# Virtual Test Driving을 이용한 ADAS 및 자율주행 시스템의 개발 및 평가

KRNet 2018

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SOLUTIONS FOR VIRTUAL TEST DRIVING

# Trends in the automotive industry

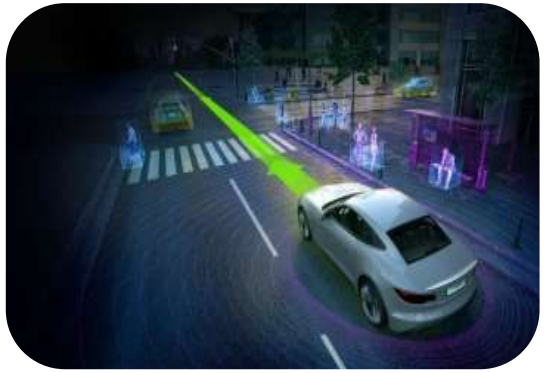

**AI can support many of these trends**

**But it also brings new challenges**

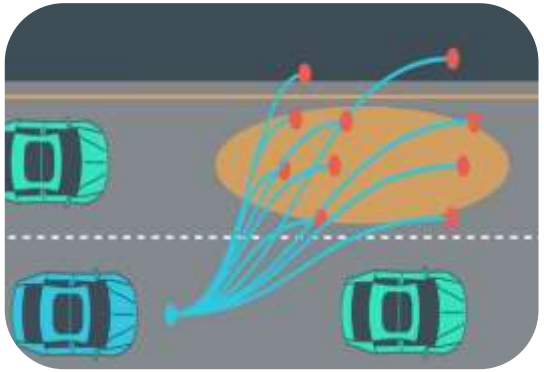
# AI is used in many different fields of applications

## In the automotive industry

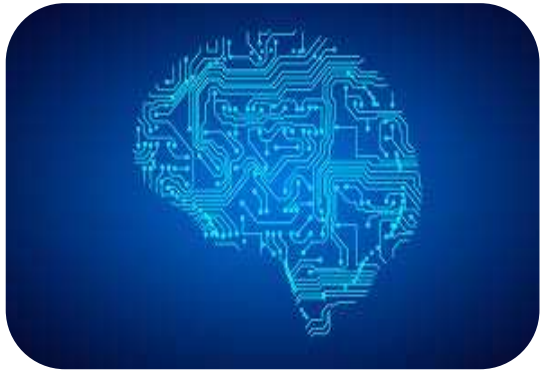
Image Processing



Decision Making



Trajectory Planning



…

# Safety-Critical Functions Must Not Fail!

## Testing in countless everyday situations






**Millions / billions of km necessary to release functions in real-world tests**

**Changes to the software (code or parameters) → Start testing again!**

# Solution: Virtual Test Driving in Addition to Real World Tests

Powerful integration and test platform for virtual test driving guarantees:

- Easy setup of complex test scenarios
- Reproducibility of tests
- Integration of controllers (Software and/or Hardware) as well as sensor fusion algorithms
- Sensor models like Radar, Lidar, Ultrasonic, Camera
- Usage in the entire development process (MIL / SIL / HIL / VIL)


**Virtual test driving based system validation in addition to real world test …**

**… will be the key for success for accident analysis!**

# Building a Virtual Test Scenario

# Virtual Test Scenario

## Roads and infrastructure



**Sources:**
Map data, road measurement, Scenario Editor

## Traffic and environment



**Sources:**
Road recordings, traffic sim s/w, Scenario Editor


**CarMaker**
virtual vehicle prototype

## Driver



**Sources:**
IPGDriver model, driver-in-the-loop, autonomous controls

## Specific subsystem models/components


Sensors


HiFi powertrain

HiFi interior

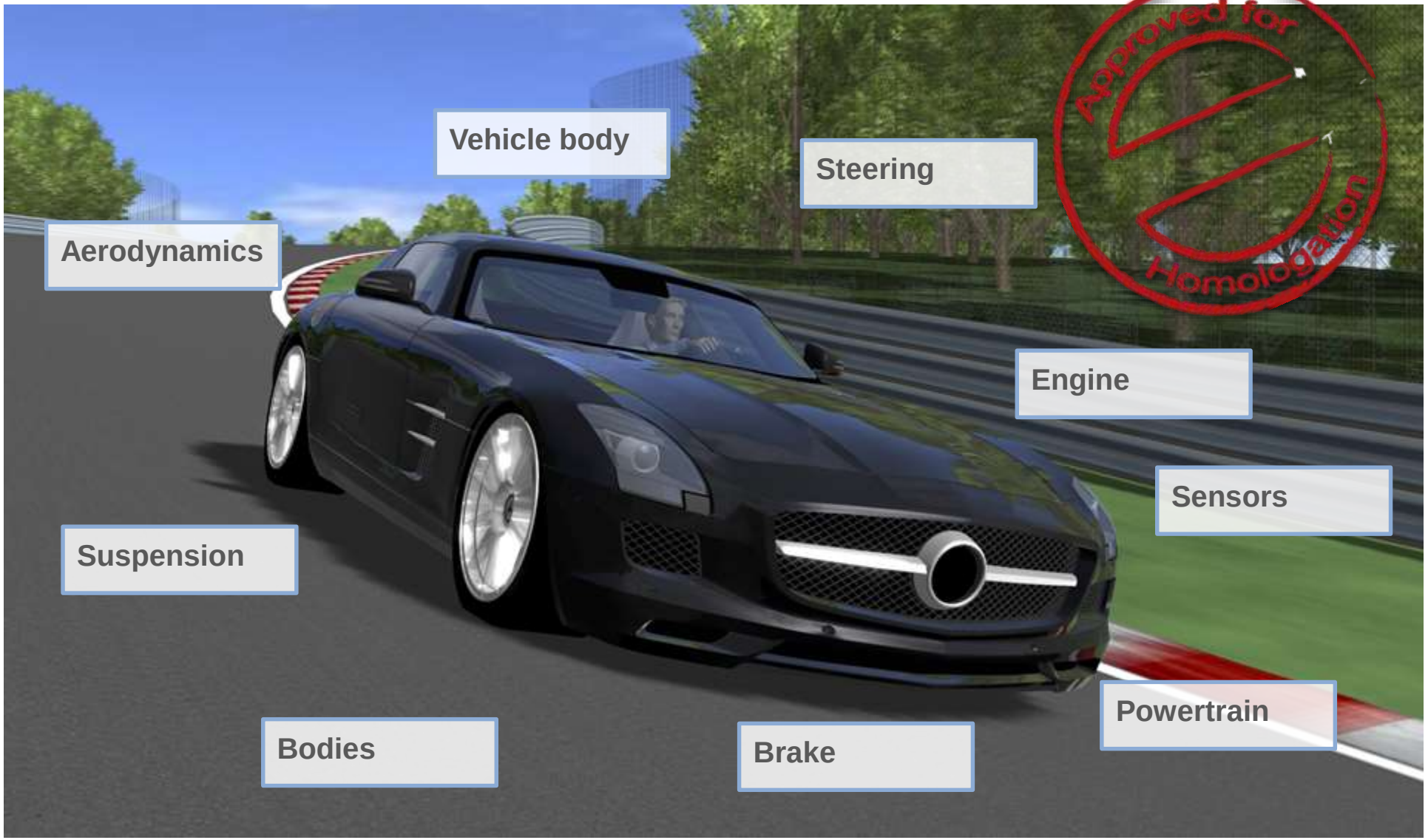
…

**Sources:**
Physical Sensor Models, 3rd party tools, real components

# VEHICLE

## IPGCar

# Technical Data IPGCar – Overview




- Models available for every vehicle component
- Different level of details
- Integration of existing customer models (Simulink, C-Code…)
- Real-time performance
- Easy parameterization via a graphical user interface

# PERFORMING MANEUVERS

## IPGDriver

# Real Test Driver’s Job: Many Tasks to Handle

State observer

Operation of test devices

- Data acquisition device
- Failure insertion
- Diagnostics
- Steering & braking machines

Full vehicle control

Operation of vehicle systems

State observer

**IPGDriver – the virtual driver – has the same tasks, too**

# IPGDriver – Impressions

## The highly sophisticated driver model

**Different abilities of IPGDriver for testing different use cases**

**E.g. lap time optimization, parking scenarios, traffic behavior, …**

# SCENARIO GENERATION

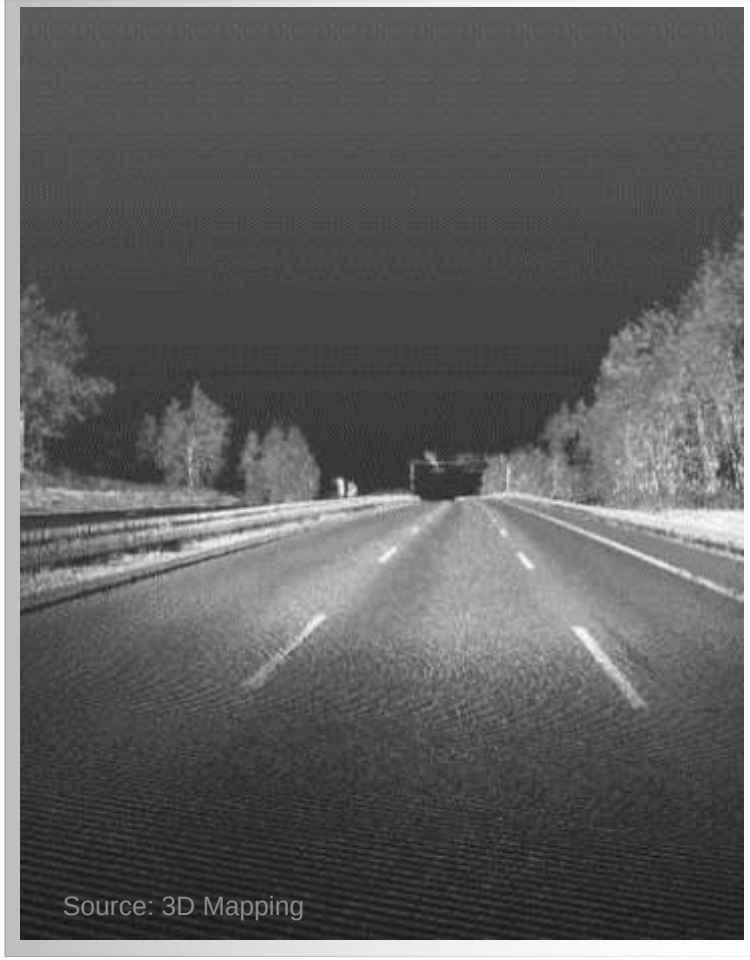
## Road

# Methods of Road Generation

## Manual

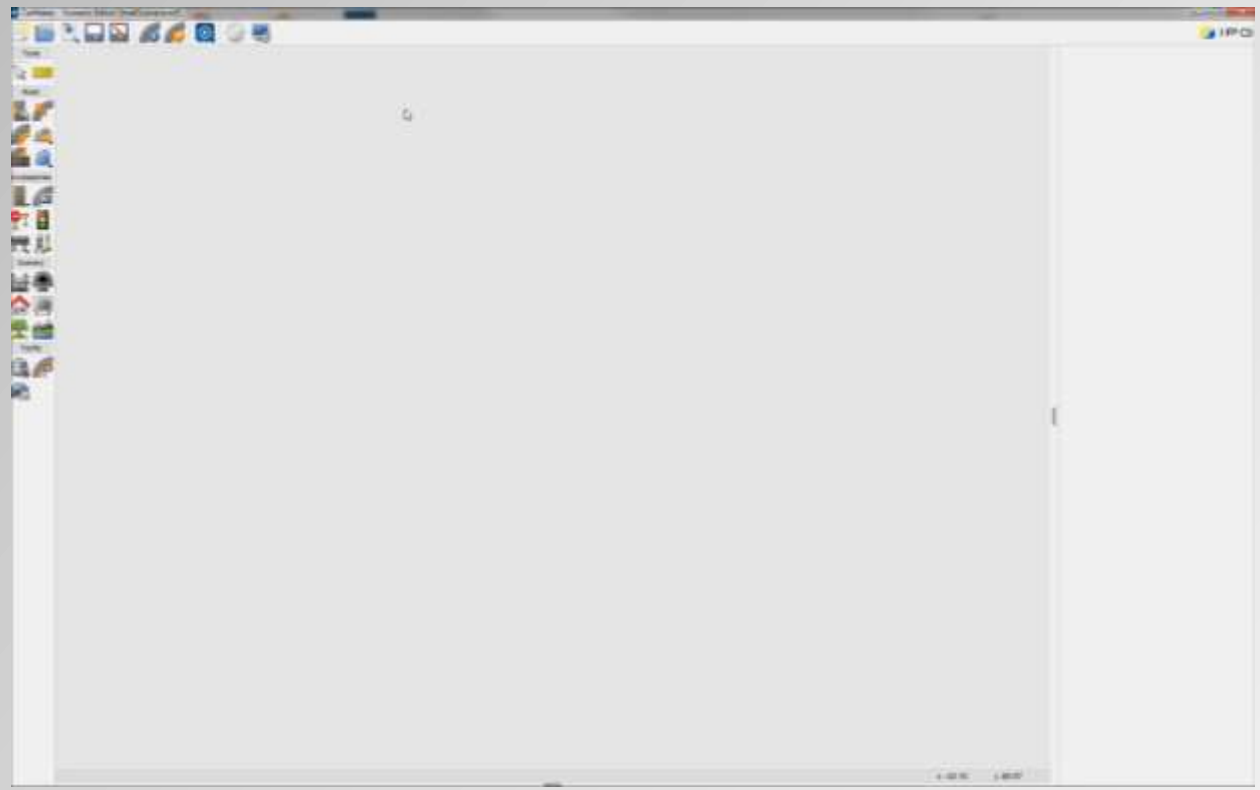

## Map-based

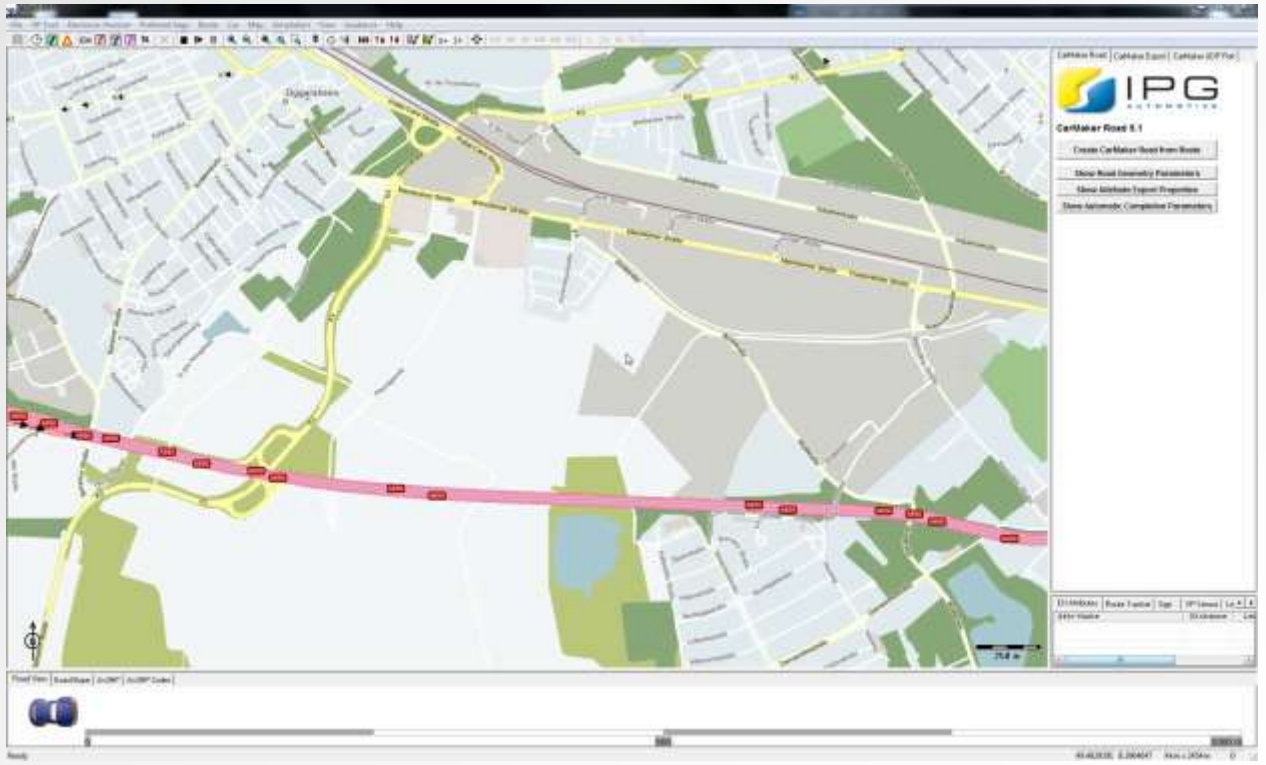
## Measurement-based



# Scenario Editor or ADAS RP import

## Manaul or Map-based



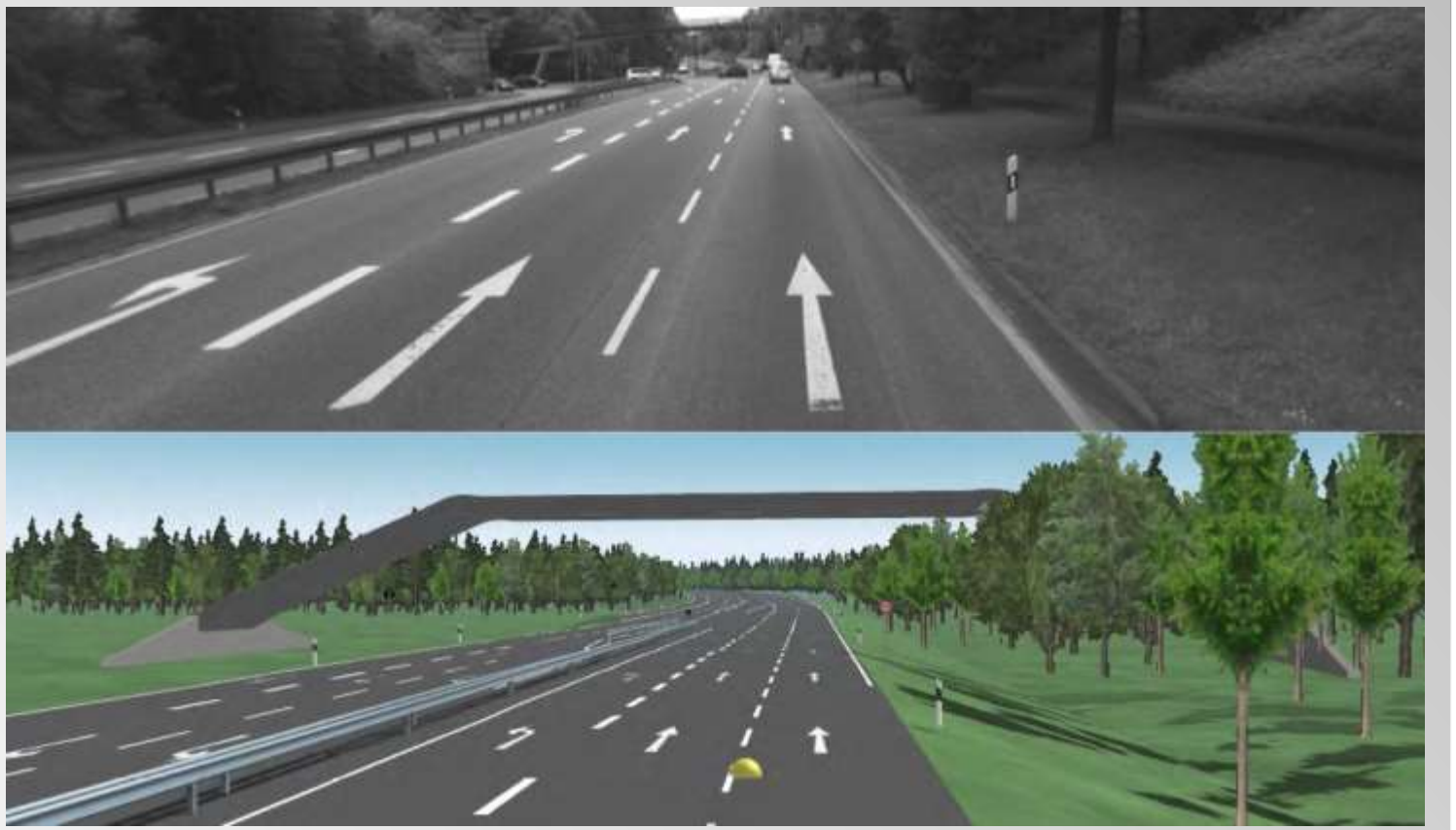


# IPG Automotive’s Partners for Real-World Data Import

Measurement-based

atlatec


3D MAPPING



# SCENARIO GENERATION

## Traffic

# Deterministic Traffic Model

## Physics based traffic motion

4-wheel model
with roll and pitch

4-wheel model
with steered axle

2-wheel model
with roll

Physical speed
calculation

Pedestrians with
natural motion

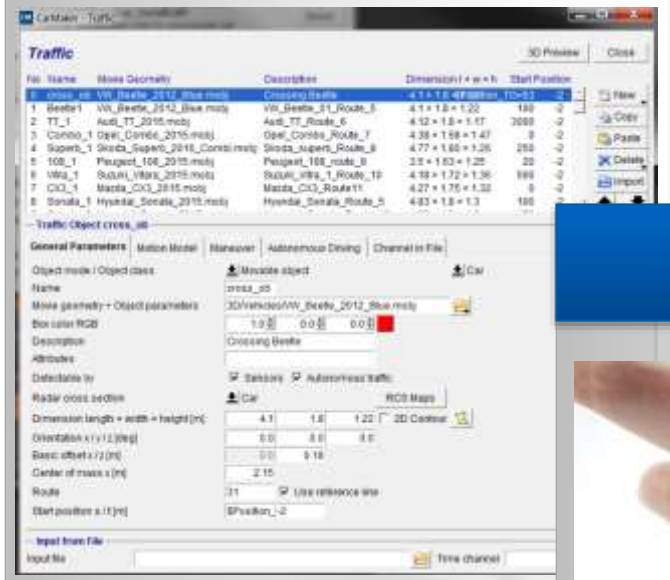
Animals with
natural motion

Ball model

Physically consistent
accelerations

# Methods of Traffic Generation

## Manual




## Coupling to other tools


## Random

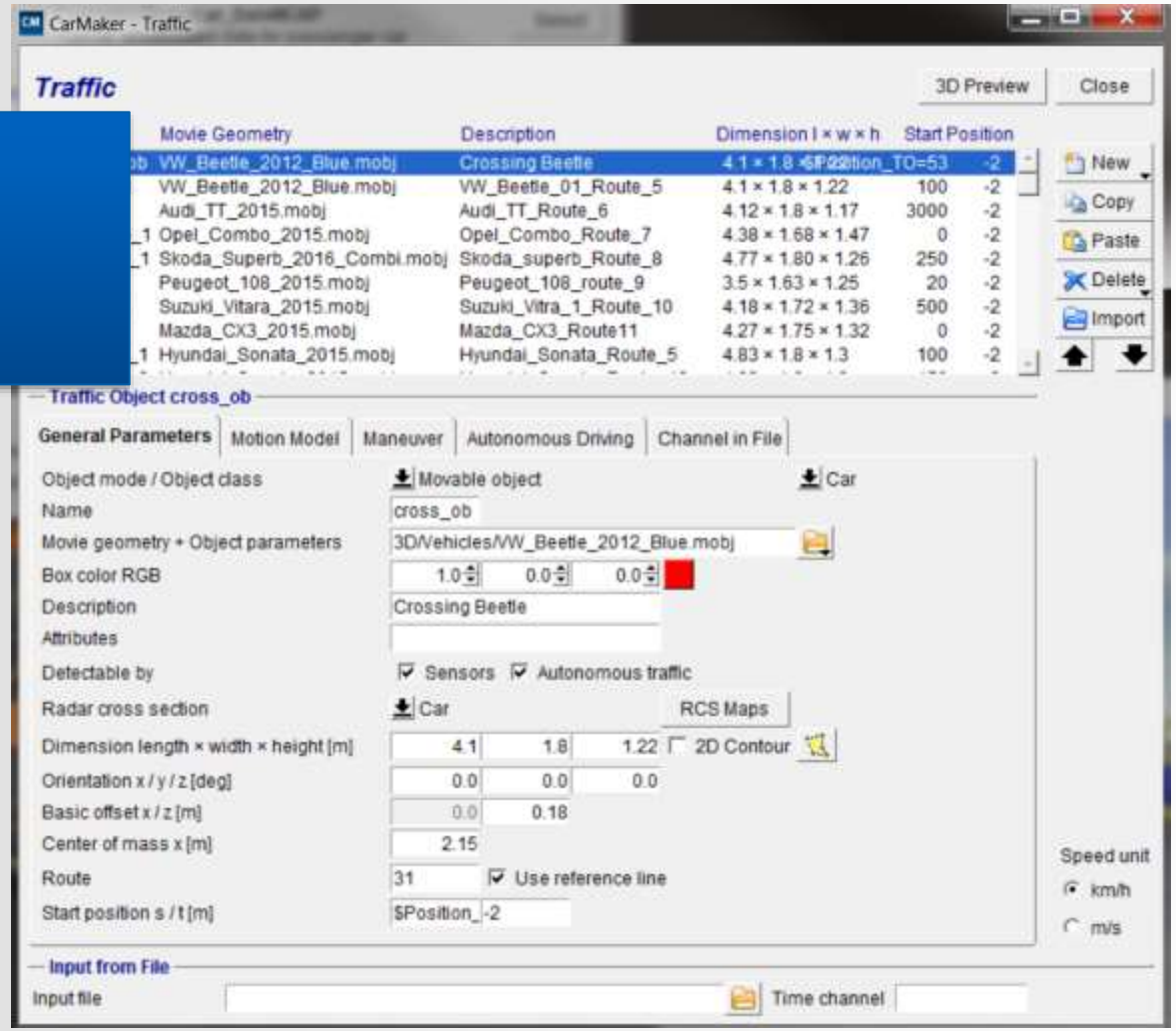
## ScenarioRRR

# Methods of Traffic Generation

## Manual

Manual

- Configuration via Traffic GUI
- Fully parameterizable



# Methods of Traffic Generation

## Coupling to other tools – new PTV VISSIM co-simulation interface

Coupling to other tools

**Preparation**

**Simulation**

**CarMaker/TruckMaker** (vehicle, driver, scenario)

Scenario generation in CarMaker

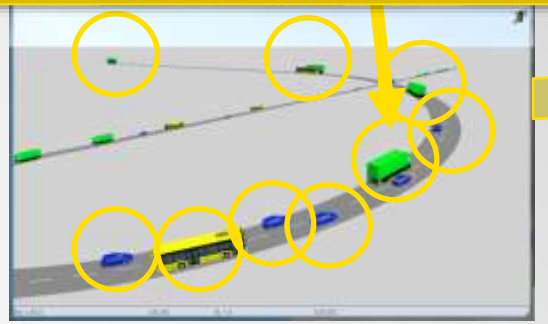
Vehicle, driver, maneuver (ego vehicle)


synchronized co-simulation

**PTV VISSIM** (traffic)

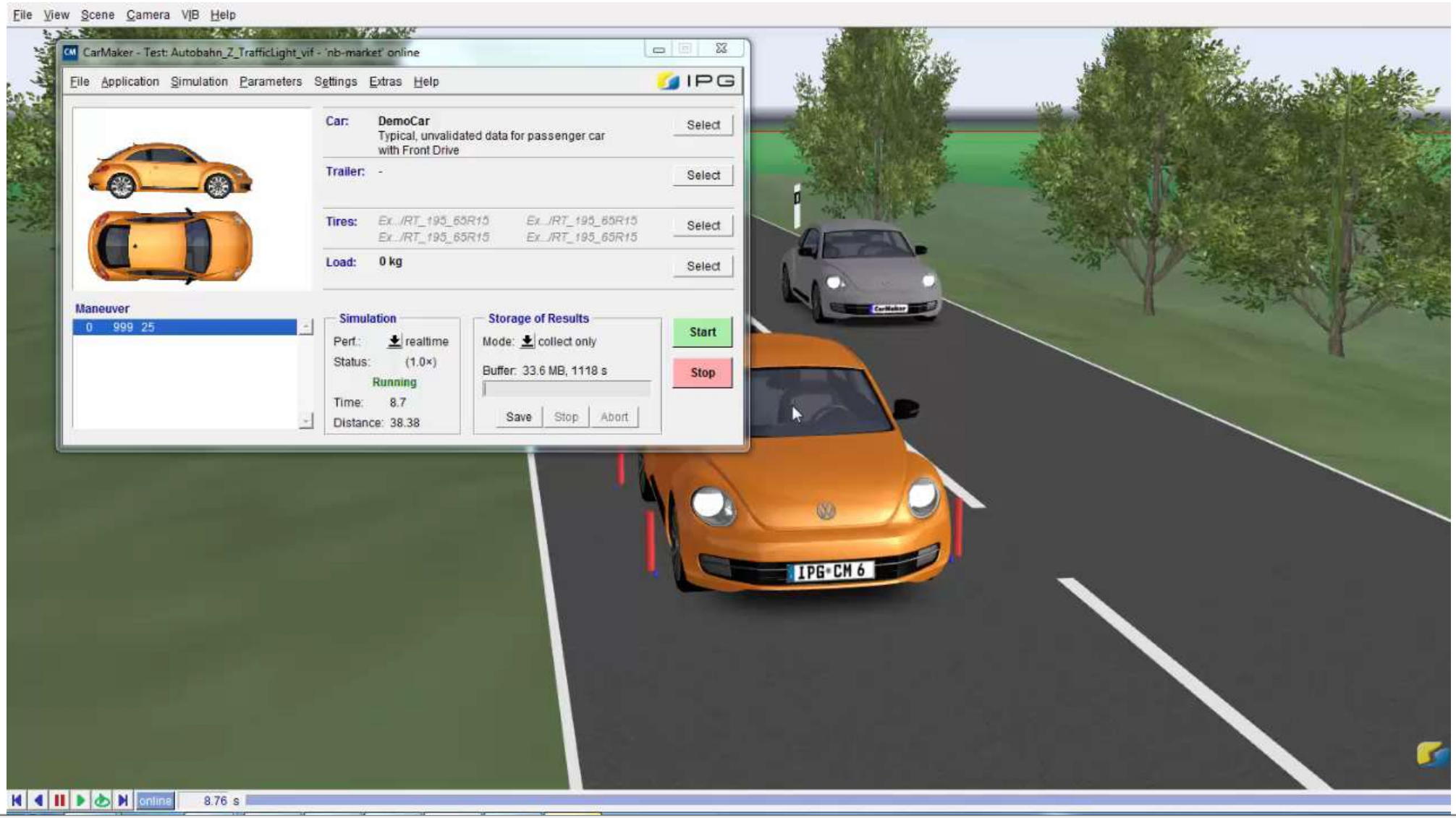
Automatic road import from CarMaker

Traffic situation definition

# Methods of Traffic Generation

## Coupling to other tools – new PTV VISSIM co-simulation interface

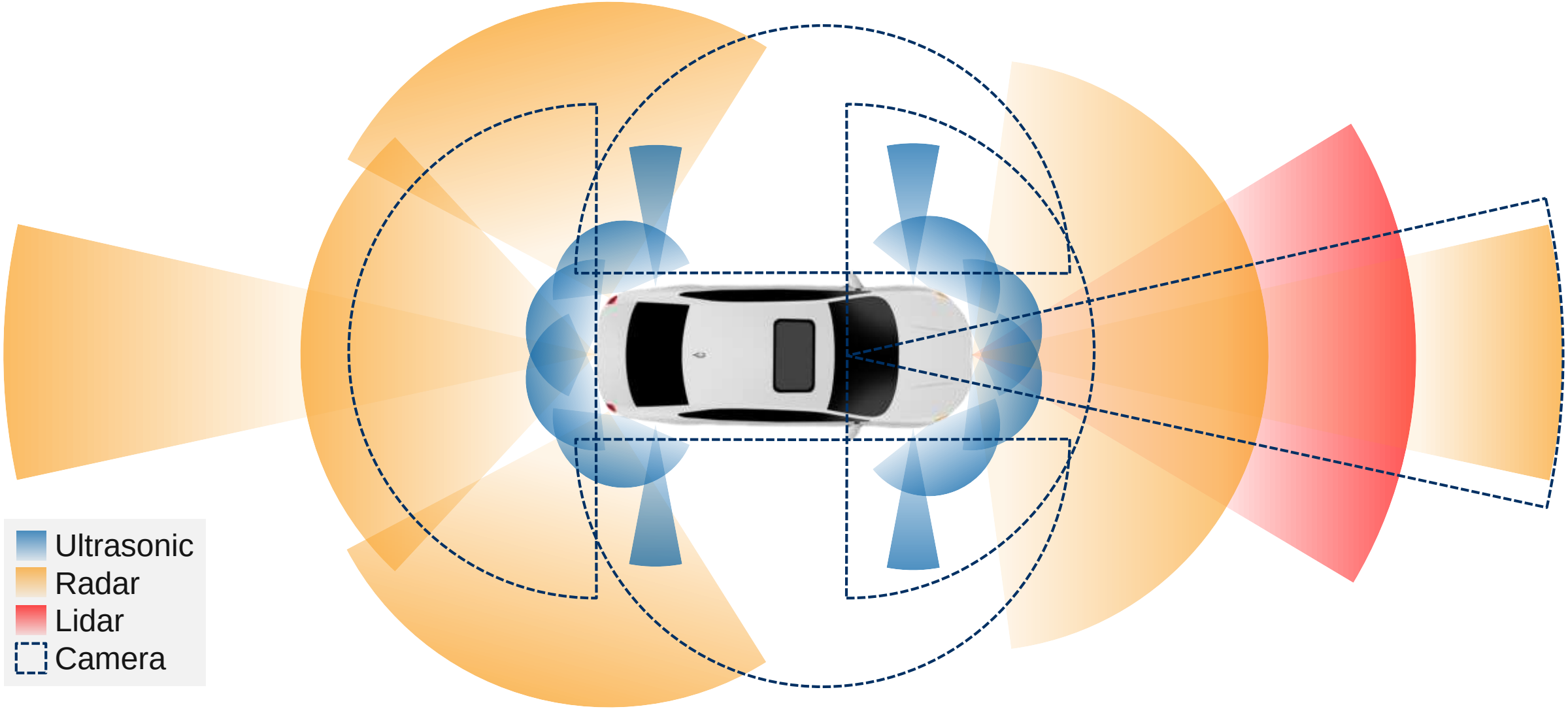


# PERCEPTION

## Sensors

# Example Sensor Configuration

## SAE Level 4/5

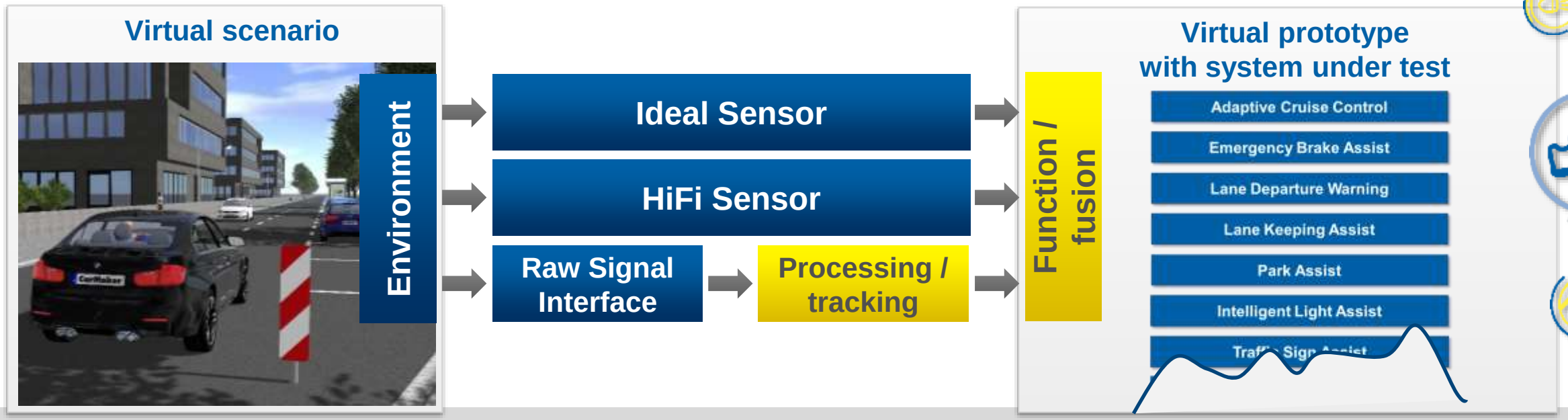


# Use Case-Specific Sensor Models

## Overview

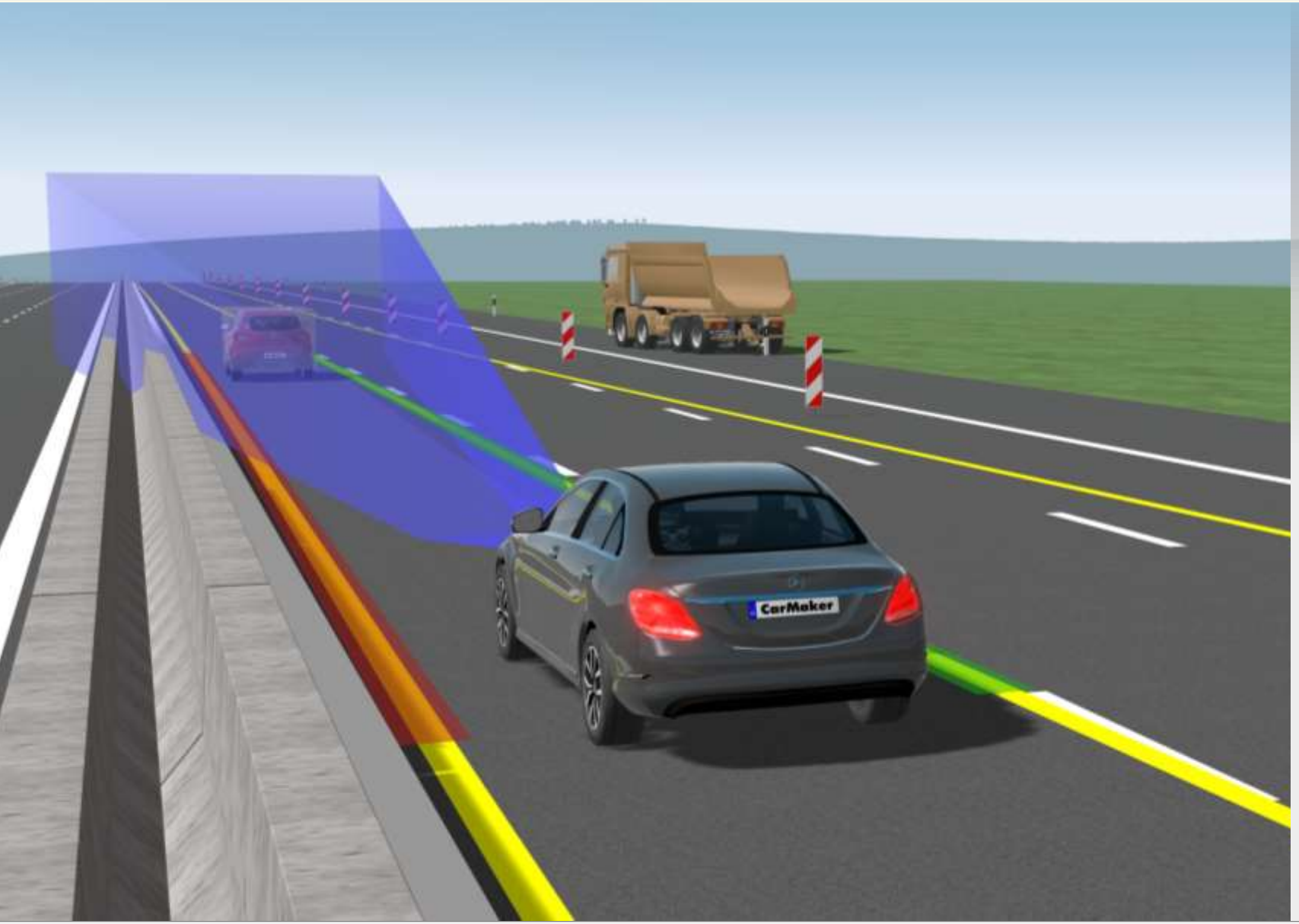
**The use case drives the level of detail:**

- Ideal Sensors for rapid prototyping / proof of concept
- HiFi Sensors for function development & testing
- Raw Signal Interface for component / signal processing development & testing




**Use case-specific sensor models for real-time simulation!**

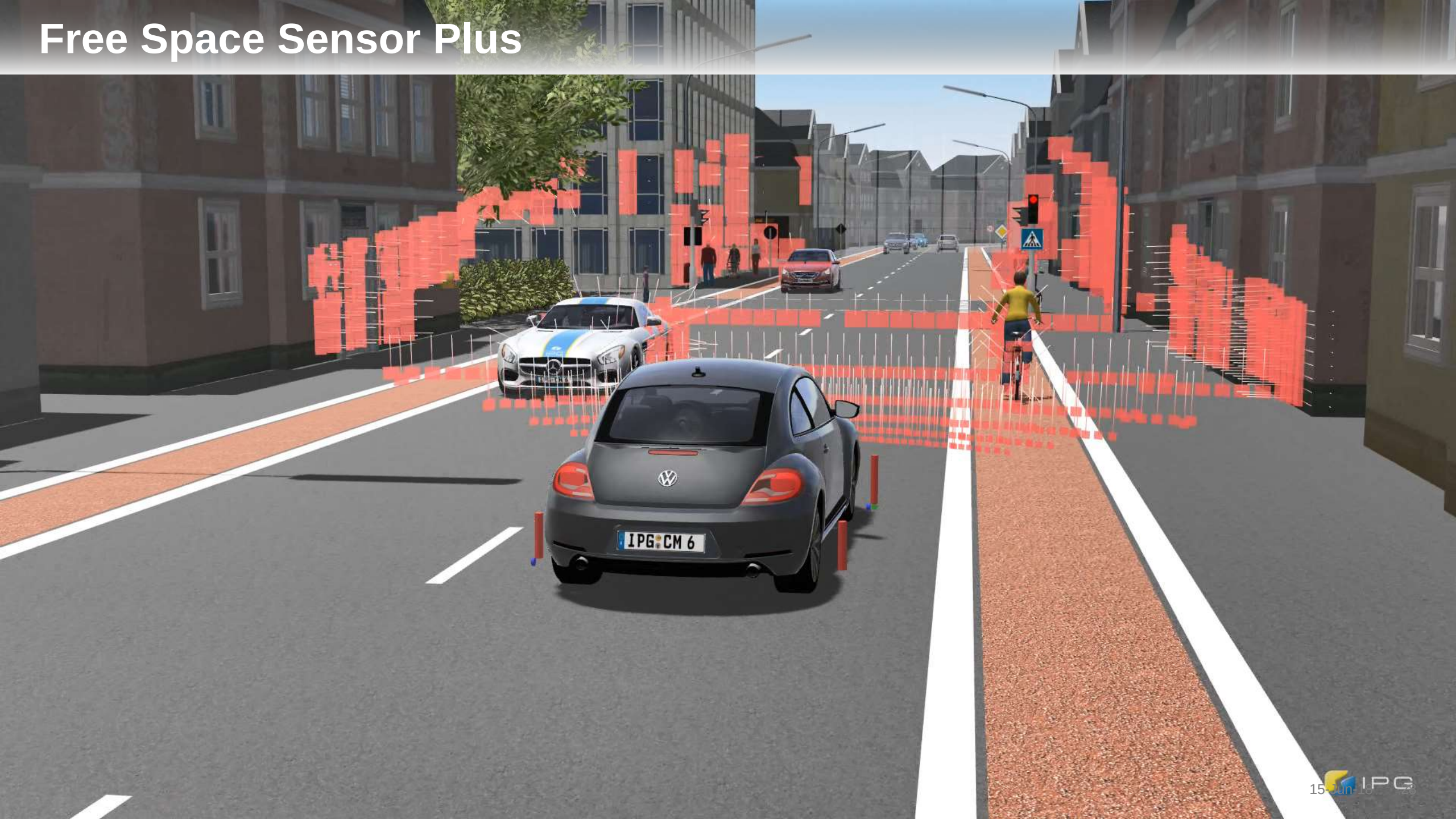
# Object and Line Sensor




## Highlights

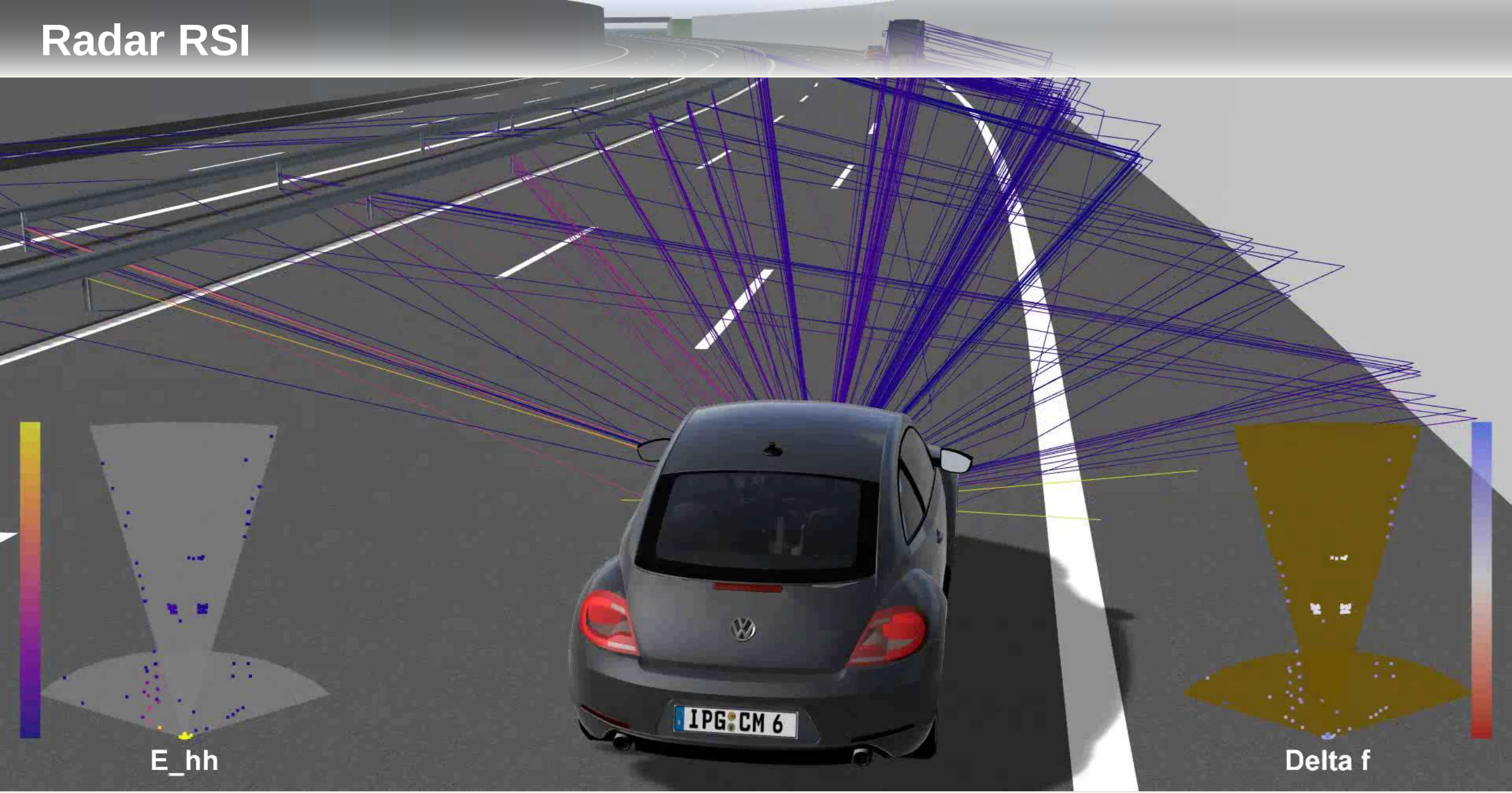
- Object sensor detects and tracks surrounding traffic
  - Object list
  - Relevant target
- Line sensor generates object list of lane boundaries
  - Road markings
  - Traffic barriers
- Application areas
  - ACC, LDW, LKA, …

# Free Space Sensor Plus

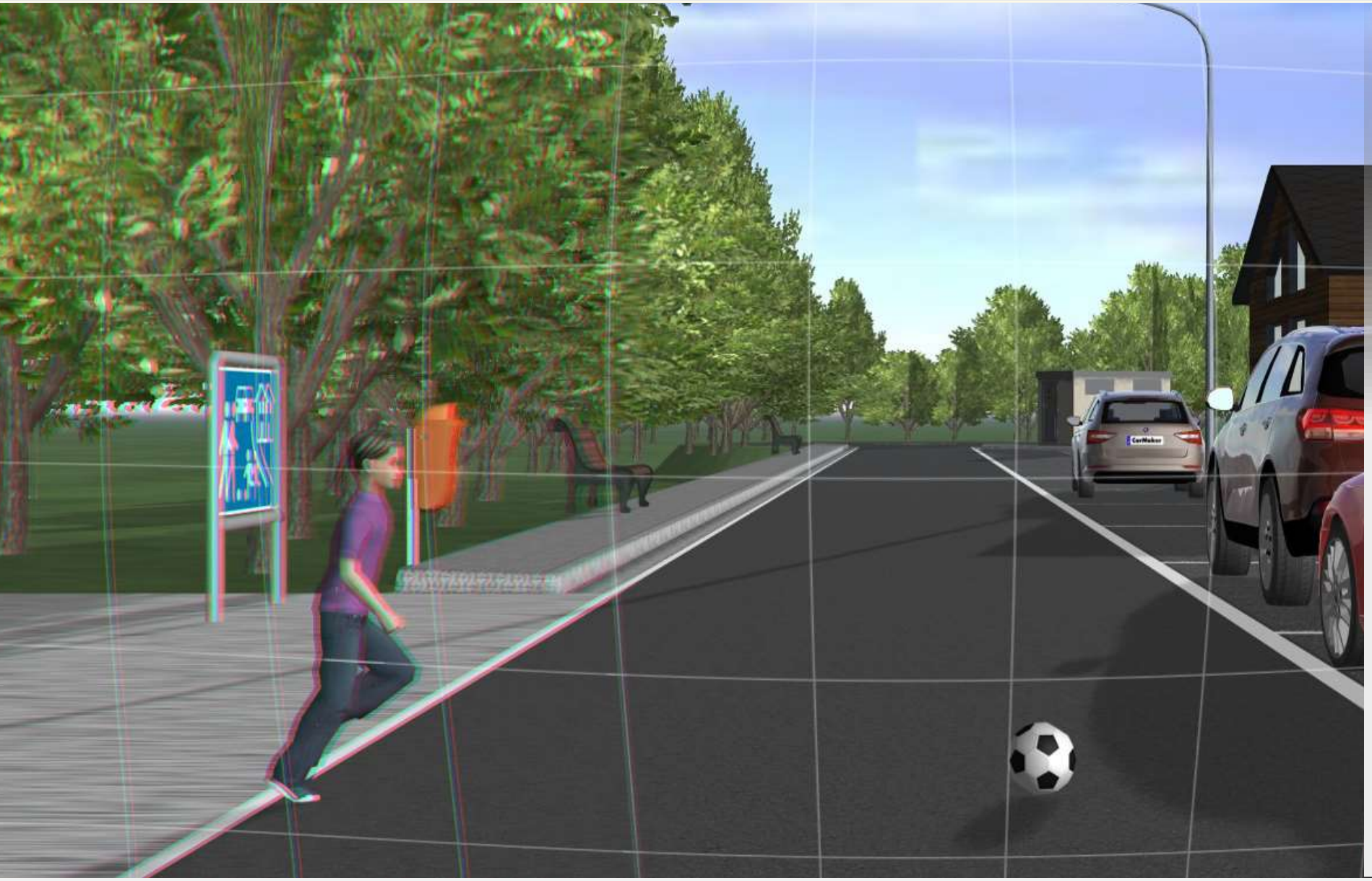


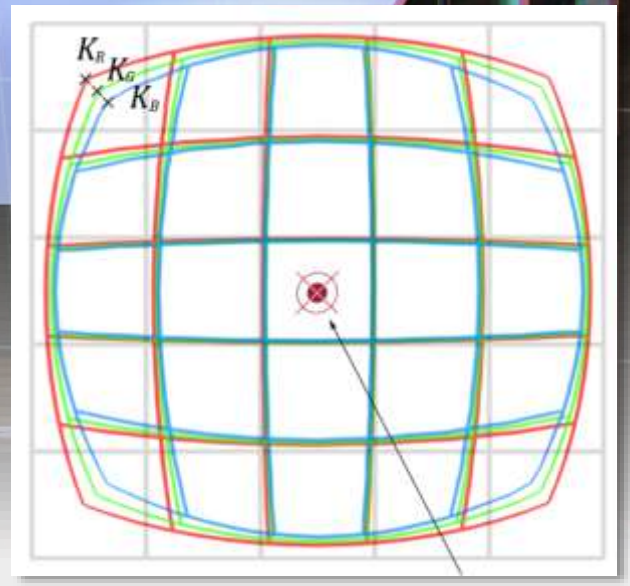
# Radar HiFi Sesnor

# Radar RSI



# Camera RSI – Physical Camera Model






## Lens model

- User-definable distortion grid
- Parameterizable chromatic aberrations

# CarMaker와 NVidia 하드웨어를 이용한 가상주행 시뮬레이션 기반 자율주행 차량의 AI 학습 및 평가 기술

# Main phases of AI

## Training vs. inferring

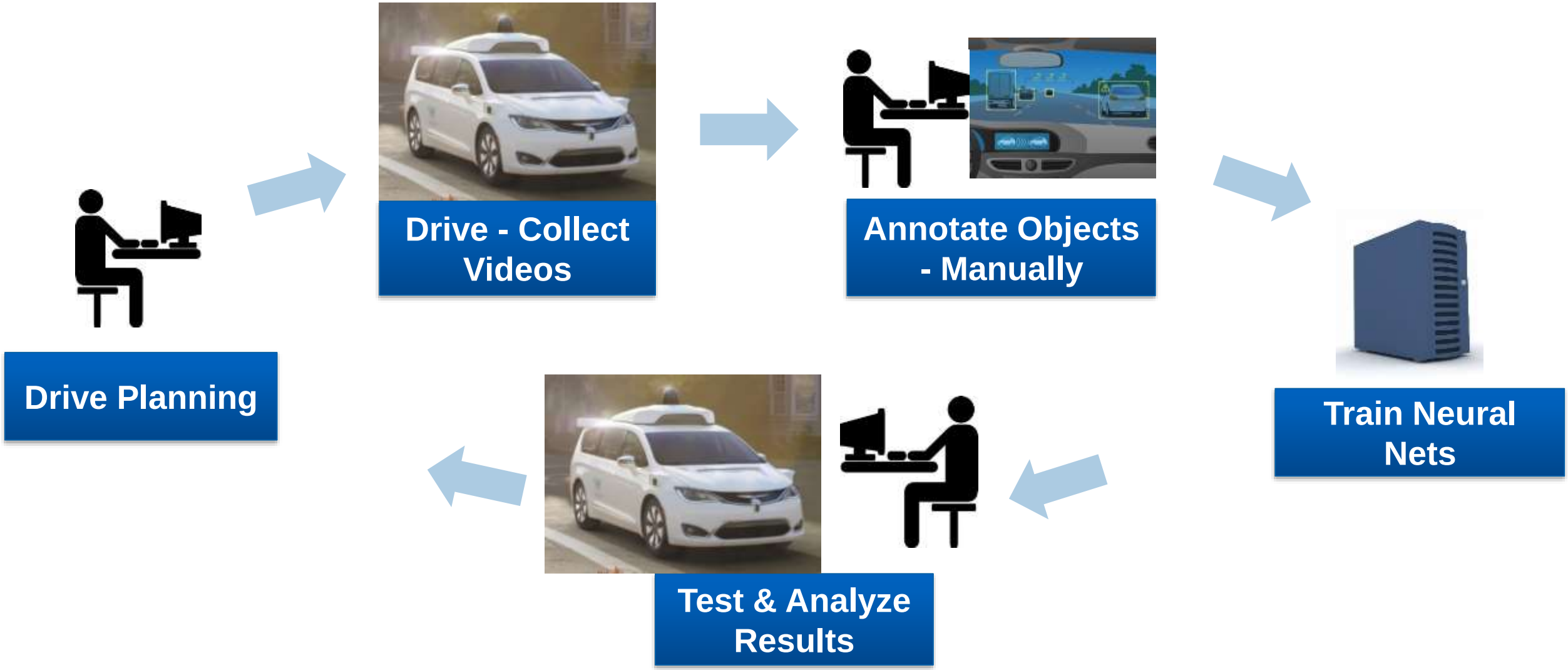
| | Training phase | Inference |
|---|---|---|
| **Task** | Train the net with training data to enable it to solve the respective problem | applying the capabilities of the net to new data |
| **Challenge** | Having enough training data with high quality | Cover the whole test space with the test scenarios to make sure the net works in all situations correctly |

**Two phases of artificial intelligence with different challenges**

**Different solutions neccessary**

# Training Neural Nets with Video Objects from a Real Environment

## Current Approach



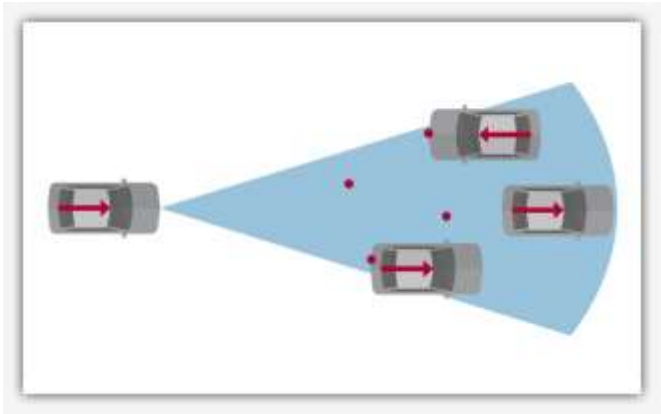
# Problems with the Current Training Approach

- Recording real-driving data is expensive and time consuming
- Labeling of recorded data is expensive and time consuming
- Real-word tests are expensive and safety critical

# Training capabilities of CarMaker

## Generation of sythetic training data

- **CarMaker can deliver training data for AI algorithms**
- **This synthetic data can be labeled automatically**
  - results in a reduction of real world training data, which has to be labelled manually
  - Customer saves manpower, time and costs for real test drives and manually labelling of data

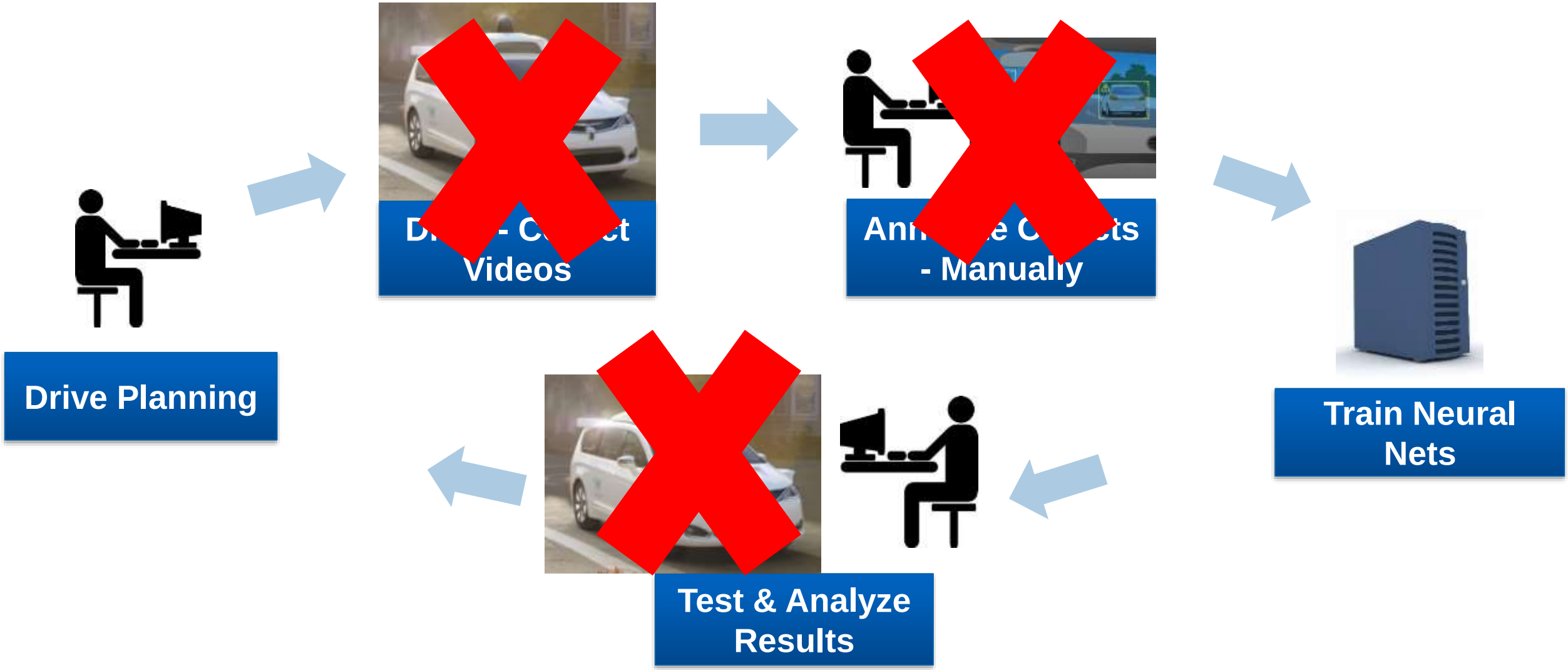


Object lists
For decision making or path planning,

Images with meta data
For image processing like object detection

# Training Neural Nets with Video Objects from a Real Environment

## Current Approach



# Training Neural Nets with Video Objects from a Virtual Environment

## Using the simulation tool CarMaker

Virtual Driving

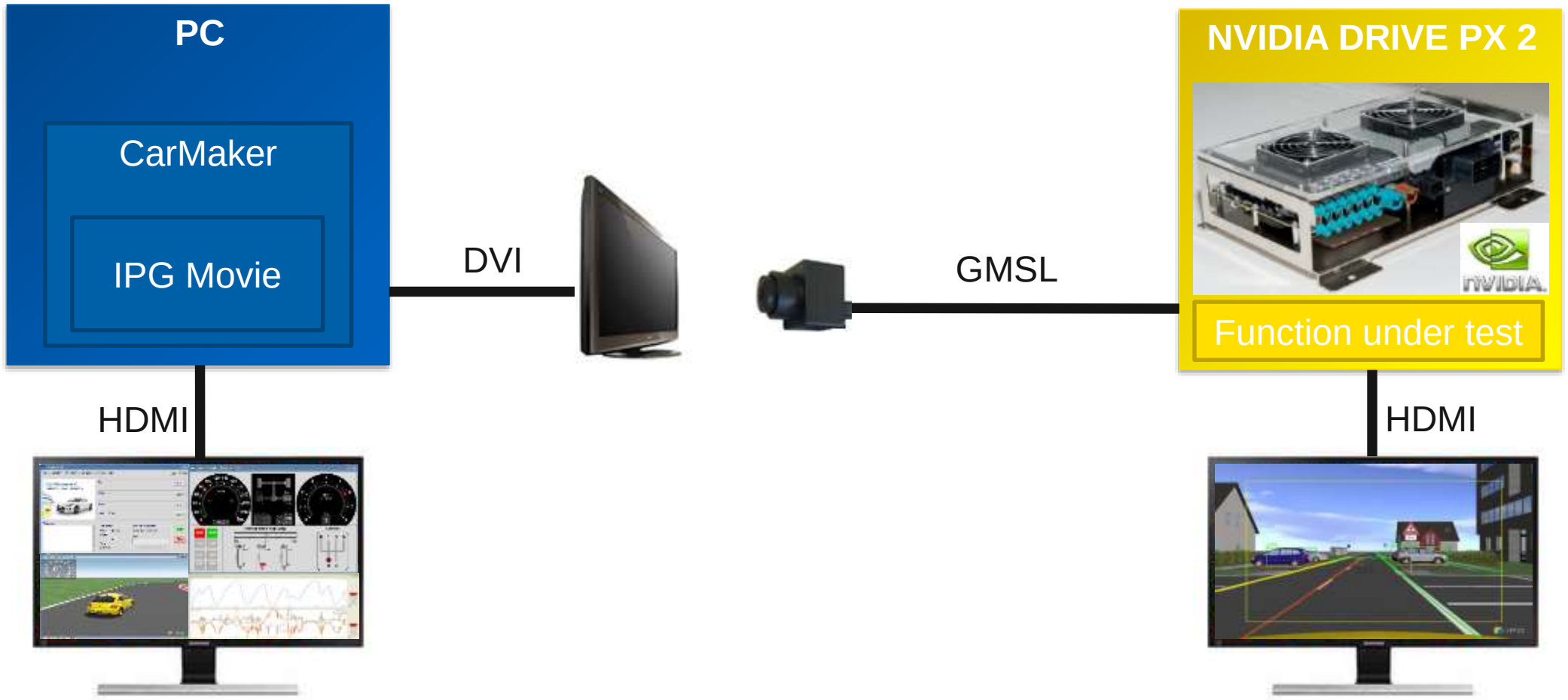
Annotate Objects - Automated

Train Neural Nets

Drive Planning in Sim Tool

Test & Analyze Results

# Example Use Case: Test of video perception algorithm



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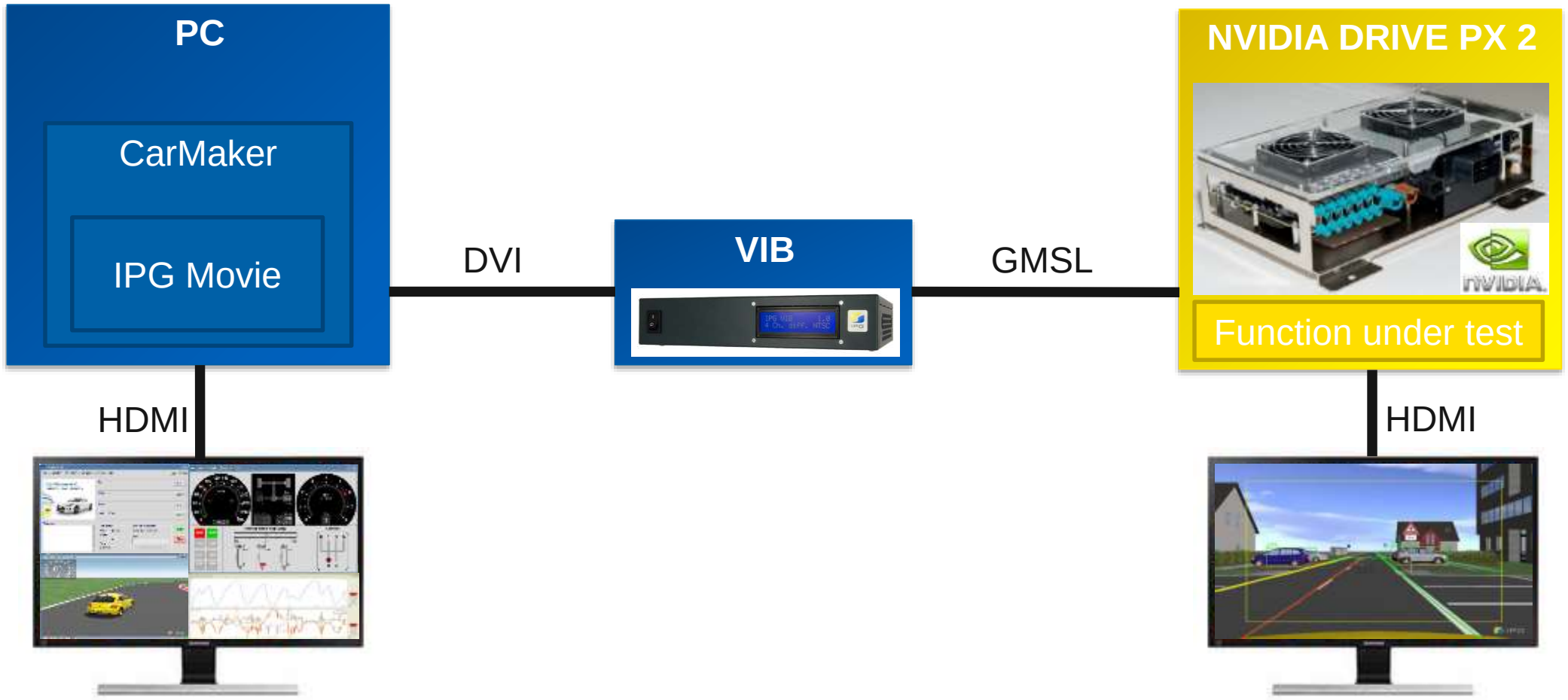
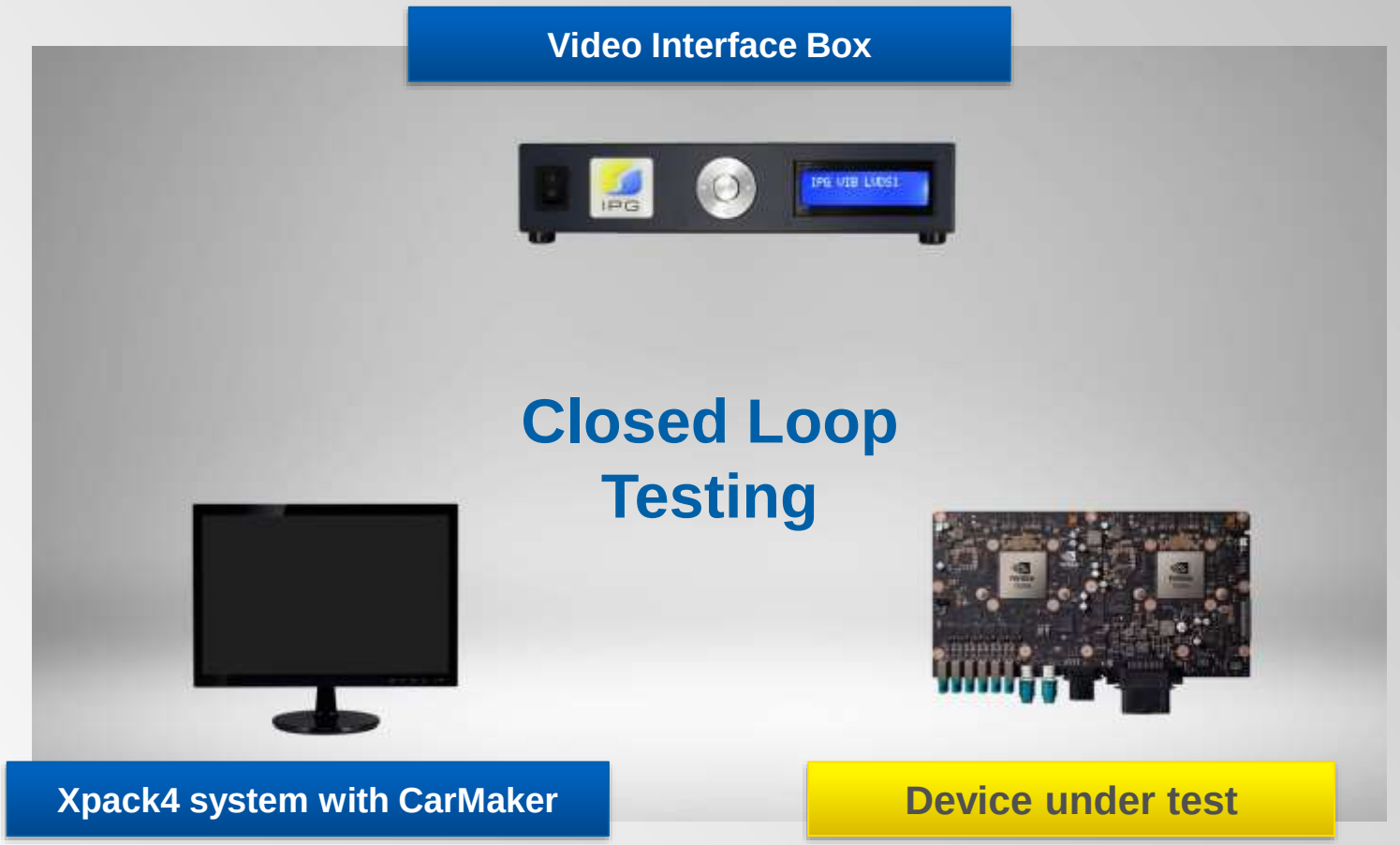
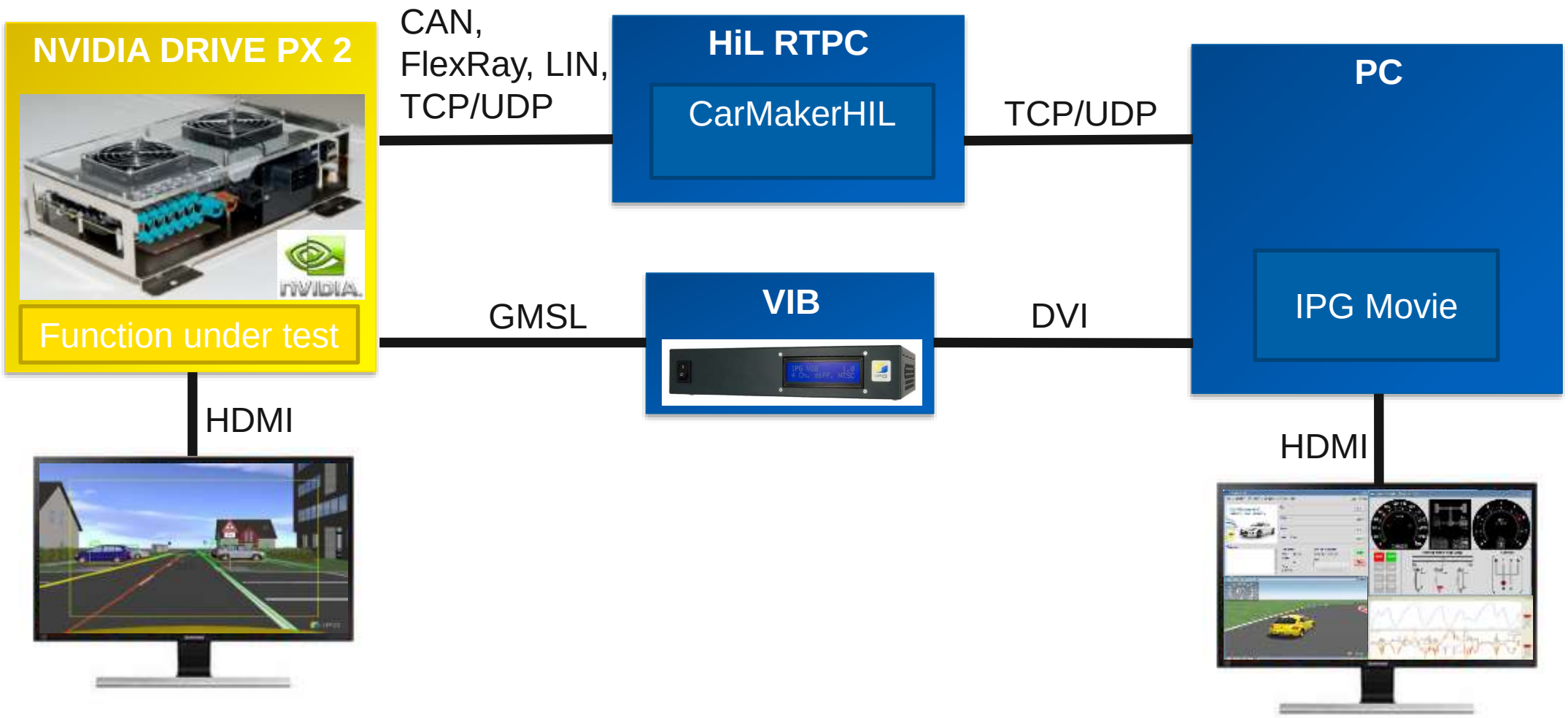


# Video Interface Box

1. Sending the virtual scenario
2. Sending the data to device under test
3. Sending back information to CarMaker
4. System reaction in CarMaker



# Test of AD-Function Based on Camera and Radar Sensor



# 자율주행 시스템 테스트 HIL Demo

Device under Test

Restbus simulation / Radar data

NVIDIA Drive PX2

GMSL

Video Interface Box

HDMI

HIL TEST SYSTEM


CarMaker

Xpack4 **RT-PC**

# 자율주행 시스템 테스트 HIL Demo

Device under Test

**Restbus simulation / Radar data**

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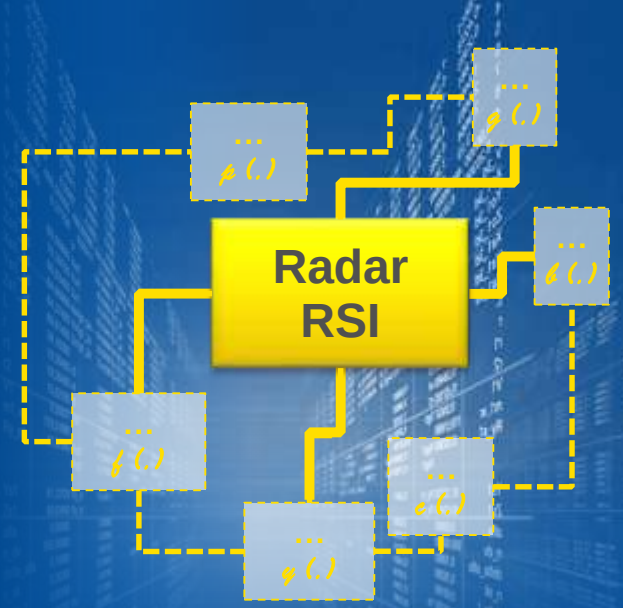



**CarMaker**

Xpack4 **RT-PC**

# Automated Driving at Volvo

## Using deep neural networks

- Steering algorithm based on deep neural network
- Trained by 1.4 million pictures and relating steering wheel angle collected in real-world driving

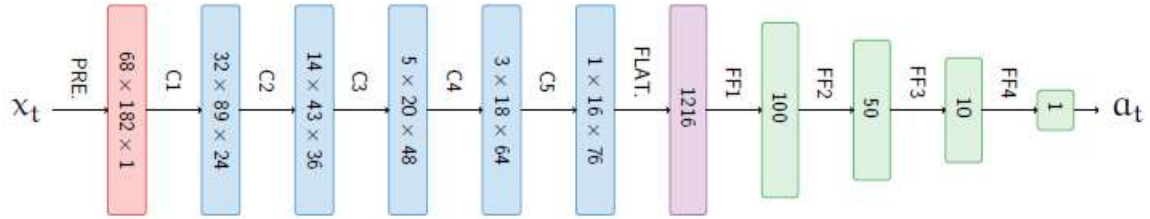
- Integration in CarMaker with video feed from Camera RSI and Video Data Stream

CHALMERS

VOLVO

ZENUITY

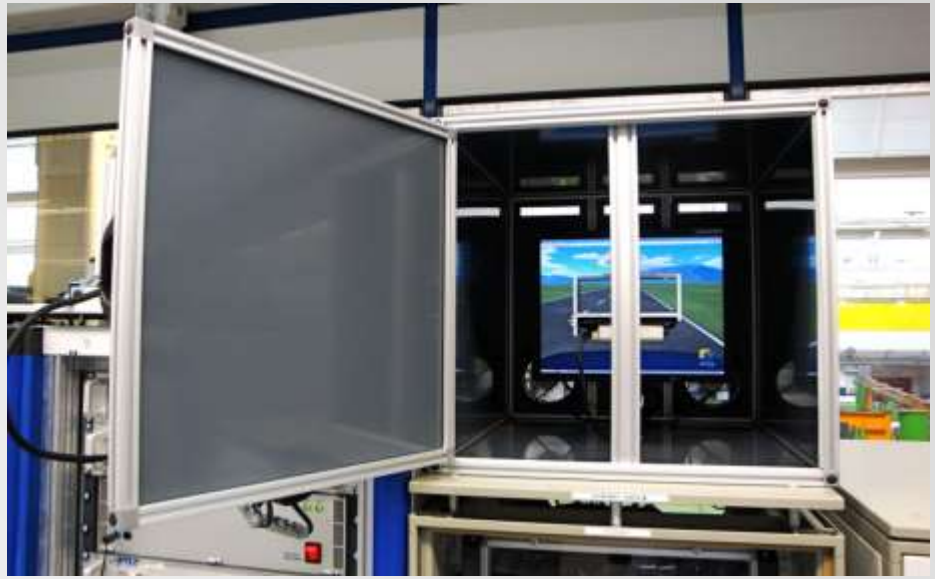
SOP
VIL
MIL
HIL
SIL




# CarMaker Test Systems @ Volkswagen

## Lane Keeping Assist HIL for VW “Lane Assist”

**Camera captures virtual scene on monitor (as sensor input)**



# Why CarMaker for training and testing of AI based functions?

- Easy generation of training data (scenario setup)
- Conversion of recorded scenarios into virtual testdata
- Less expensive and quicker than real world data recording
- Automatic labeling
- Re-use of testcases for training and testing
- Less expensive and quicker than real word testing
- Easy integration of real ECUs

**SOLUTIONS FOR VIRTUAL TEST DRIVING**

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