

# A Co-Ordinated set of Tools for the Delivery of Scenario Based Testing which Includes Support for Complex Sensor Simulation with Full Over the Air Capability.

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**ZENZIC**<sup>2</sup>

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## A Coordinated Set of Tools for Scenario Based Testing & Complex Sensor Simulation

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# Scenario Based Testing

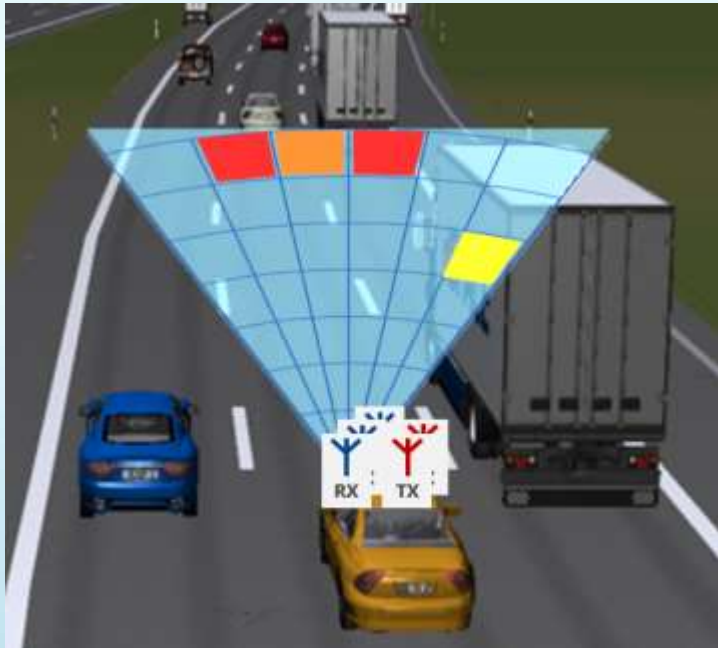
- Scenario is a collection of elements that constitutes a test – A description of a driving situation
- The content of a scenario is dependent on its context
  - Pegasus Project has a definition
  - MUSICC has a definition
- Scenario based test needs to be executed
- This presentation looks at means of test delivery

Functional scenarios	Logical scenarios	Concrete scenarios
<u>Base road network:</u> three-lane motorway in a curve, 100 km/h speed limit indicated by traffic signs	<u>Base road network:</u> Lane width [2.3..3.5] m Curve radius [0.6..0.9] km Position traffic sign [0..200] m	<u>Base road network:</u> Lane width [3.2] m Curve radius [0.7] km Position traffic sign [150] m
<u>Stationary objects:</u> -	<u>Stationary objects:</u> -	<u>Stationary objects:</u> -
<u>Moveable objects:</u> Ego vehicle, traffic jam; Interaction: Ego in maneuver „approaching“ on the middle lane, traffic jam moves slowly	<u>Moveable objects:</u> End of traffic jam [10..200] m Traffic jam speed [0..30] km/h Ego distance [50..300] m Ego speed [80..130] km/h	<u>Moveable objects:</u> End of traffic jam 40 m Traffic jam speed 30 km/h Ego distance 200 m Ego speed 100 km/h
<u>Environment:</u> Summer, rain	<u>Environment:</u> Temperature [10..40] °C Droplet size [20..100] µm	<u>Environment:</u> Temperature 20 °C Droplet size 30 µm

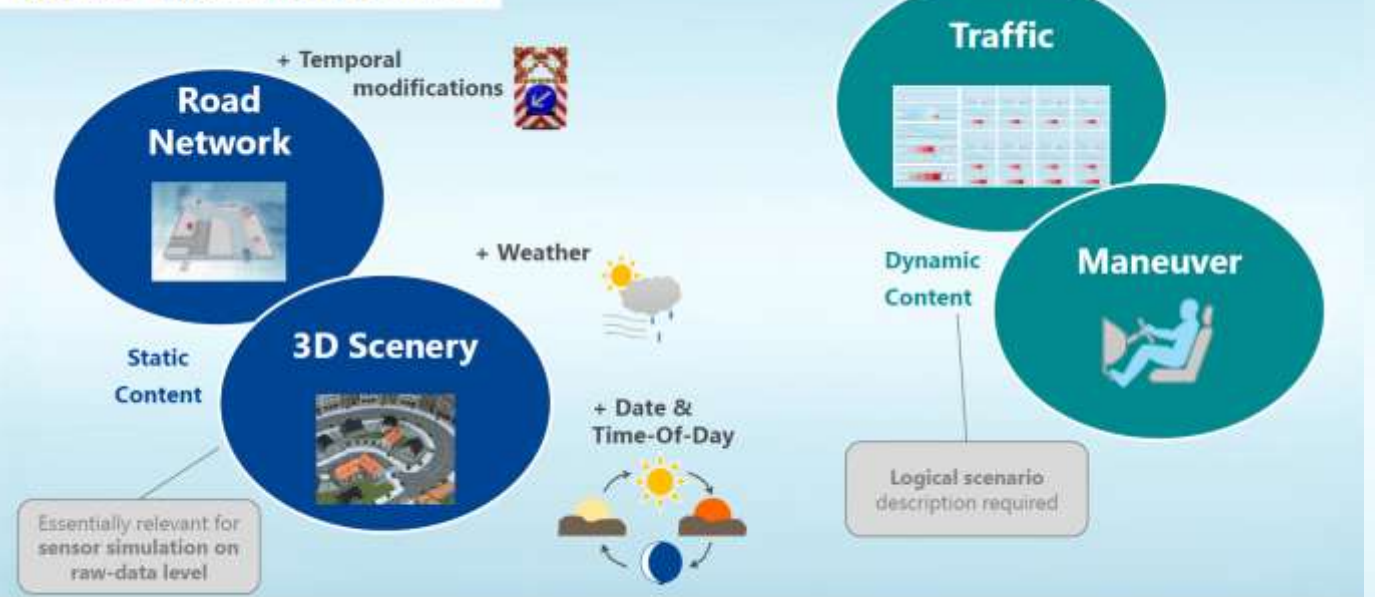
  

Level of abstraction	>
Number of scenarios	>

# Example: Motorway Overtake



## What is a simulation scenario ?



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# Main Components of Scenarios

## Vehicle Dynamics



### Vehicle simulation

- Vehicle Dynamics
- Drivetrain
- Soft-ECU network
- Driver model
- Maneuver



### Traffic Objects

- Static and dynamic objects
- Vehicles, trucks, pedestrians
- Traffic signs, traffic lights, parking vehicles, ...

## Traffic

## Environment



### Road networks

- Roads and intersections
- Lane support
- Artificial/real world roads
- Road import
- Roadside structures



### Environment Sensors

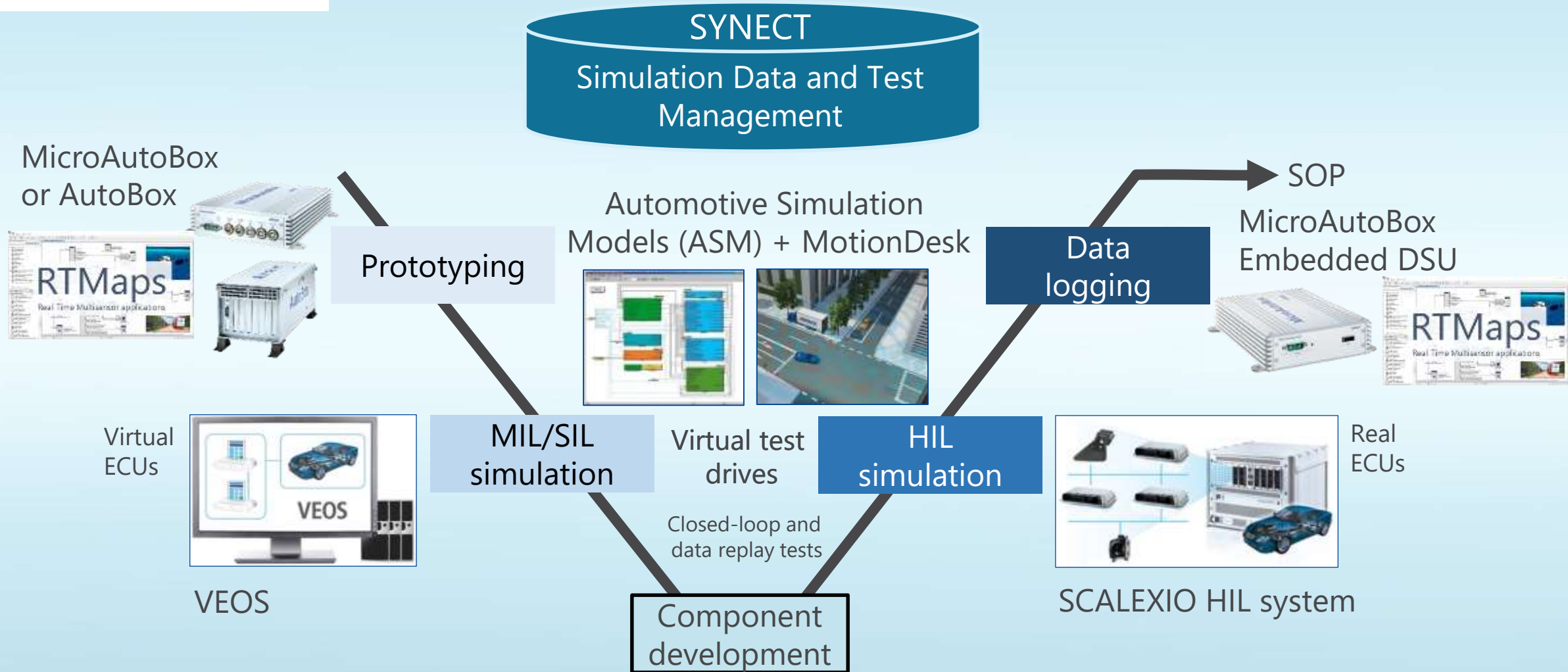
- 2-D/3-D sensors
- Camera, radar, lidar, ...
- Line, lane and traffic sign recognition
- Object list simulation

MotionDesk  
Visualization

ModelDesk  
Parameterization



# Implementing Tests

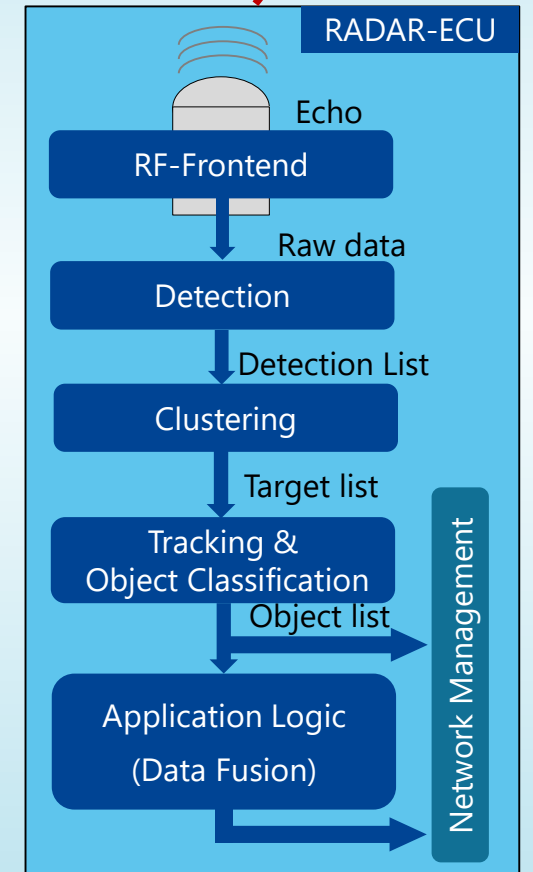
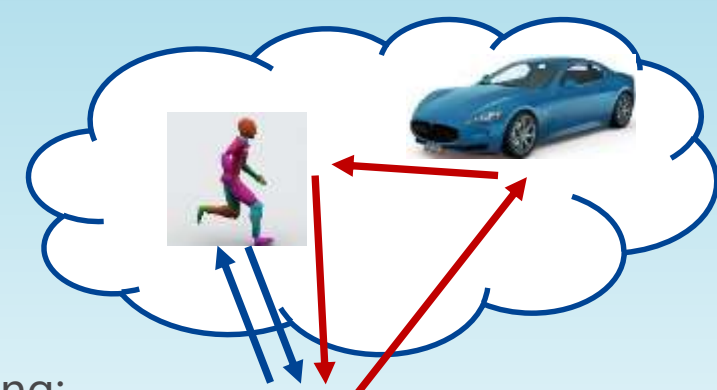


SOP: Start of production

# Complex Sensor Simulation – RADAR Signal Processing

## General Overview

- Sensor's objective is to extract the following properties of objects in its surrounding:
  - range
  - velocity
  - azimuth angle
  - elevation angle
  - Reflectivity (Amplitude)
- The surrounding environment determines the channel of the signal
  - Hence the requested properties of the objects can be extracted from the channel
- Hence sensor's objective is to characterize the channel
  - From a signal theory point of view: the channel is characterized by the channel impulse response  $h(t)$





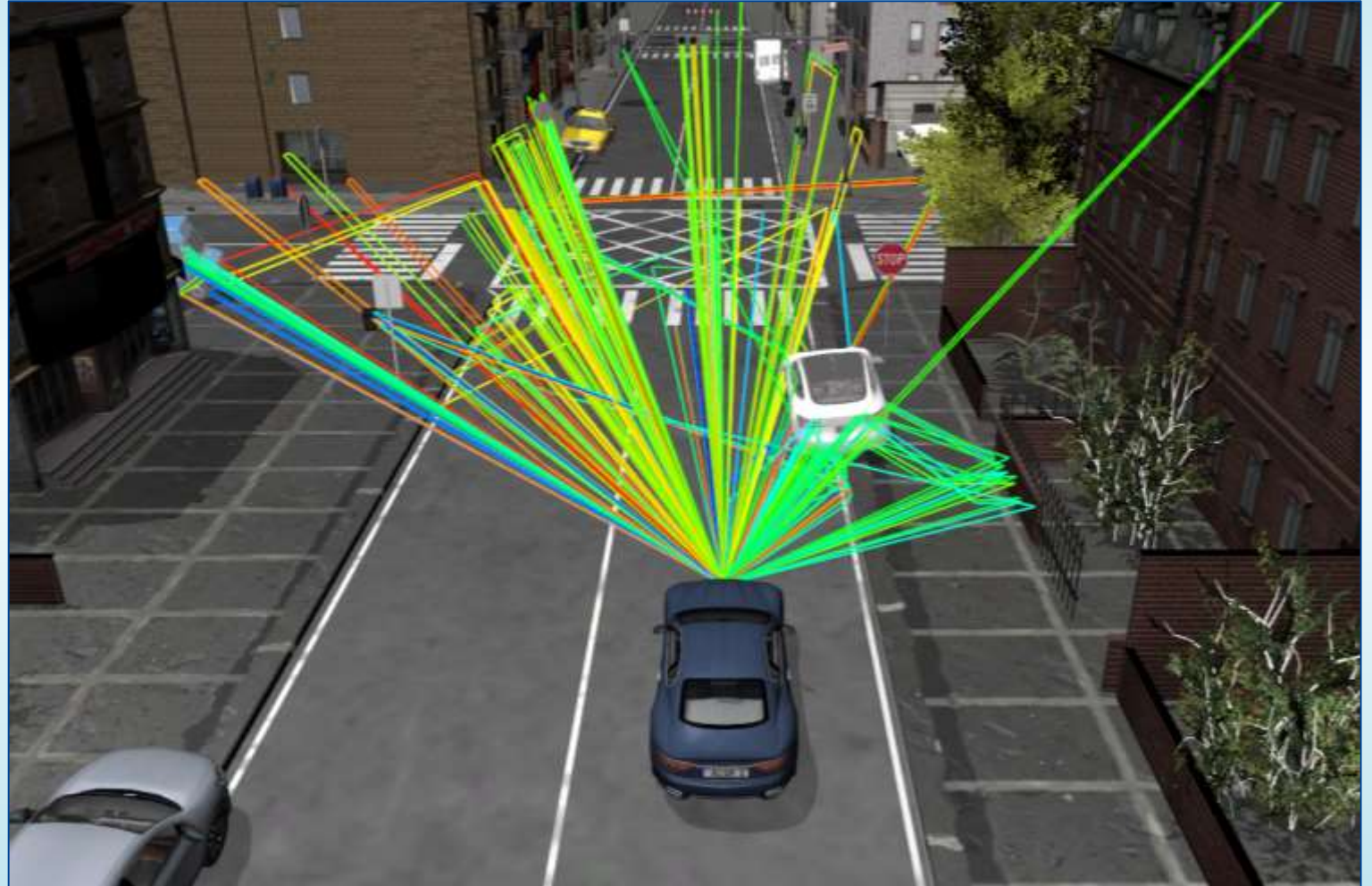
# Radar simulation based on ray-tracing

## Physics-based radar sensor model

- Real-time capable raytracing for the computation of the radar propagation channel
- For HIL and SIL applications

## Features

- Generation of
  - Raw data
  - Target list on detection level
- Propagation effects included
  - specular reflection
  - diffuse scattering
  - multipath propagation



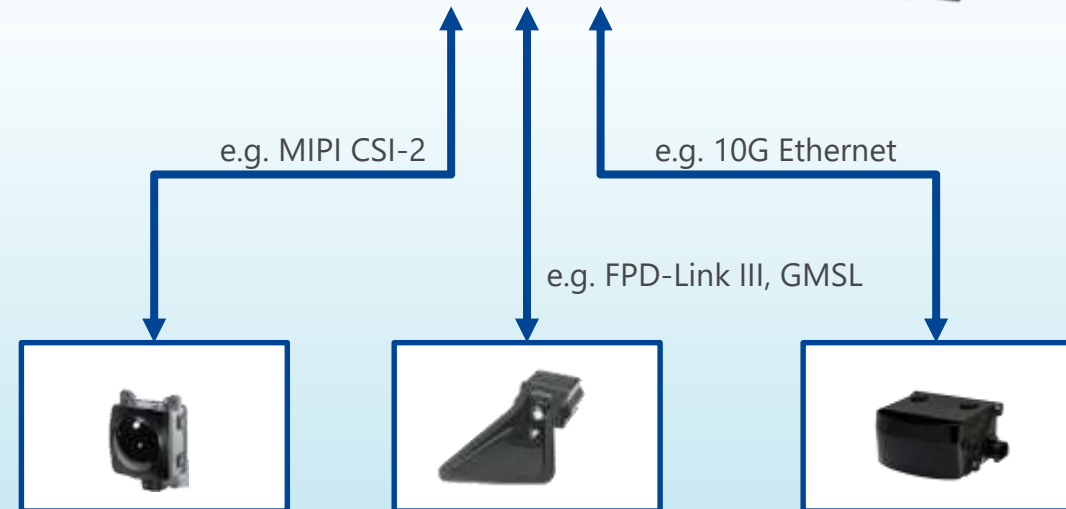
# Environment Sensor Interface Unit for Radar, Lidar and Camera

## Environment Sensor Interface (ESI) Unit

- Flexible and highly scalable platform
- Support of all interfaces for data injection
- Closed-loop and open loop scenarios

## Features

- Powerful FPGA-based platform
  - Xilinx Zynq UltraScale+ MPSoC ZU9
  - Up to 50 Gbit/s aggregated data transfer rates
  - Multiple ESI Units in one test system
- Support of
  - Long range interfaces (Maxim GMSL, TI FPD-Link III, etc.)
  - Short range interfaces (MIPI CSI-2, HiSPI, LVDS, etc.)



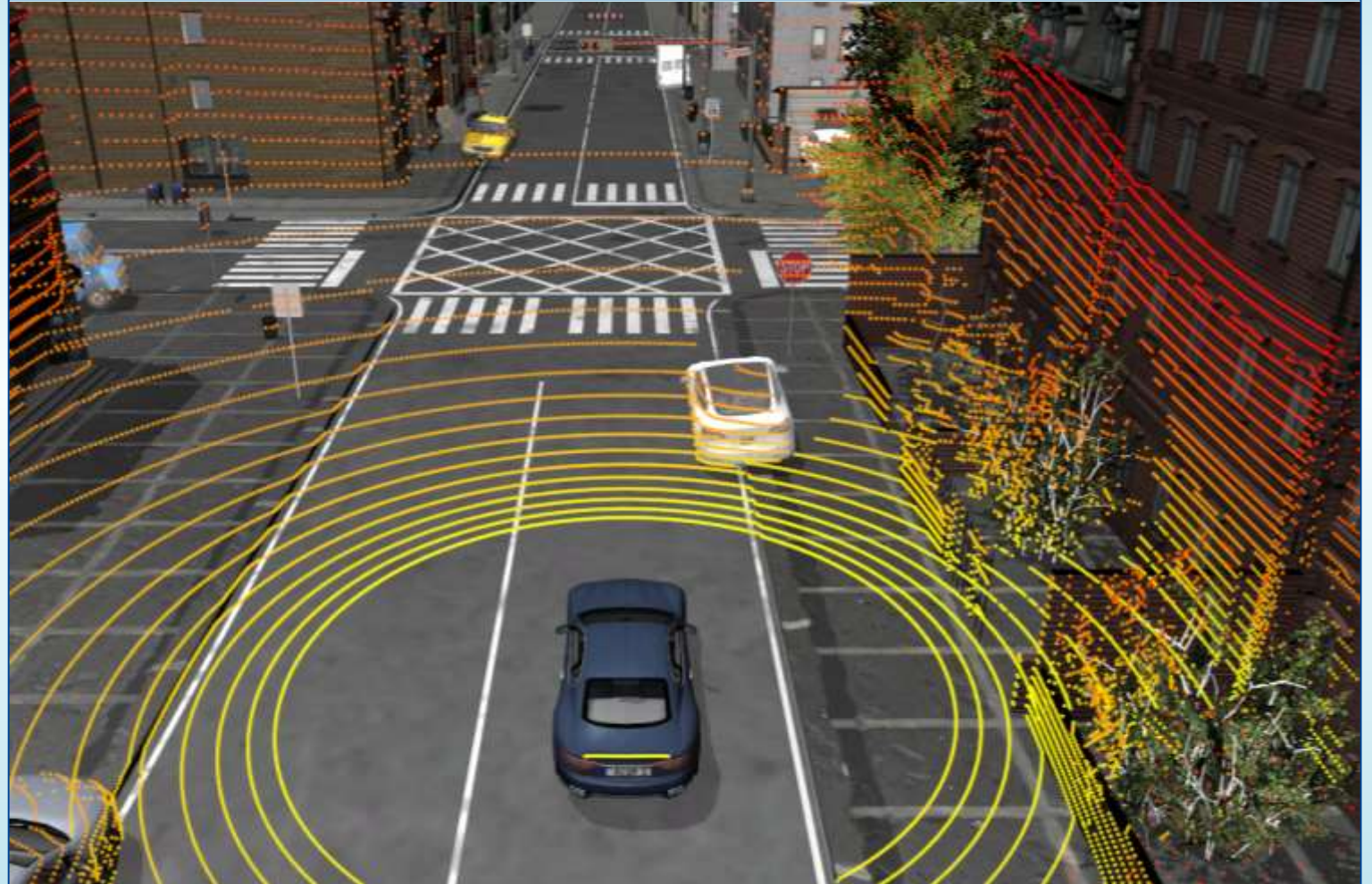
# Lidar simulation based on ray-tracing

## Physics-based lidar sensor model

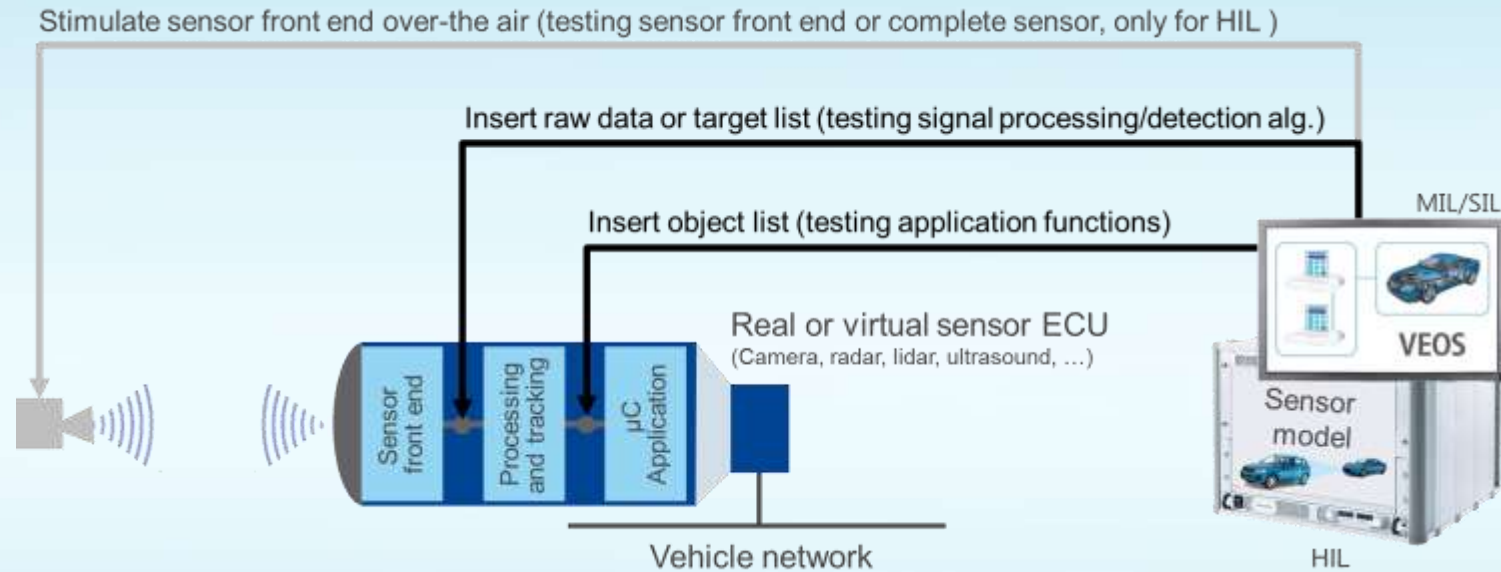
- Real-time capable raytracing for the computation of an extended point cloud
- For HIL and SIL applications

## Features

- Generation of
  - Raw data
  - Point cloud / target list
- Parametrizable sensor properties
  - Scanning lidar
  - Flash lidar
  - Field of view
  - Angular resolution



# Portfolio – Sensor models and sensor integration options



Option	Camera	Radar	Lidar	Ultrasound	GNSS	V2X	Electr. horizon
Object list	✓	✓	✓	✓	Position data	DSRC, LTE/5G	ADASIS v2/v3
Target list, raw data	✓	✓	✓	-	-	-	-
OTA stimulation	✓	✓	Under discussion	✓	✓	DSRC, LTE/5G planned	GNSS RF signal

DSRC: Dedicated short range communication, IEEE 802.11p  
 OTA: Over-the-Air  
 RF: Radio Frequency

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