



# IPG在智能驾驶仿真领域的解决方案

# Continuous Development , Continuous Testing

持续研发，持续测试



**MIL / SIL**  
模型在环、软件在环

**Virtual ECU**  
虚拟控制器

**HIL**  
硬件在环

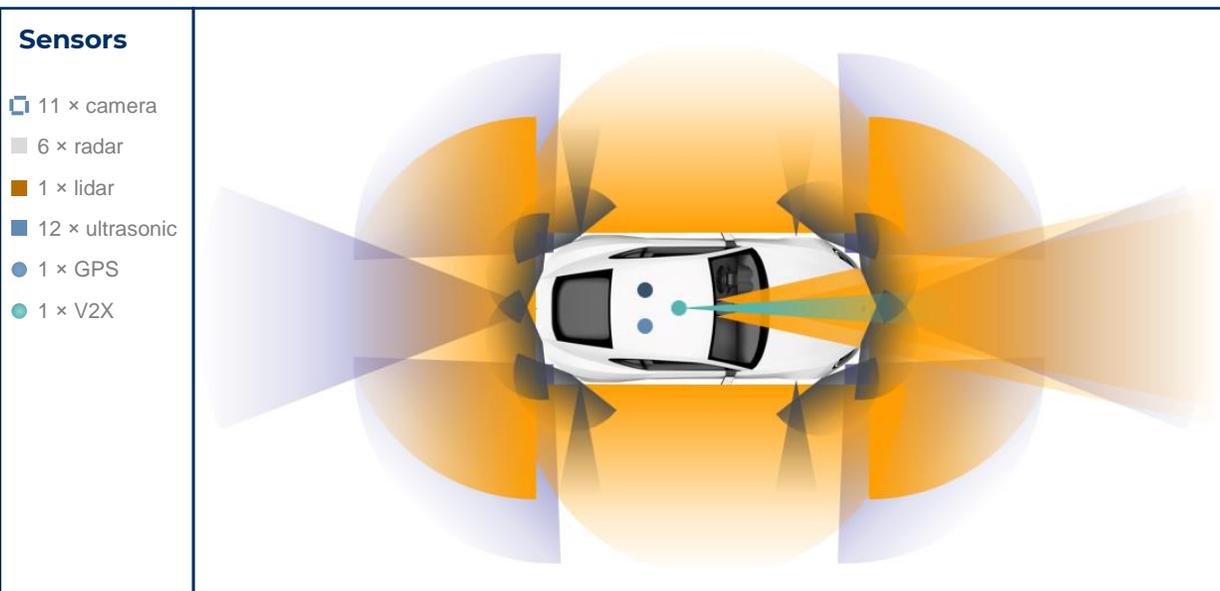
**VIL**  
车辆在环

# Challenges faced by ADAS testing

## 智能驾驶测试面临的挑战

### Automated Driving (SAE Level 3+)

- Scene coverage and corner cases  
场景覆盖度和corner cases
- very high system complexity (i.e. 30+ sensors) | 系统复杂 (多传感器)
- Realtime and computational load  
实时性和计算负载



- How to perform scenario-based testing ? -> Scene Coverage  
如何进行基于场景的测试? -> 场景覆盖度
- How to ensure simulation accuracy? -> Especially for Vehicle & Sensor model  
如何保证仿真精度? -> 尤其是车辆 & 传感器建模
- How to build AV HIL Test bench? -> Realtime and communications  
如何搭建高阶智驾HIL测试台架? -> 实时性和通信

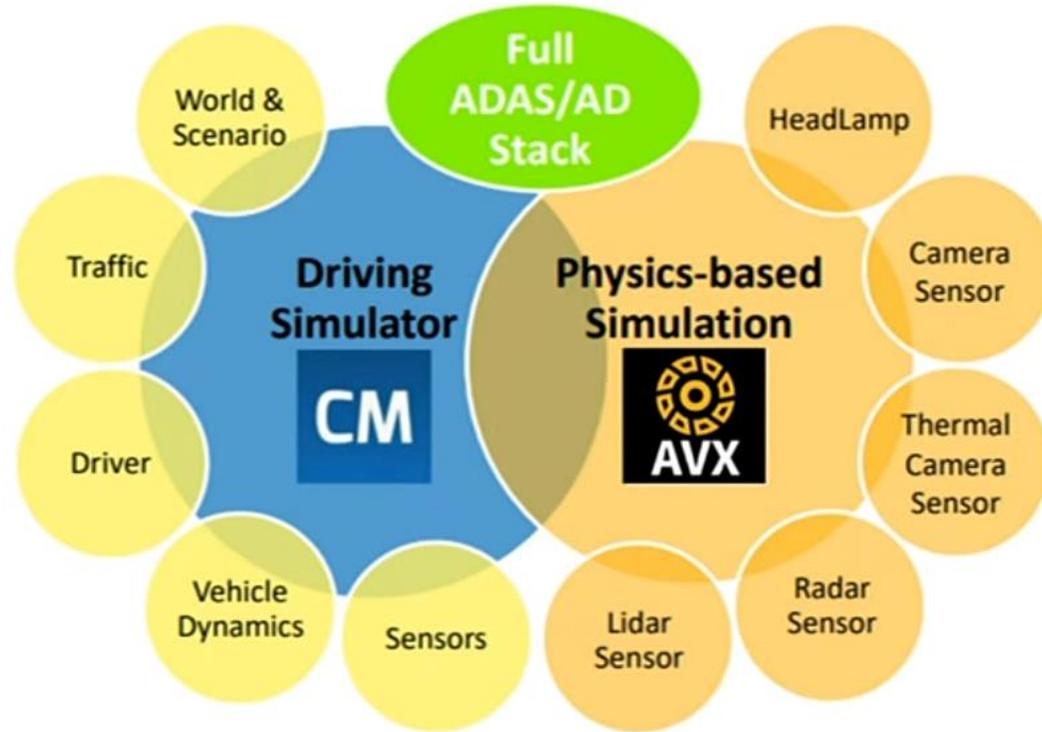


## Collaboration between Ansys and IPG Automotive



IPG Automotive is market leader in simulation solutions consisting of software as well as hardware components for virtual vehicle development.

IPG Automotive是虚拟车辆开发领域中软硬件一体化仿真解决方案的市场领导者



Ansys is market leader in engineering simulation of physical phenomena.

Ansys 是工程物理级仿真领域的市场领导者。

**IPG and ANSYS have started a partnership in August 2021.**

IPG和ANSYS早在2021年8月开始合作

**IPG and Ansys have developed an interface between Carmaker and AVXcelerate, respectively .**

IPG和Ansys开发了CarMaker & AVXcelerate联仿的接口

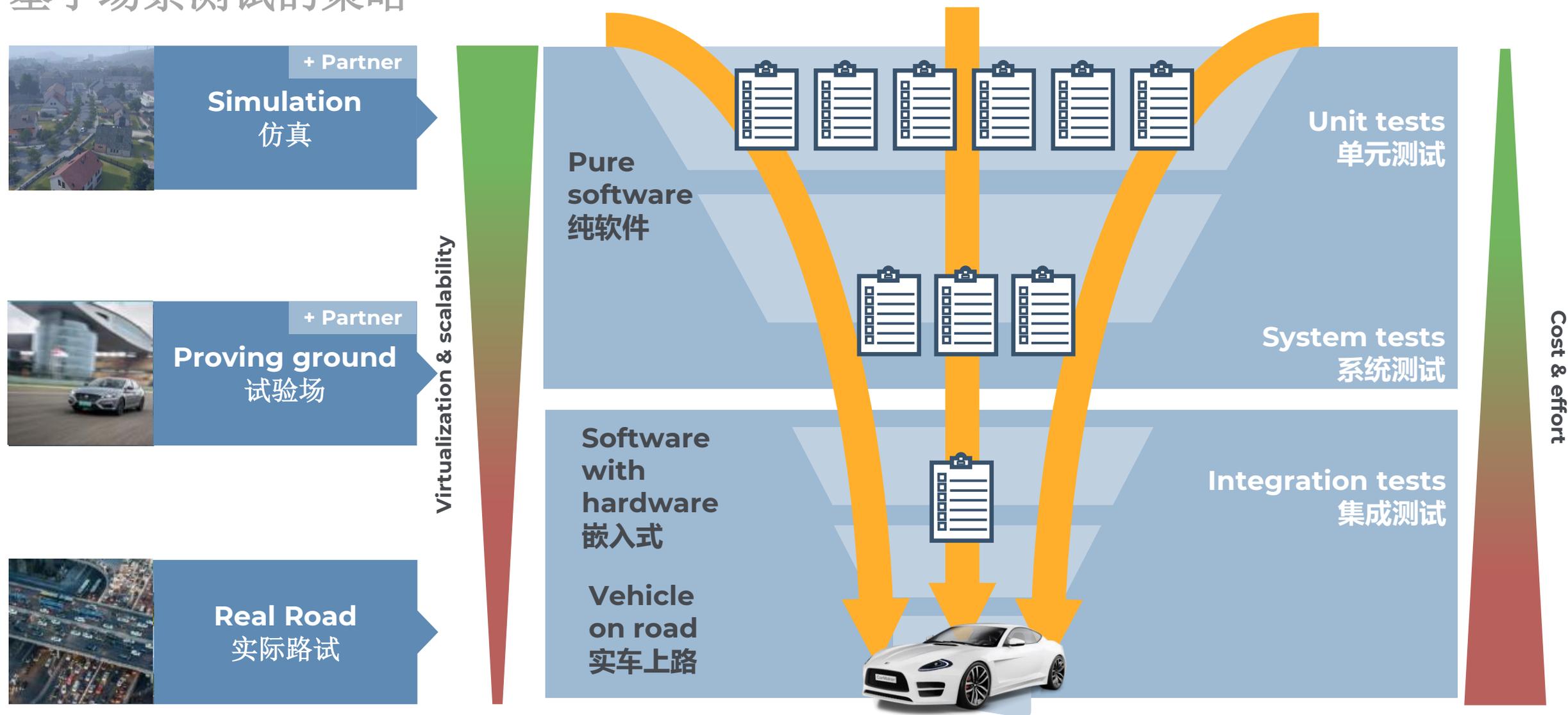


# MIL/SIL: Software Solution

## 软件方案

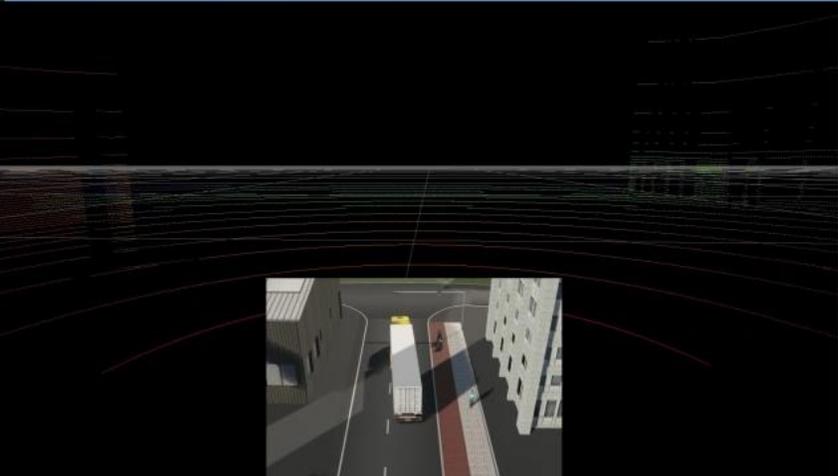
# Scenario-Based Testing Strategy

## 基于场景测试的策略





**Off-road**



**Transportation**

**Platooning**

**Trucks**

**Off-highway**

# Scenario-Based Testing Process

## 基于场景测试的过程

Standards & Laws | 标准法规:

- ISO/SAE、UN/ECE
- NCAP、i-VISTA
- PEGASUS

OEM & Tier1:

- Safe oriented | 安全
- Function Req | 功能需求

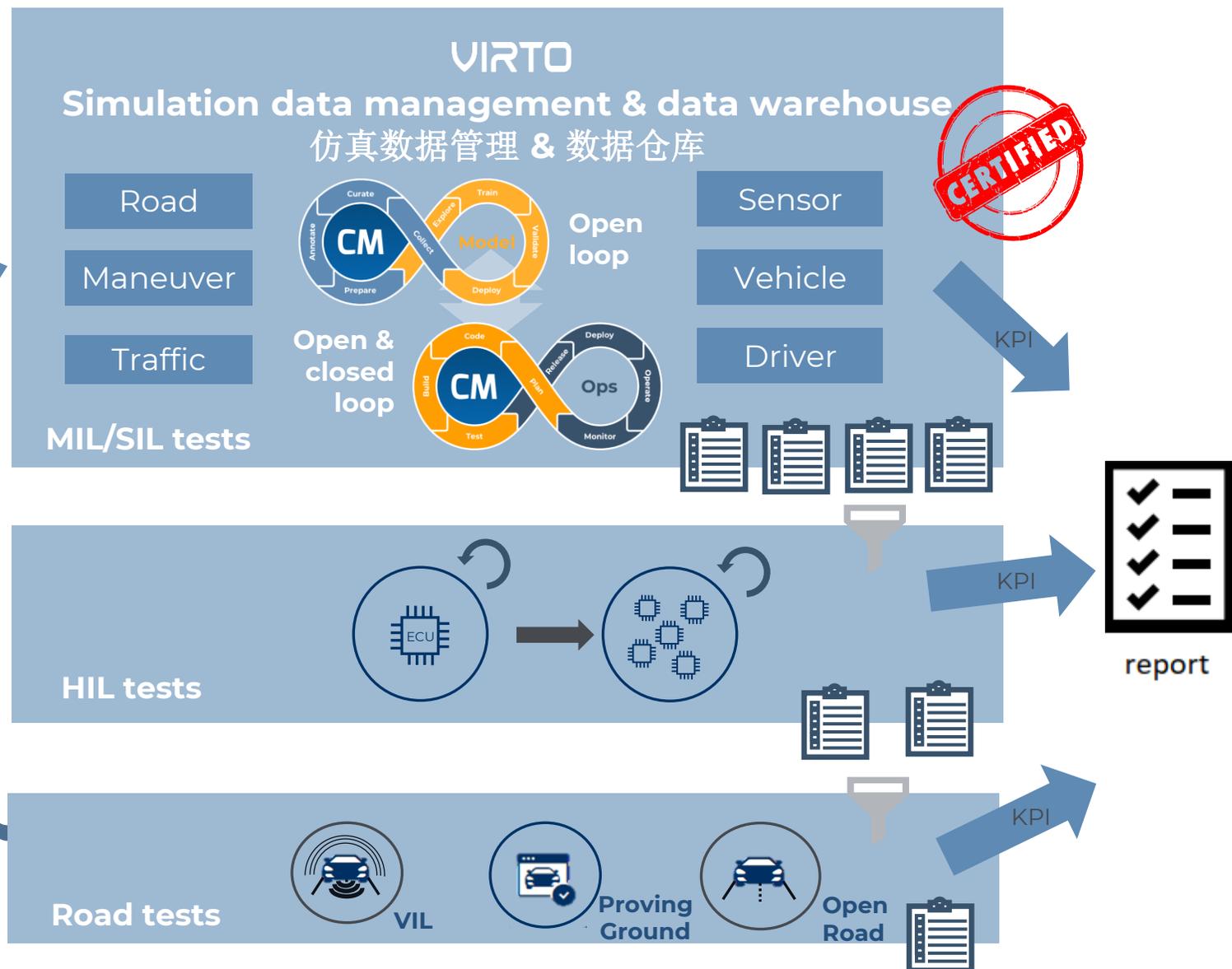
Real Road | 实际道路

- Record data | 实采数据
- Accident data | 事故数据

Mis. | 其他:

- Custom scene | 自定义场景
- Simulation tool | 工具本身

Synthetic Data



# Generating Scenarios

## 创建场景



### Random scenarios | 随机场景

- Road API
- Swarm traffic | 随机智能交通
- Key-/NamedValues (via CarMaker Python API)
- Movie NX Python API



### Scenario variations | 场景泛化

- Scenario Editor | 场景编辑器
- Key-/NamedValues (via CarMaker Python API)
- **Movie NX Python API**

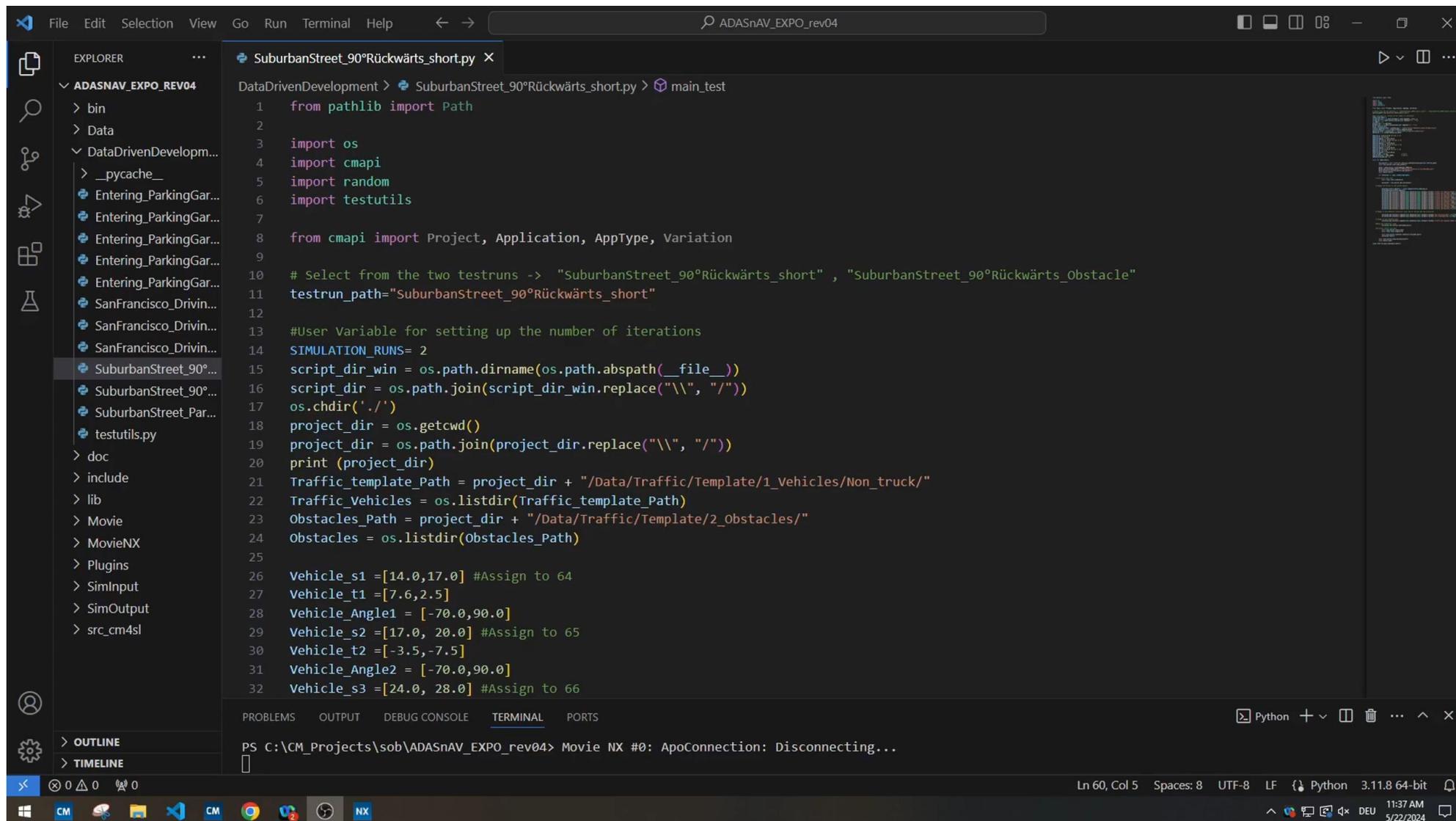


### Edge cases | 极限工况

- HD Scenarios & partners | 高质量场景（合作伙伴）
- Scenario Editor
- Custom asset import | 自定义元素导入

# Demo: Variation of Parking HD Scenarios

演示：泊车高清场景的泛化



The image shows a Python IDE window with a file explorer on the left and a code editor in the center. The file explorer shows a project structure for 'ADASNAV\_EXPO\_REV04'. The code editor displays a Python script named 'SuburbanStreet\_90°Rückwärts\_short.py'. The script includes imports for Path, os, cmapi, random, and testutils. It defines a testrun path and sets up simulation parameters like 'SIMULATION\_RUNS', script directory, and project directory. It also lists traffic templates and obstacles, and defines vehicle parameters for three vehicles (s1, t1, s2, t2, s3).

```
1 from pathlib import Path
2
3 import os
4 import cmapi
5 import random
6 import testutils
7
8 from cmapi import Project, Application, AppType, Variation
9
10 # Select from the two testruns -> "SuburbanStreet_90°Rückwärts_short", "SuburbanStreet_90°Rückwärts_Obstacle"
11 testrun_path="SuburbanStreet_90°Rückwärts_short"
12
13 #User Variable for setting up the number of iterations
14 SIMULATION_RUNS= 2
15 script_dir_win = os.path.dirname(os.path.abspath(__file__))
16 script_dir = os.path.join(script_dir_win.replace("\\", "/"))
17 os.chdir('.')
18 project_dir = os.getcwd()
19 project_dir = os.path.join(project_dir.replace("\\", "/"))
20 print (project_dir)
21 Traffic_template_Path = project_dir + "/Data/Traffic/Template/1_Vehicles/Non_truck/"
22 Traffic_Vehicles = os.listdir(Traffic_template_Path)
23 Obstacles_Path = project_dir + "/Data/Traffic/Template/2_Obstacles/"
24 Obstacles = os.listdir(Obstacles_Path)
25
26 Vehicle_s1 =[14.0,17.0] #Assign to 64
27 Vehicle_t1 =[7.6,2.5]
28 Vehicle_Angle1 = [-70.0,90.0]
29 Vehicle_s2 =[17.0, 20.0] #Assign to 65
30 Vehicle_t2 =[-3.5,-7.5]
31 Vehicle_Angle2 = [-70.0,90.0]
32 Vehicle_s3 =[24.0, 28.0] #Assign to 66
```

The terminal at the bottom shows the command prompt: 'PS C:\CM\_Projects\sob\ADASNAV\_EXPO\_rev04> Movie NX #0: ApoConnection: Disconnecting...'

# Vehicle Models: Open integration platform

## 车辆模型:开放的集成平台

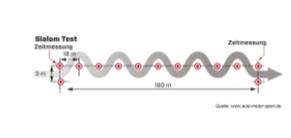
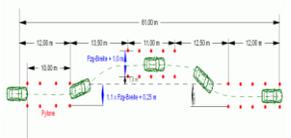


# Vehicle Dynamics Attribute Evaluation

## 车辆动力学属性评估

Typical driving maneuvers 典型驾驶工况

Open Loop  
Closed Loop

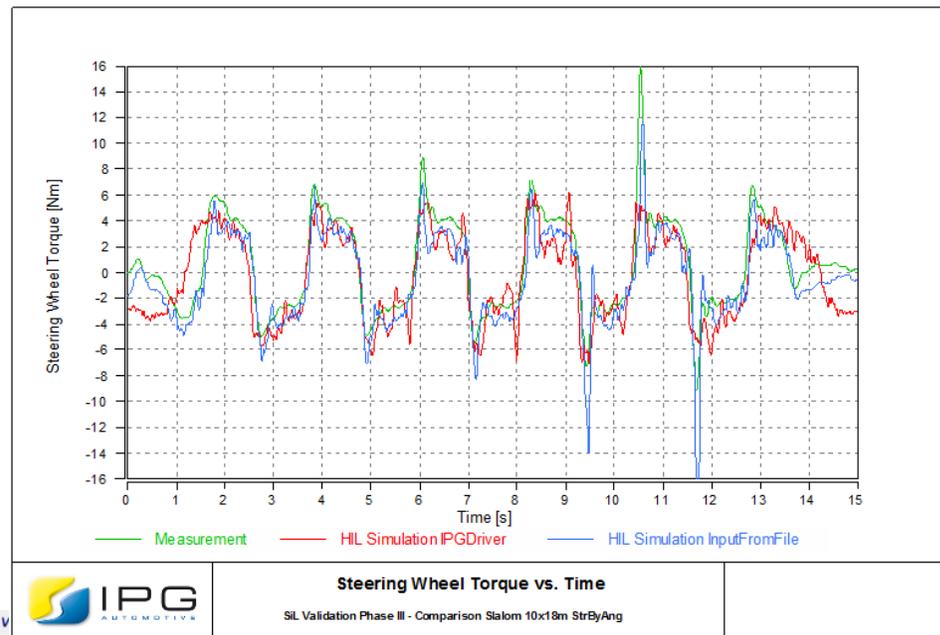
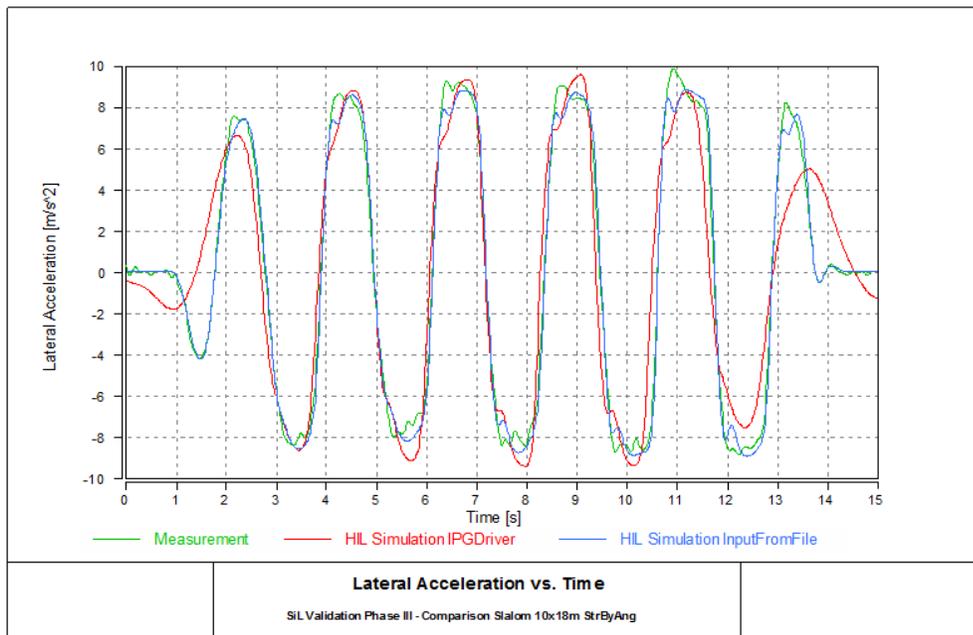
Driving Maneuver	Evaluation	Open Loop	Closed Loop	Picture
Handling Course	Evaluation of the driving behavior in extreme cornering situations		X	
Slalom 10x18m 10x36m	Evaluation of the driving behavior in very fast course directions.		X	
Single Lane Change	Simulation of a evasive maneuver at the high way		X	
Double Lane Change 1 (FAST)	Simulation of a fast evasive maneuver with return to the lane (~120km/h; ISO 3888-1 Lane Change)		X	
Double Lane Change 2 (SLOW)	Simulation of a intensive evasive (obstacle avoidance) maneuver with return to the lane (~70km/h; ISO-3888-2 [VDA] Lane Change or „Elk Test“)		X	



# Vehicle model accuracy verification

## 车辆模型精度验证

Sample function and test: Catch-up during virtual vehicle test → slalom



slalom测试结果验证

Steering Column	Intermediate Shaft	Torsion Bar	Steering Rack	Misc.
Inertia of upper column [kgm <sup>2</sup> ]		0.026		
Inertia of lower column [kgm <sup>2</sup> ]		0.001		
Stiffness [Nm/rad]		12.0		
Friction torque gradient [Nm/rad]		7000.0		
Friction torque min/max [Nm]		-0.2 / 0.2		
Damping coefficient [Ns/rad]		0.06		
Damping torque min/max [Nm]		0.1		

Friction torque max = 0.2 Nm  
Friction torque min = -0.2 Nm

General Power Assistance Options  
Power Assistance:  EPS to Rack  
Assistance torque at  Column  Pinion

Electrical Power Steering  
Motor torque constant [Nm/A] 0.3  
Ratio electrical motor to tie rod [-] 2.5  
Ratio recirculating ball system [m/rad] 0.0016

Velocity [km/h]	Torque [Nm]	Current [A]
0.0	-4.3	30.00
0.0	-4.2	20.00
0.0	-4.1	15.10
0.0	-3.9	10.00
0.0	-3.5	5.10

Amplification [-] 1.0

# Sensor Models – Purpose-driven Fidelity

## 传感器模型 – 基于目的驱动的保真度



	<b>Ideal</b> 理想	<b>HiFi</b> 目标列表	<b>RSI</b> 原始信号
<b>Use cases</b> 案例	<ul style="list-style-type: none"><li>Basic function test   基础功能测试</li><li>Reference sensor   参考传感器</li></ul>	<ul style="list-style-type: none"><li>Function test   功能测试</li><li>Fail-safe test   失效测试</li></ul>	<ul style="list-style-type: none"><li>Perception algorithm development   感知算法开发</li><li>Signal chain test   信号链路测试</li></ul>
<b>Features</b> 功能	<ul style="list-style-type: none"><li>Output: object list   输出: 目标</li><li>Ground truth information   真值</li><li>Easy to parameterize   易配参</li></ul>	<ul style="list-style-type: none"><li>Output: object list   输出: 目标</li><li>Technology-specific errors   特定技术问题</li><li>Physical phenomena   物理级现象</li><li>Post processing / target selection included   后处理 / 包括目标选择</li></ul>	<ul style="list-style-type: none"><li>Output: raw signal   输出: 原始信号</li><li>Technology-specific errors   特定技术问题</li><li>Detailed physical effects   详细的物理效应</li><li>Validated   验证</li></ul>

# How to Generate Synthetic Data with CarMaker

## 如何利用CarMaker生成合成数据



Rich environments & scenarios

丰富的环境和场景



Realistic sensor data

逼真的传感器数据



Configurable annotations

可配置的标注信息

**Dataset generator** 数据集生成器



**Data storage**

数据存储

# Synthetic Data for Corner Cases

合成数据下的Corner Cases

Joint solution  
with ANSYS

# AVXcelerate & CarMaker

## Active Headlamp

主动大灯

# Active Headlamp Virtual Validation

## 主动大灯虚拟验证

### 工程目标

在复杂的物理环境下，例如夜间弯路上高速行驶的车辆，对主动前照灯验证非常重要。

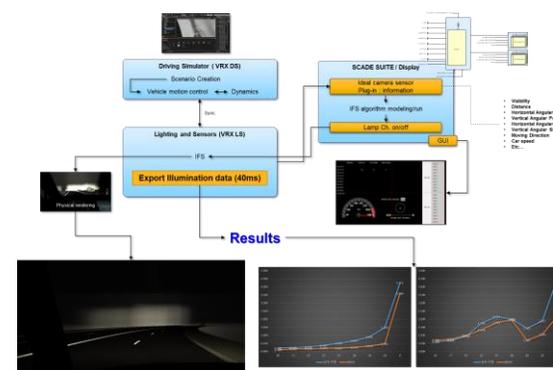
- 零风险，确保周围车辆安全，需设计无眩光远光灯。
- 根据周围环境，针对特定区域调暗前照灯。
- 设计像素级数字远光灯控制。

### 解决方案

- 算法设计：轻松创建主动前照灯算法。(SCADE)
- 前照灯模拟：轻松设置前照灯光学特性。(AVxcelerate Lighting and Sensors)
- 创建测试场景：轻松创建测试场景。

### 益处

- 虚拟验证前照灯性能，支持在设计各阶段的改进。
- 优化前方道路的可视性。
- 避免周围车辆的眩光和致盲，确保安全。



Simulation Architecture



Operational Scenario (Movie)

Preparing the CarMaker Co-Sim... Creating a CarMaker Co-Sim... Launching the CarMaker Co-Sim...

https://ansysproducthelpqa.win.ansys.com/account/secured/returnurl=/Views/Secured/corp/W332/en/Optis\_UG\_VRX/Optis/UG\_VRX/launching\_the\_carmaker\_co-simulation.html

ANSYS HOME API DOCS HELP VIDEOS CUSTOMER PORTAL ANSYS.COM SIGN OUT

AVxcelerate.2023.R2 | AVxcelerate.Lighting and Sensors User

Country\_LHT\_CM

Headlamps View Car Tools Record Environment Deploy

Current Car: Car #1

Lighting Systems: Volvo\_XC60\_2018\_Standalone

Light Functions: [Icons for Light Functions]

CarMaker Simulation Controls: [Play, Stop, Refresh, etc.]

3. To make the...  
 a. In the ma...  
 b. In Shared...  
 CarMaker...  
 c. In Shared...  
 4. In CarMaker,  
 In carMaker,  
 Simulation  
 Perf: [Dropdown]  
 Status: [Dropdown]  
 Time: 0  
 Distance: 0

Contents

Expand/Collapse

- Welcome!
- ANSYS AVxcelerate Lighting and Sensors Overview
- Project Management
  - Project Modes
  - Simulation Modes
  - Creating a Standalone Project
  - Opening a Project
  - Saving a Project
- Multi-User Simulation
- Execution Management
- Headlamps Management in Editor

CarMaker - Test: Country\_LHT\_AVxcelerate\_Headlamp - 'demo2' online

File Application Simulation Parameters Settings Help

IPG

Car: Volvo\_XC60\_2018\_blue\_ego\_car  
 AVxcelerate LS CoSimulation Library  
 Traffic EGO Car [Selected]

Trailer: - [Selected]

Tires: \_IRT\_235\_60R18-p2.50 ... \_IRT\_235\_60R18-p2.50 [Selected]  
 \_IRT\_235\_60R18-p2.50 ... \_IRT\_235\_60R18-p2.50

Load: 0 kg [Selected]

Maneuver: 0 3600 50

Simulation  
 Perf: realtime  
 Status: Idle  
 Time: 0.1  
 Distance: 1.55

Storage of Results  
 Mode: save all  
 Buffer: 33.6 MB, 659 s

Start Stop

Save Stop Abort

Demo\_Highend\_LB\_RH Lies

- Deploying a Project in an Immersive Environment - Deploying a Project consists in experiencing a simulation in an immersive environment.



# HIL&VIL: HIL Solution

## HIL方案

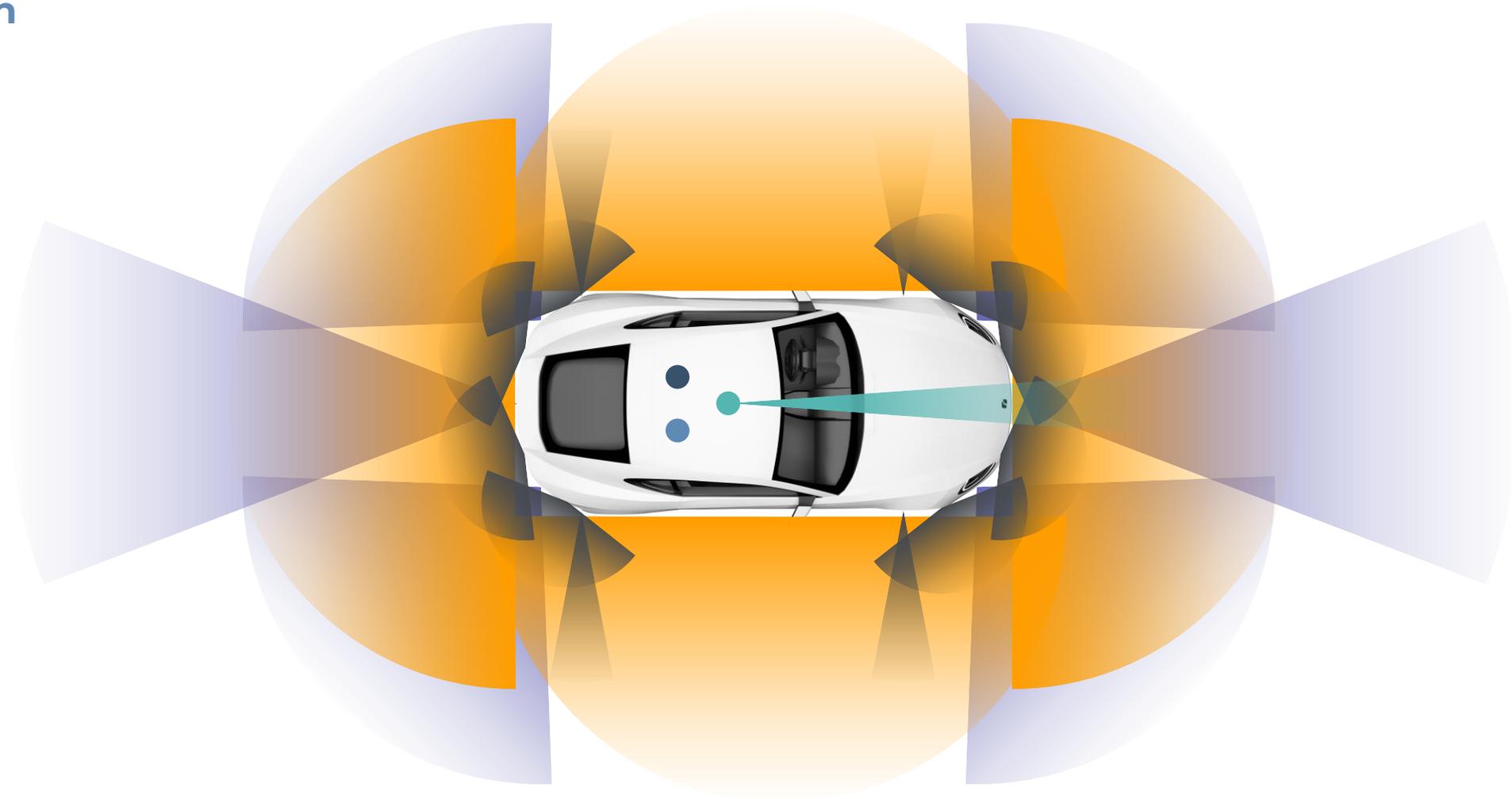
# High Level Autonomous Driving Sensor Configuration

## 高阶自动驾驶主流传感器配置

### Sensor Distribution

#### 传感器分布

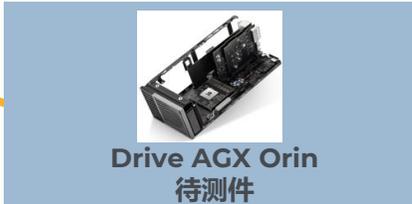
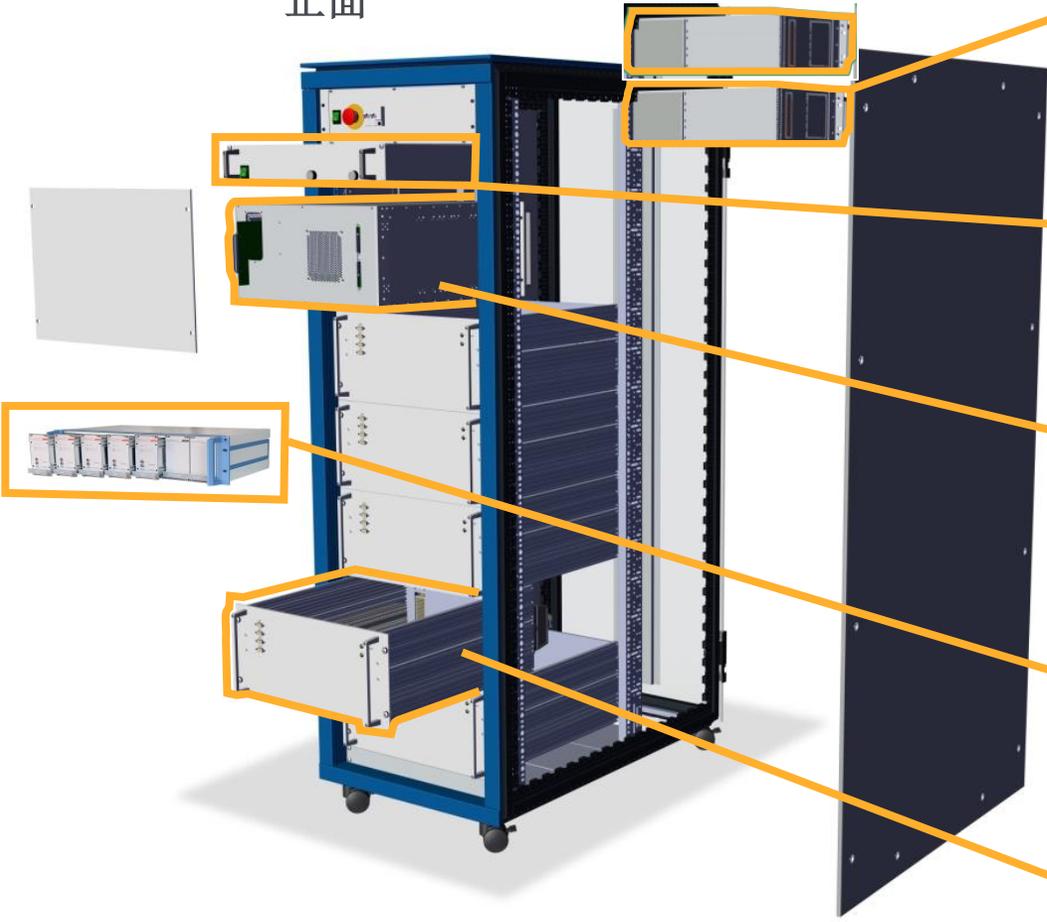
- 11 × camera
- 6 × radar
- 1 × lidar
- 12 × ultrasonic
- 1 × GPS
- 1 × V2X



# Hardware Platform

## HIL硬件平台

HIL Front  
正面

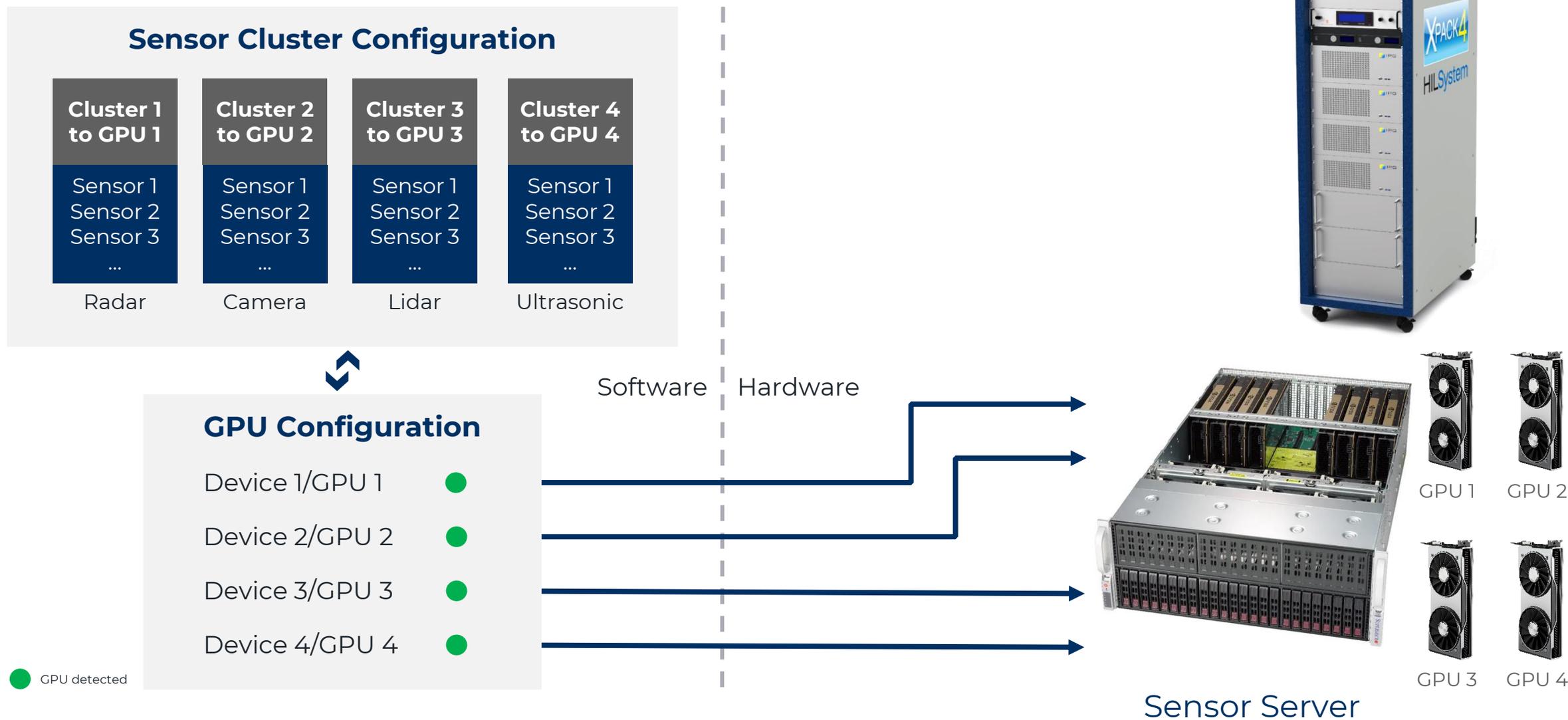


HIL Back  
背面



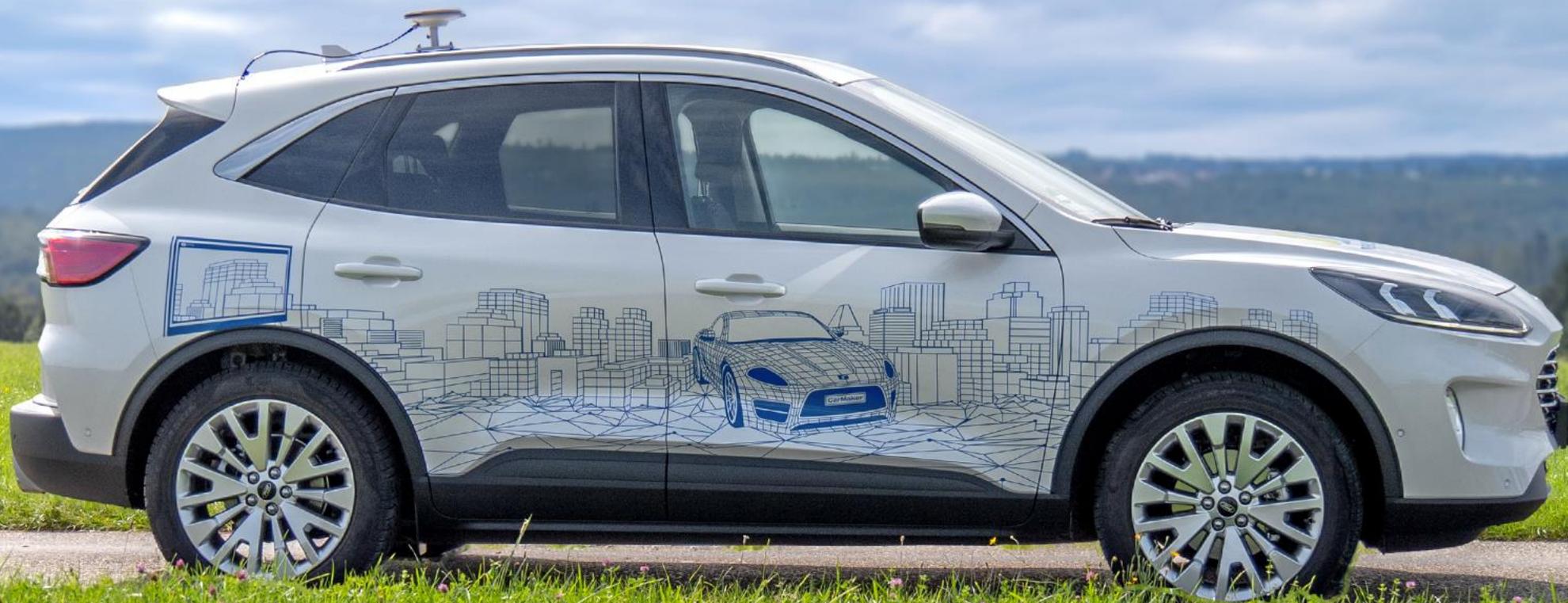
# GPU and Sensor Cluster Configuration

## GPU和传感器集群配置



# Outdoor Vehicle-in-the-Loop

## 室外车辆在环





 **IPG**  
AUTOMOTIVE  
VEHICLE-IN-THE-LOOP



Joint solution  
with ANSYS

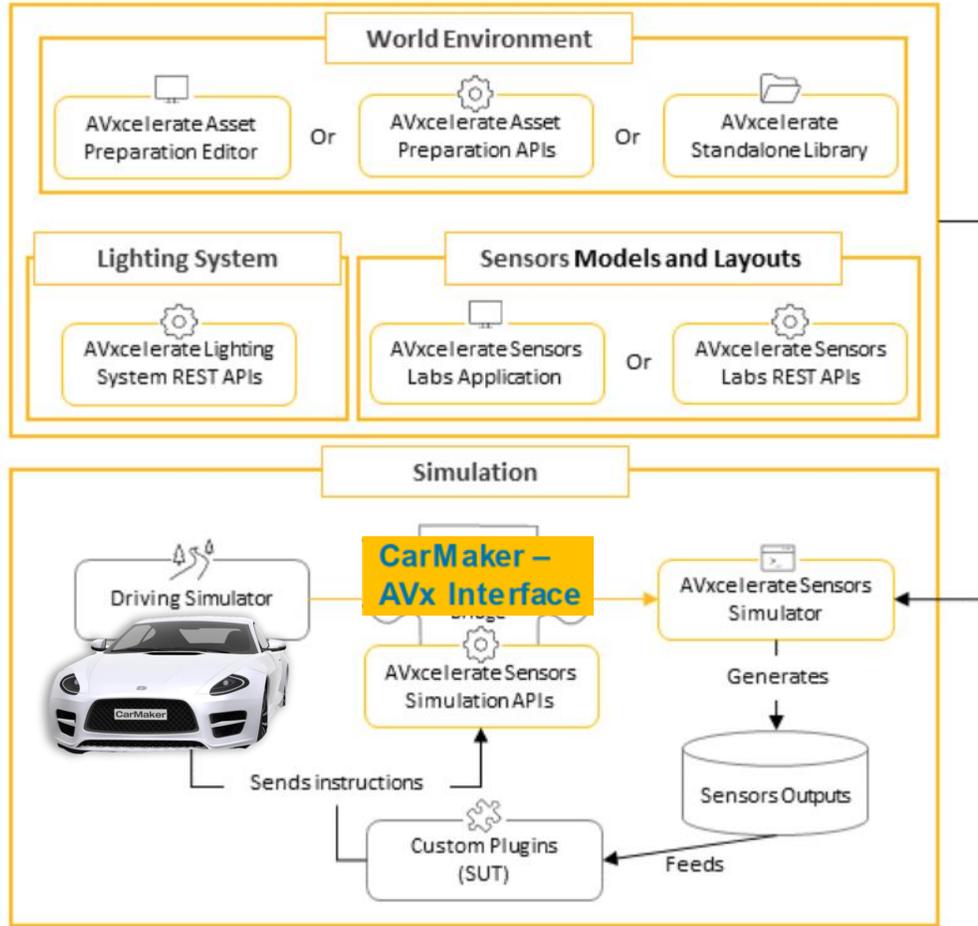
# AVxcelerate Sensor & CarMaker

## Camera Sensors

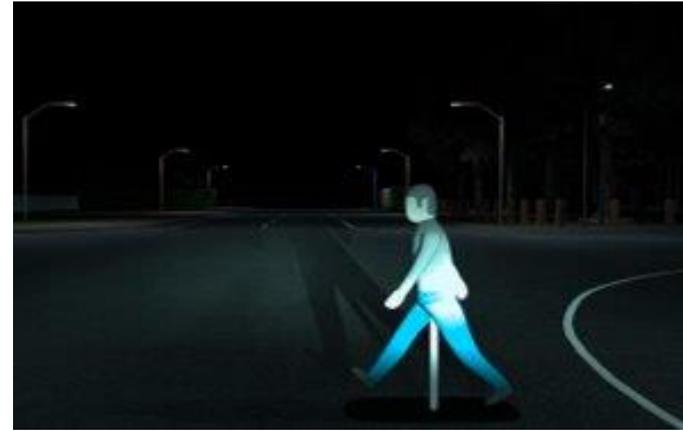
摄像头传感器

# Camera Sensor Validation

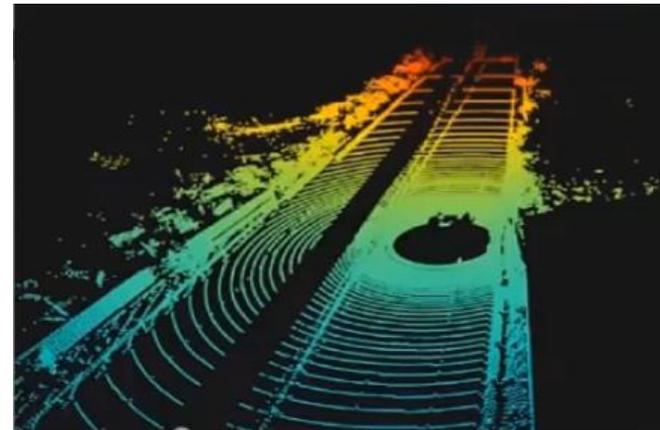
## 摄像头传感器验证



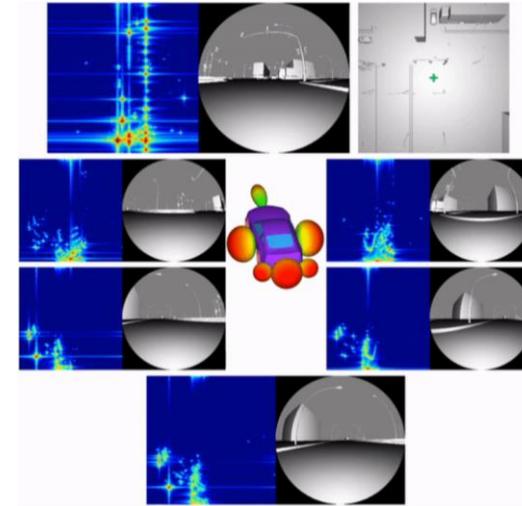
AVxcelerate Sensors Simulator Workflow



Ansys Real-Time Camera simulation



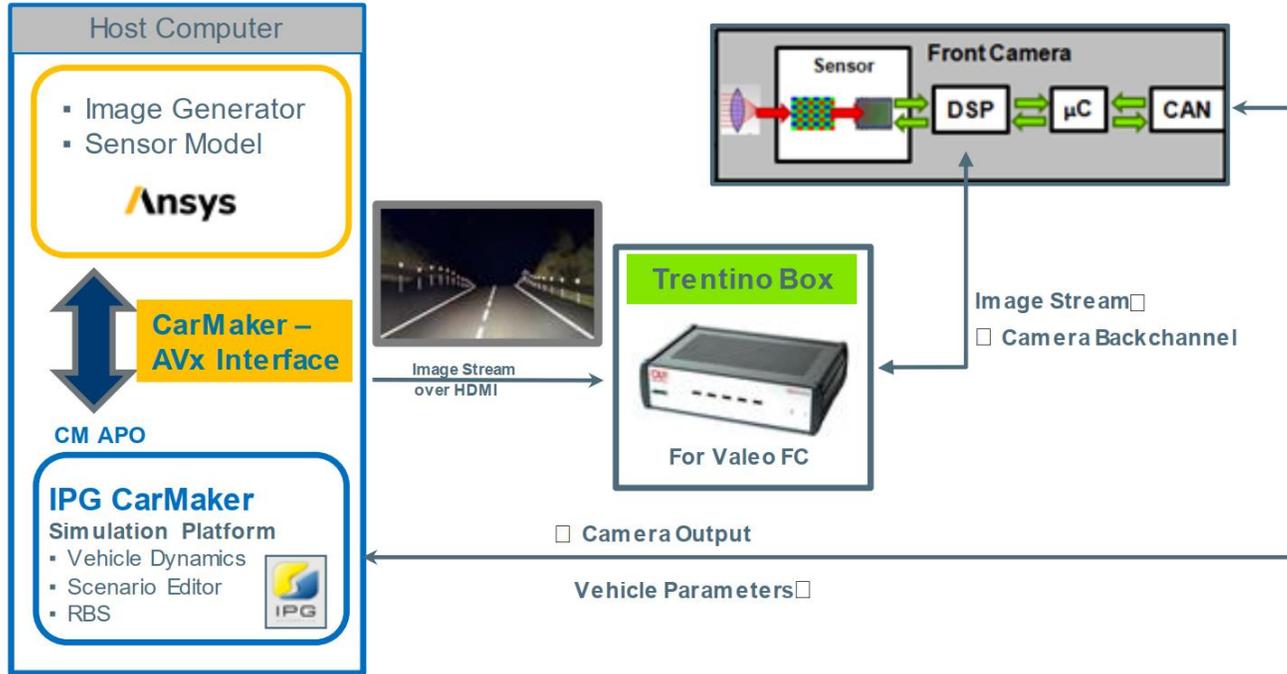
Ansys Real-Time Lidar simulation



Ansys Real-Time Radar simulation

# Front Camera Injection Testing

## 前置摄像头视频注入测试



### 软件配置:

- CarMaker
- Ansys Avx
- Matlab & Simulink

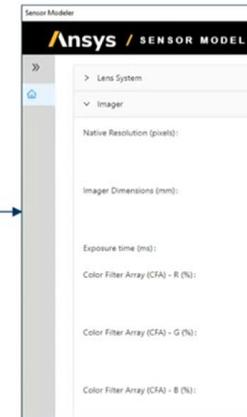
### 硬件配置:

- Workstation with Nvidia GPU
- Trentino Box
- Front Camera
- Option: RTPC

Valeo Front Camera



AVx Sensors Modeler



# AVxcelerate & CarMaker: Camera Injection Testing

摄像头视频注入测试





✉ [contact-cn@ipg-automotive.com](mailto:contact-cn@ipg-automotive.com)

🌐 [www.ipg-automotive.com](http://www.ipg-automotive.com)

🔄 @IPG Automotive

📺 @IPG 中国

📺 @亦佩捷

📺 @亦佩捷

