

## Reference Scenarios and Traffic Spaces

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**dSPACE**

**ETAS**



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O P E L



**PROSTEP**  
integrate the future



# Agenda

- Motivation / Main Goal
- Scenario Description
- Traffic Spaces
- Reference Scenarios
- Road Generation Tool

# Motivation

SET Level Main Goal



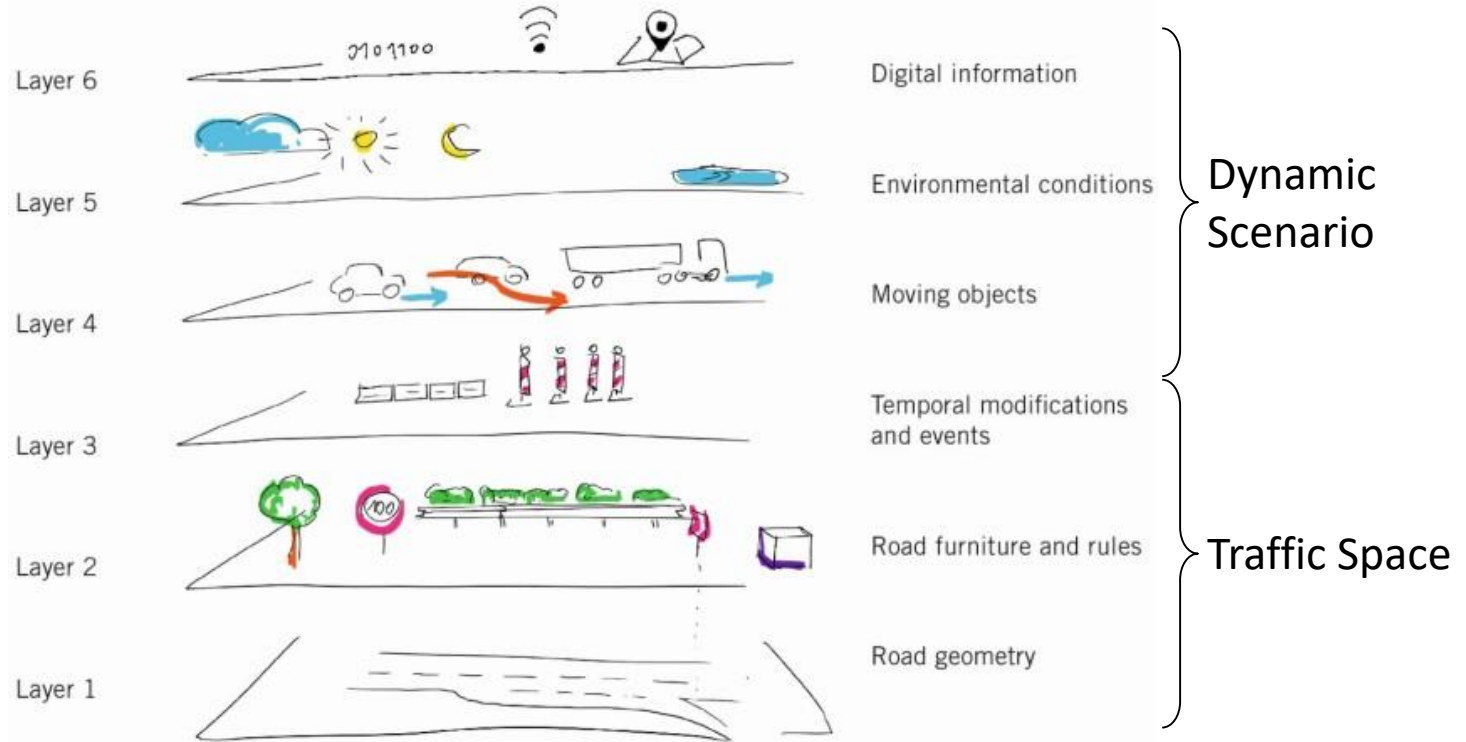
Build up a simulation environment

- to test and validate **automated driving functions**
- to test and validate **vehicle components**, e.g. environmental sensors
- to identify **critical scenarios**

➤ Stepwise approach with increasing complexity.

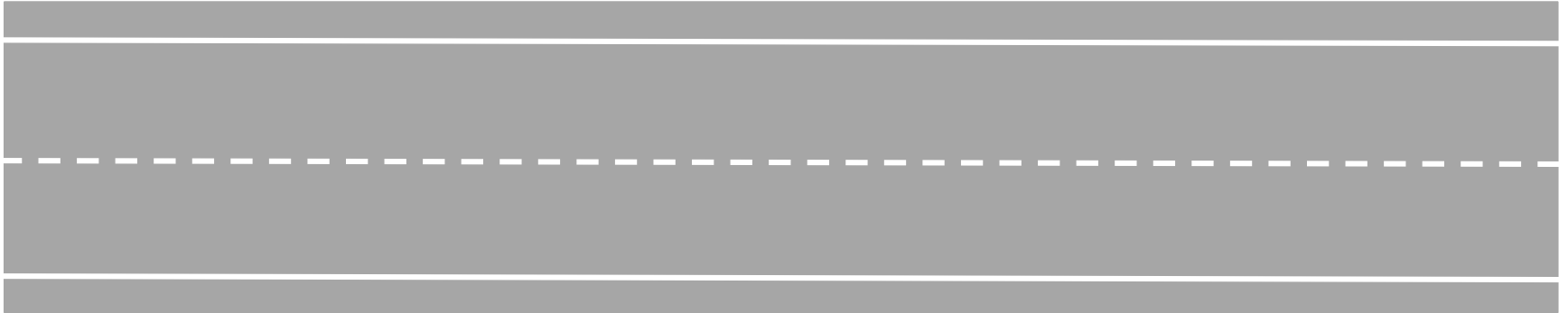
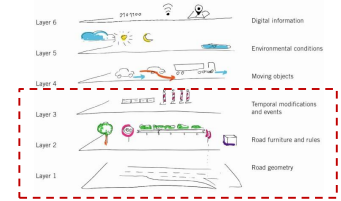
# Basis for scenario description

## Pegasus 6-Layer Model



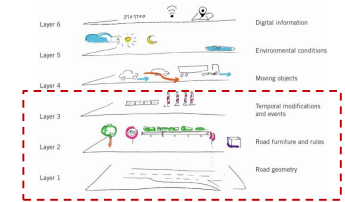
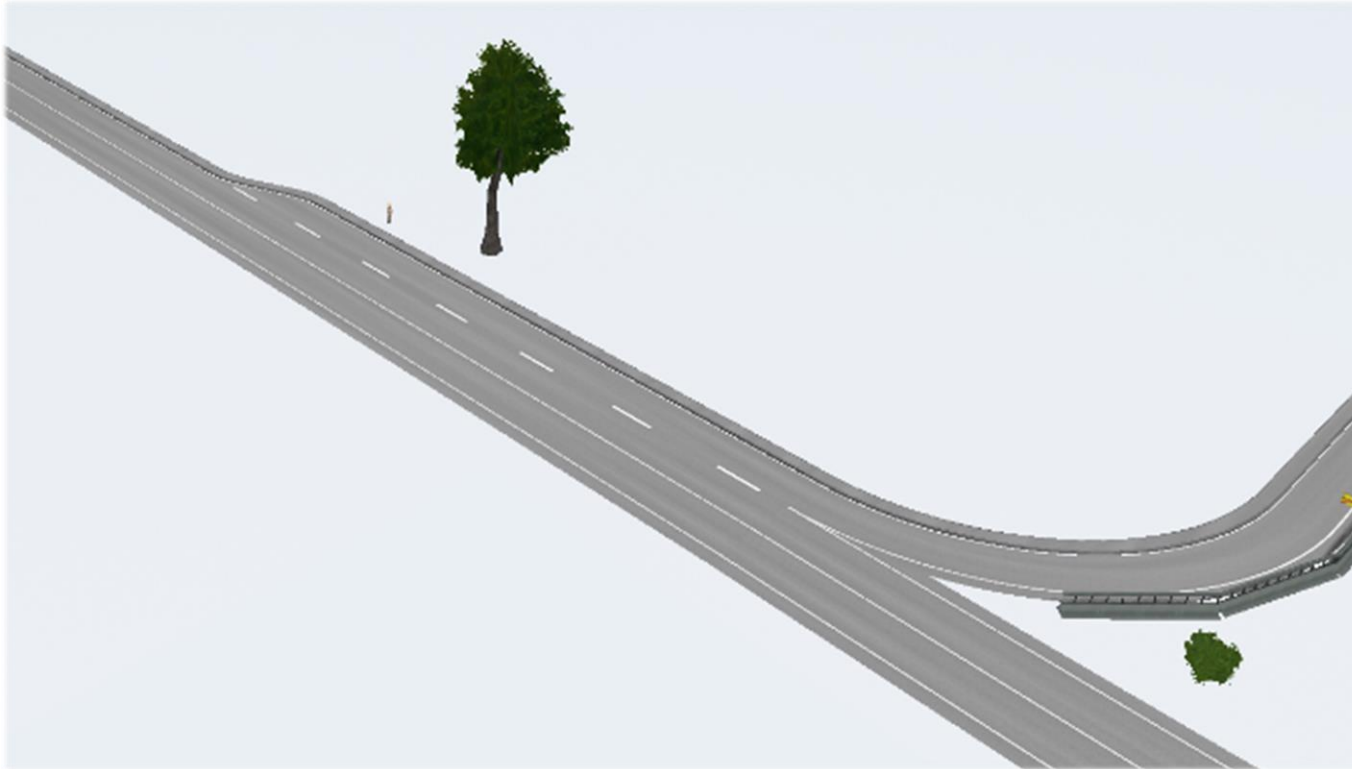
# Traffic Spaces – TS0

Straight road



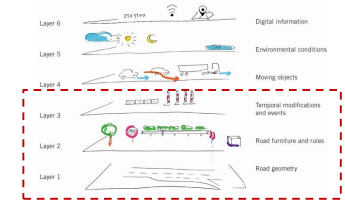
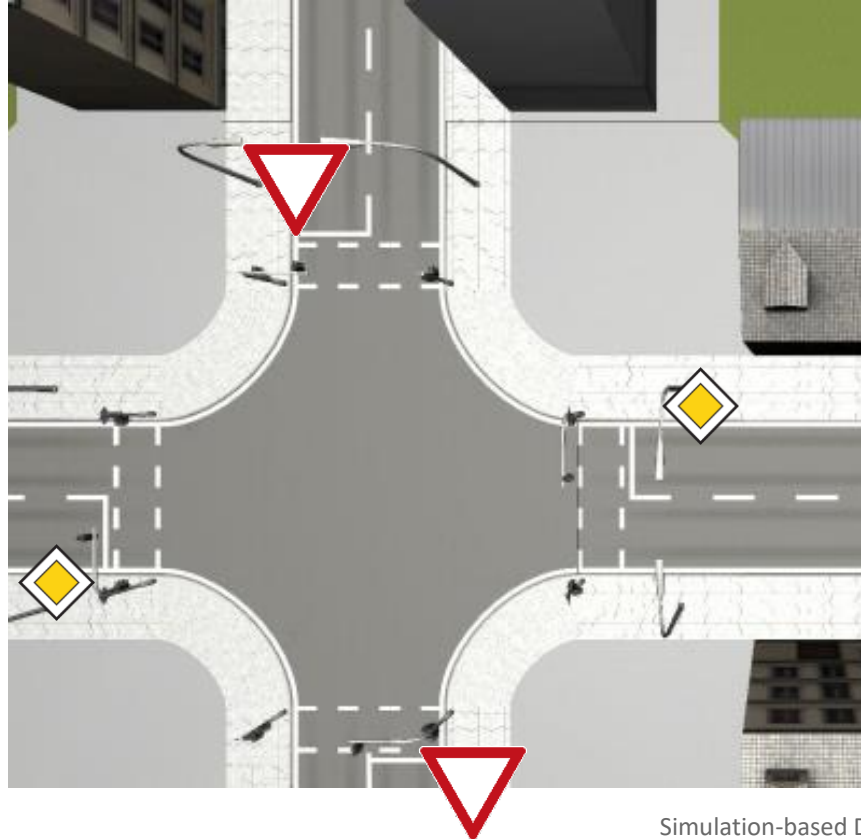
# Traffic Spaces – TS1

Arterial road with merging lane



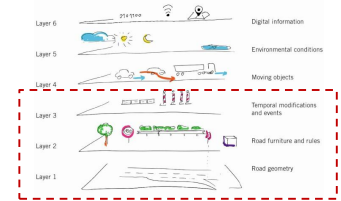
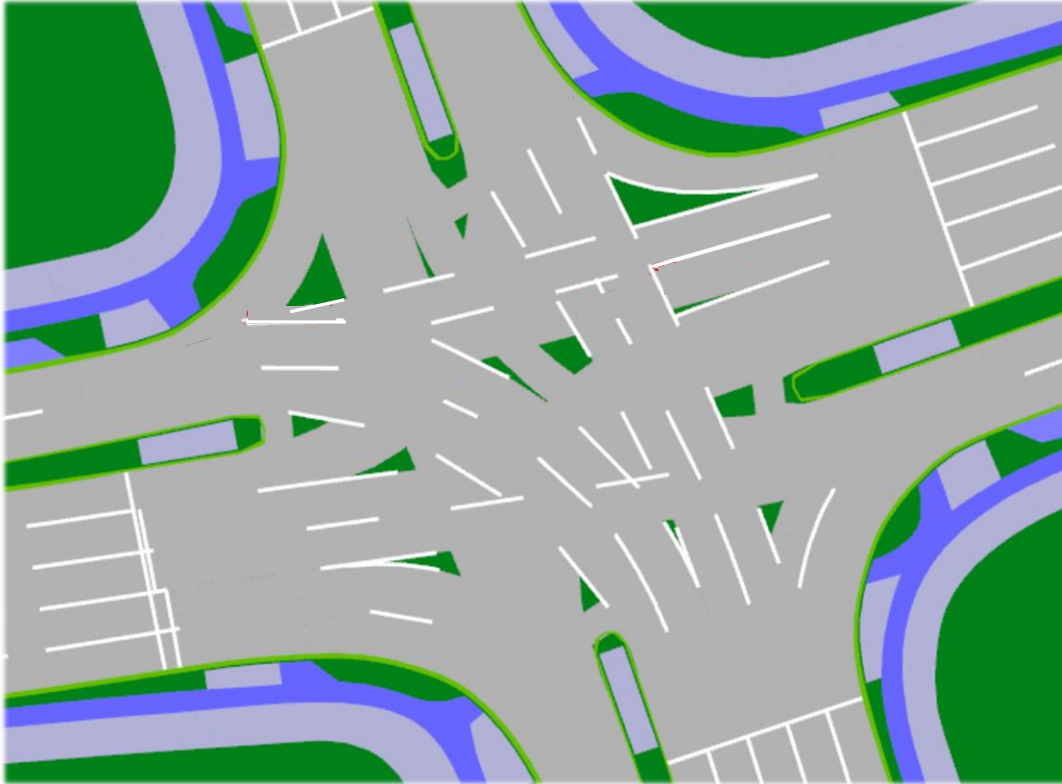
# Traffic Spaces – TS2

## Simple intersection



# Traffic Spaces – TS3

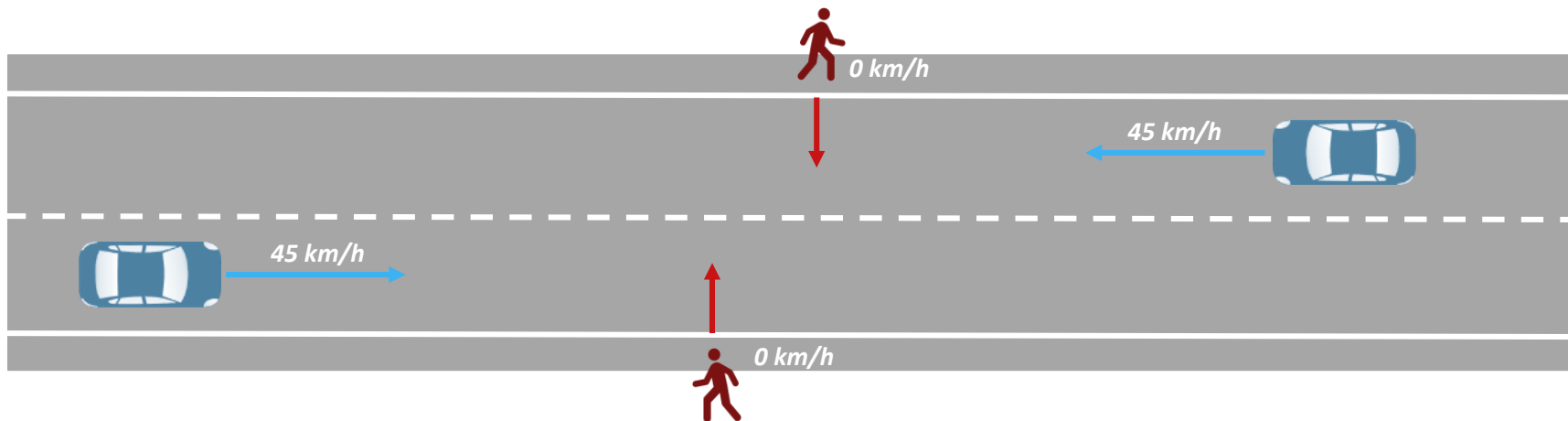
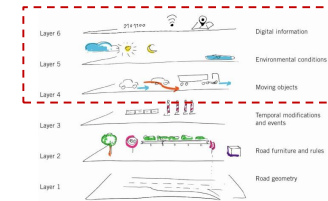
Complex intersection





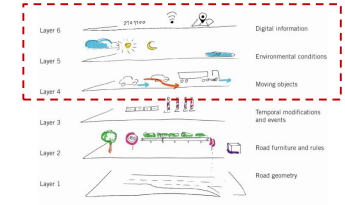
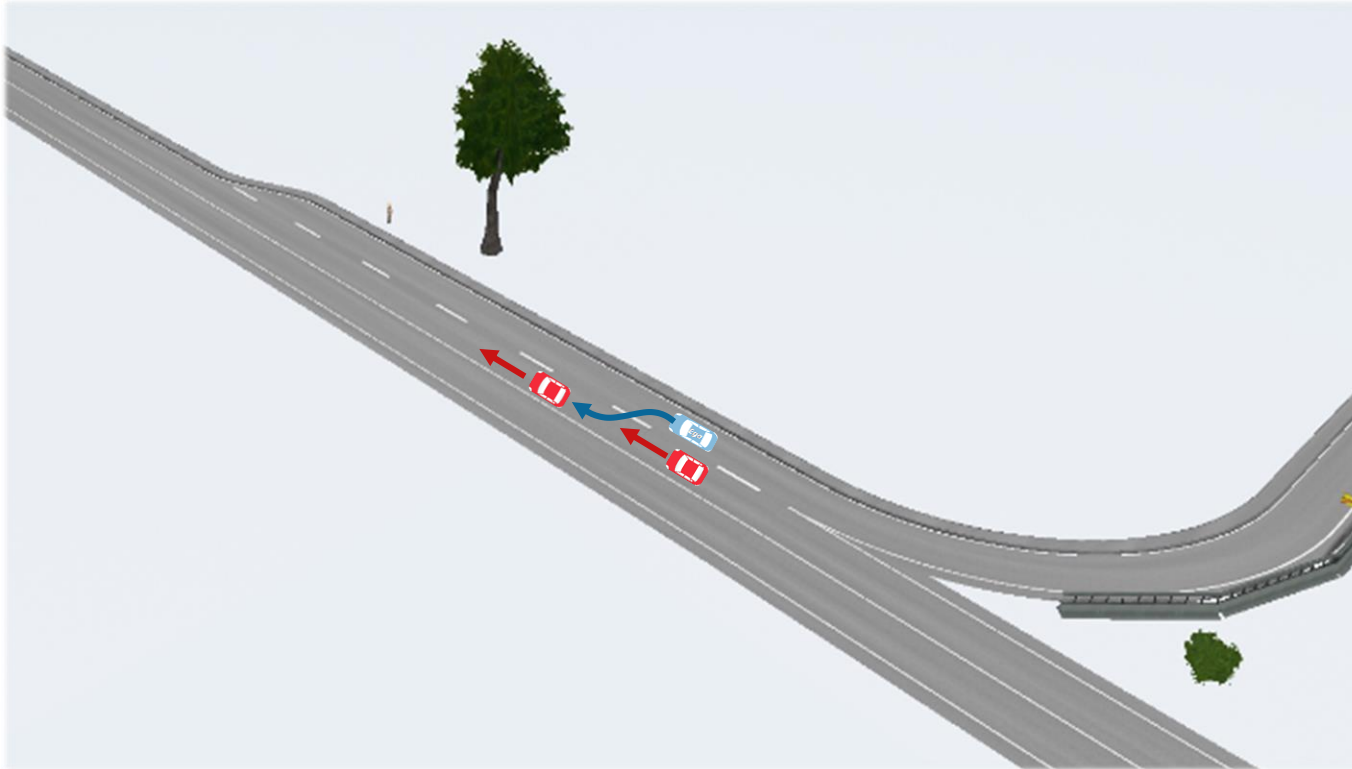
# Reference Scenarios – RS0

## Crossing pedestrians



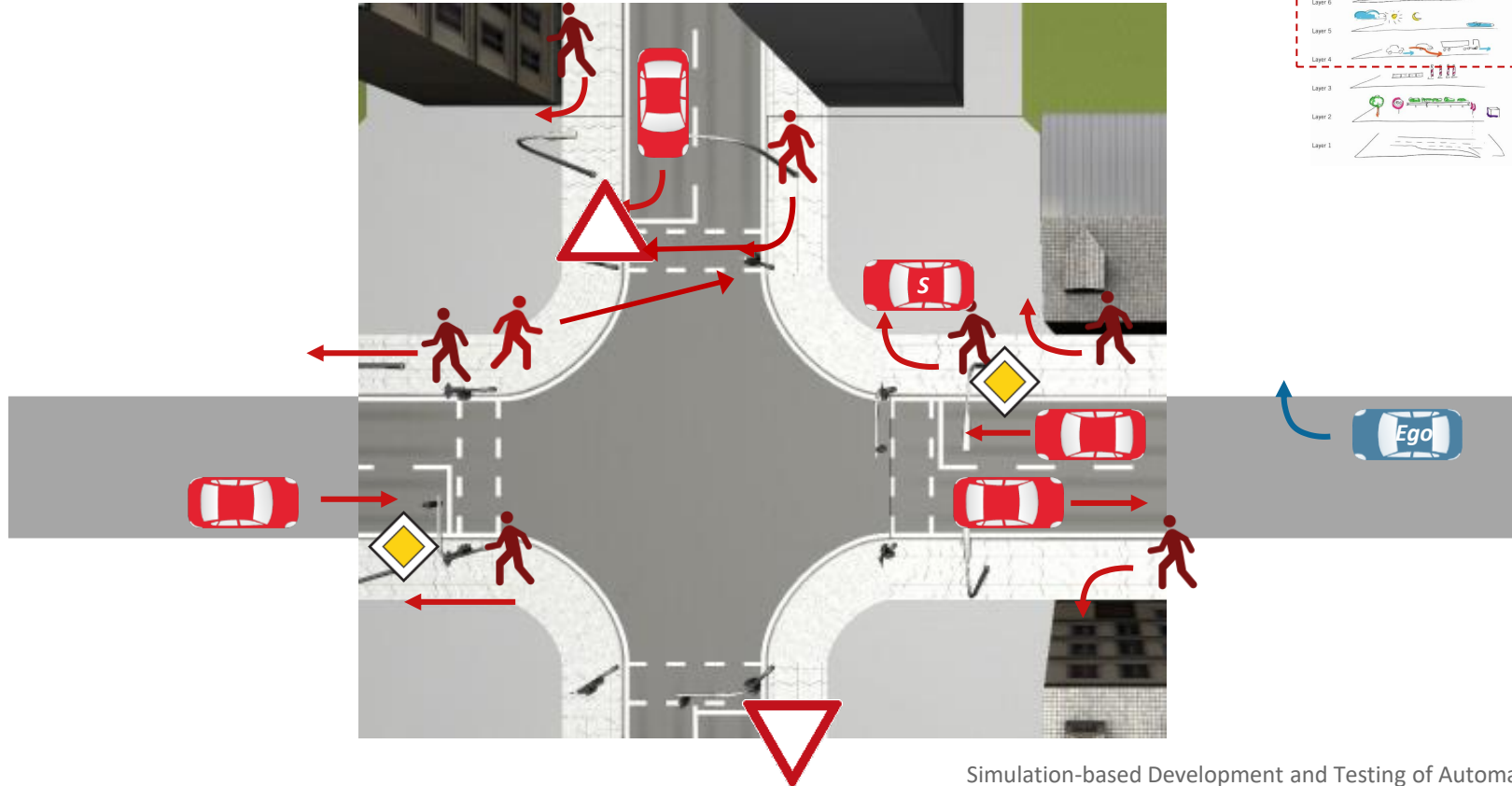
# Reference Scenarios – RS1

## Merging into an arterial road



# Reference Scenarios – RS2

## Right turn with crossing pedestrians

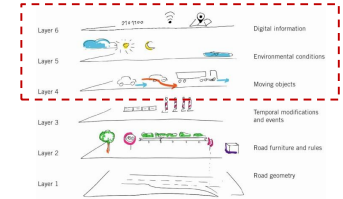
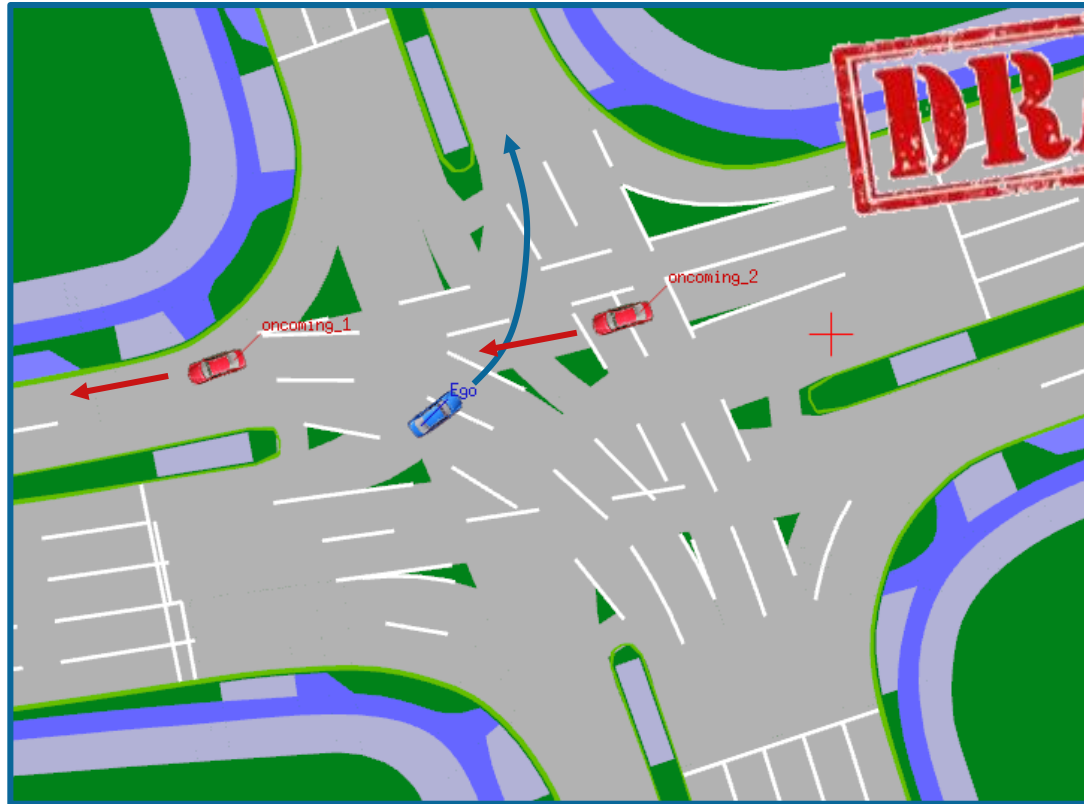




# Video Reference Scenarios – RS2



# Reference Scenarios – RS3

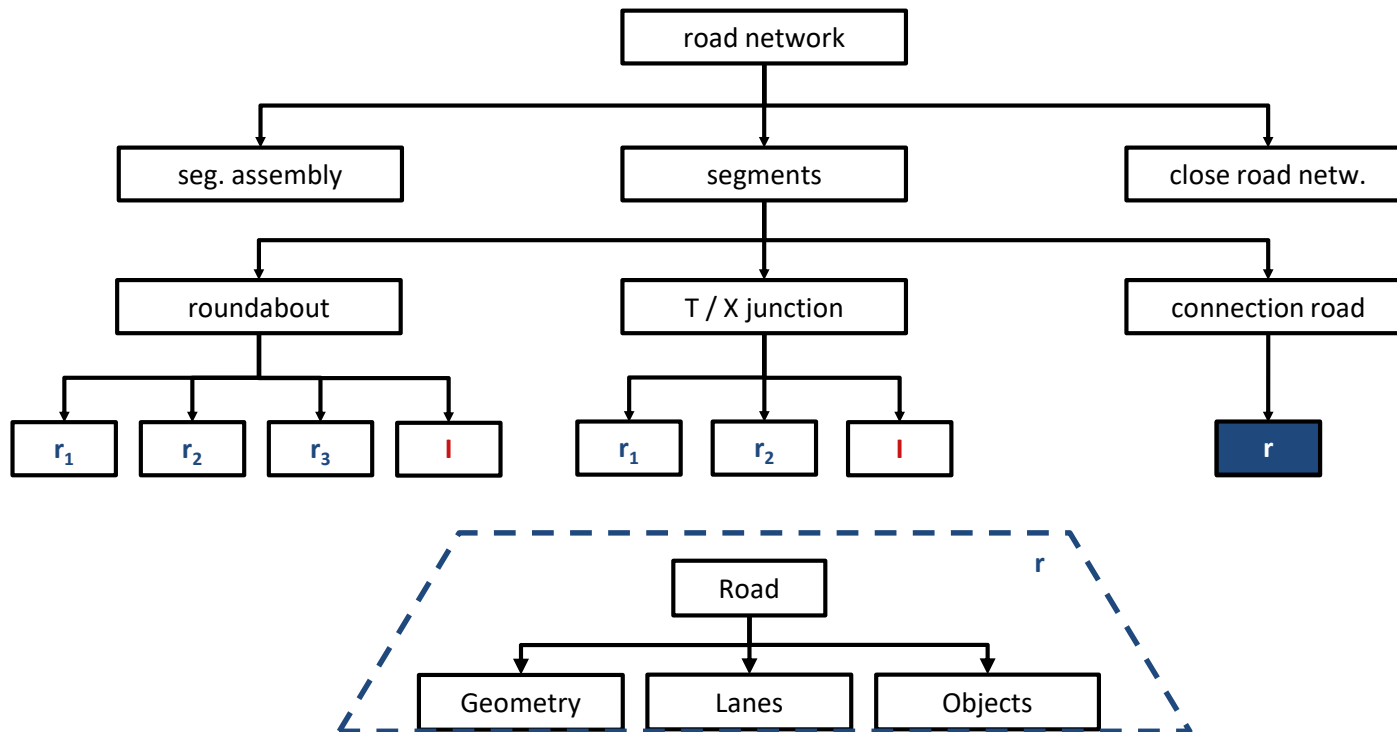
Left turn across oncoming traffic



- Existing **standard formats** for concrete scenarios
  - Static aspects:  **ASAM** OpenDRIVE
  - Dynamic aspects:  **ASAM** OpenSCENARIO
- **Focus of this work**
  - Static part of scenario
  - Find logical description similar to OpenDRIVE, but:
    - Non-redundant
    - Easy to vary
    - **Modular** approach
    - Oriented on real road construction
      - **Use of spiral, arcs, lines** as geometric primitives only

# Road network

## Concept

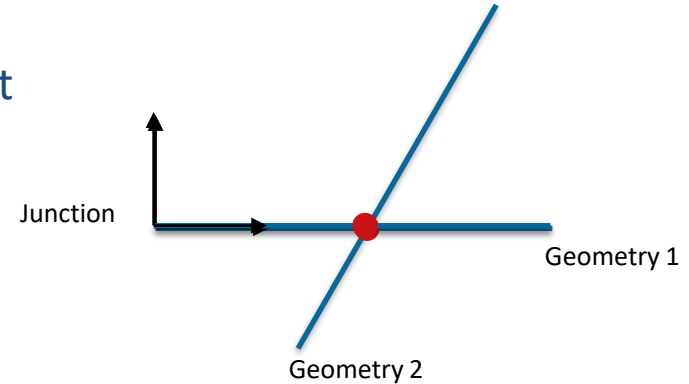
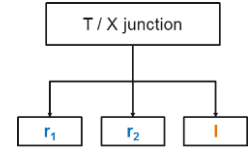


# Road generation

## Generation of Reference Lines of an X-Junction

- Two road definitions are required ( $r_1, r_2$ )
  - For simplicity: **Two straight lines**
- One intersection coupler ( $I$ ) is needed
  - Orange dots indicate desired **intersection point**
  - $r_1$  is defined as reference segment
  - An **angle** for the junction is defined
  - Junction dimensions are specified (next slide)

SET  Level

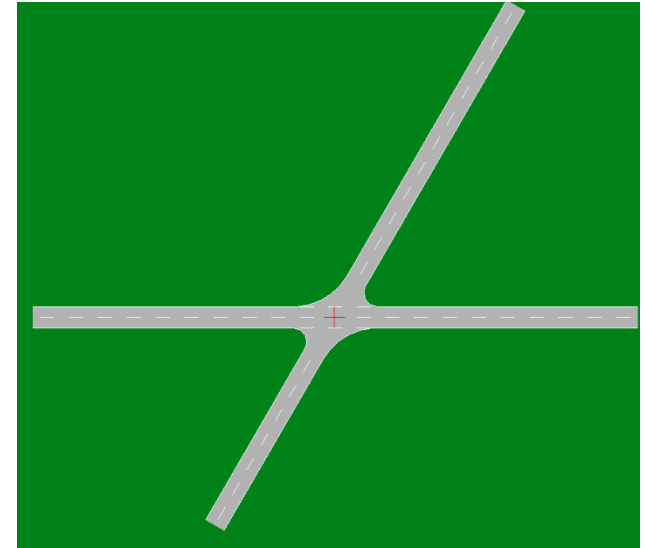
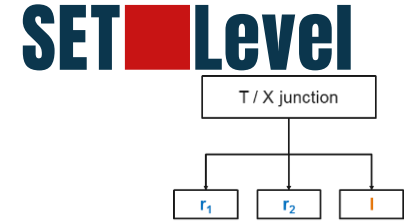




# Road generation

## Generation of Lanes and Connection Roads

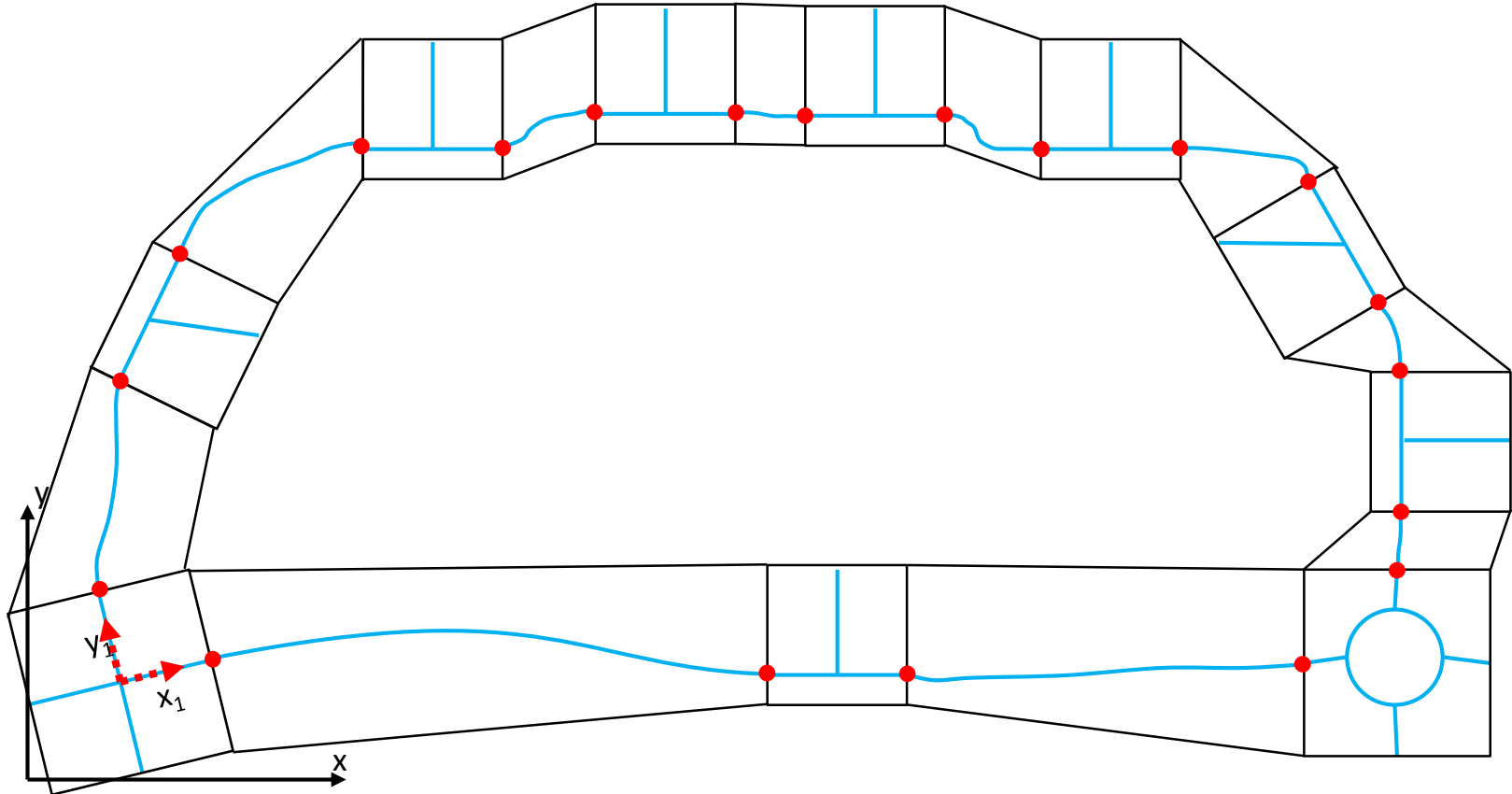
1. Cut free the intersection area
  - Each direction to junction center can be specified
  - New reference lines are stored internally
2. Generate lanes of in-/outgoing roads
  - If nothing is specified, standard values are taken
  - Possible road classes: “main”, “access”
3. Calculate connection roads inside the intersection
  - Angle continuous course (line + arc)
  - Every possible transition is generated
4. Generate lanes for those connection roads
  - “source” and “end” lane may have different width



Visualized in ODR Viewer

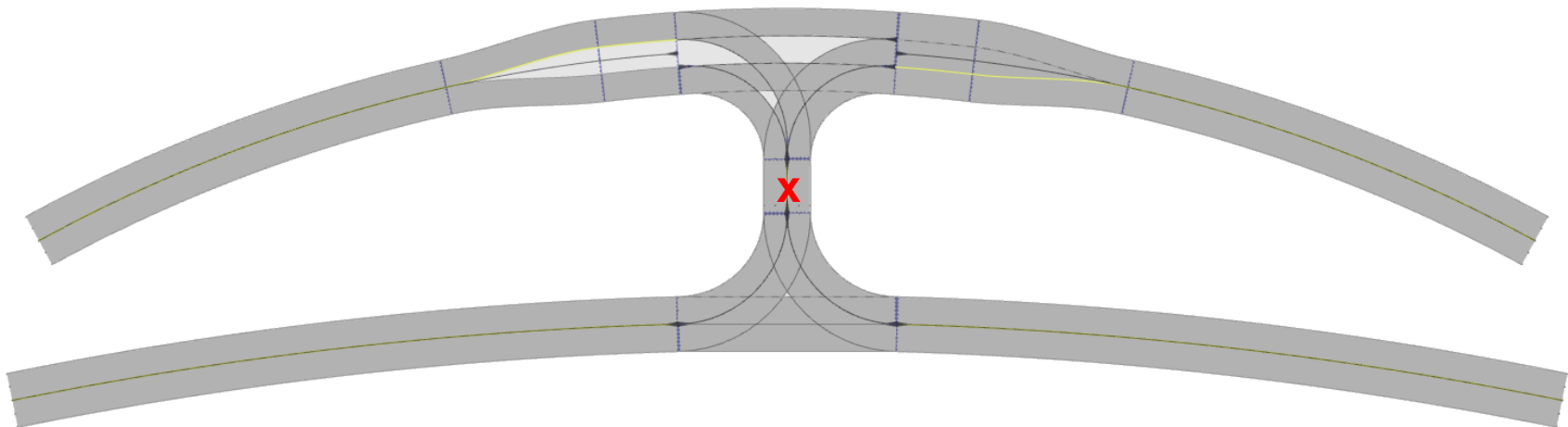
# Concept and Implementation

## Road network creation



# Examples

## Two concatenated junctions



Visualized in IPG CarMaker

- Two T-junctions
- Definition only changed at two positions:
  - Arc's curvature
  - Flag for „additional left turn lane“

→ The rest is generated and positioned automatically

Lines of code	
Logical Descr.	47
OpenDRIVE	937

# Examples

Example: Complex road network



Visualized in ODR Viewer

- Three intersections
- One roundabout
- One manual connection road
- Four automatically generated “close road network” roads

Lines of code	
Logical Descr.	219
OpenDRIVE	5477



Up to now lots of research regarding the variation of Layer 4 (6LM)

Among others: in PEGASUS project family



Hypothesis is that Layer 1 can challenge a VUT as well



Questions:

Which Properties of a road network are relevant?

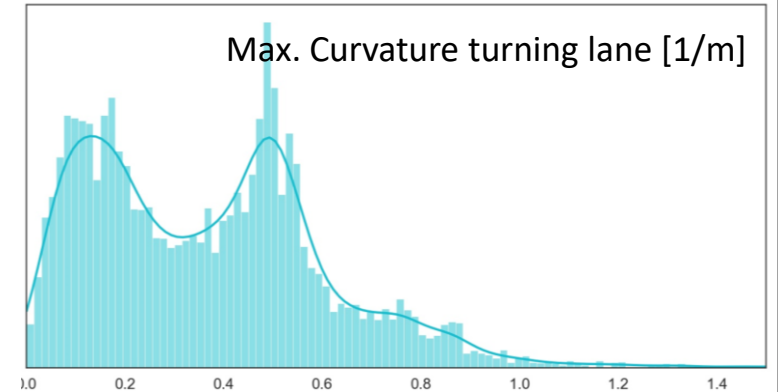
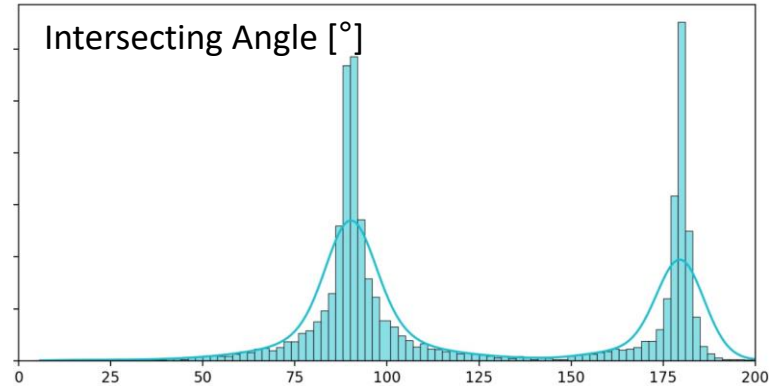
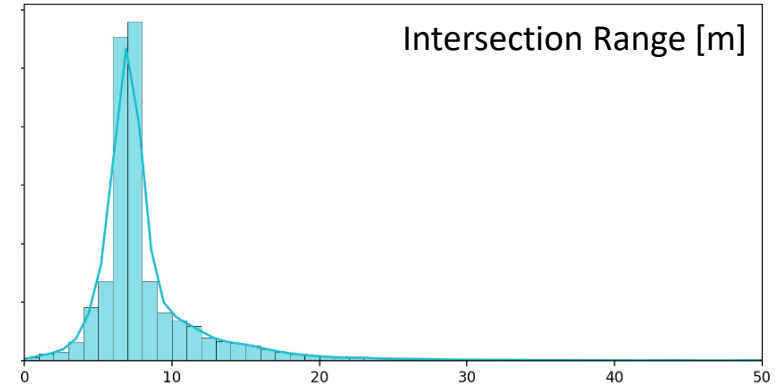
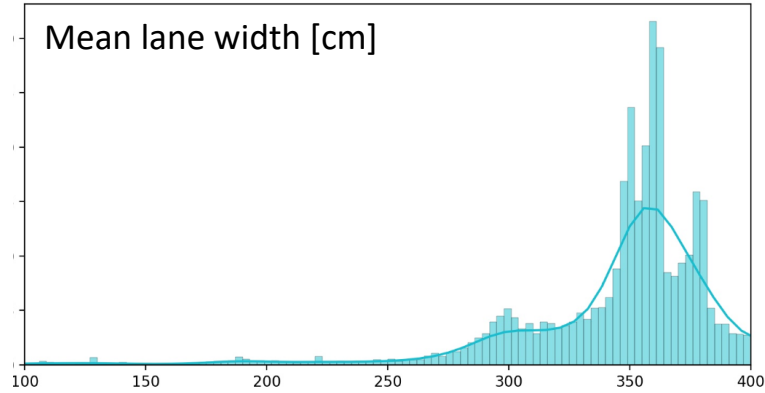
How can that be shown?



Analysis of real road networks to extract key performance indicators that can be used to parametrize the simulated road network

# Stochastic Variation

Data Distribution of sampled Area (Berlin)



# Stochastic Variation

## Implementation

- Extended input format by random numbers
  - Each value can be set as uniform and normal distribution
  - Linear dependencies between variables can be realized as well
- Parts of this tool chain will be available on GitHub within this year

