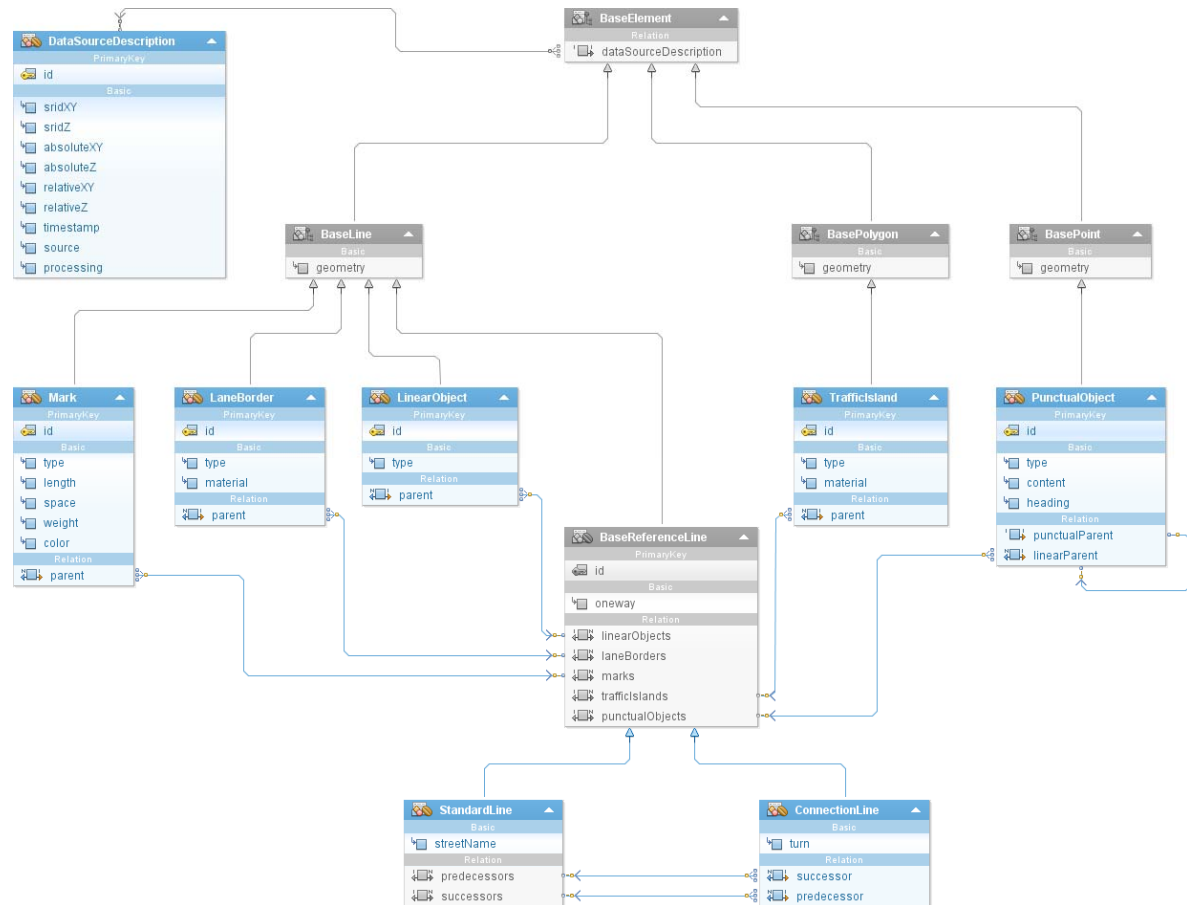
- More than just a standard: “Road2Simulation” includes a data model and description how to pre-process the data (format, spatial reference, topological integrity, etc.) and also guidelines, how to model the data for different scenarios, etc.



Road2Simulation

simplified Data Model

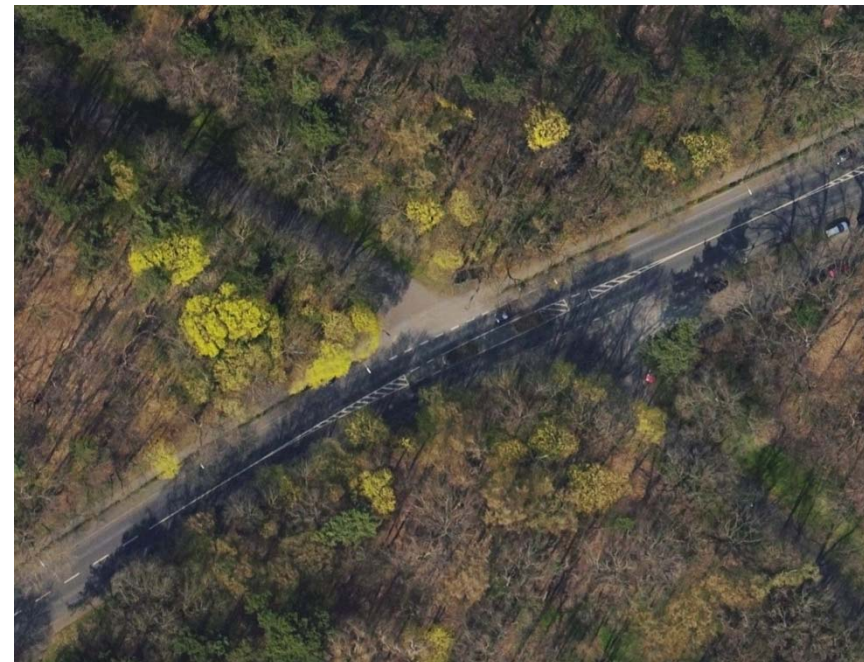
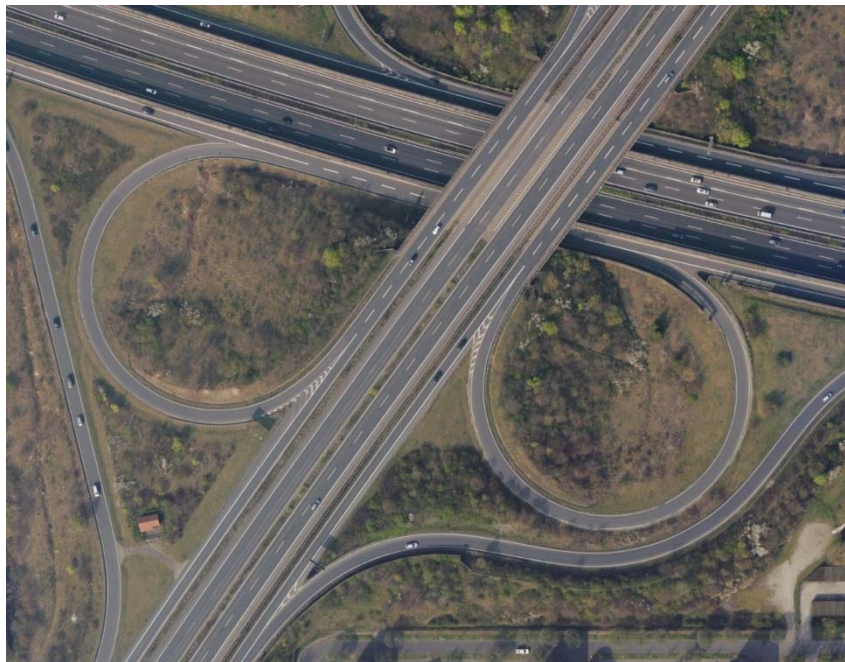
- linear objects as WKT/WKB LineString Z
- punctual objects as WKT/WKB Point Z
- areal objects as WKT/WKB Polygon Z
- data source description including absolute and relative accuracy in XY and Z, etc.



Road2Simulation

Guidelines for Modelling of Roads

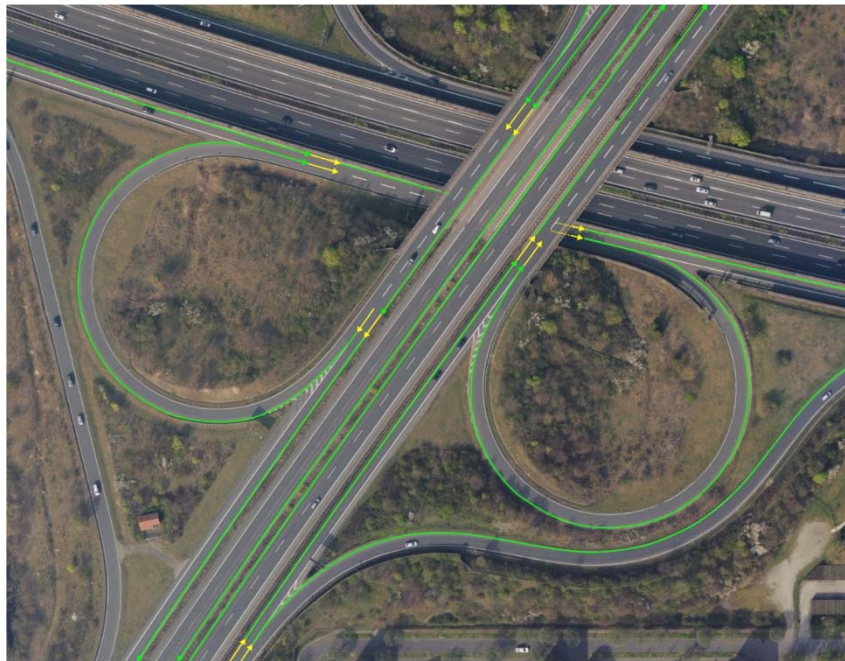
- how to model different types of roads:



Road2Simulation

Guidelines for Modelling of Roads

- how to model different types of roads:
 - course of the road



Road2Simulation

Guidelines for Modelling of Roads

- how to model different types of roads:
 - course of the road, lane borders



Road2Simulation

Guidelines for Modelling of Roads

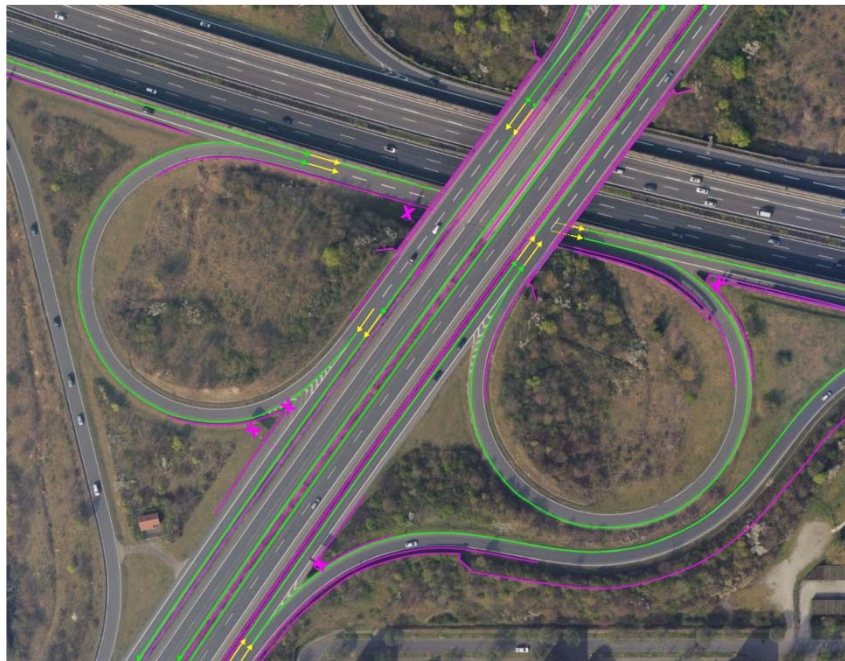
- how to model different types of roads:
 - course of the road, lane borders, road marks



Road2Simulation

Guidelines for Modelling of Roads

- how to model different types of roads:
 - course of the road, lane borders, road marks, linear and punctual objects,



Road2Simulation

Guidelines for Modelling of Roads

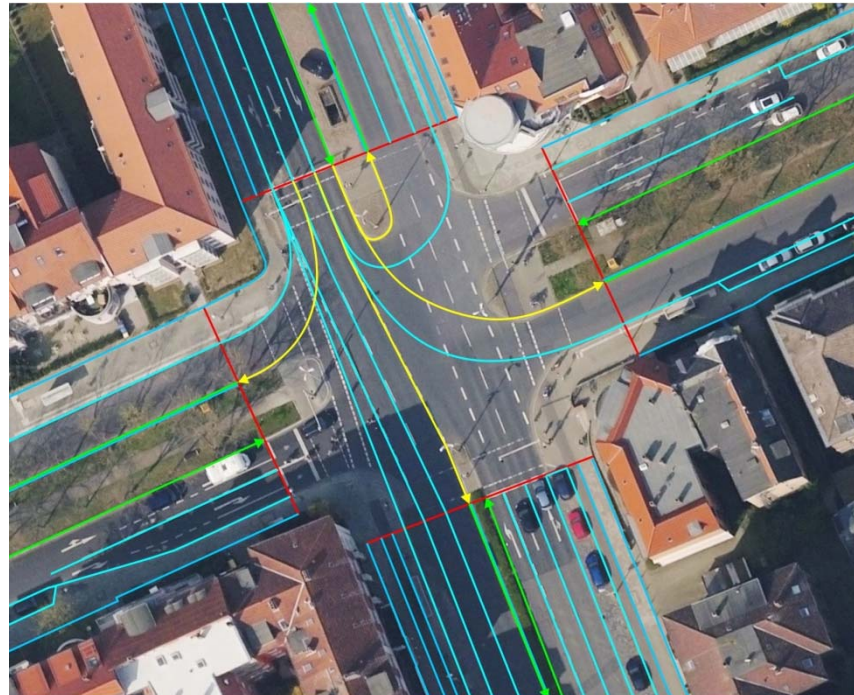
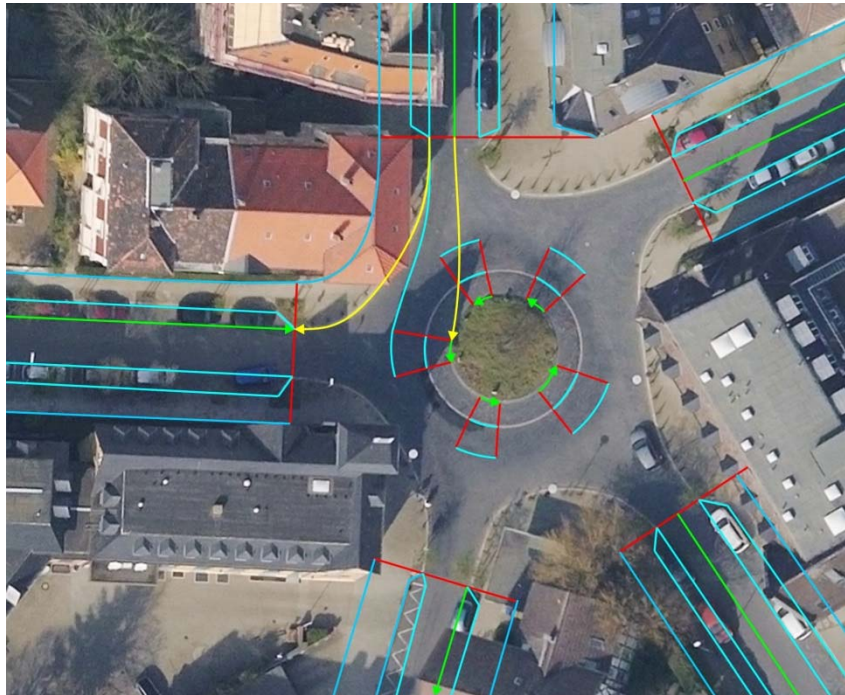
- how to model different types of roads:
 - course of the road, lane borders, road marks, linear and punctual objects, areal objects



Road2Simulation

Guidelines for Modelling of Intersections

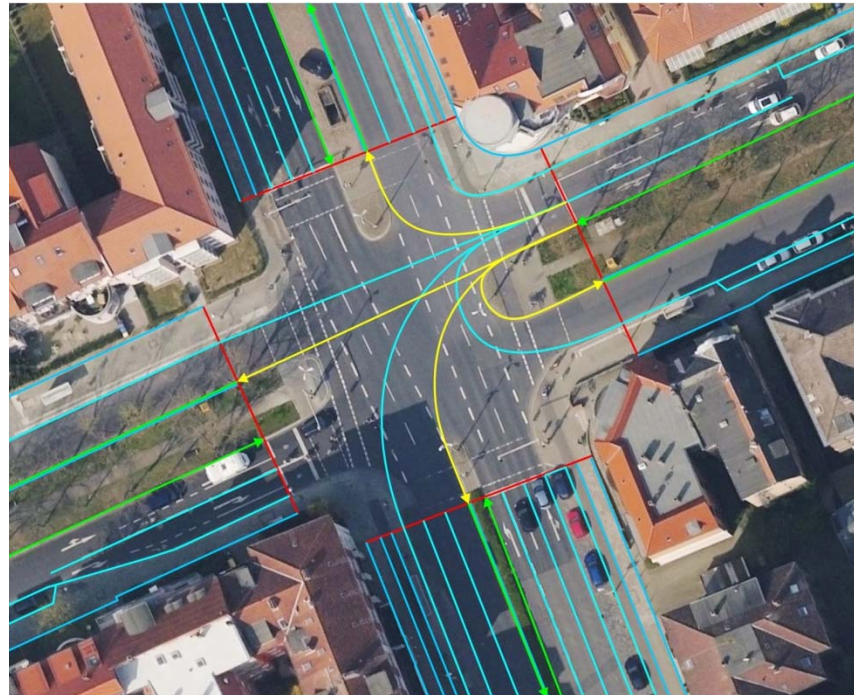
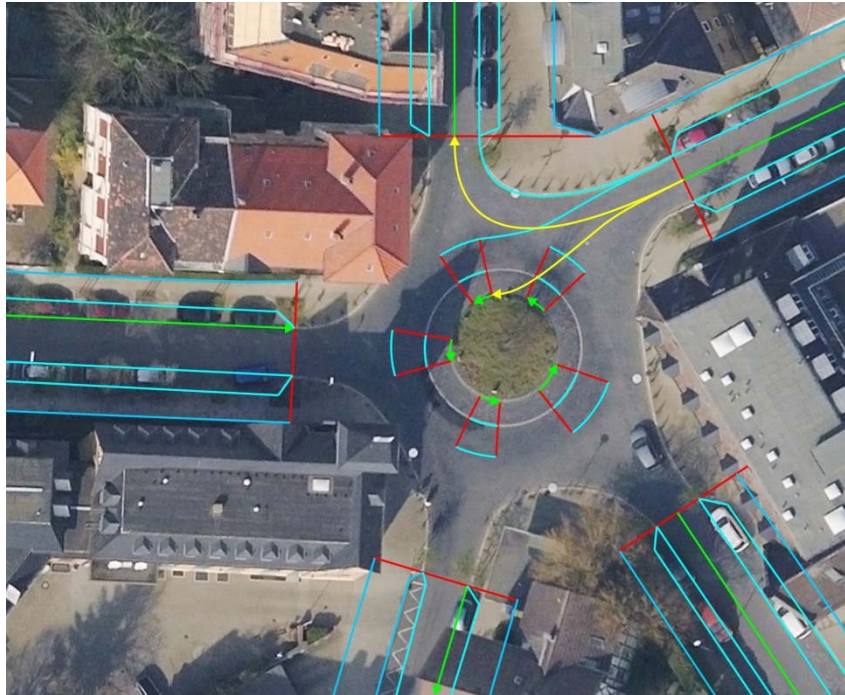
- how to model different kinds of intersections:
 - north



Road2Simulation

Guidelines for Modelling of Intersections

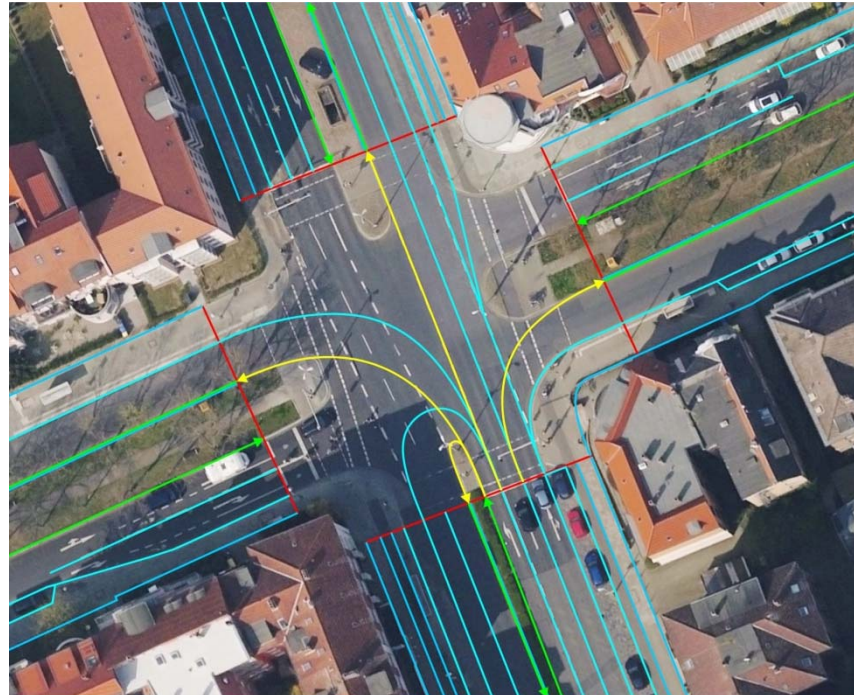
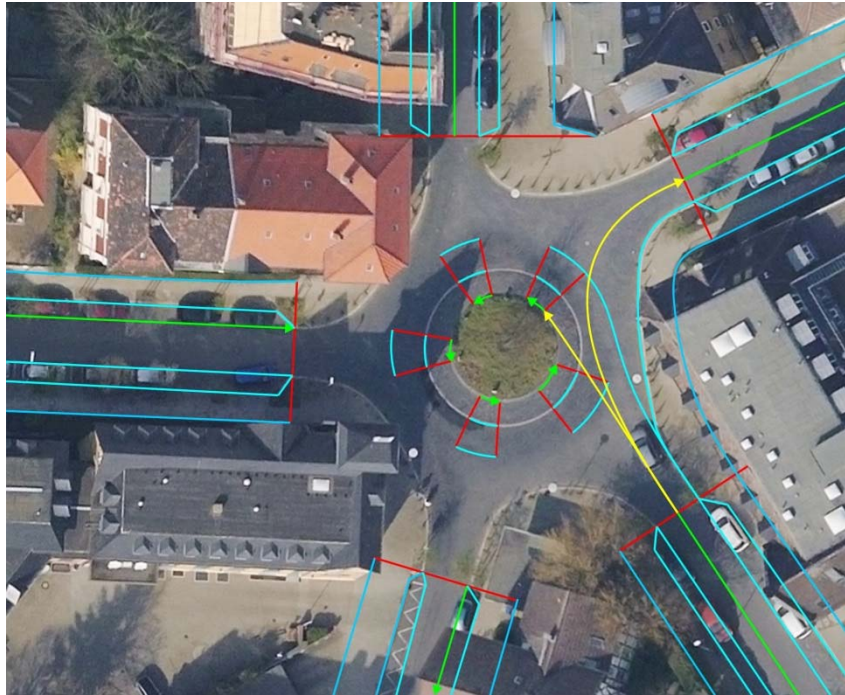
- how to model different kinds of intersections:
 - north, east



Road2Simulation

Guidelines for Modelling of Intersections

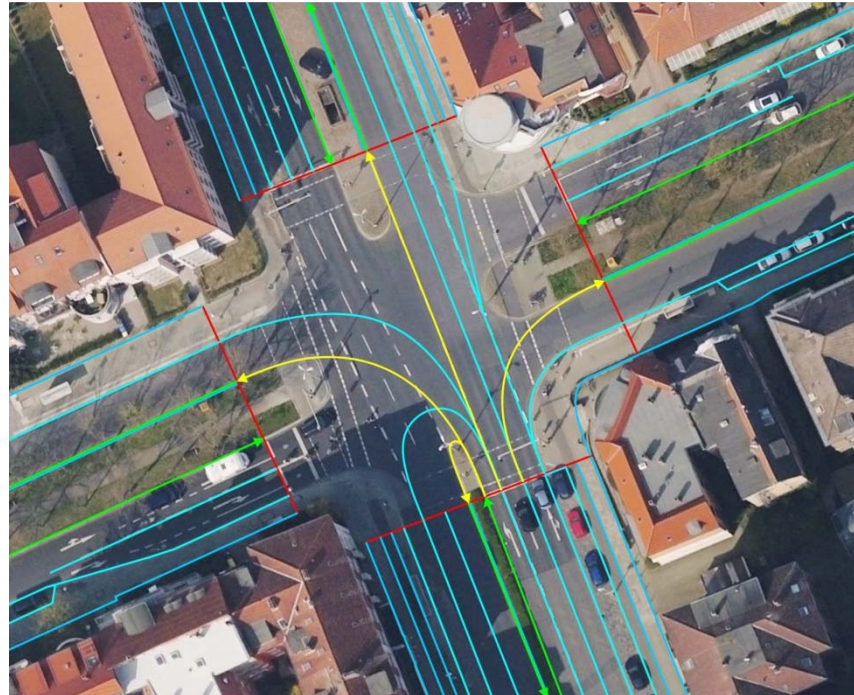
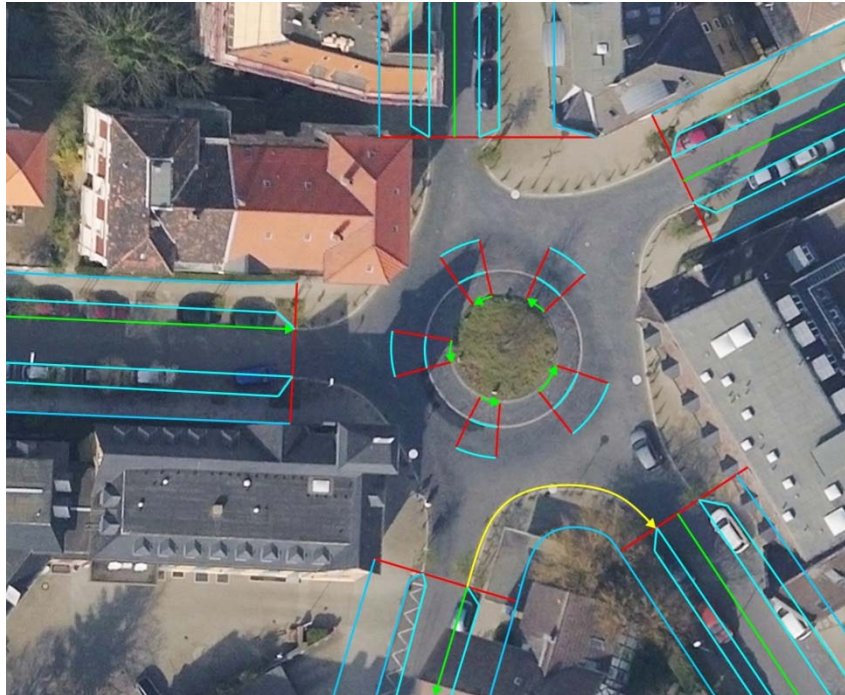
- how to model different kinds of intersections:
 - north, east, south



Road2Simulation

Guidelines for Modelling of Intersections

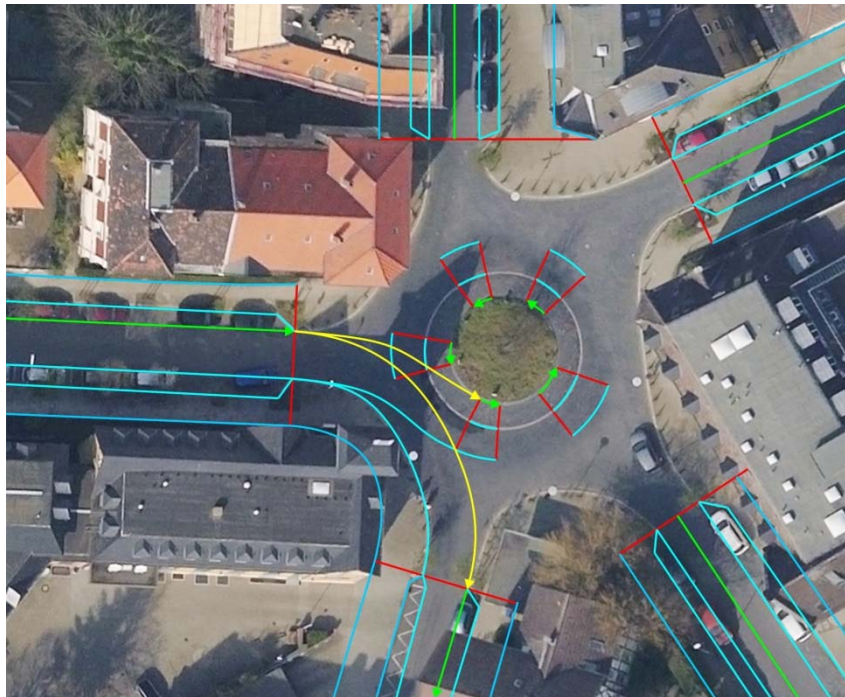
- how to model different kinds of intersections:
 - north, east, south



Road2Simulation

Guidelines for Modelling of Intersections

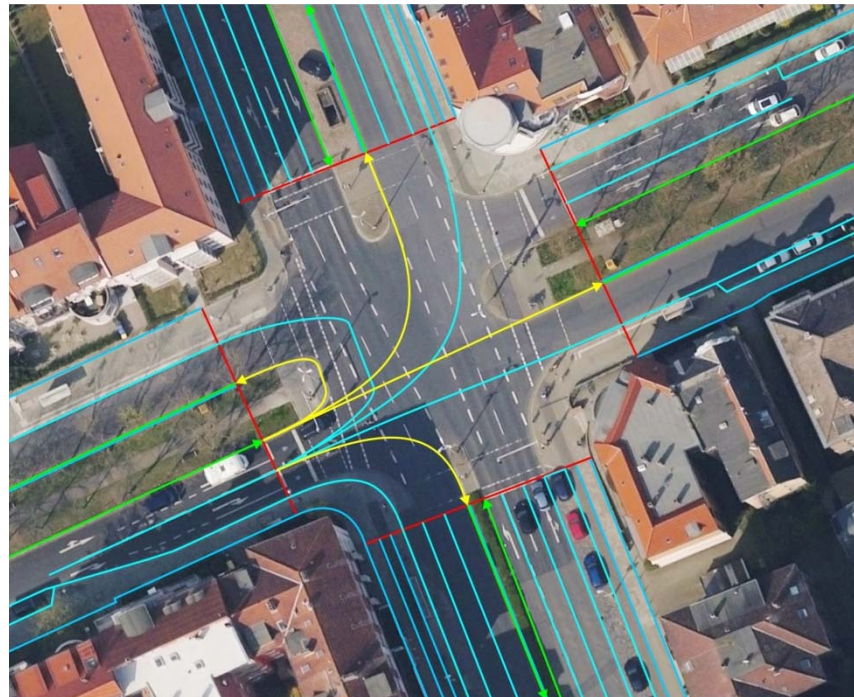
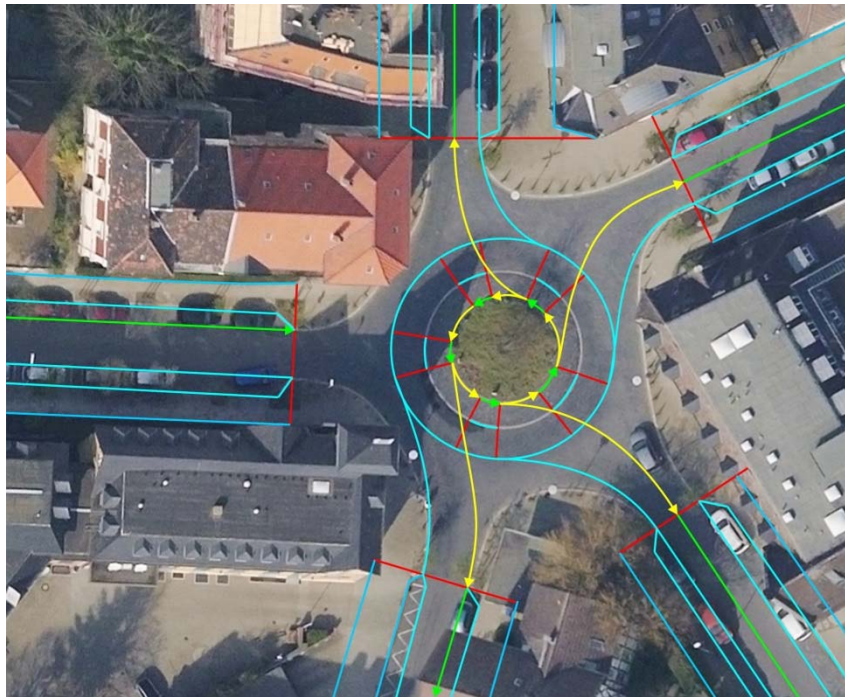
- how to model different kinds of intersections:
 - north, east, south, west



Road2Simulation

Guidelines for Modelling of Intersections

- how to model different kinds of intersections:
 - north, east, south, west, inner parts



Road2Simulation

Guidelines for Modelling of Complex Intersections

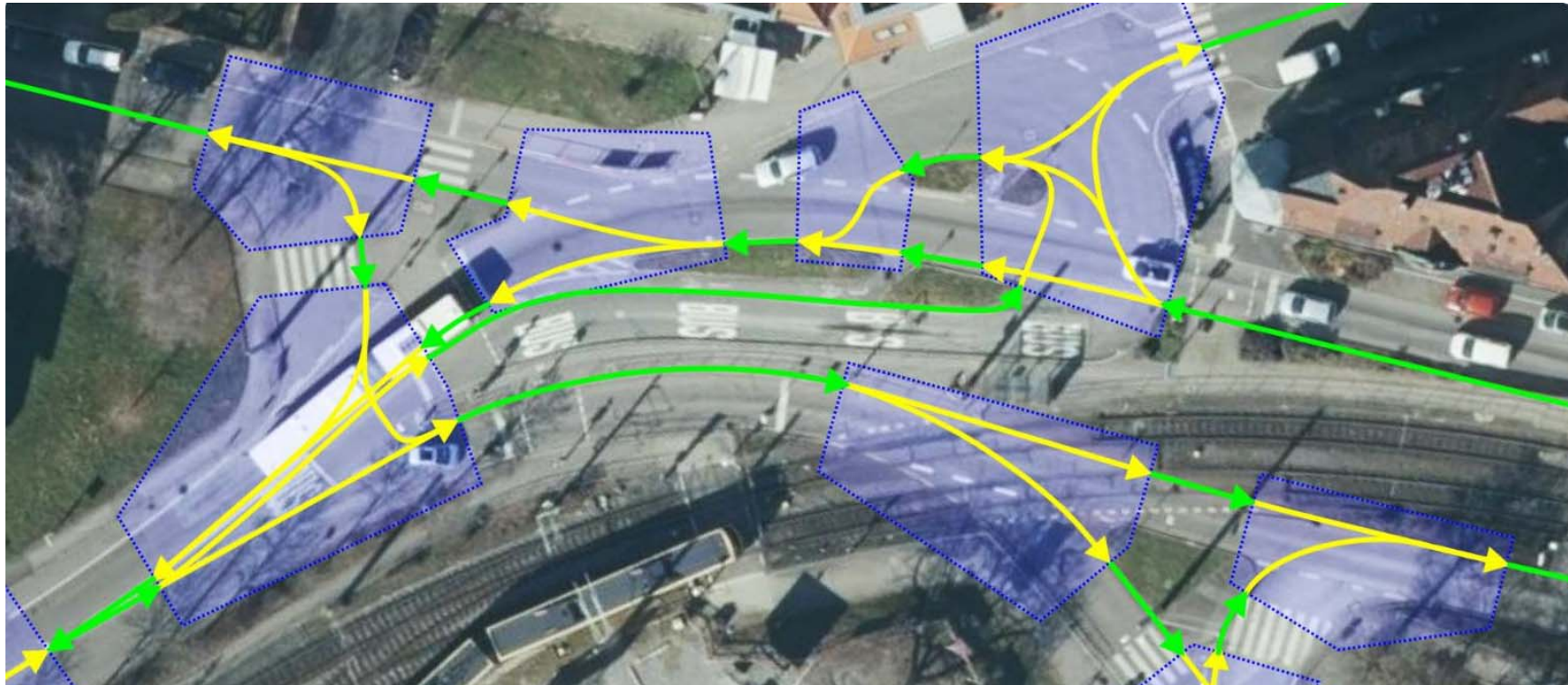
- how to divide complex intersection in multiple simple intersections



Road2Simulation

Guidelines for Modelling of Complex Intersections

- how to divide complex intersection in multiple simple intersections



Road2Simulation

Guidelines for Modelling of Punctual Objects

- how to model:



Road2Simulation

Guidelines for Modelling of Punctual Objects

- how to model:
 - traffic lights
 - road signs
 - infrastructure
 - street furniture
 - ...



Road2Simulation

The grid contains 50 thumbnails, each representing a page from a technical document. The pages are organized into sections, likely corresponding to the numbered sections in the image. The content includes:

- Introduction and project overview (top-left).
- Methodology and data collection (middle-left).
- Simulation setup and parameters (middle-right).
- Results and analysis (bottom-left).
- Conclusion and future work (bottom-right).



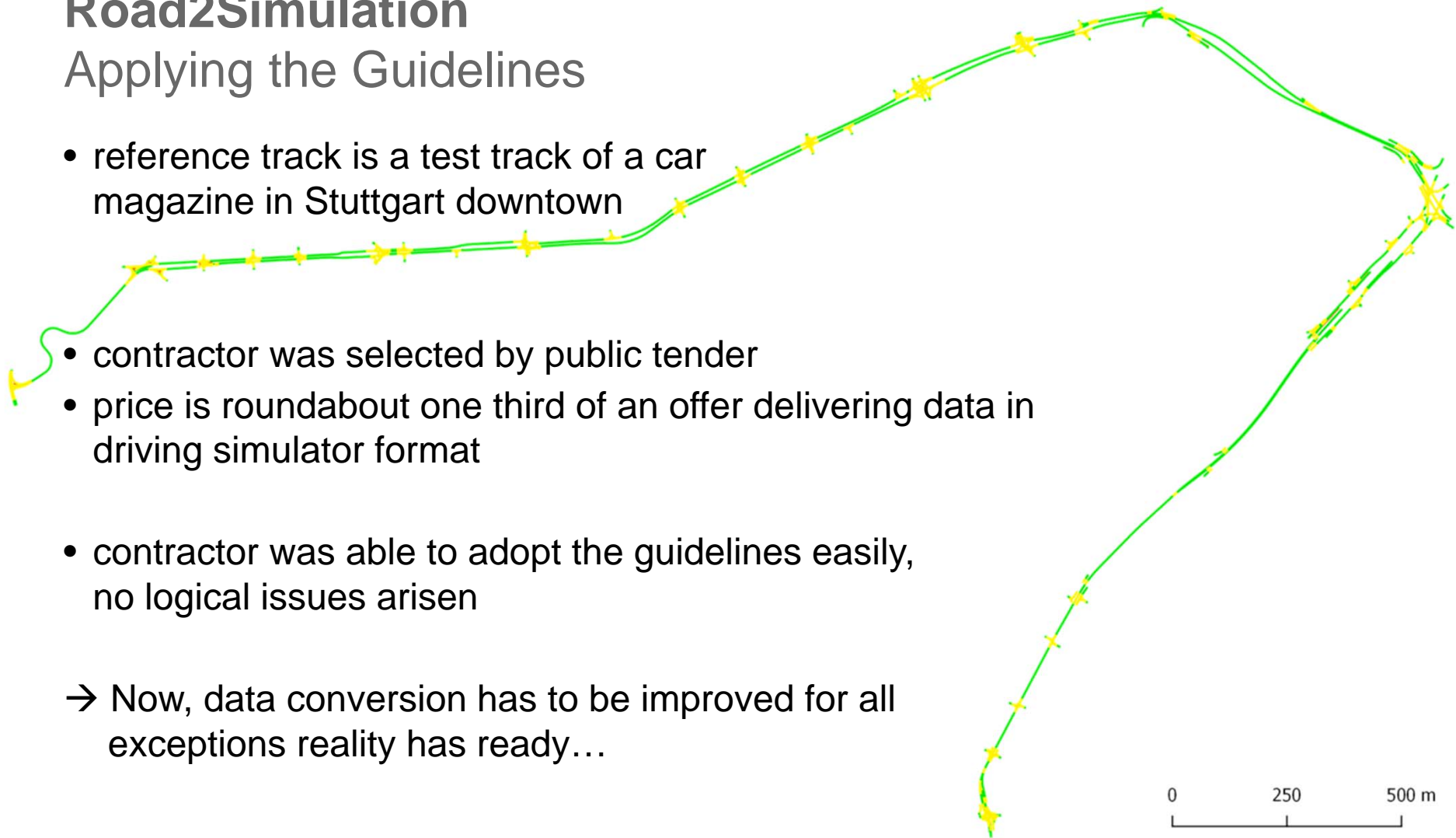
DLR



Road2Simulation

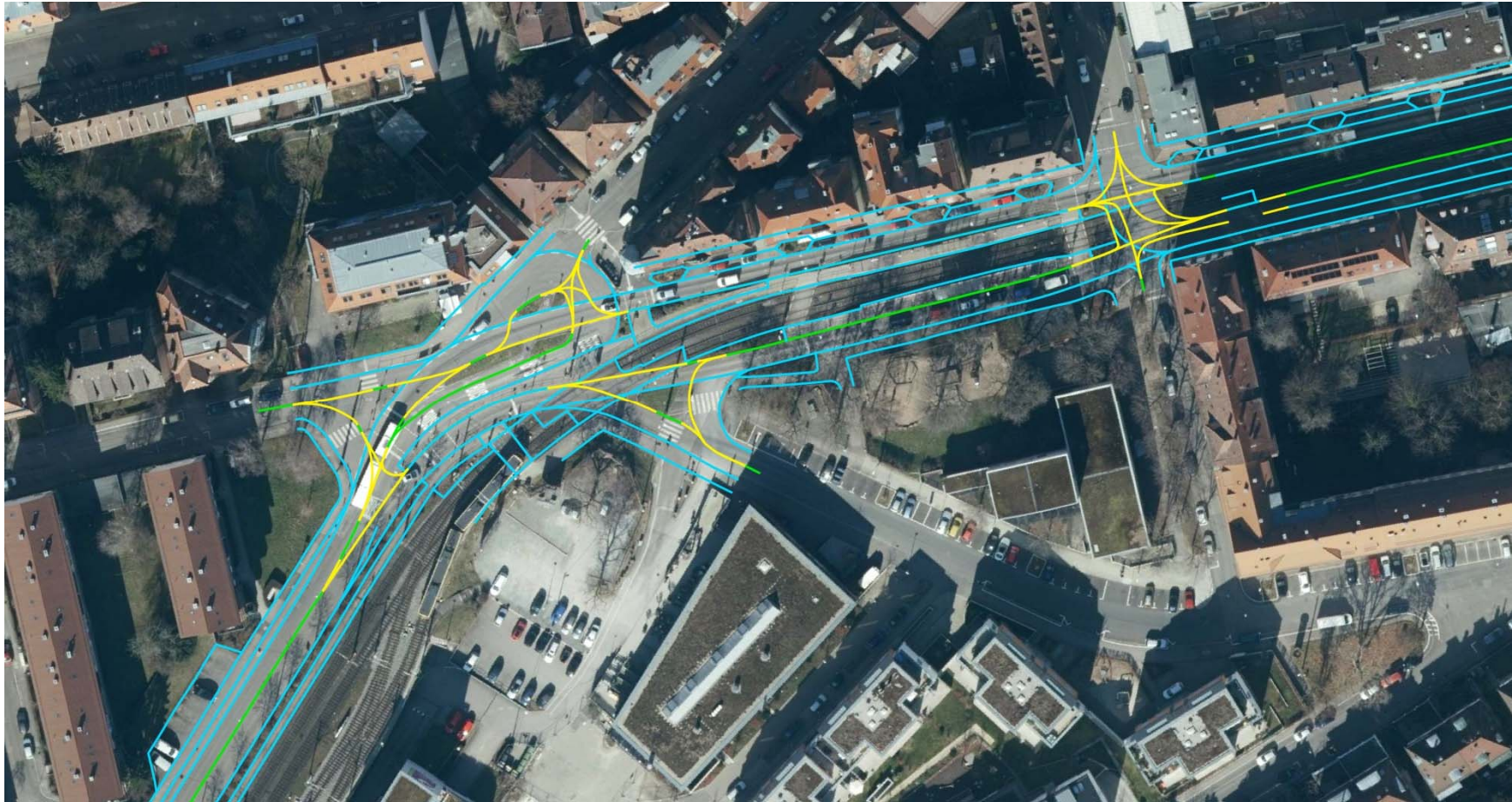
Applying the Guidelines

- reference track is a test track of a car magazine in Stuttgart downtown
 - contractor was selected by public tender
 - price is roundabout one third of an offer delivering data in driving simulator format
 - contractor was able to adopt the guidelines easily, no logical issues arisen
- Now, data conversion has to be improved for all exceptions reality has ready...



Road2Simulation

Applying the Guidelines



Road2Simulation

Applying the Guidelines



Urban Road Networks in Driving Simulators

Summary

- No data format is available that meets requirements for public authorities and driving simulator operators.
→ Thus, exchange of real world data is complex (but nevertheless possible) and there are no synergies for data acquisition (experience of surveying companies, data usage, etc.).
- Project “Road2Simulation” developed guidelines on how to pre-process and how to store the road data to meet cadastral and simulation requirements:
 - simplified data model with included meta data for transformation
 - suggestions and examples for typical road situation
 - guidelines are available free of charge
- Guidelines is tested with a reference track in an urban environment.
- Currently results are looking very promising...



The Surveyor's Guide to Automotive Simulation

available for free at: <http://www.dlr.de/ts/road2simulation>

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