Journée Outils Logiciels et Matériels pour la Recherche sur les Véhicules Terrestres Autonomes

Création des scénarios critiques – SOTIF

5 Octobre, 2023 – ENS Paris Saclay, France

Presenter – Hans Van den Wijngaert

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From infinite to finite

The ADAS/AV development challenge

Simulation

Testing

Infinite number of different scenarios can occur in real-world traffic. How to break these down into a finite set of scenarios, and find those which are representative in order to make testing manageable?

X-in-the-Loop

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Safety according ISO26262 and SOTIF

The safety assessment

Safety Assessment

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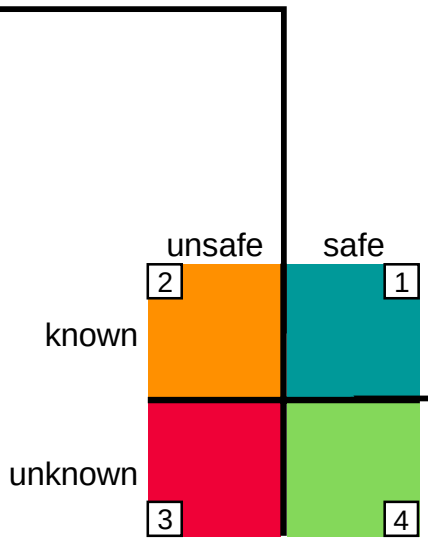
Scenario Creation: safe and unsafe

Scene focused methodology

Criticality

Many criticality indicators are available e.g. TTC, ITTC, ...



Novelty

As there is no indicator for novelty, Siemens developed it.

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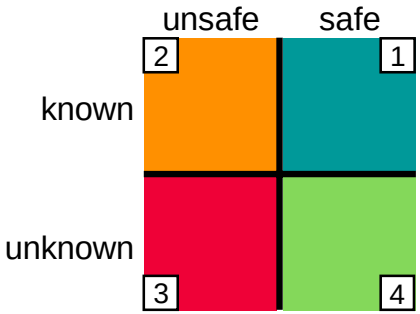
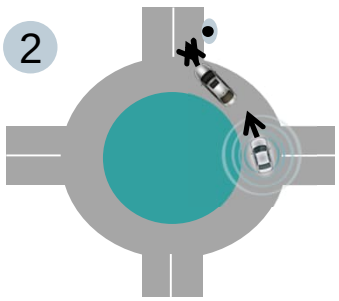
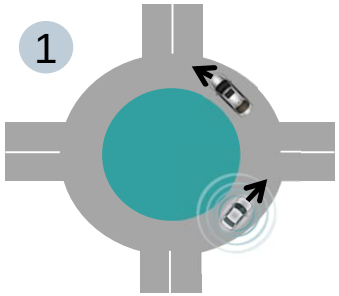
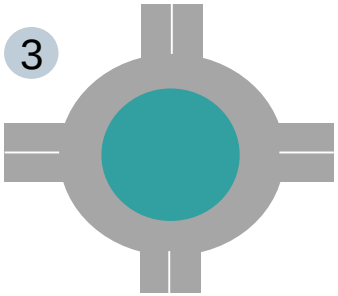
Safety of the Intended Functionality (SOTIF)

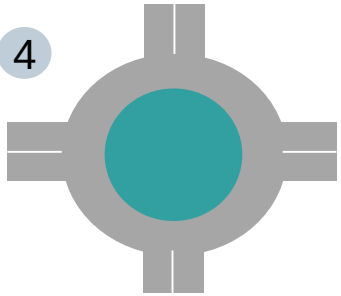
Identifying unknown-unsafe scenarios











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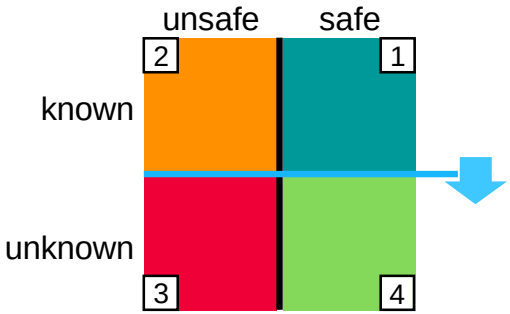
Safety of the Intended Functionality (SOTIF)

Identifying unknown-unsafe scenarios



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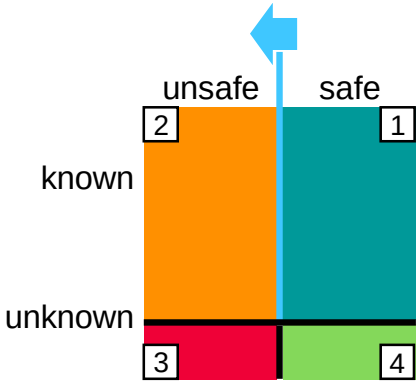
Safety of the Intended Functionality (SOTIF)

Mitigating unsafe scenarios



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Scenario Creation: safe and unsafe

Approaches to unknown scenarios

Actor-focus approach:

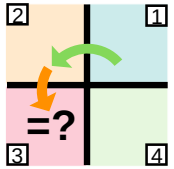
- Uses recorded data
- Changes behaviour of one of the actors in the data relative to the ego-vehicle to create a critical scenario
- Limited by the imagination of engineers and/or actors present in the data

Applying actor-focus to the data recorded:

- Speeds up the movement of the actor

Visualization process:

Takes scenarios from area 1 to area 2, to potentially (!) uncover a scenario in area 3. Engineering the reaction allows the scenario to return to area 1 from area 2.



Scene-focus systematic methodology:

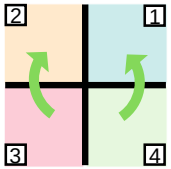
- Uses recorded or synthethic data
- Considers all possible routes in a traffic situation by all recorded and potentially present actors
- Limited only by scientific constraints: the physically possible routes of actors

Applying scene-focus to the intersection:

- Adds cyclist and truck

Visualization process:

Takes scenarios from area 3 to area 2; and at the same time from area 4 to area 1. Engineering the reaction allows the scenario to move to area 1 from area 2.



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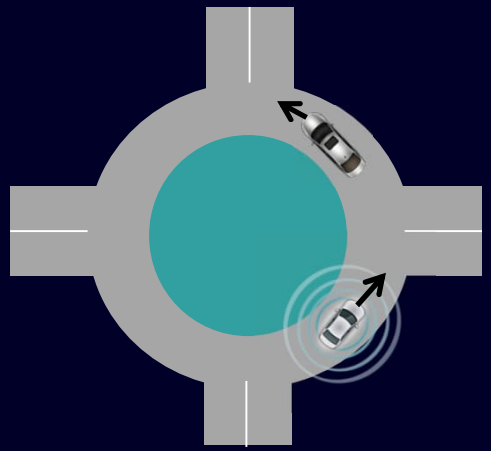
Framework

Definitions

Scene: an environment in which a scenario takes place. Location, weather condition and lighting condition are defining one scene.

Basic scenario elements: a basic scenario element is defined as an abstracted model which describes behavior of a road user in lateral and longitudinal direction.

Scenario: is the combination of all road users and their respective basic scenario elements (i.e., their behavior) in a certain scene.



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Critical Scenario Creation

Framework

Data

Given path or road network

Scene selection

Data Recording

Record Traffic

Record Road Layout

Data Coverage

Data selection

Post-Processing

Generate OpenScenario files

Generate OpenDrive file

Extraction

Basic Scenario Element Extraction

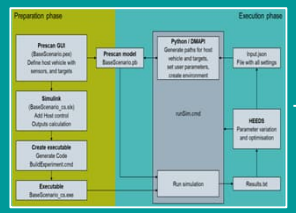
Path Database

Automatic Gate Generation

Probability of an actor movement

Generation

Toolchain Simcenter Prescan & HEEDS



Optimization

Simcenter HEEDS Optimization setups Identify relevant scenarios

Critical scenarios and probability of occurrence

Data recording

SETS

Real2Sim

Critical Scenario Creation

Actor focussed

Scene focussed

OpenDrive, OpenScenario files

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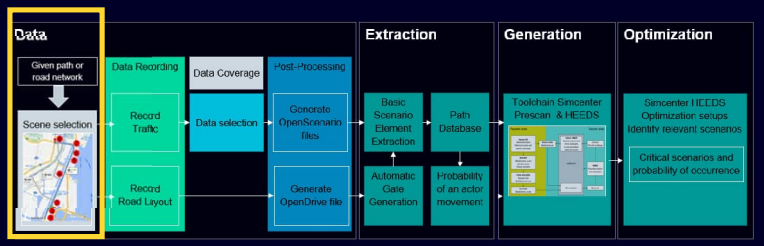
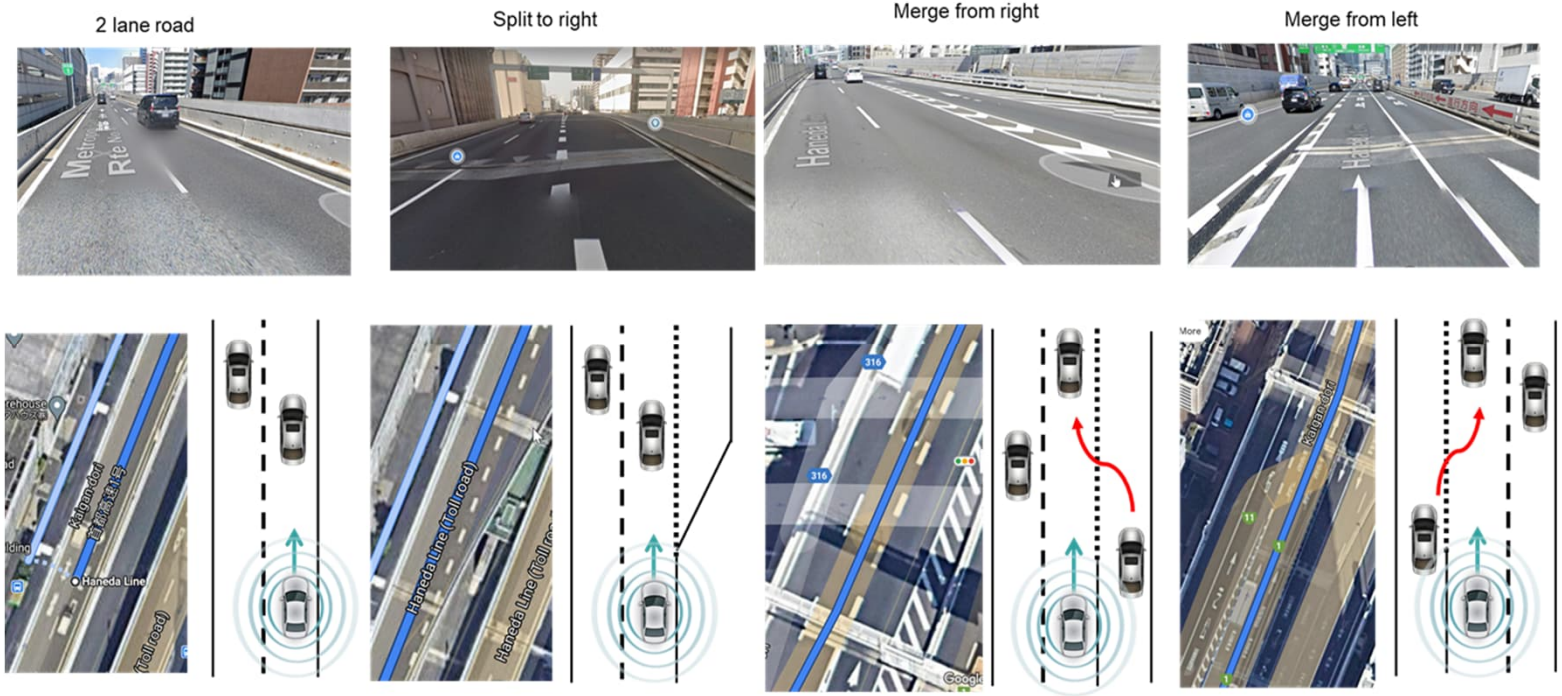
Data

Scene selection





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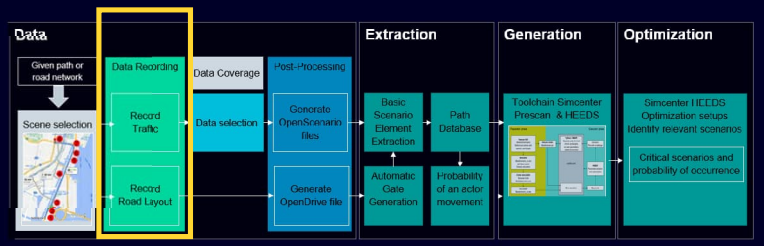
Data

Recording



Real data

Data

post processing drone

Data

post processing infrastructure

Data

post processing Carlab

Data

post processing fleet

Synthetic data

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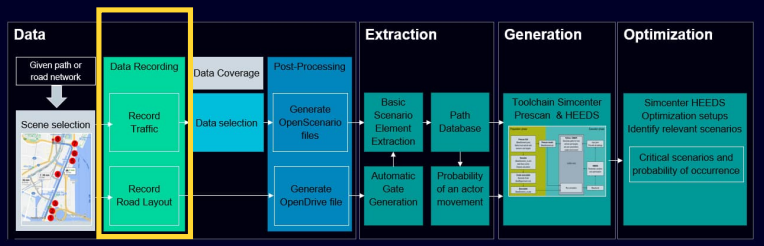
Data

Simcenter SCAPTOR



Recorder

Storage

Extension slot

High bandwidth

Up to 3GBytes/s of sustained data per unit

Optional GPU

Allows for live data processing

Flexible interfaces

Records all data streams in the vehicle

Accurate timestamps

IEEE1588 synchronization and hardware timestamps

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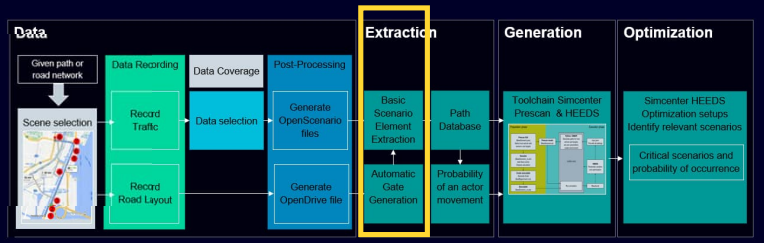
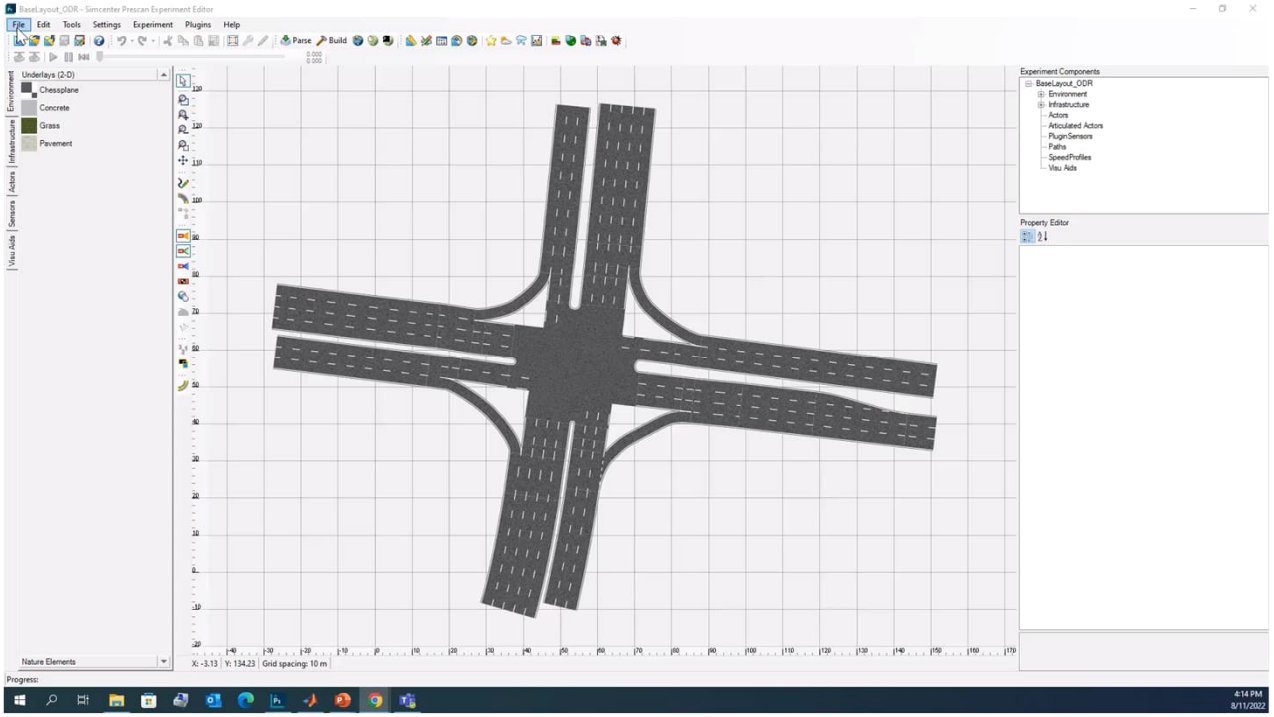
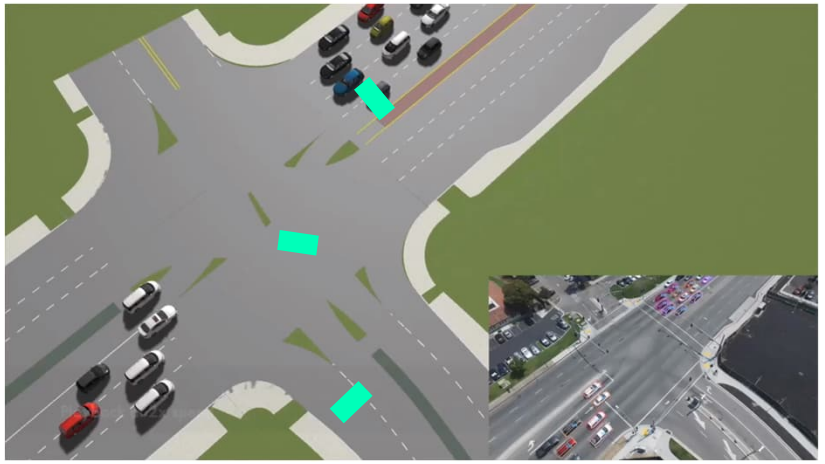
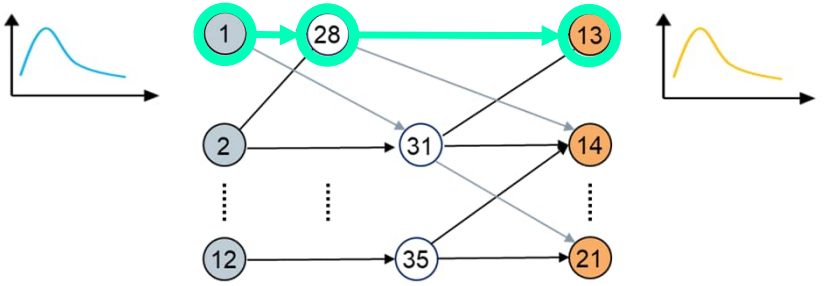
Extraction

Basic scenarios and gates









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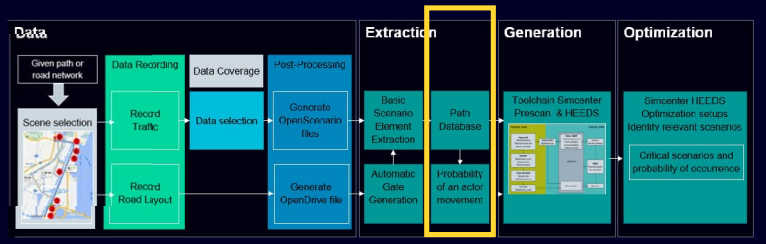
Extraction

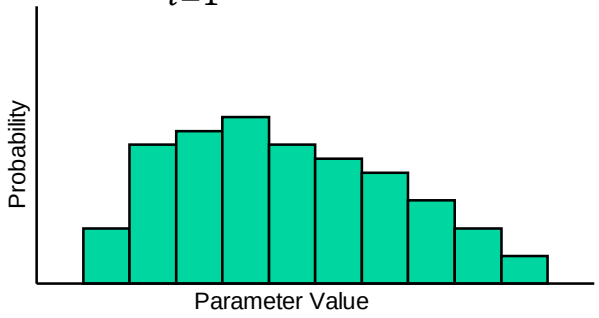
Probability calculation

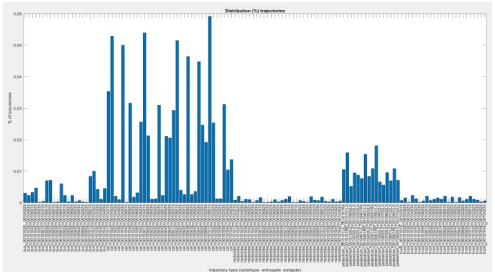


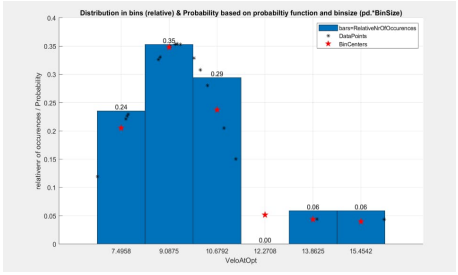
Calculation for each actor-movement based on parameters probability

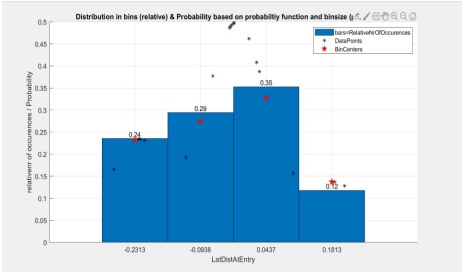
$$P_{parameters} = P_i \;\&\; i\,\{1: \ldots : n\}$$

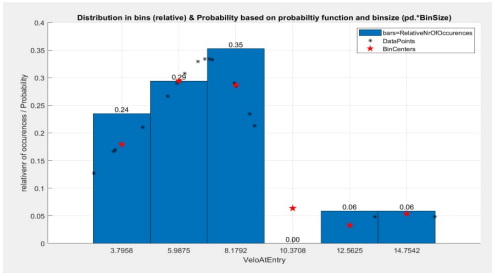
$$P_{actor} = \prod_{i=1}^{n} P_{parameter,i}$$

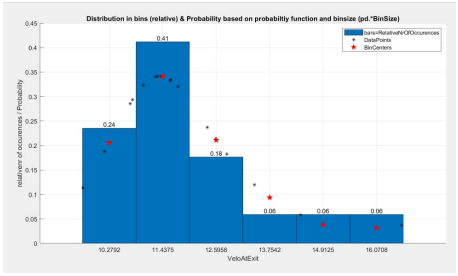


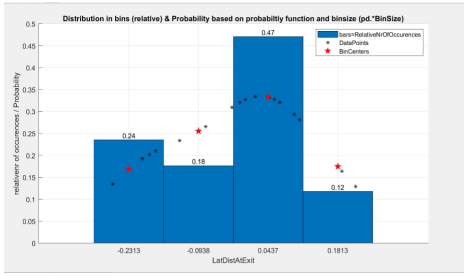












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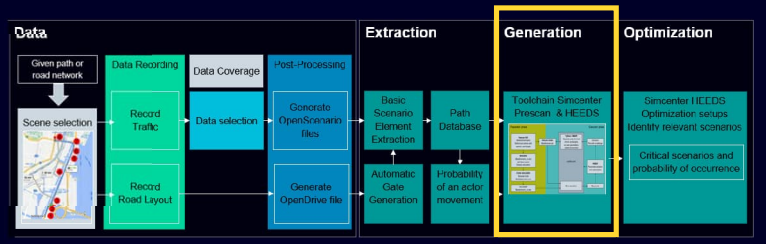
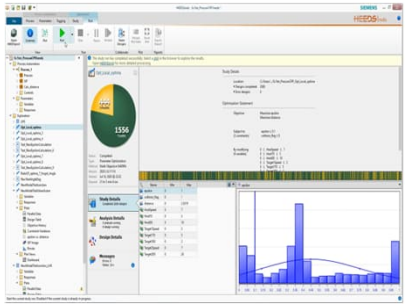
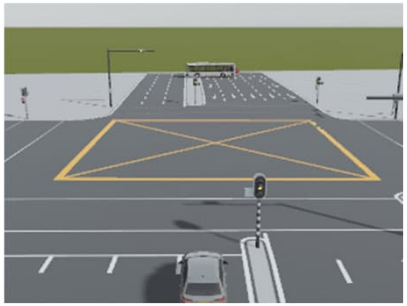
Generation

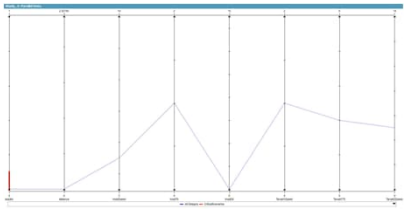
Simcenter Prescan360

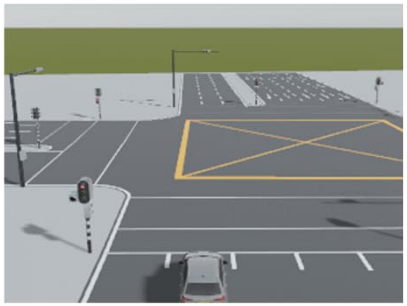


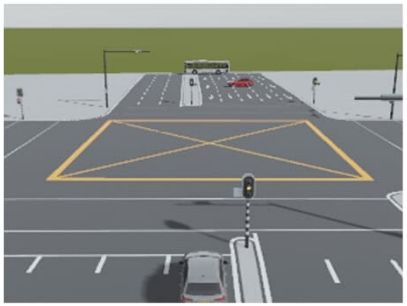


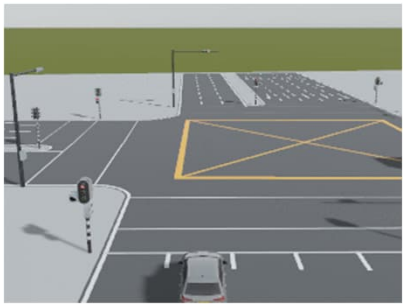


$$P_{scenario} = \prod_{j=1}^{m} P_{actor,j}$$









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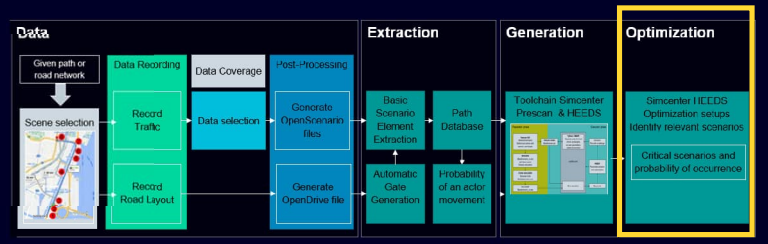
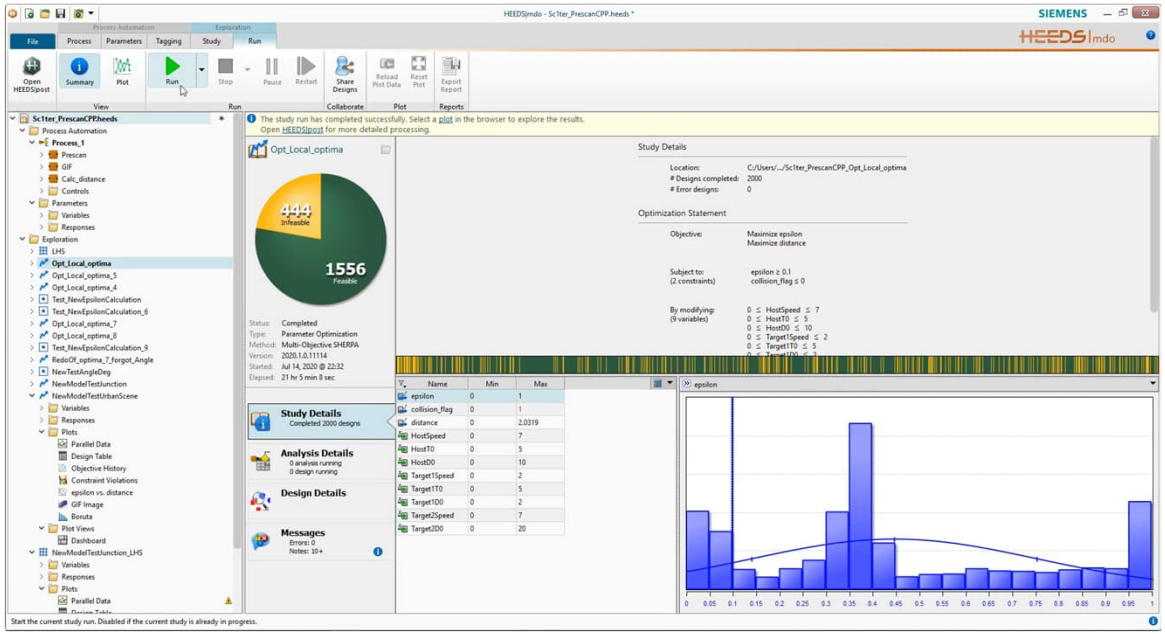
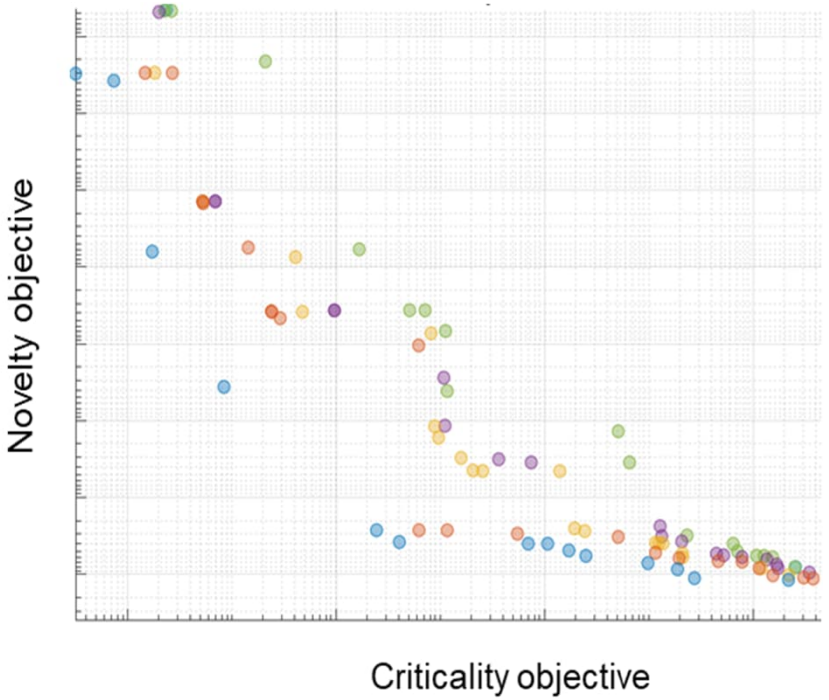
Optimization

Critical, probable scenarios







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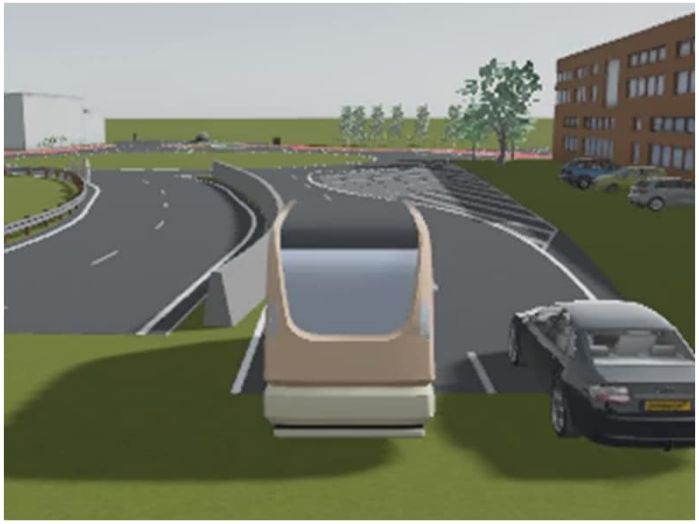
Process

Results



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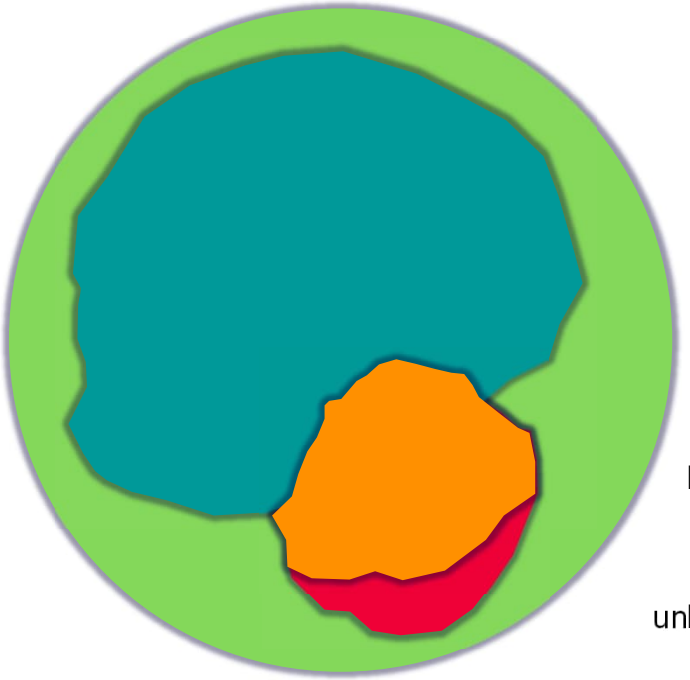
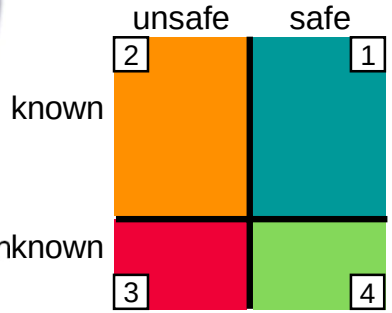
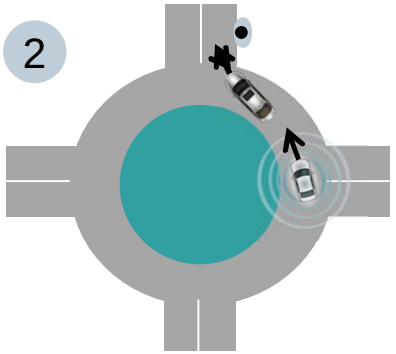
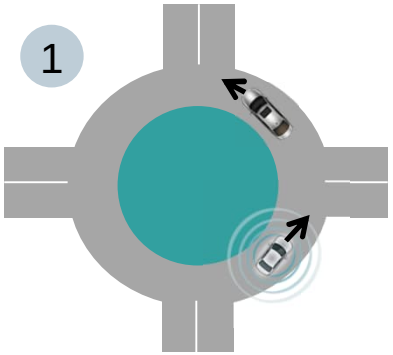
Safety of the Intended Functionality (SOTIF)

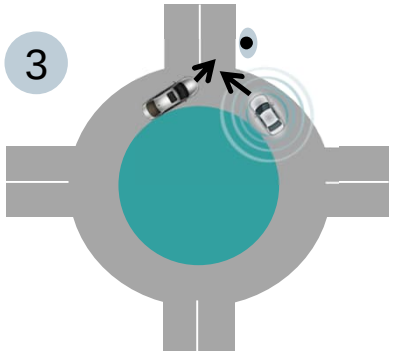
Identifying unknown-unsafe scenarios

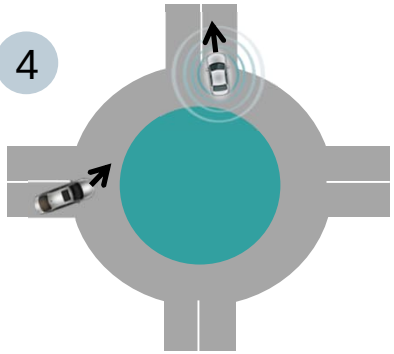












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Process

Results

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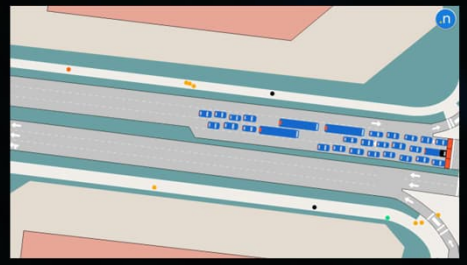
Critical Scenario Creation

Framework

Data

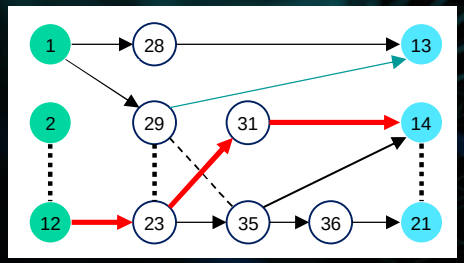
Road users trajectories and traffic light status



- Use real data in OSC and synthetic data in format of CSV files

Extraction

Realistic behavior of each actor from collected data



$$P_{actor} = \prod_{i=1}^{n} P_{param,i}$$

- Automatic gate generation
- Probability calculation

Generation

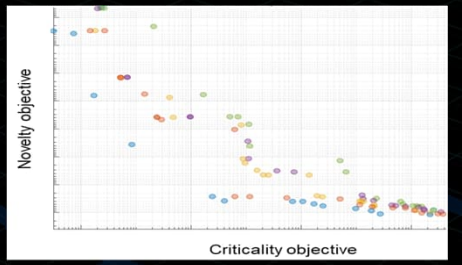
Realistic combinations of actor behavior in the scene

$$P_{scenario} = \prod_{j=1}^{m} P_{actor,j}$$

- Including traffic light cycle as parameter for optimization

Optimization

Multi-objective optimization on Novelty and Criticality



$$Obj = S * P_{scenario}$$

- Using probability of scenario in optimization
- Using Simcenter Prescan 360

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Critical Scenario Creation

Added Value

Systematic approach to identify high probable critical scenarios and reduce the unknown space

Generating realistic scenarios based on realistic actor behavior in the scene.

Reduce effort to find relevant, critical/nominal scenarios for specific ODD

Increase system confidence by testing against previously unknown scenarios

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