MathWorks助力NVIDIA DRIVE Sim加速自动驾驶开发

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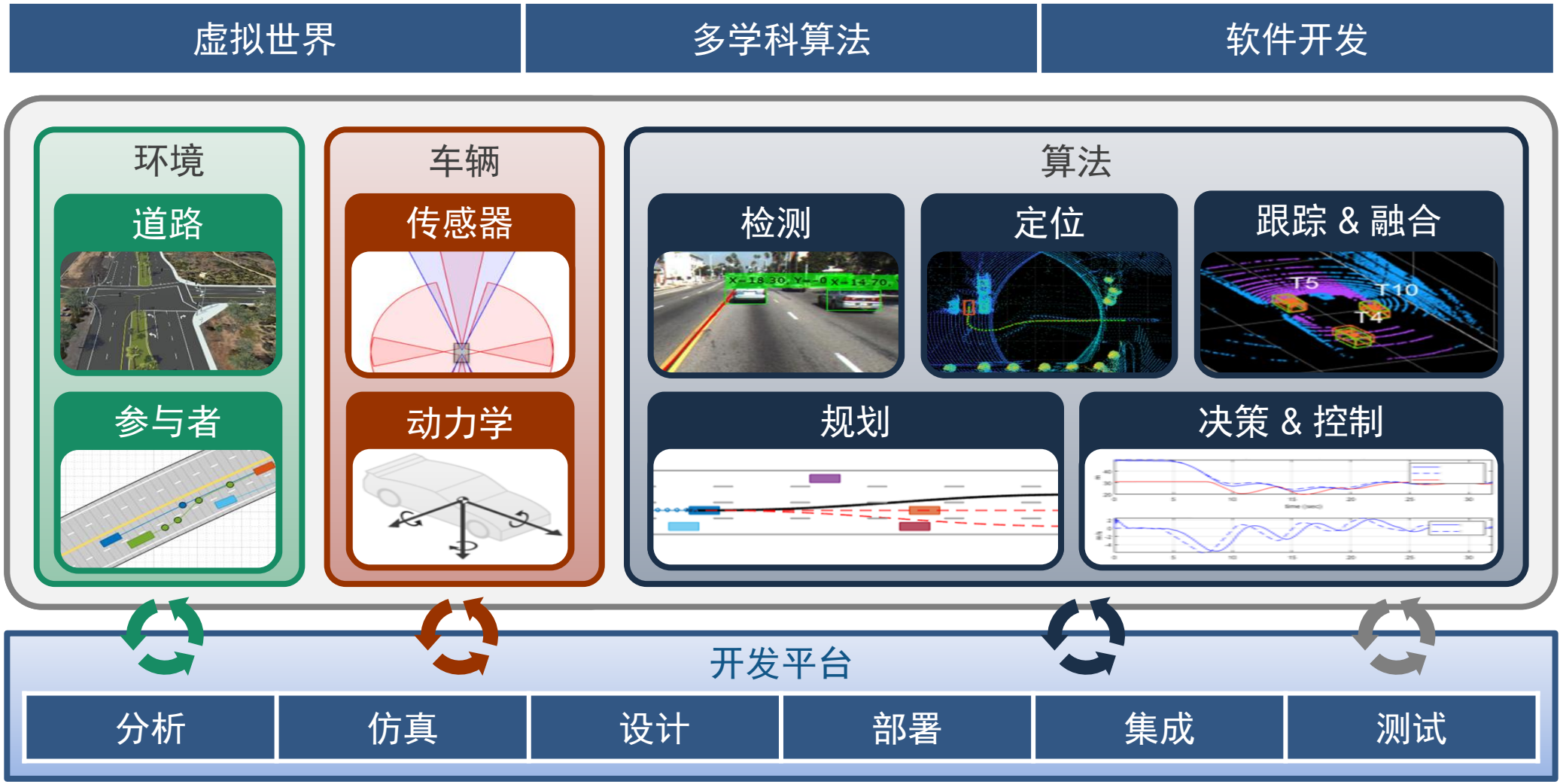
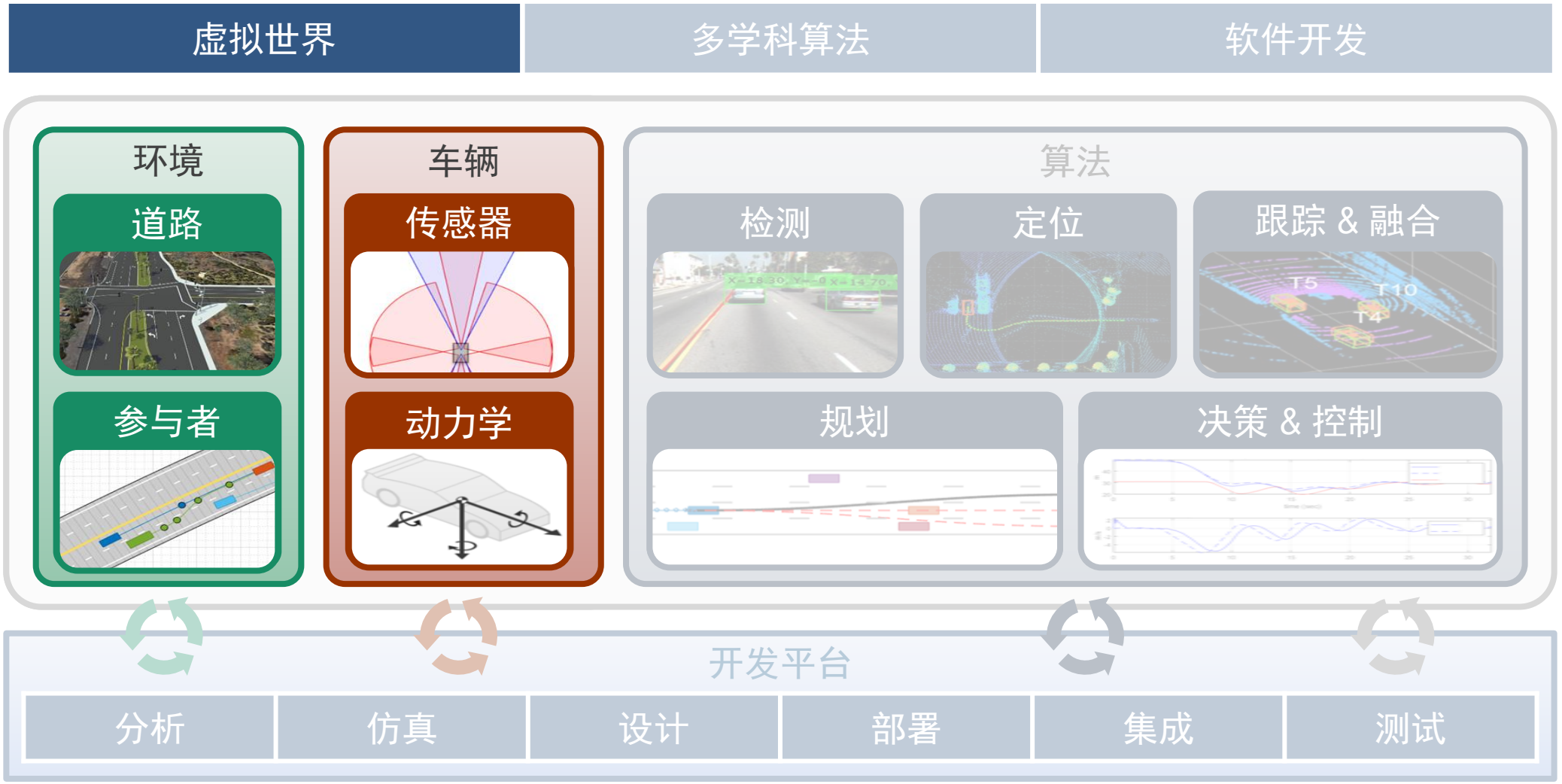
MATLAB EXPO 2021

开发自动驾驶系统——MATLAB, Simulink和相关工具箱



建立用于自动驾驶仿真的虚拟世界



使用RoadRunner，为自动驾驶仿真创建3D场景

导入

- HERE HD Live Map
- OpenDRIVE
- 地理信息系统 (GIS) 数据
  - 点云数据
  - 航空影像
  - 矢量数据
  - 高程数据
- 用户自建资源

编辑

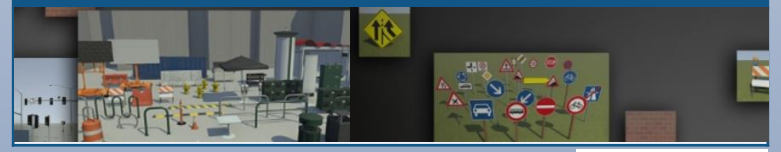
RoadRunner Scene Builder

R2020b

RoadRunner

R2020a

RoadRunner Asset Library

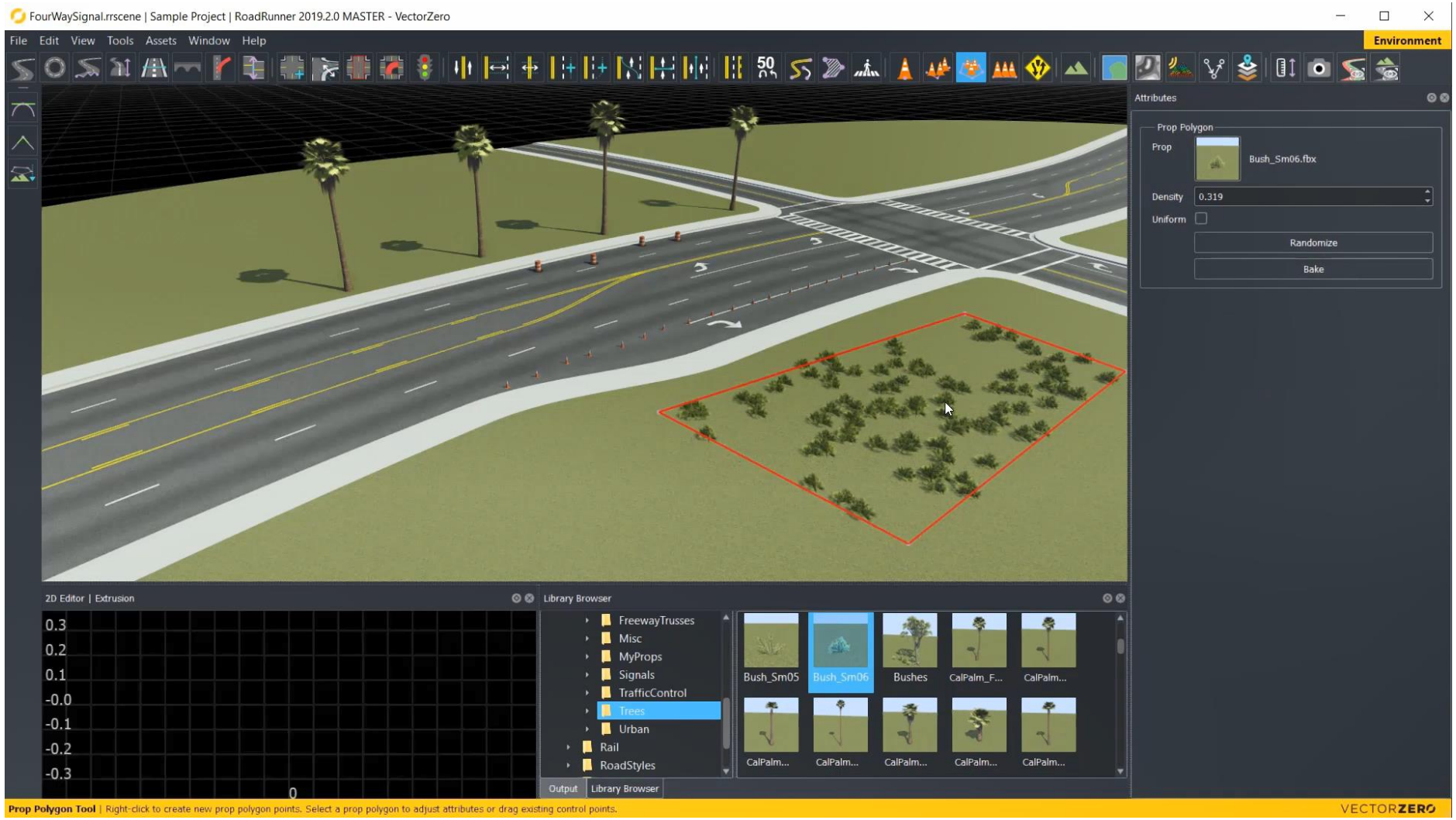


R2020a

导出

- OpenDRIVE
- .FBX
- 第三方仿真软件
  - CARLA
  - Unreal Engine®
  - Unity®
  - LGSVL
  - VIRES Virtual Test Drive
  - Metamoto
  - IPG Carmaker
  - Cognata
  - Baidu Apollo
  - Tesis Dynaware
  - TaSS PreScan
  - NVIDIA DRIVE Sim

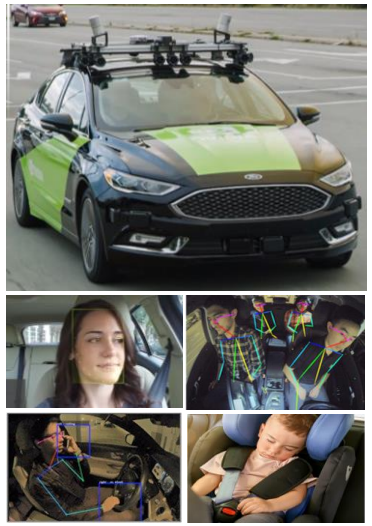
使用RoadRunner，为自动驾驶仿真创建3D场景



NVIDIA END-TO-END DRIVE PLATFORM

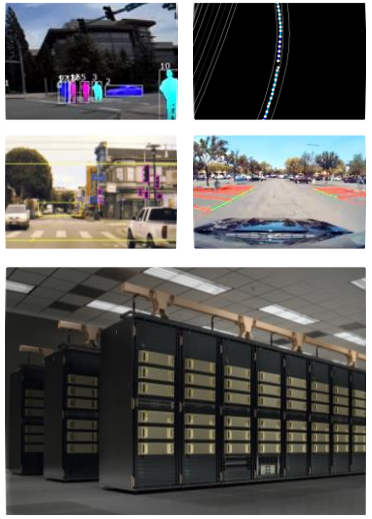
Autonomous Driving & AI Cockpit of the Future

COLLECT DATA



Hyperion 8 Vehicle Platform

TRAIN MODELS



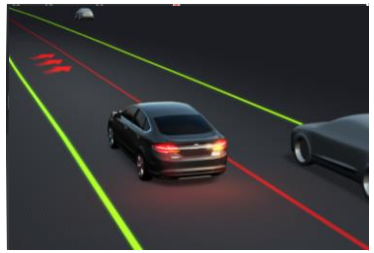
DGX A100

SIMULATE

DRIVE Sim & Constellation

DRIVE AV

DRIVE IX



DRIVE AGX Orin

DRIVE RC

NVIDIA DRIVE

E2E AV Solution to Enable Rapid, Large Scale AI Development & Testing

DRIVE AV

Perception | Mapping | Planning

1,000's Engineers
20+ DNNs, 50 Parallel Experiments

DRIVEWORKS

Sensor Abstraction | Vehicle IO,Tools | Calibrate

Image / Point Cloud | Recorder | Ego Motion

1,000's Engineers HW & SW
20 million lines of code

Sensor Data+Logs

ACTIVE LEARNING
TARGETED LEARNING

TRANSFER LEARNING
FEDERATED LEARNING

INGESTION	CURATION	LABELING	TRAINING	REPLAY	SIMULATION
					
300k hours, 300M frames 10 PB/wk data collected	1,500 labelers 50M+ labeled images	1000+ DGX Saturn V	1M+ virtual miles driven 200+ DRIVE Constellations		

DRIVE INFRA

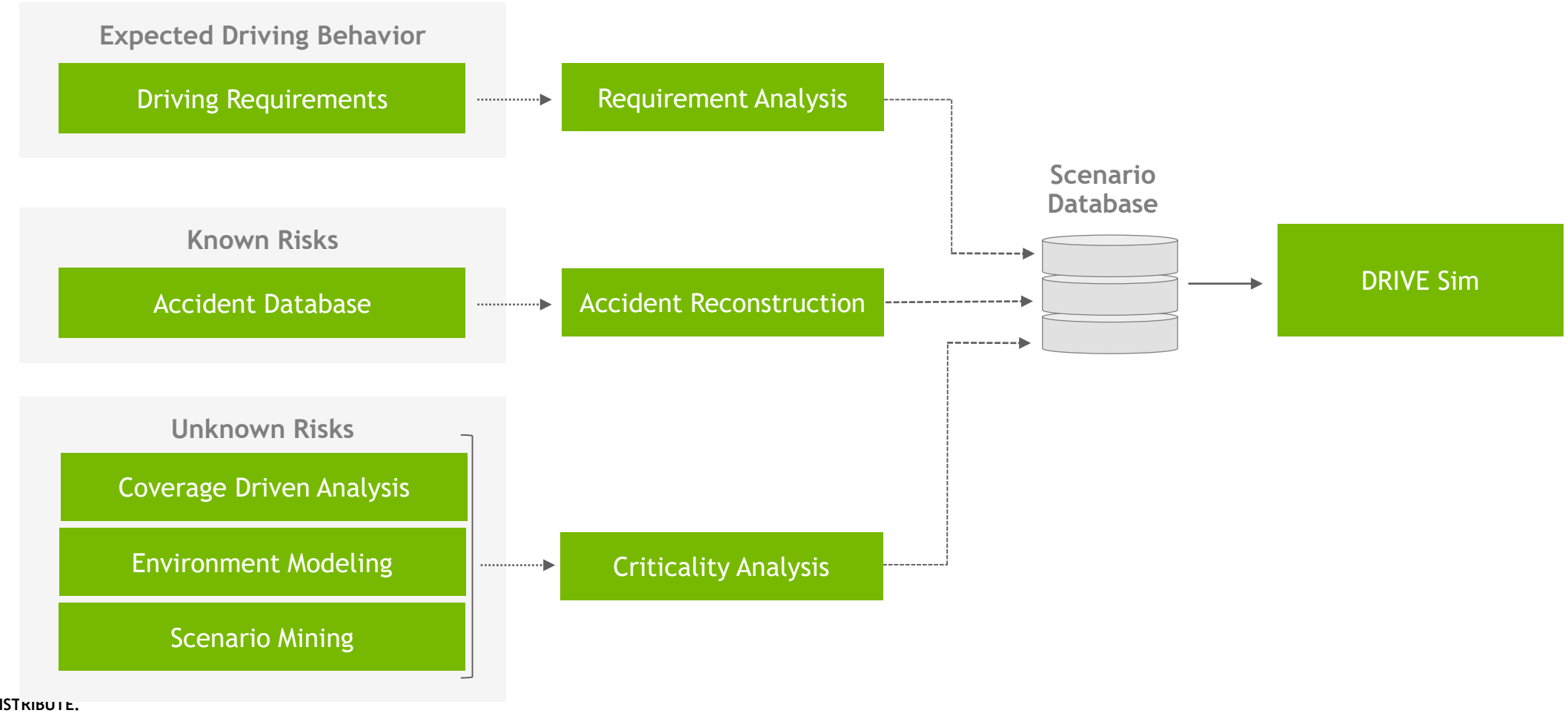
Data Management | Workflow Management

Data Center Backbone

1,000's of engineering hours develop and run Deep Ops & Dev Ops SW on Saturn V

CONSTRUCTING SCENARIOS

Covering the Known Risks | Discovering the Unknown Risks



NVIDIA DRIVE SIM 2.0

System Level AV Simulator

Built on Omniverse | Cloud Native

Scenario-based | Repeatable & Reproducible

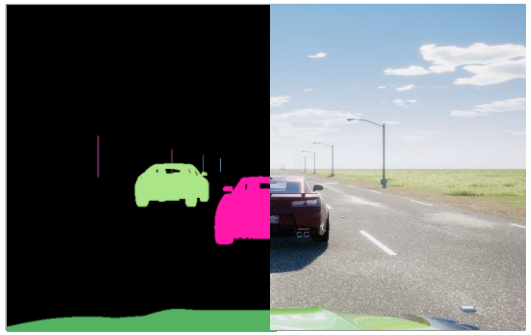
Scalable | Workstation to Data Center | SIL or HIL

Improved Asset Import | RTX-based Sensors

Open | Modular | Extensible

DRIVE SIM 2.0 - USE CASES

Accelerated AV Development to Large Scale Validation



PERCEPTION

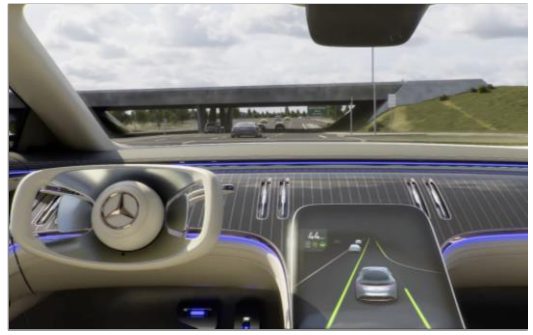
- Generate synthetic dataset from Sim
- Rapidly iterate on DNNs & algorithms

PLANNING & CONTROL

- Bypass perception with GT sensors
- Develop and debug P&C algorithms

FULL AV STACK

- Evaluate AV stack end-to-end
- From sensor input to actuation



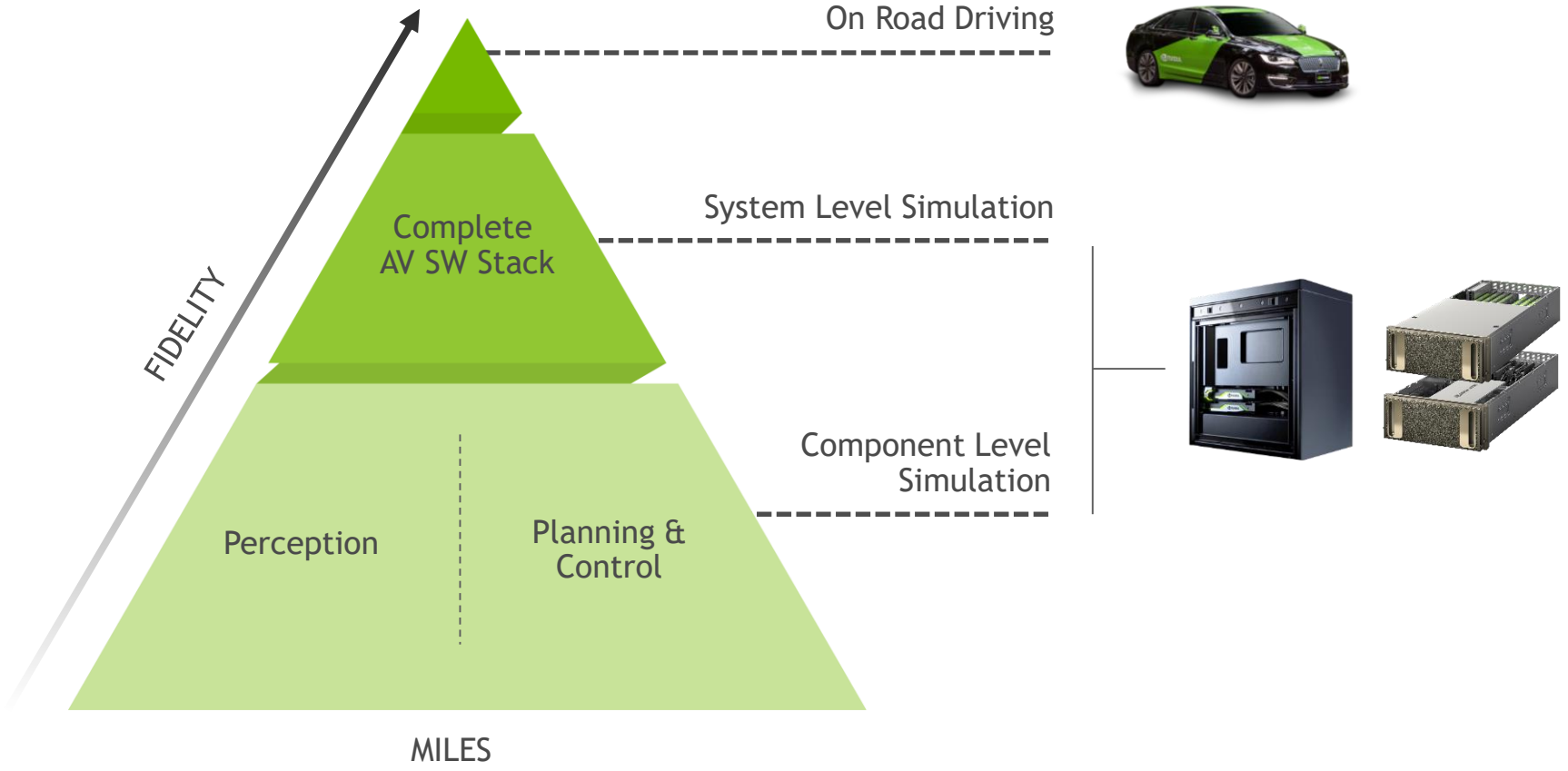
VIRTUAL VEHICLE

- Evaluate full driving experience
- UI/UX, cockpit displays, HMI, speech etc.

Common Toolchain | Seamless Transition | SIL or HIL

INCREASING DEVELOPERS EFFICIENCY, SPEED & COVERAGE

Optimizing for Productivity and Cost



GAME ENGINES ARE NOT DESIGNED FOR AV SIMULATION

	AV Simulation Requires:	Game Engine
Scalability	Scalability across multiple GPUs and multiple GPU nodes	Not designed to scale across multiple GPUs or nodes
Sensors	Physically accurate sensors | Optimized for accuracy	Viewports | Optimized for gamers | Beautiful but not accurate
Timing	Timing control | Repeatability | Single process to schedule all threads	Non-deterministic behavior | No timing guarantees
Modularity	Modularity | Extensions easy to write, load, distribute	Not modular | Content exported into proprietary format
Sim World State	API to access and modify world state | Full history | Ability to replay Sim	Opaque to other codebase | No history
Cloud	Cloud native architecture	Authoring & runtime closed | Not cloud native

NVIDIA OMNIVERSE

NVIDIA’s Simulation & Collaboration Platform

Architected for large-scale, multi-sensor simulation

Physically accurate, real time rendering with RTX

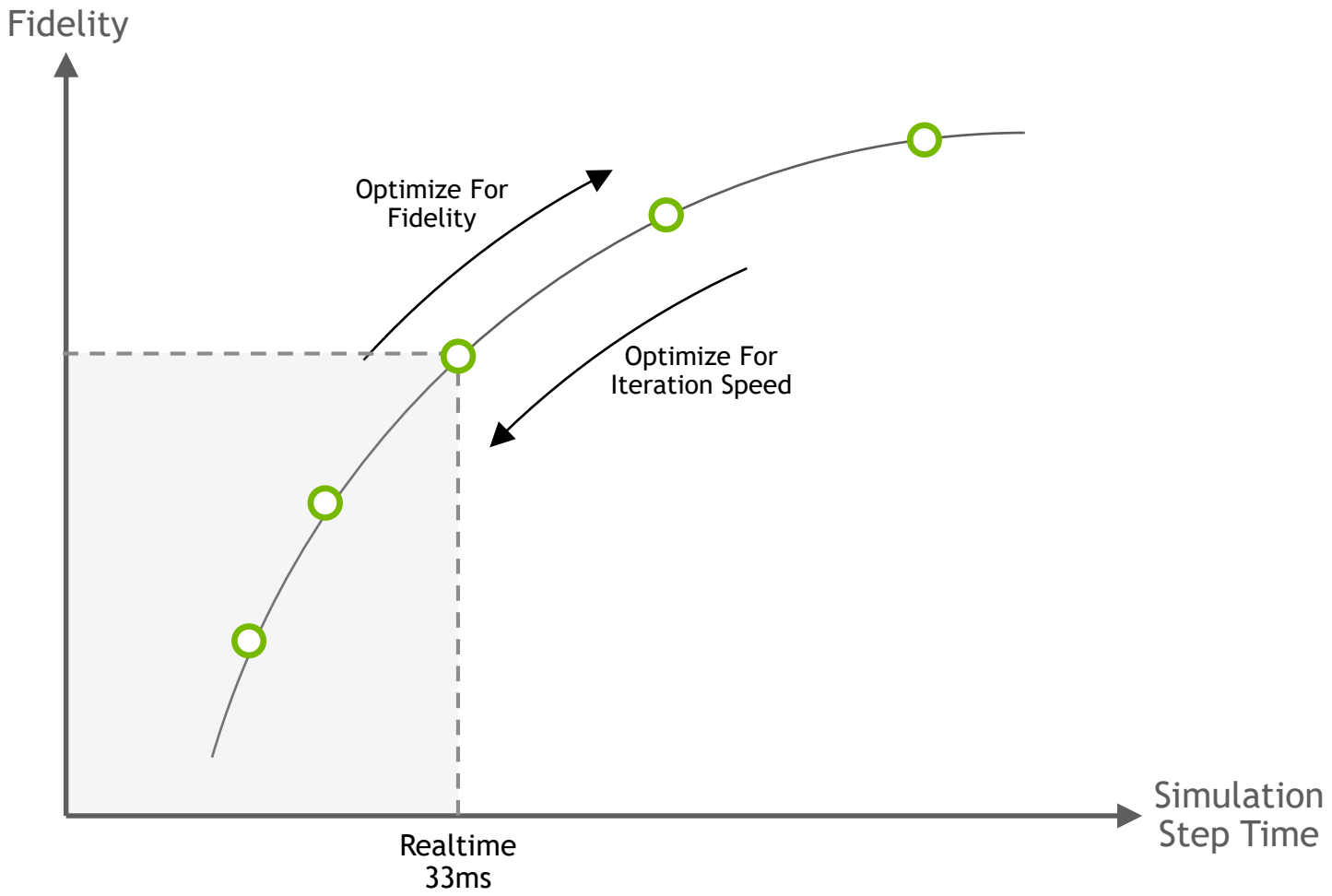
Built on Pixar’s Open Universal Scene Description (USD)

Deployed on any NVIDIA RTX™ GPUs

Open | Modular | Extensible | Cloud native

DRIVE SIM 2.0 ENABLES ELASTIC SIMULATION TIME

Can Run Faster or Slower than Realtime - Use Case Driven



SENSOR MODELS IN DRIVE SIM

Raytracing-Based Sensor Models

Camera

Radar

Lidar

USS

Preset Models

DRIVE Sim directly support many sensors from well-known manufacturers

Configure Models

Parameters of NVIDIA sensor models can be adjusted to meet specific sensor requirements

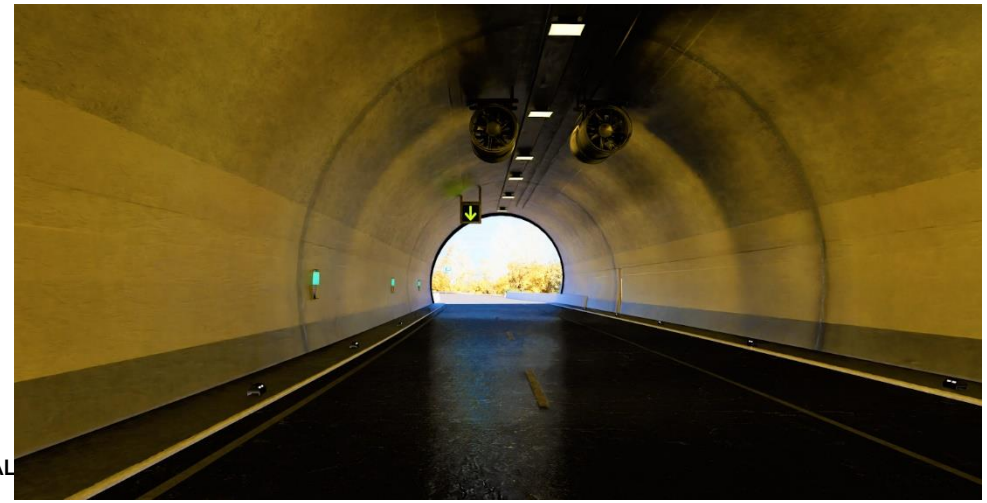
Custom Models

Custom models can be created by users for new sensor types

Partner Models

NVIDIA Ecosystem Partners build DRIVE Sim compatible models

DRIVE SIM 2.0 - RTX CAMERA IMAGES



DRIVE SIM 2.0 - RTX CAMERA IMAGES

GENERATING GT DATA FROM SIMULATION

Accelerating Perception Development

Fast | Perception development can start from day one

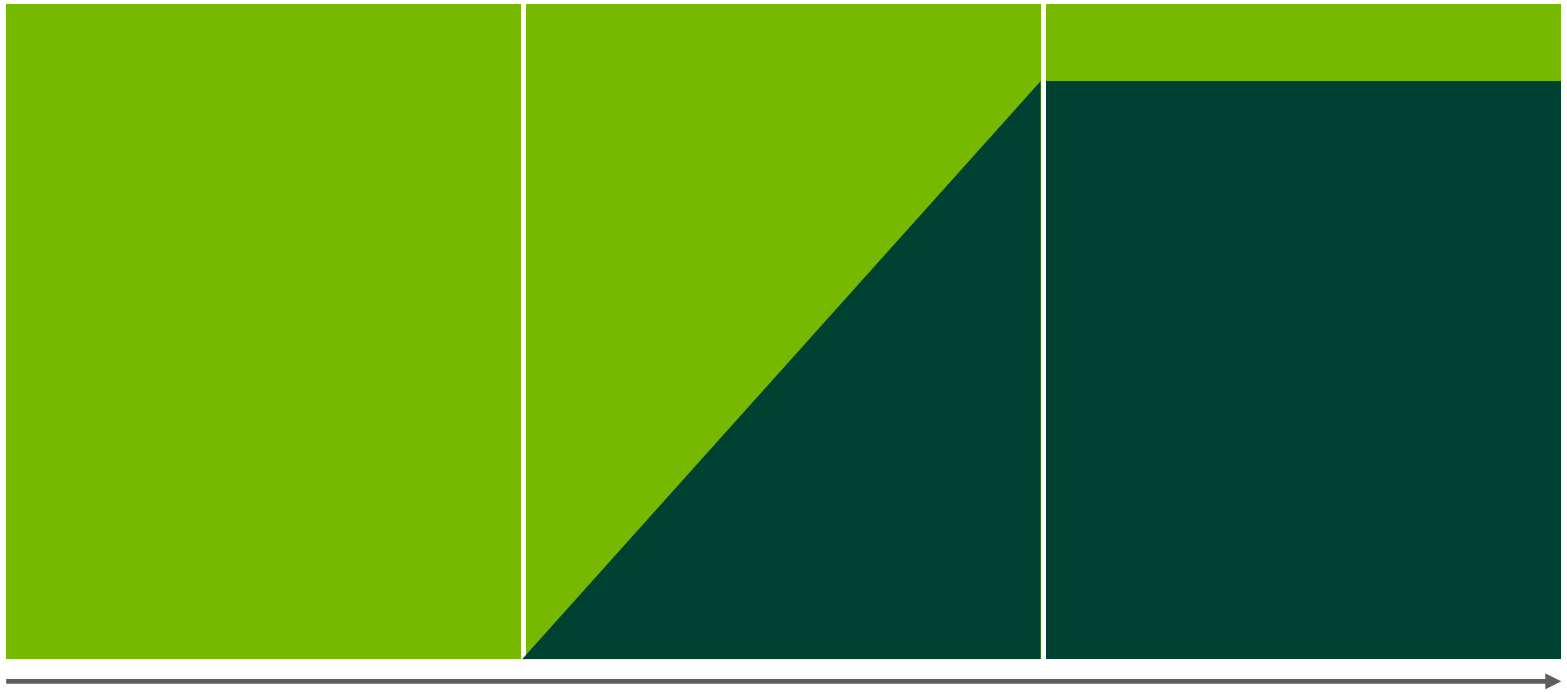
Accurate | No humans in the loop

Diverse| Corner cases & rare conditions

Low cost | Compared to collecting real data

PERCEPTION DNN DEVELOPMENT – THREE PHASE APPROACH

Simulation First Approach for Fastest Time to Production



PHASE 1
RAPID DNN DEVELOPMENT

- All synthetic data generated from Sim
- Rapidly iterate on new DNNs

PHASE 2
SCALE DNN DEVELOPMENT

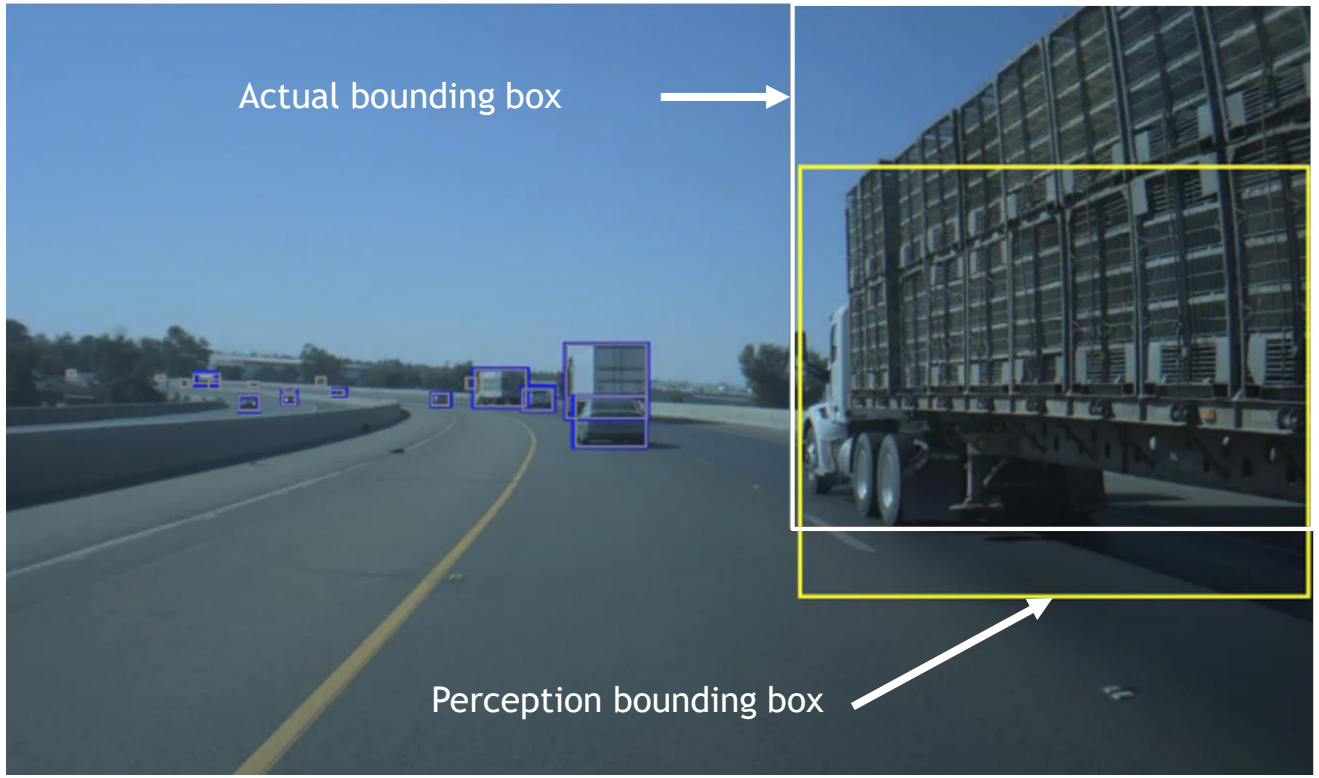
- Scale real data collection and labeling
- Train on hybrid dataset

PHASE 3
OPTIMIZE PRODUCTION DNNs

- Find the optimal sim/real dataset mix

DRIVE SIM FOR PERCEPTION DEVELOPMENT

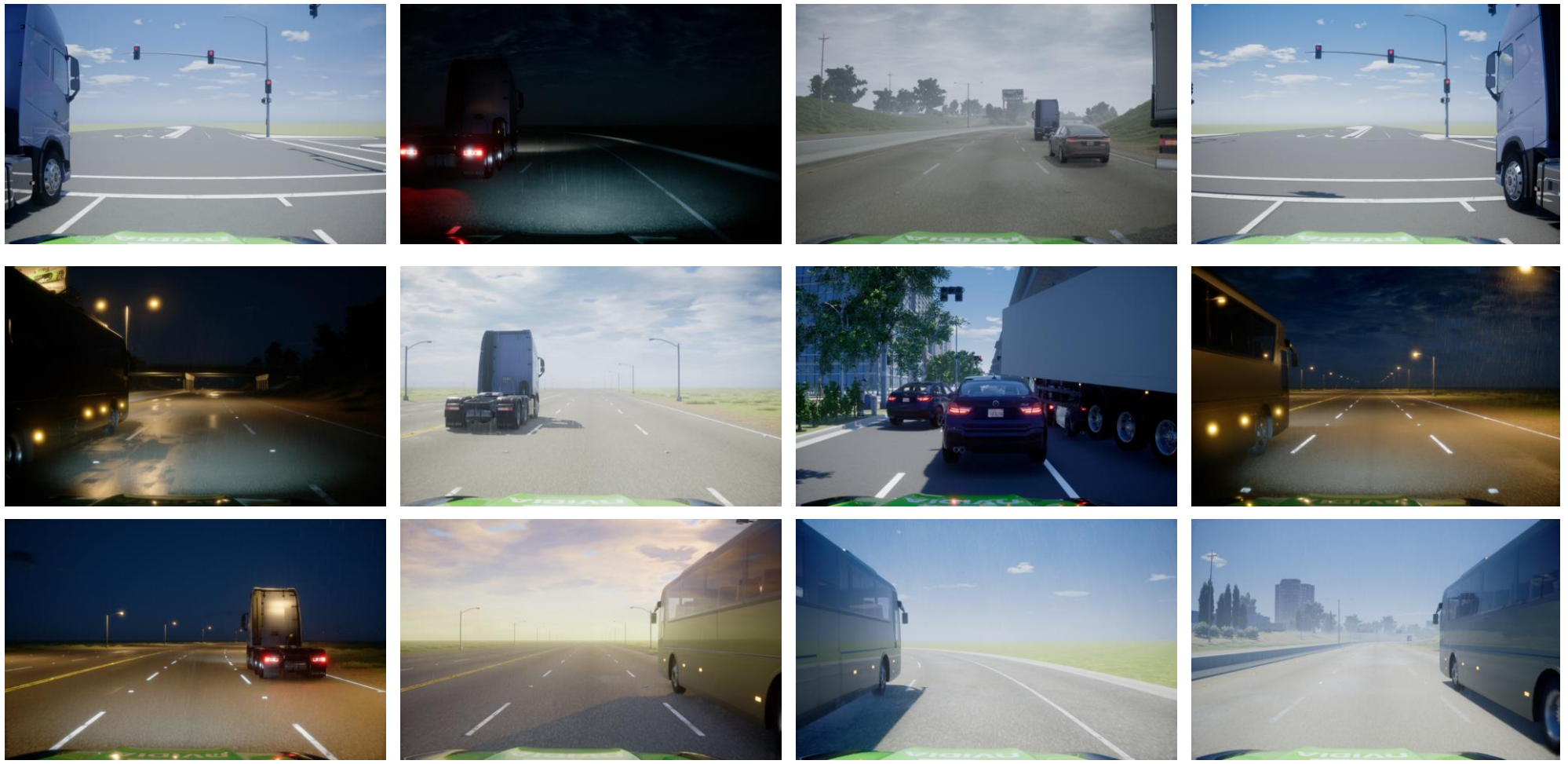
Case Study: Using imitation training to better classify trucks



Perception Failure Event

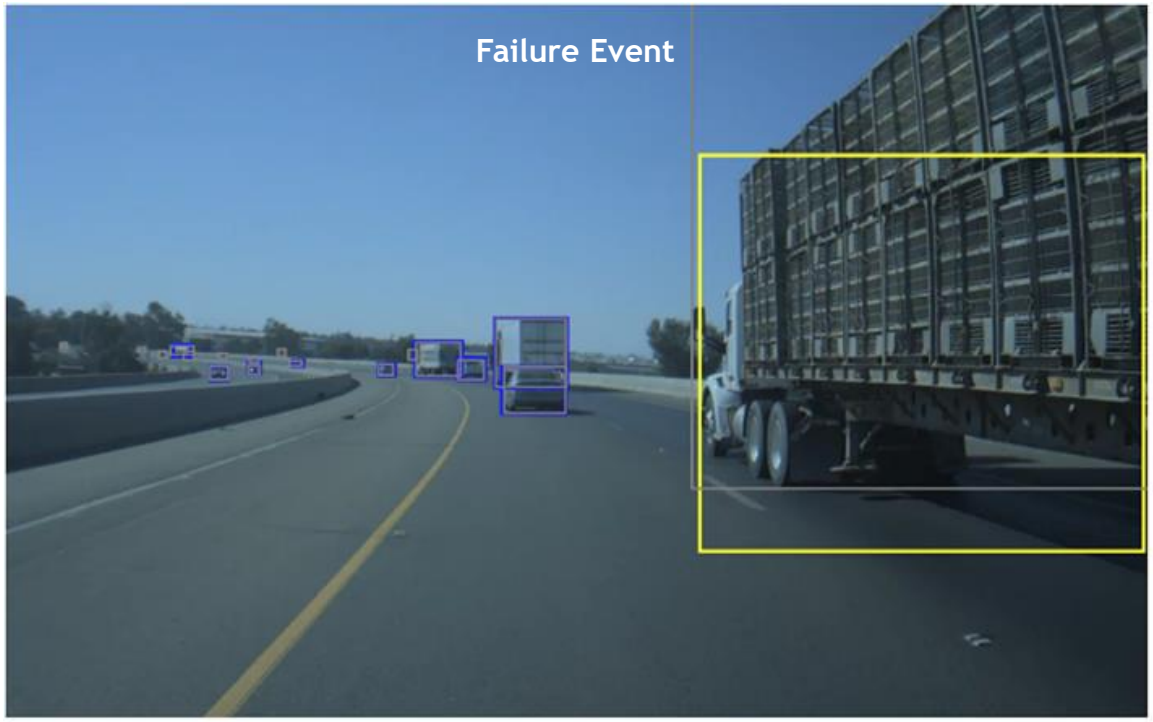
DRIVE SIM FOR PERCEPTION DEVELOPMENT

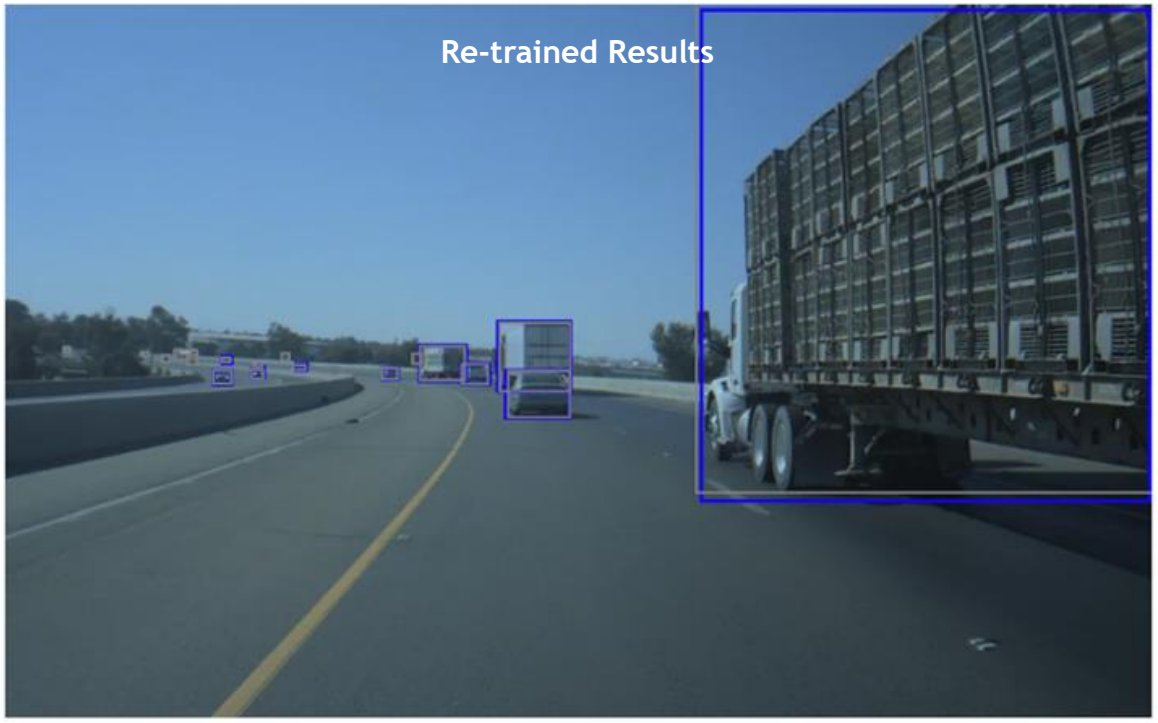
Sample of DRIVE Sim generated training data to better detect trucks



RETRAINED RESULT

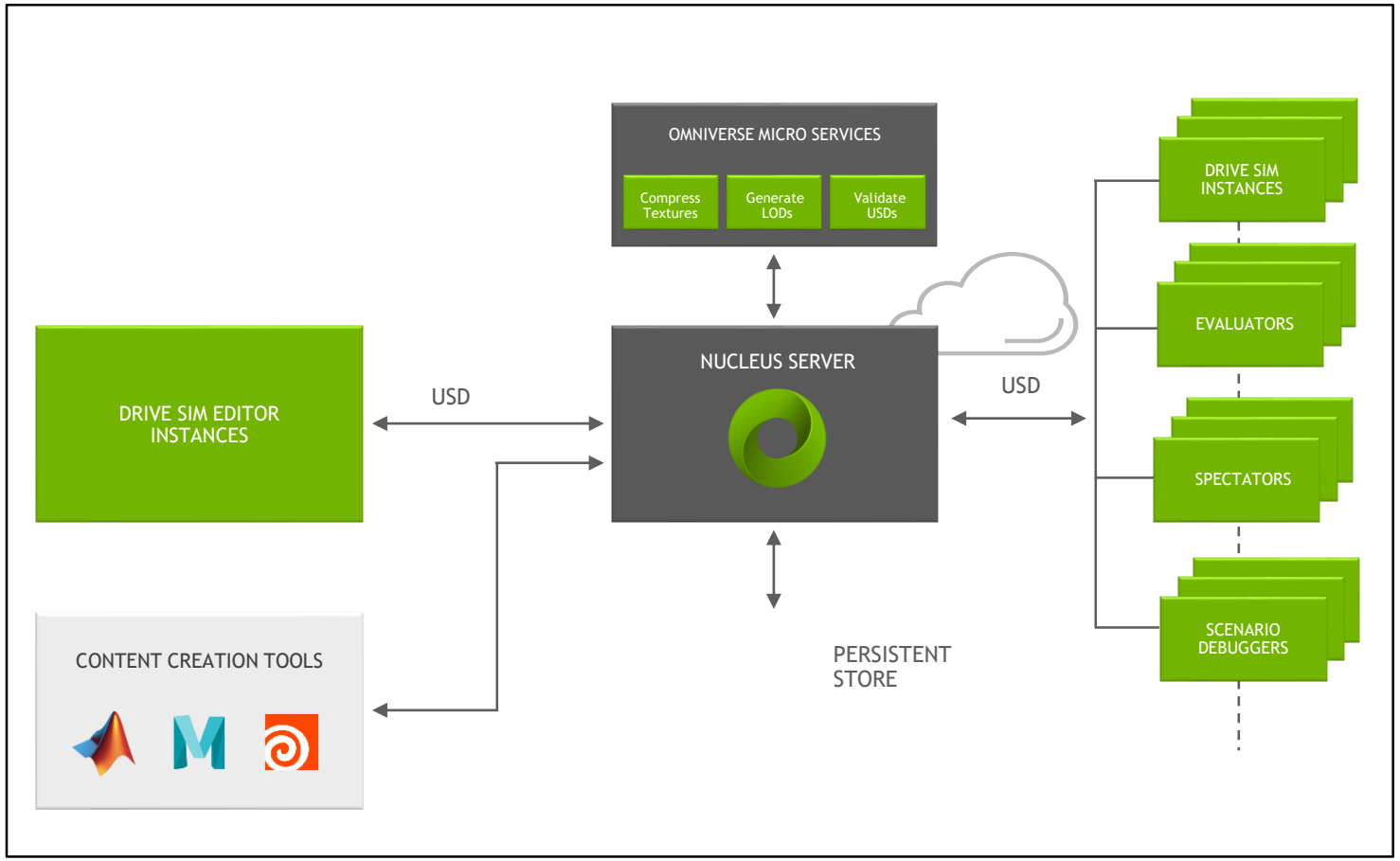
Failure Event & Re-train





DRIVE SIM CLOUD NATIVE WORKFLOW

“Google Docs” for Simulated Worlds



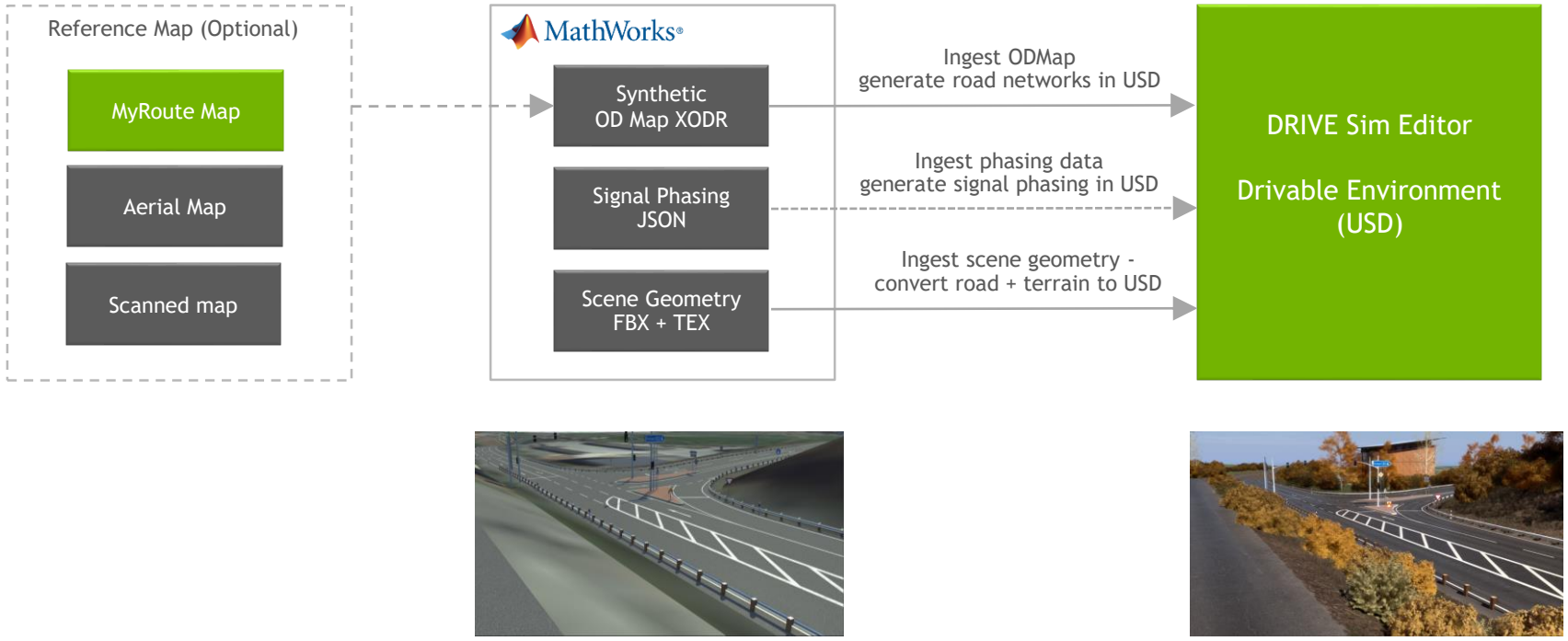
Content and application are decoupled
- Content pushed to Nucleus, loaded at runtime

USD assets remain editable and ‘live’ at runtime
- no pre-baking to ‘dead’ game engine format

Content updates published as diffs
- Lite, fast and efficient

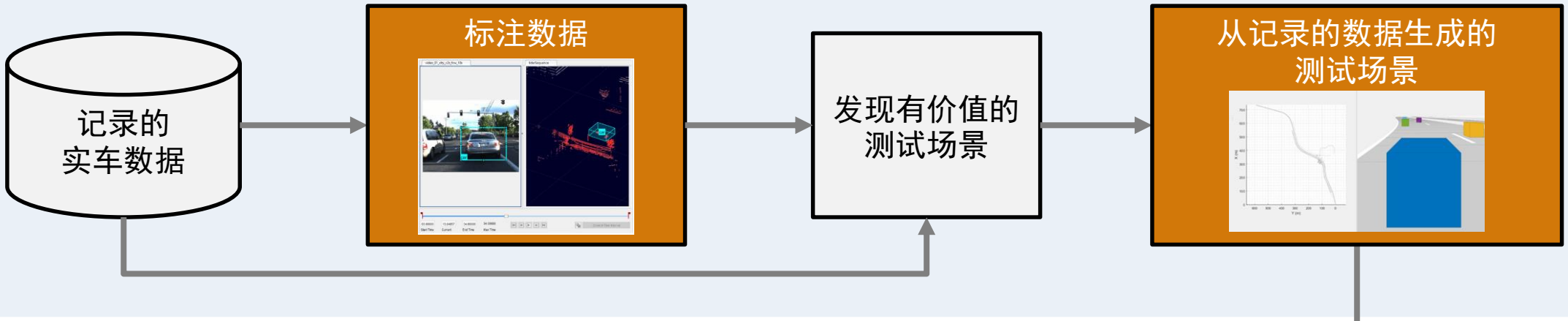
Fast turnaround from content generation to Sim results

CREATING & IMPORTING ROAD NETWORK TO DRIVE SIM

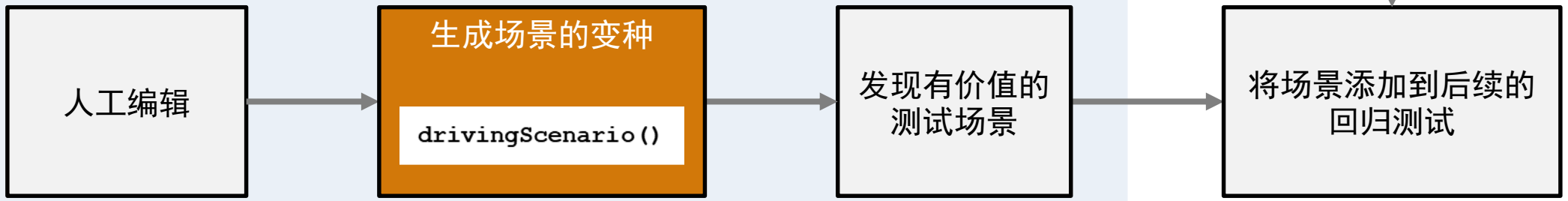


自动驾驶测试场景的两种来源

从记录的实车数据，发现潜在的测试场景

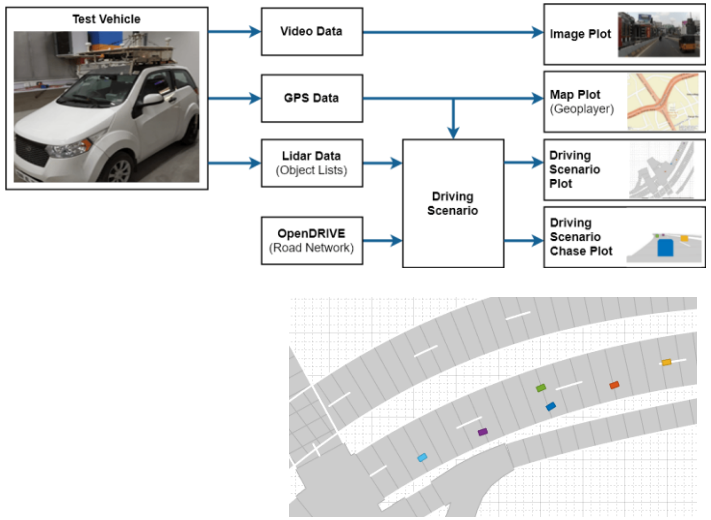


生成人工建立场景的变种，发现潜在的测试场景



如何生成自动驾驶的测试场景？

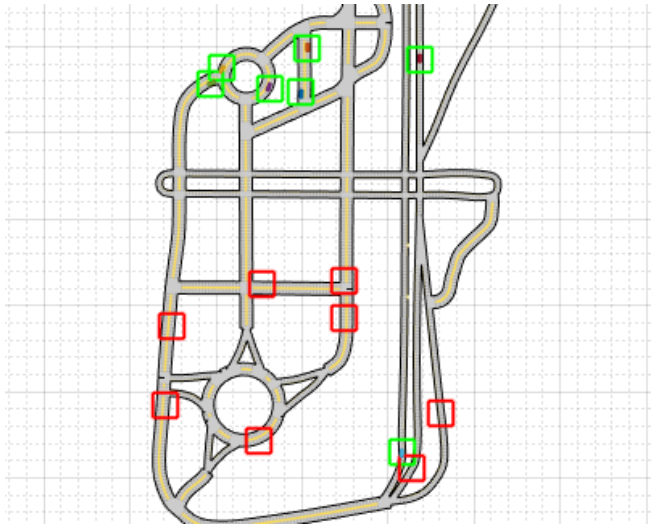
从记录的数据生成场景



[Scenario Generation from Recorded Vehicle Data]
Automated Driving Toolbox

R2019a

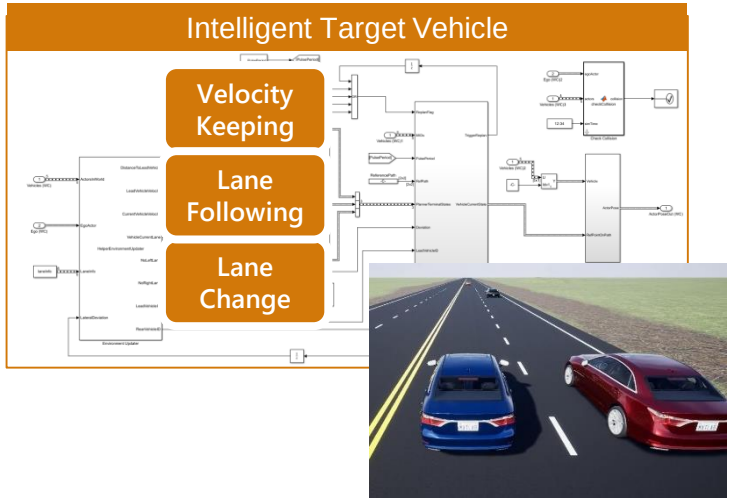
自动生成场景的变种



[Automatic Scenario Generation]
Automated Driving Toolbox

R2020b

仿真带人工智能的目标车辆

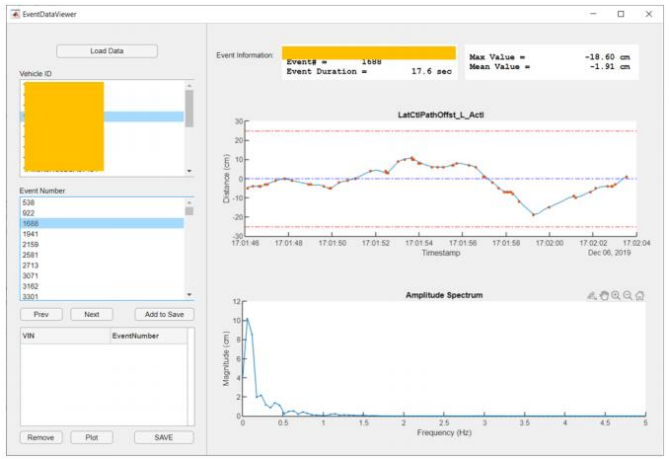


[Highway Lane Following with Intelligent Vehicles]
Automated Driving Toolbox, Navigation Toolbox, Model Predictive Control Toolbox

R2020b

MathWorks提供用于分析和重建驾驶场景的数据技术

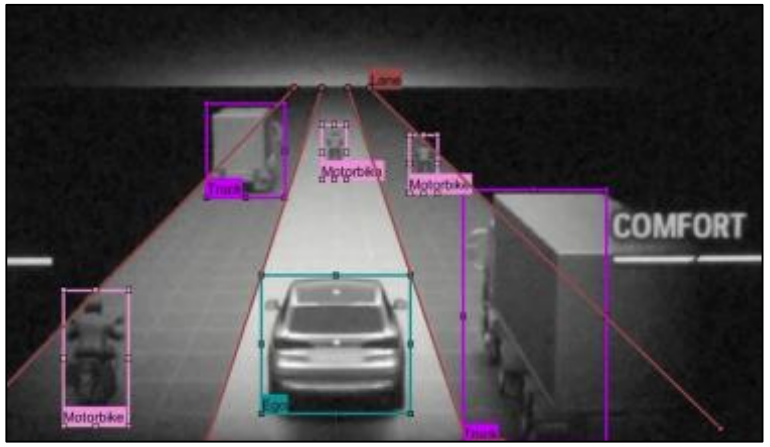
Ford 从记录的数据中提取事件



[Using MATLAB on Apache Spark for ADAS Feature Usage Analysis and Scenario Generation]

MathWorks Automotive Engineer Conference 2020

BMW 自动标注记录的图像



[Automated Verification of Automotive Infotainment]

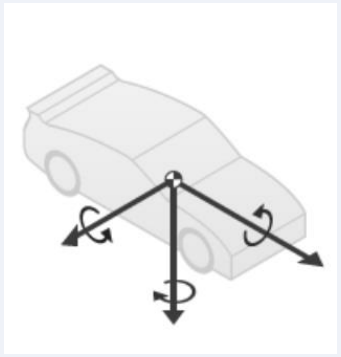
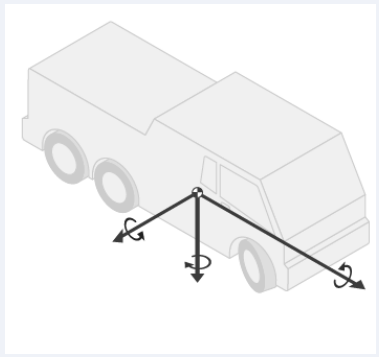
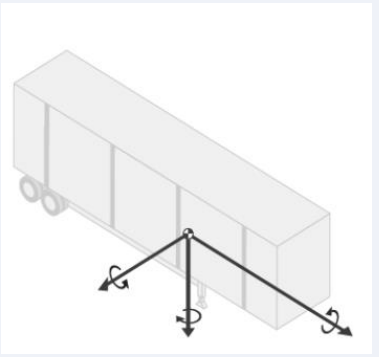
MathWorks Automotive Conference 2020 – Europe

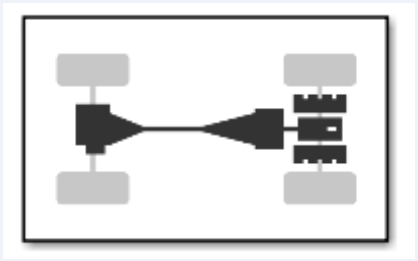
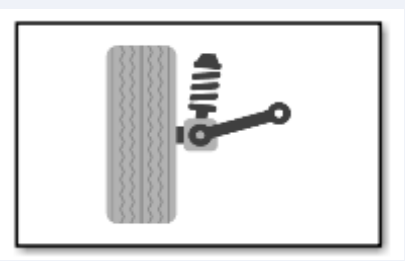
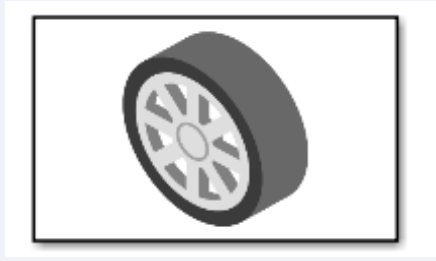
GM 从记录的数据生成仿真场景

[Creating Driving Scenarios from Recorded Vehicle Data for Validating Lane Centering Systems]

MathWorks Automotive Conference 2020 – North America

MathWorks提供用于仿真车辆动力学的Simulink附加库

2轴车辆	3轴车辆	挂车
		

动力	转向	悬架	轮胎
			

相关工具箱: Vehicle Dynamics Blockset, Automated Driving Toolbox

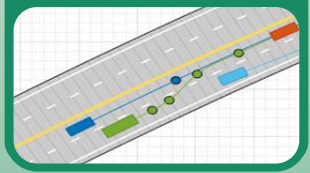
开发自动驾驶系统——MATLAB, Simulink, 以及RoadRunner

虚拟世界 | 多学科算法 | 软件开发

环境

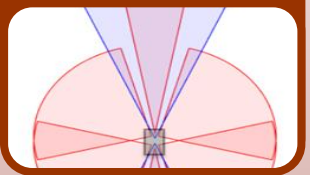
道路

参与者

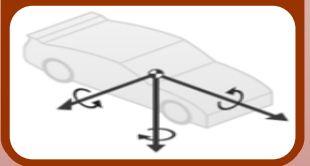


车辆

传感器

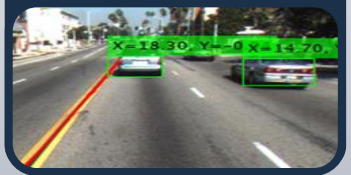


动力学

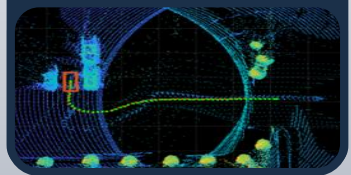


算法

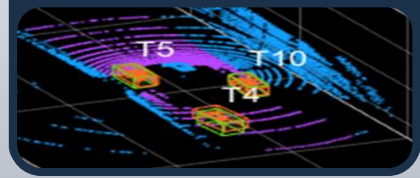
检测



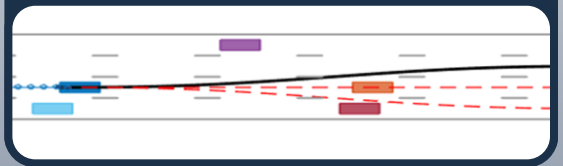
定位



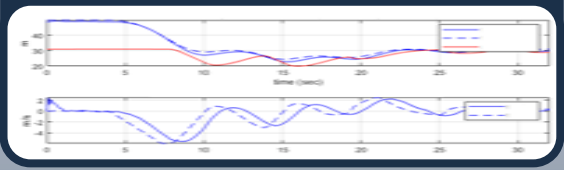
跟踪 & 融合



规划



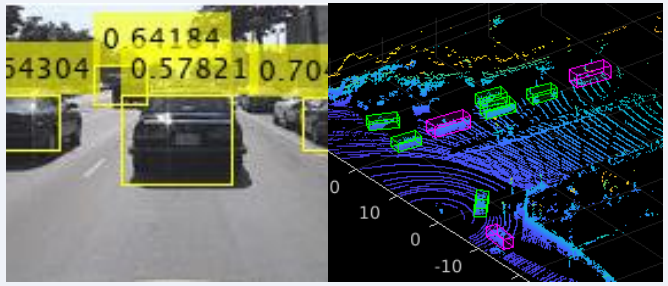
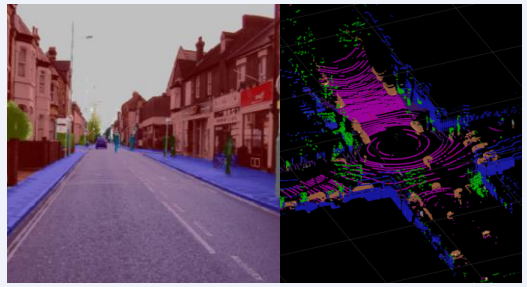
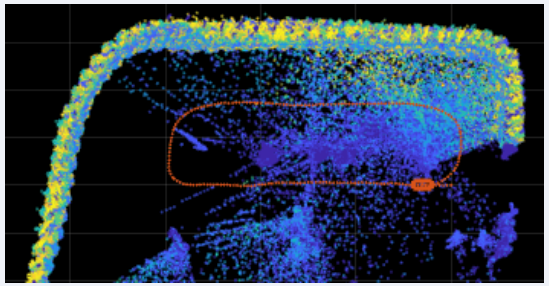
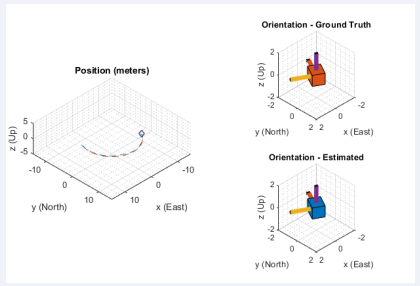
决策 & 控制



开发平台

分析 | 仿真 | 设计 | 部署 | 集成 | 测试

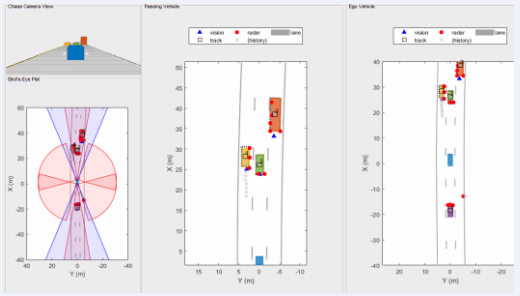
设计检测与定位算法

车道线	车辆	语义分割
		
SLAM	**地图**	**惯性传感器**
		

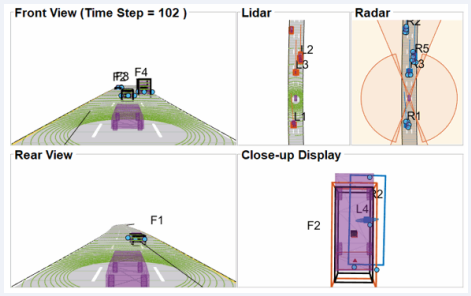
相关工具箱: Automated Driving Toolbox, Computer Vision, Lidar Toolbox, Radar Toolbox, Deep Learning Toolbox, Navigation Toolbox

设计跟踪与融合算法

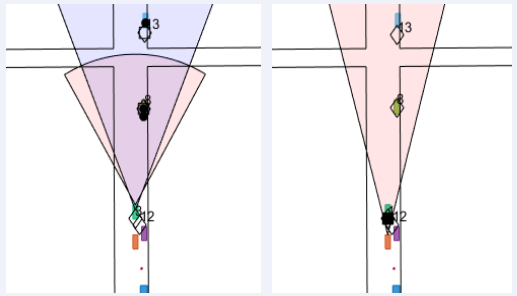
雷达 & 视觉



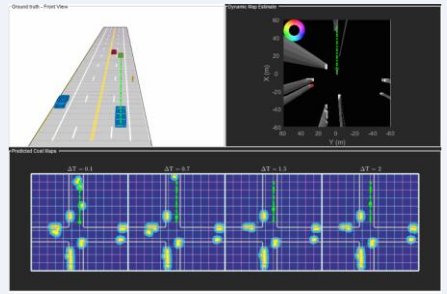
激光雷达 & 雷达



V2V

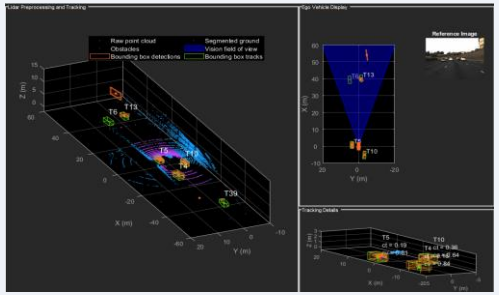


障碍物栅格

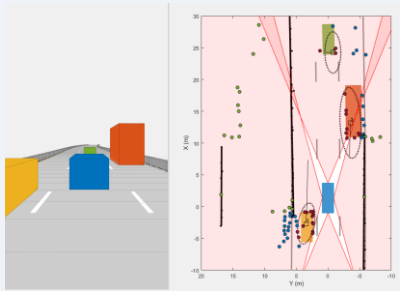


相机

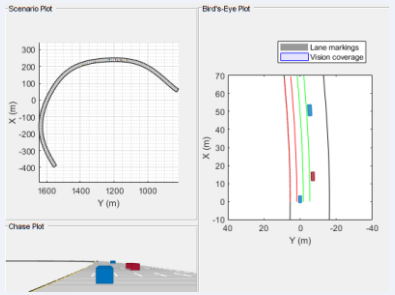
激光雷达



多径效应

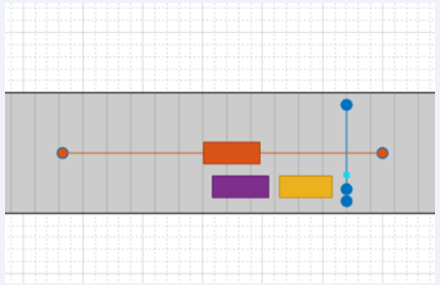
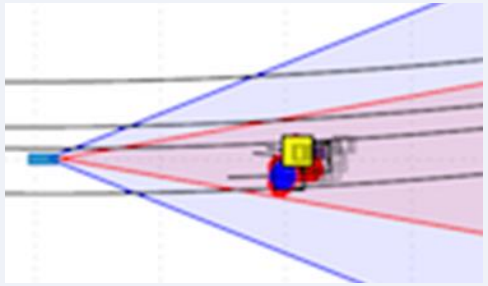
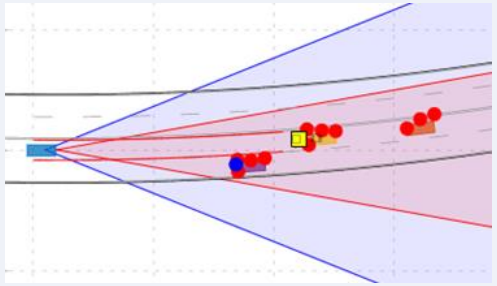
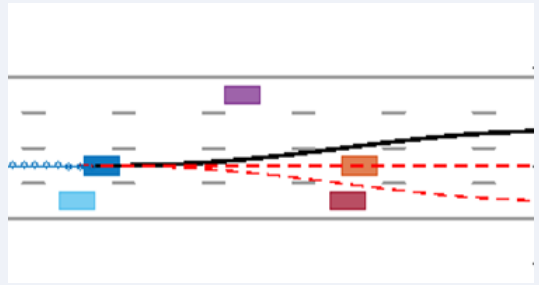
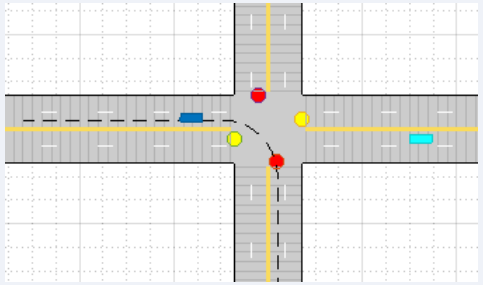
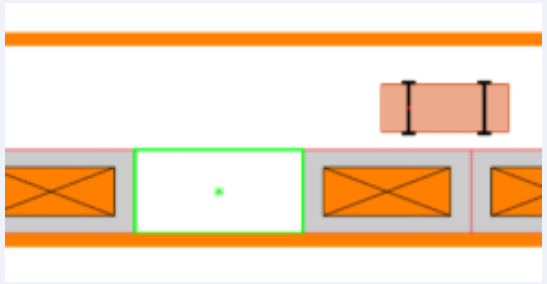
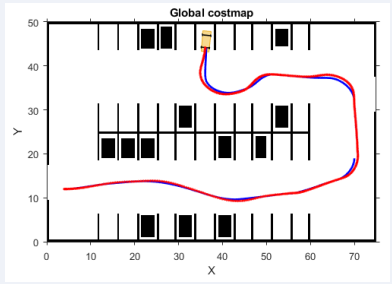
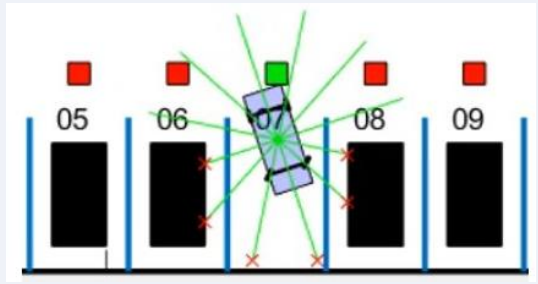


车道线



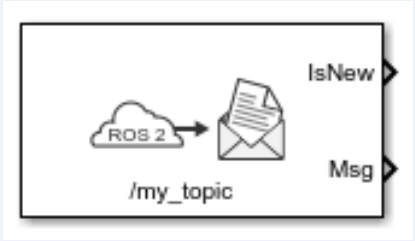
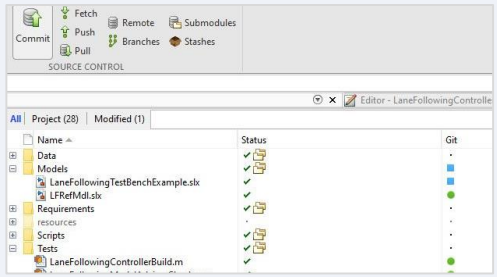
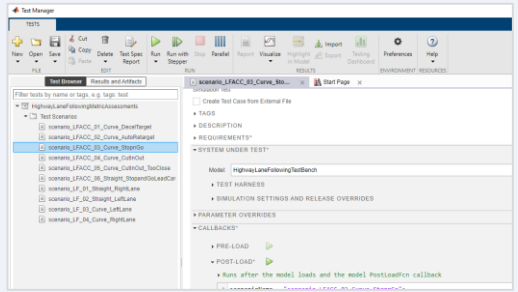
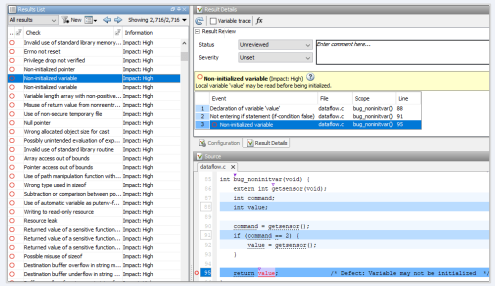
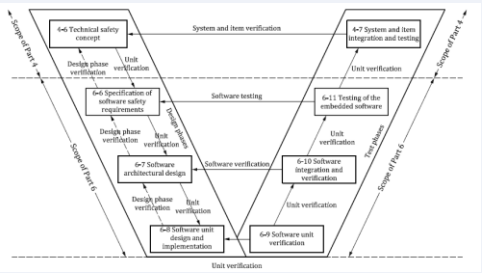
相关工具箱: Automated Driving Toolbox, Tracking and Fusion Toolbox, Radar Toolbox

设计规划与控制算法

AEB	ACC	车道跟随	车道变换
			
信号灯辅助	**侧方位泊车**	**代客泊车**	**强化学习**
			

相关工具箱: Automated Driving Toolbox, Model Predictive Control Toolbox, Stateflow, Navigation Toolbox, Reinforcement Learning, Robotics System Toolbox

开发自动驾驶应用软件

代码生成	ROS / ROS 2.0	AUTOSAR	DDS
C C++ GPU HDL			
持续集成	**自动化测试**	**代码分析**	**ISO 26262**
			

相关工具箱: MATLAB Coder, Embedded Coder, GPU Coder, HDL Coder, ROS Toolbox, AUTOSAR Blockset, DDS Blockset, Simulink Test, Simulink Coverage, Polyspace, IEC Certification Kit