

MathWorks AUTOMOTIVE CONFERENCE 2022 India

Environment modeling and Virtual
Validation for ADAS/AD features



Munish Raj
Application Engineer
MathWorks India
mraj@mathworks.com



Dr. Rishu Gupta
Principal Application Engineer
MathWorks India
rishug@mathworks.com

References from Today's MAC

MathWorks
AUTOMOTIVE CONFERENCE 2022
India

Bringing real world to simulation for virtual testing of Automated Driving (AD)

November 16 | Pune



Ninad Pachhapurkar, ARAI



Jyoti Kale, ARAI

MathWorks
AUTOMOTIVE CONFERENCE 2022
India

End-to-end closed loop validation of Automated Driving (AD) systems

November 16 | Pune



Deepika CP, KPIT Technologies



Bhagayashree Mukkavar,
KPIT Technologies



Chinmayi Jamadagni, KPIT Technologies



Sanket S Shinde, KPIT Technologies

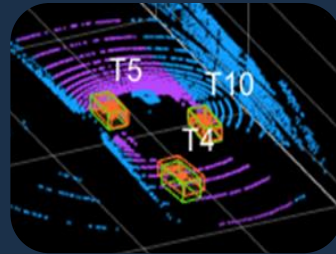
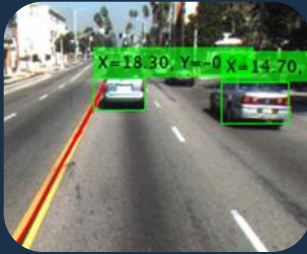


Srinivas Boppidi, KPIT Technologies

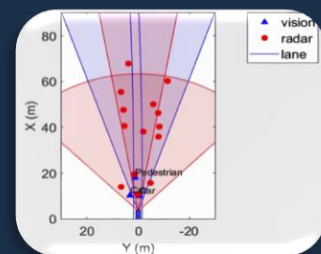
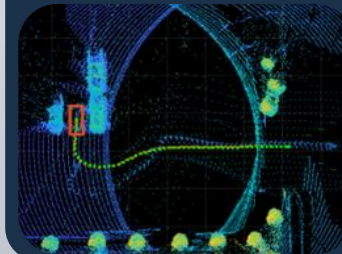
Key subsystems of an automated driving system

Algorithms

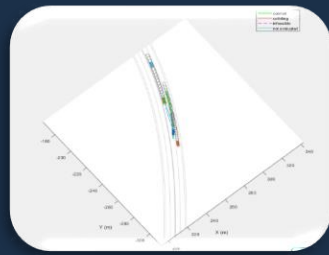
Perception



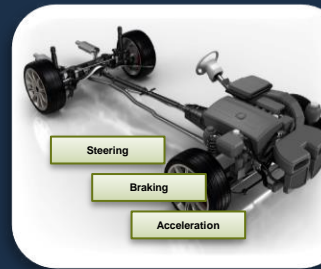
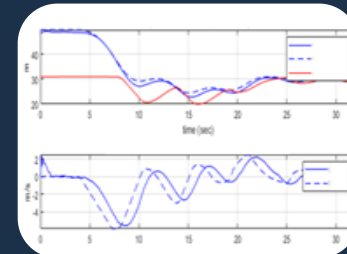
Sensor Fusion



Planning

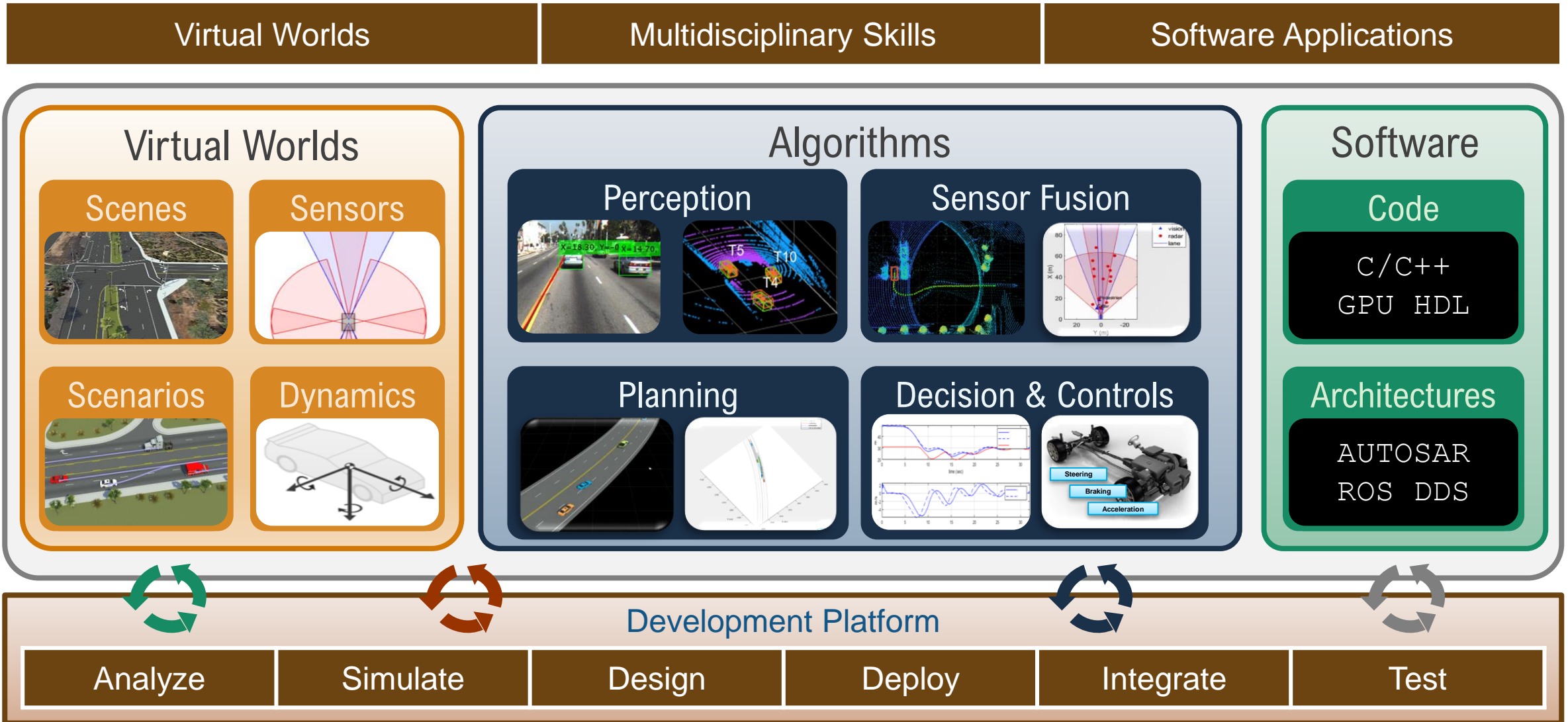


Decision & Controls



Virtual Validation of Automated Driving Applications

with MATLAB, Simulink, & RoadRunner



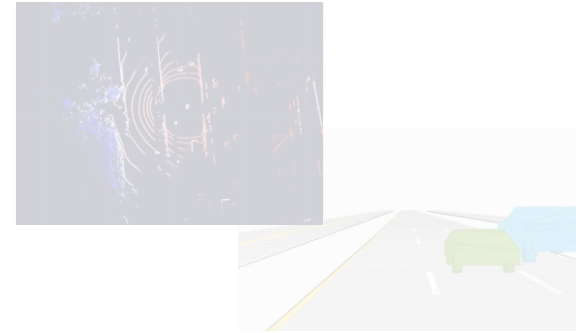
Today's Agenda

ENVIRONMENT MODELLING

Create Virtual Scenes and Scenarios

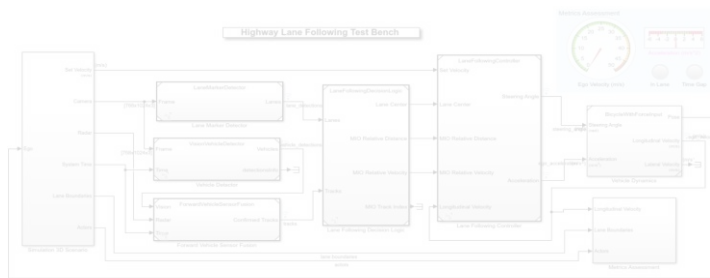


Recreating real world for virtual simulation



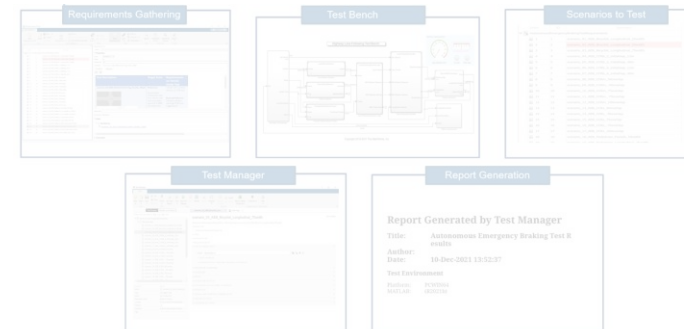
VIRTUAL VALIDATION

Open/ Close loop testing



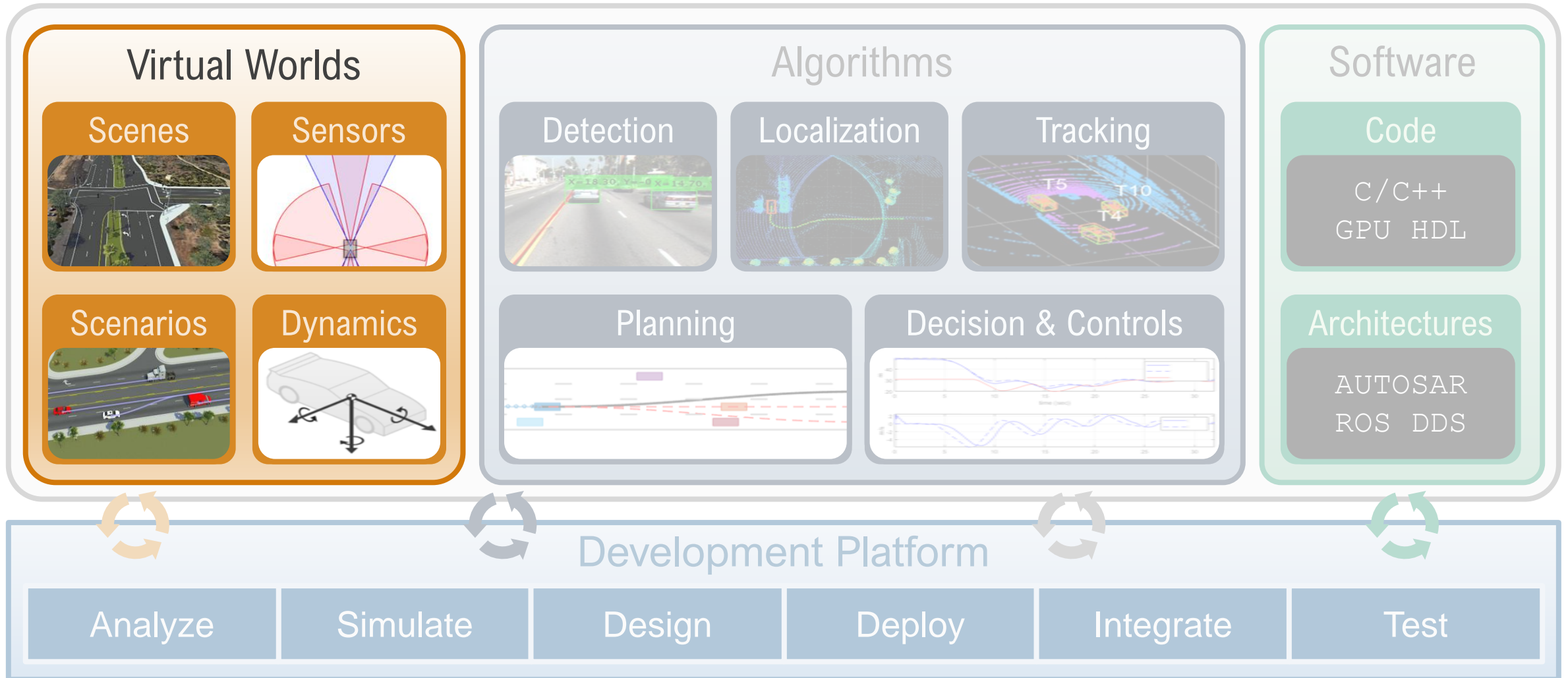
Copyright 2019-2021 The MathWorks, Inc.

Test Automation for AD/ADAS



Develop Automated Driving Applications

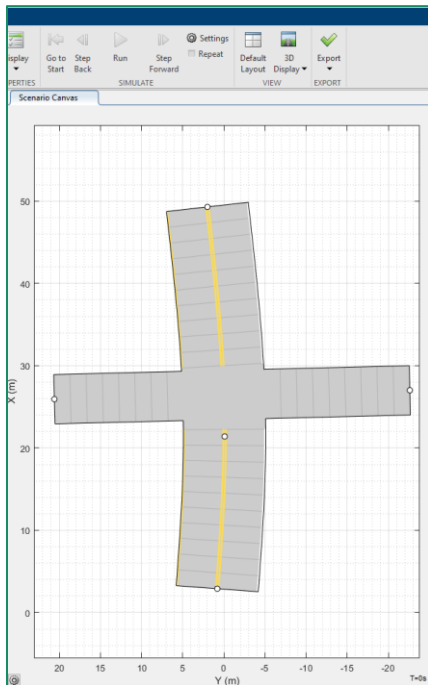
with MATLAB, Simulink, & RoadRunner



A Virtual world is made up of Scenes and Scenarios

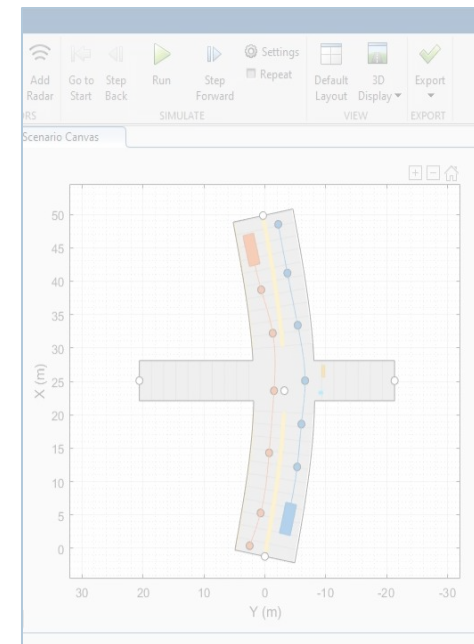
Scenes

- Static elements of the environment
- Roads, lanes, signs, traffic cones, etc.

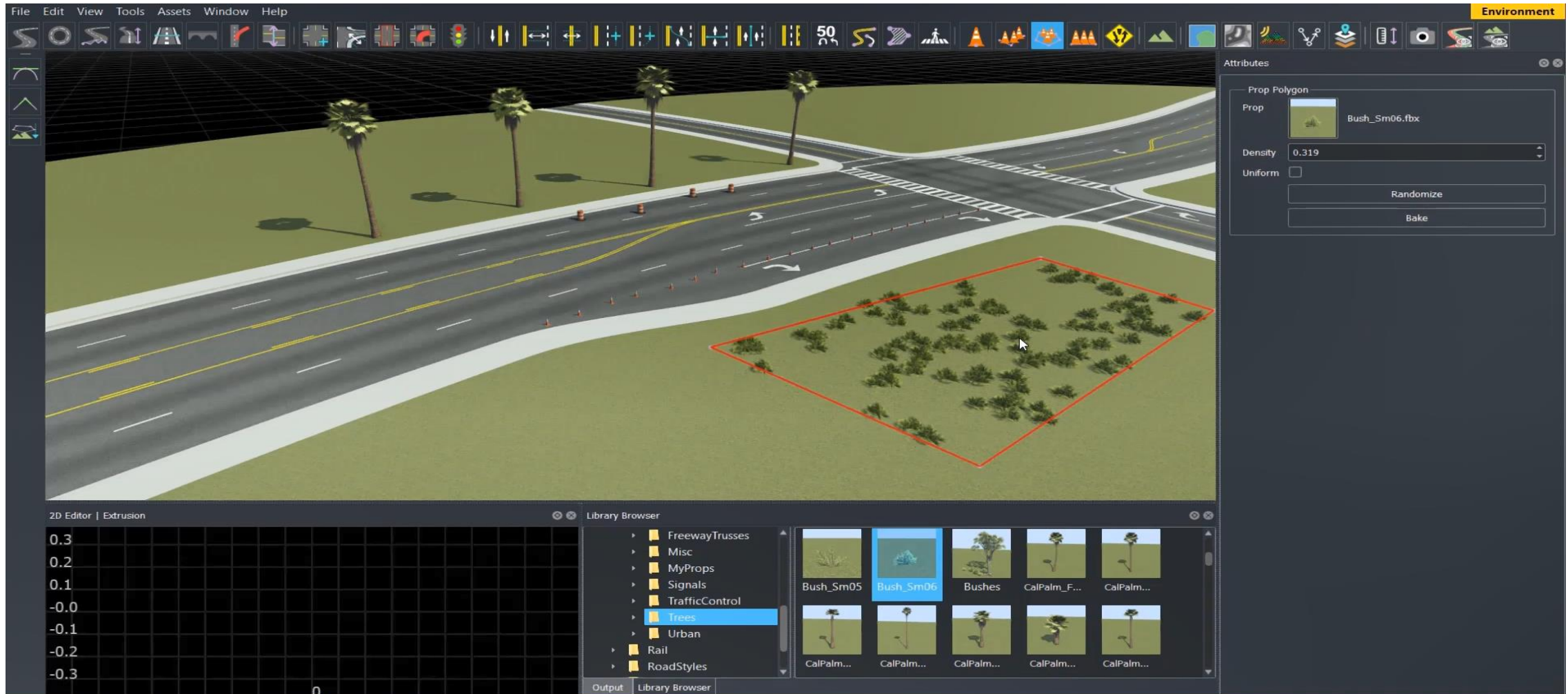


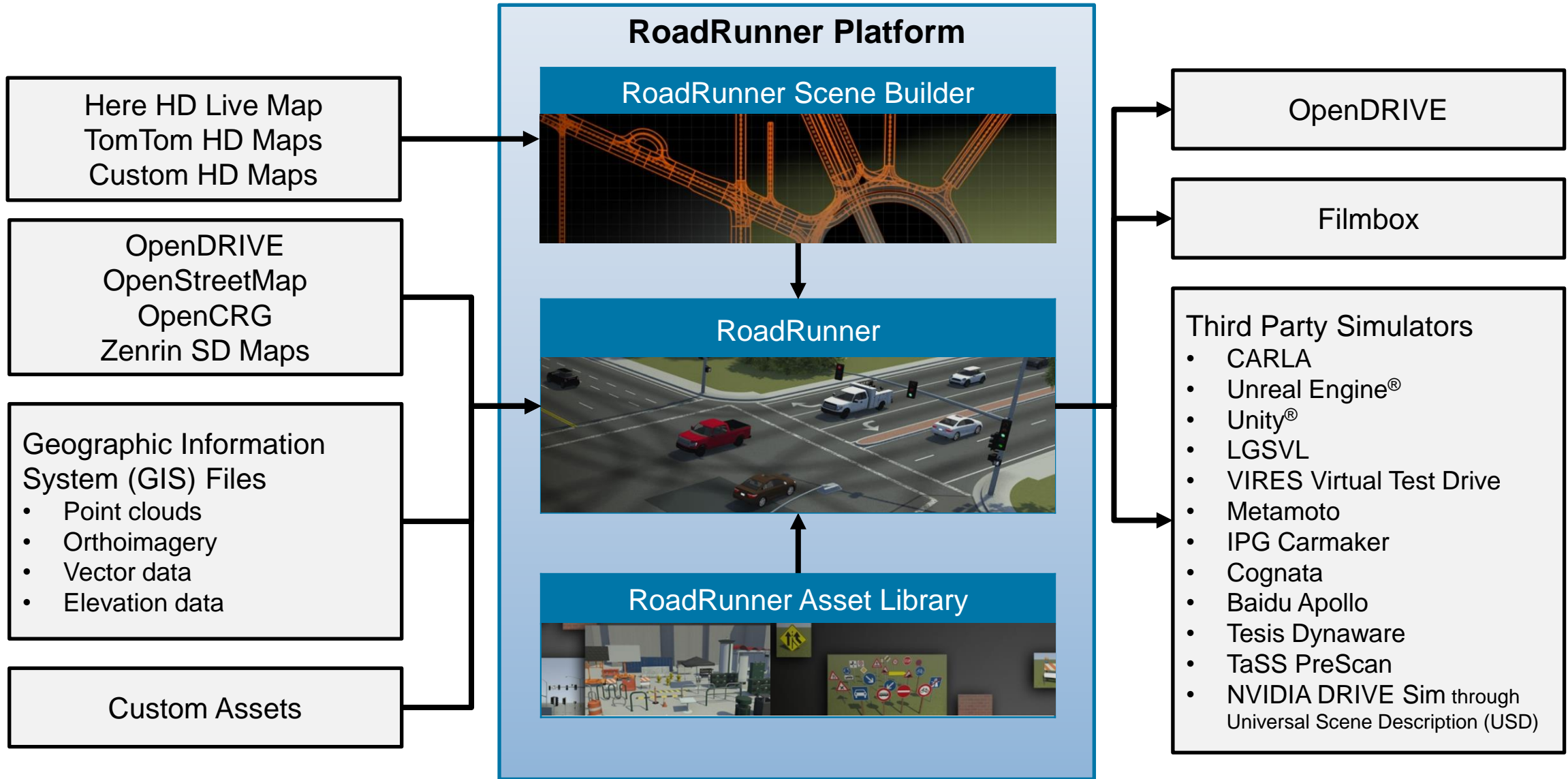
Scenarios

- Description of dynamic elements in driving simulation
- Vehicle trajectories, pedestrian/cyclist movement, traffic light changes, etc.



RoadRunner enables Engineers to create Scenes





Porsche and NVIDIA use RoadRunner

PORSCHE

1. PEVATeC Architecture & Tools

PEVATeC Simulation Environment

3D World + Controls

- Traffic
- Test Automation
- Scalable
- KPIs
- Middleware
- Re-Simulation/Play
- Data Processing

UNREAL ENGINE CARLA

Scene/Scenario Creation

OpenX Standards

OpenCRG OpenDRIVE
OpenSCENARIO OpenSceneGraph

Vehicle Dynamics SIL to HiL

MATLAB SIMULINK → as source code

↻

- ✗ PEVATeC is **NOT** a product
- ✗ PEVATeC is **NOT** a tool
- ✓ PEVATeC is a simulation environment that integrates the most suitable tools on project demand
- ✓ PEVATeC can be integrated in an ADAS simulation platform – flexible API

May 4-5 2021
 - 6 -
 PEVATeC @ MATLAB EXPO 2021
 Title Karoline Rupp (PEG-AB)
Porsche Engineering
 driving technologies

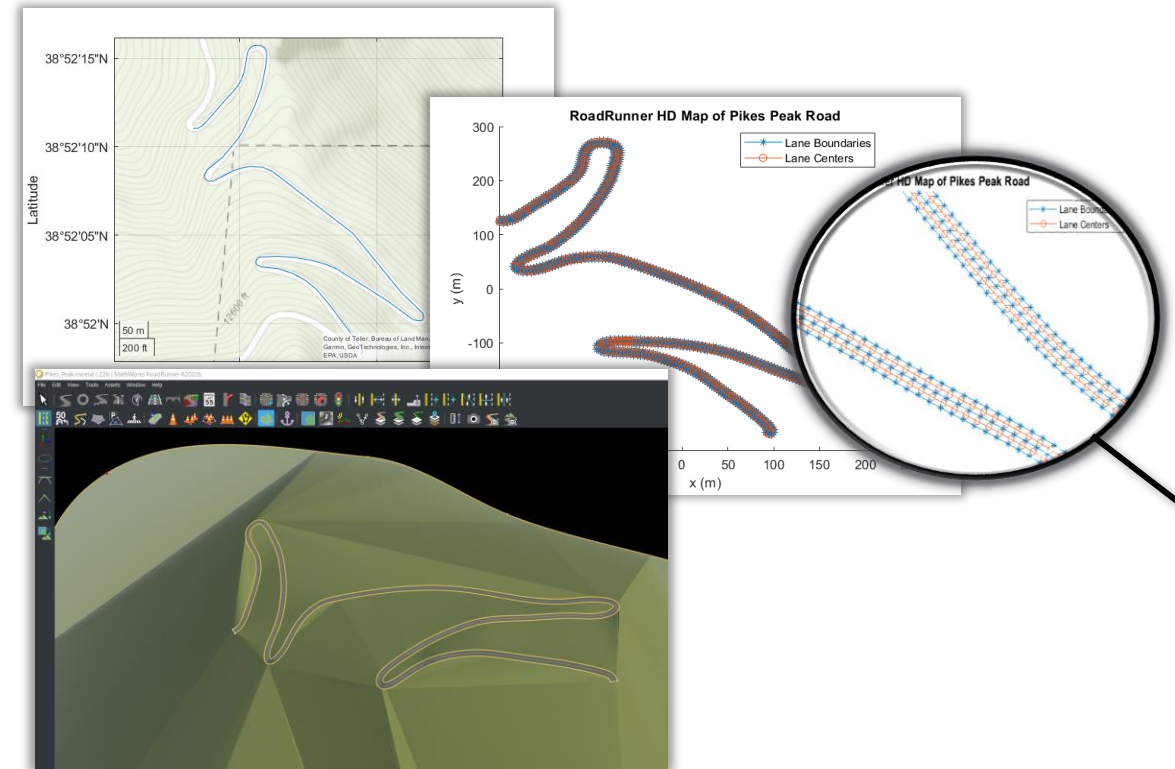
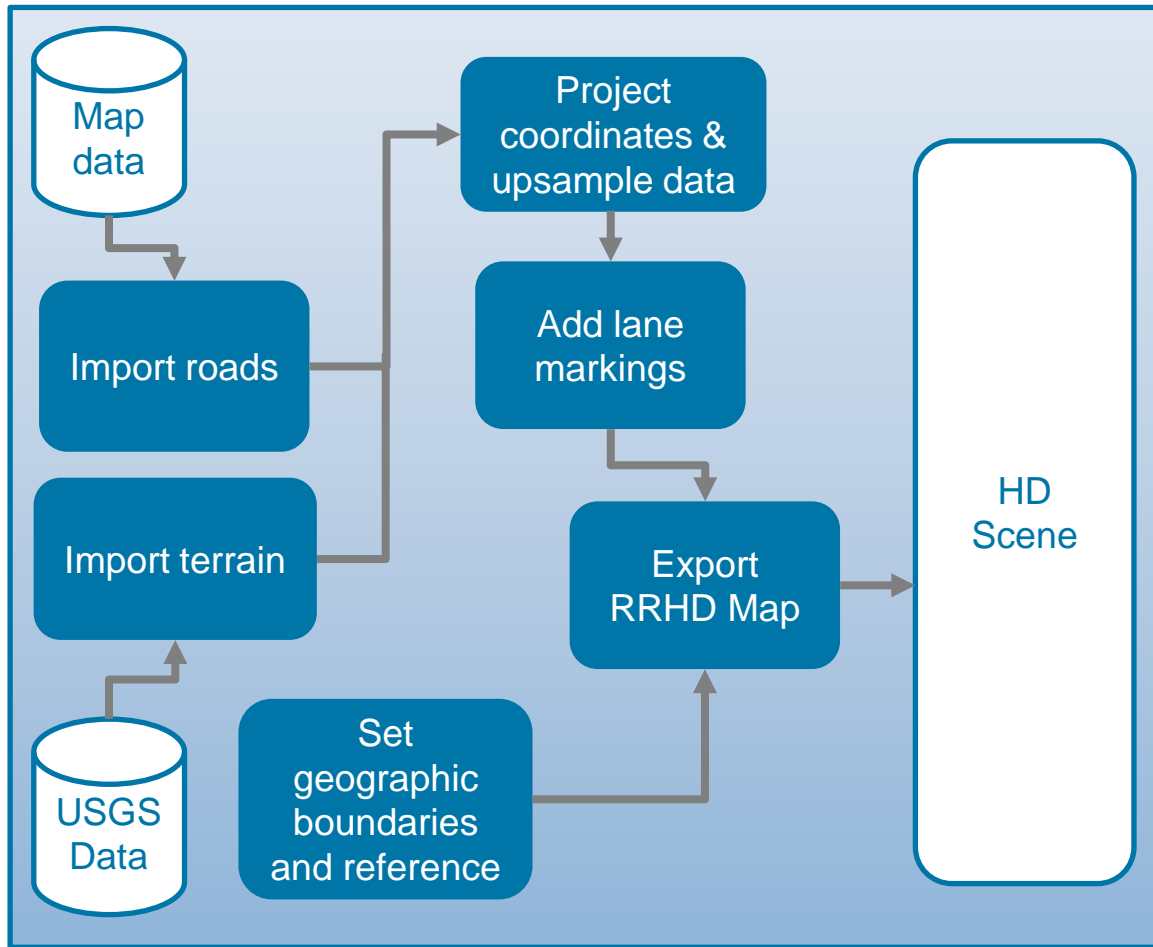
[NVIDIA: Connecting in the omniverse- The making of GTC Keynote \(Blog\)](#)



[PORSCHE: ADAS/AD virtual platform for end-to-end software development, testing and validation](#)

[CARLA: Roadrunner recommended software to create scenes](#)

Programmatically create RoadRunner HD Map from real world map data



- Import map and elevation data into MATLAB
- Upsample data and create RoadRunner HD Map
- Import into RoadRunner

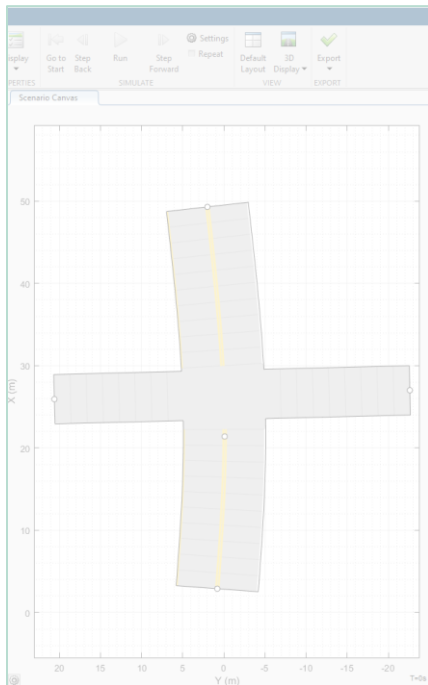
[Build Pikes Peak RoadRunner 3D Scene](#)

Automated Driving Toolbox, Mapping Toolbox

A Virtual world is made up of Scenes and Scenarios

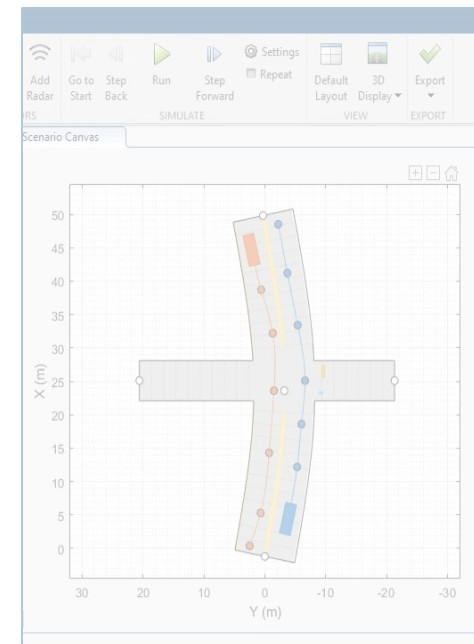
Scenes

- Static elements of the environment
- Roads, lanes, signs, traffic cones, etc.



Scenarios

- Description of dynamic elements in driving simulation
- Vehicle trajectories, pedestrian/cyclist movement, traffic light changes, etc.



Interactively design scenarios with RoadRunner Scenario

- Add various vehicles
- Author trajectories
- Specify actions and logic
- Parameterize variations

SpeedBump Actions.rsscenario | 22a Project | MathWorks RoadRunner R2022a

File Edit View Tools Assets Window Help

Simulation

Simulation Controls

Pause Step Forward Stop

Time: 1.640 s

Enable Pacing to Slow Down Simulation

Slower 0.05x 1x 20x Faster

Simulation Properties

Step Size: 0.02000 s Max Time: 1000.000

Camera

Camera View: Follow

Actor: Car

Distance: 5.000

Height: 3.000

Variables

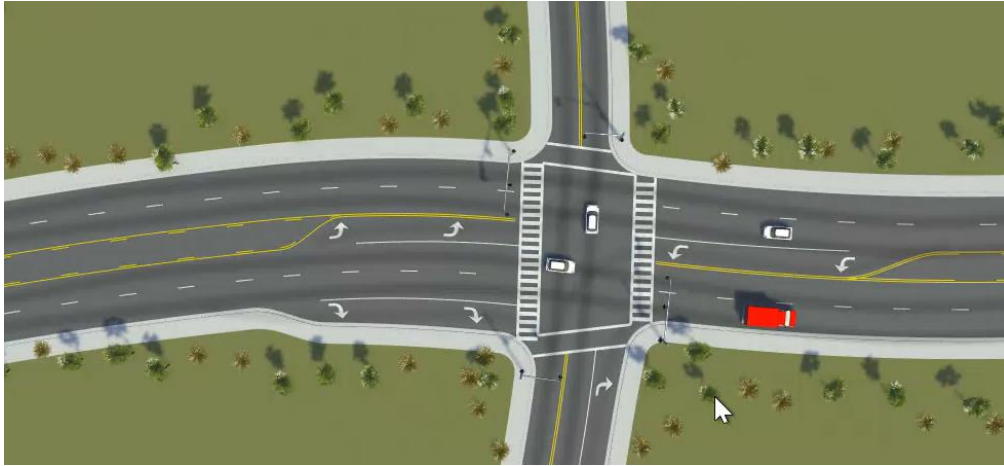
Name	
1 Hatchback_InitialSpeed	14
2 Car_NumLanesToChange	2
3 Car_LaneChangeDirection	LeftOf
4 Car_DistanceBehindSpeedBump	-17.98385

Simulation Tool

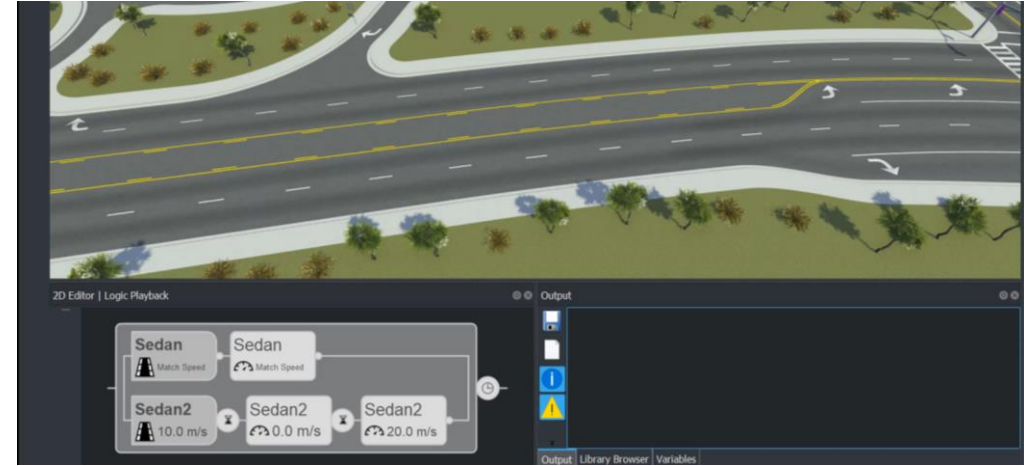
[Scenario Edit Tool](#)
RoadRunner Scenario

Simulate map-aware paths and scenario logic

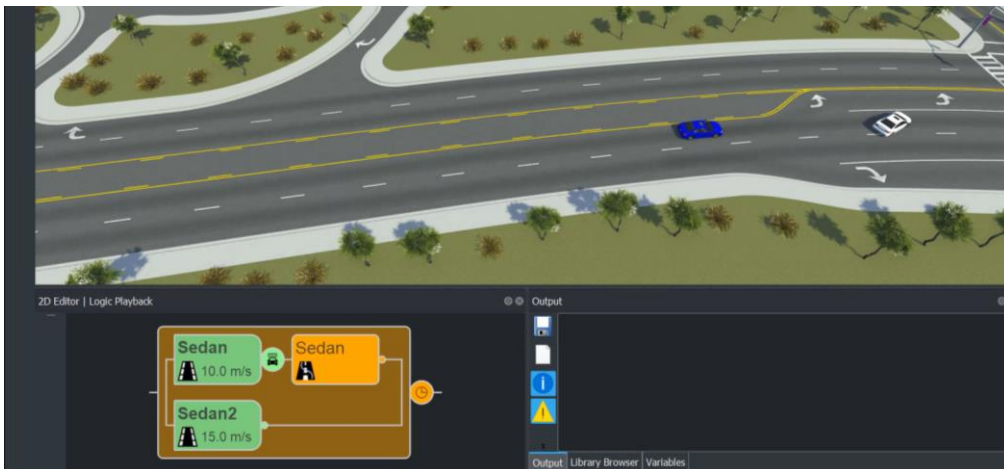
Follow lanes when no path is specified



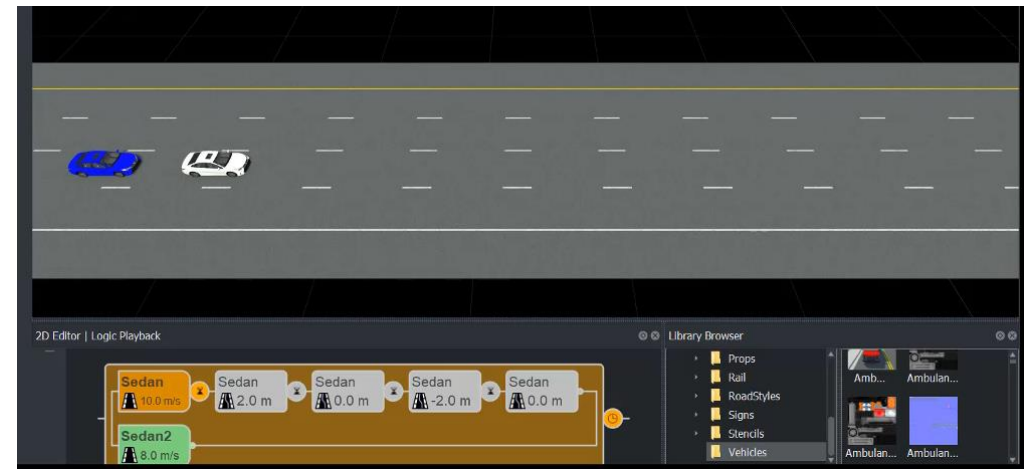
Speed actions



Lane change actions



Lateral offset actions



Create complicated scenarios accurately

- Cubic interpolation
- Clothoid interpolation
- EuroNCAP
(clothoid-arc-clothoid)

NCAP_example.rsscenario | Project_Beta10 | MathWorks RoadRunner R2022a

Attributes

Route Parameters

Name: CompactCar Route

Lane Change Distance: 20.000 m

Route Segment Parameters

Freeform:

Curve Type: Clothoid Spline

Preferred Arc Radius: 9.00 m

Computed Arc Radius: 9.00 m

Total Turn Angle: 90.00°

Clothoid Proportion: 45%

Circular Arc Angle: 48.76°

Clothoid Angle: 20.62°

Scenario Edit Tool | Right click to create new routes or insert nodes into existing routes.

Scenario Edit Tool | Right click to create new routes or insert nodes into existing routes.

Test speed	Part 1 (clothoid)			Part 2 (constant radius)			Part 3 (clothoid)		
	Start Radius R1 [m]	End Radius R2 [m]	Angle α [deg]	Start Radius R2 [m]	End Radius R2 [m]	Angle β [deg]	Start Radius R2 [m]	End Radius R1 [m]	Angle α [deg]
10 km/h to Farside	1500	9.00	20.62	9.00	9.00	48.76	9.00	1500	20.62
15 km/h to Farside	1500	11.75	20.93	11.75	11.75	48.14	11.75	1500	20.93
20 km/h to Farside	1500	14.75	21.79	14.75	14.75	46.42	14.75	1500	21.79
10 km/h to Nearside	1500	8.00	22.85	8.00	8.00	44.30	8.00	1500	22.85

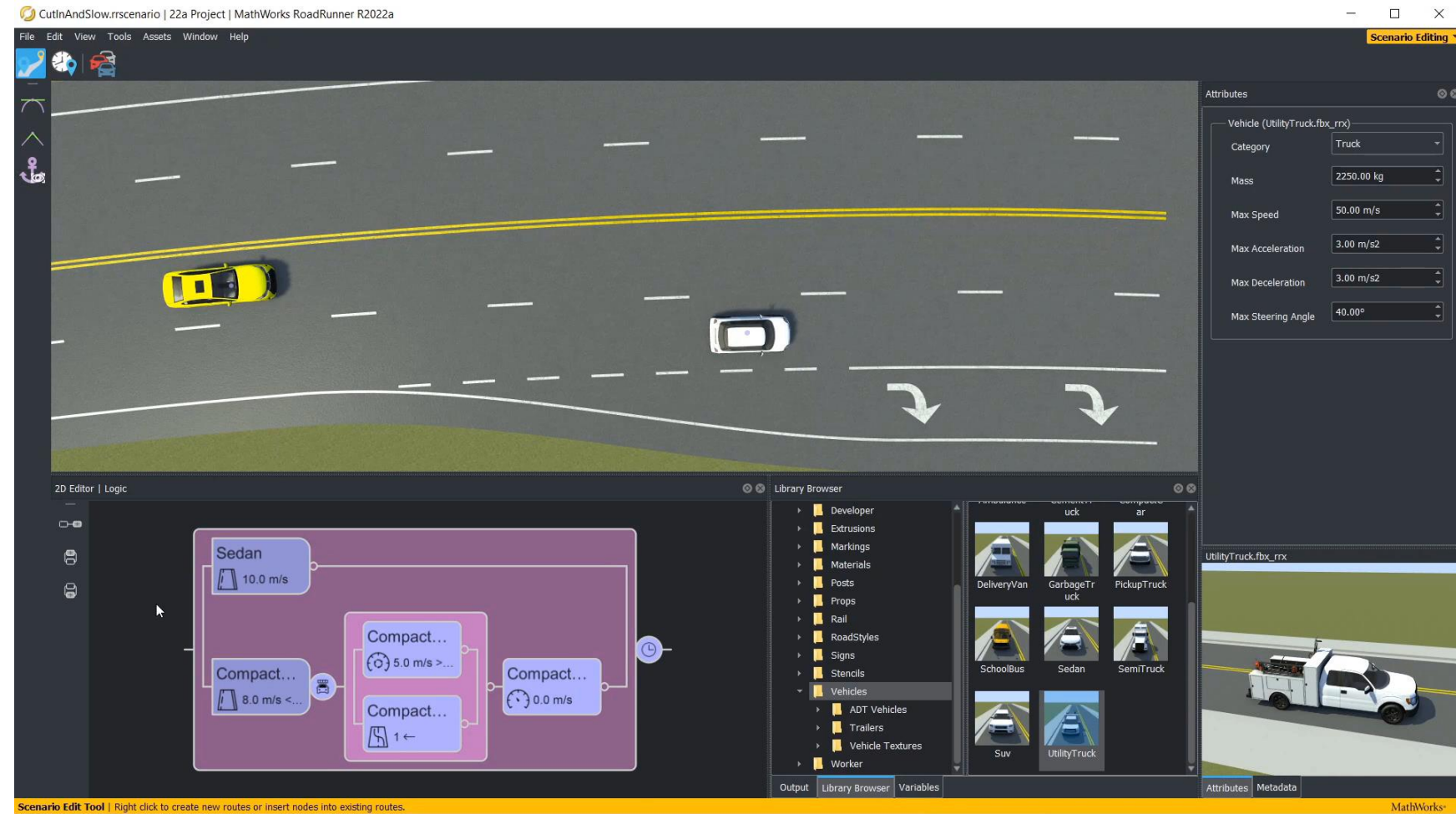
[Route Timing Tool](#)
RoadRunner Scenario

R2022a

Programmatically vary scenario parameters

MATLAB, gRPC, and Command-line APIs

- Define scenario variables in editor
- Set variables programmatically from API
- Run simulations
- Export to OpenSCENARIO

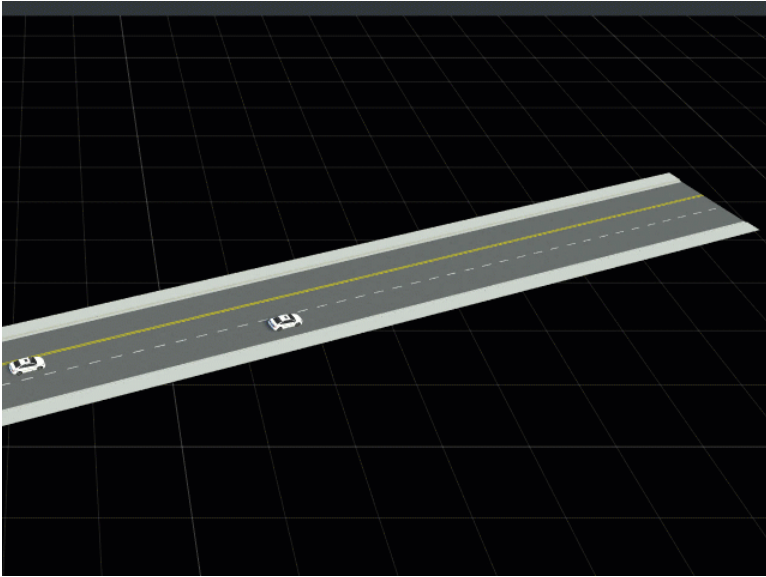


[Programmatic Scenario Interfaces](#)

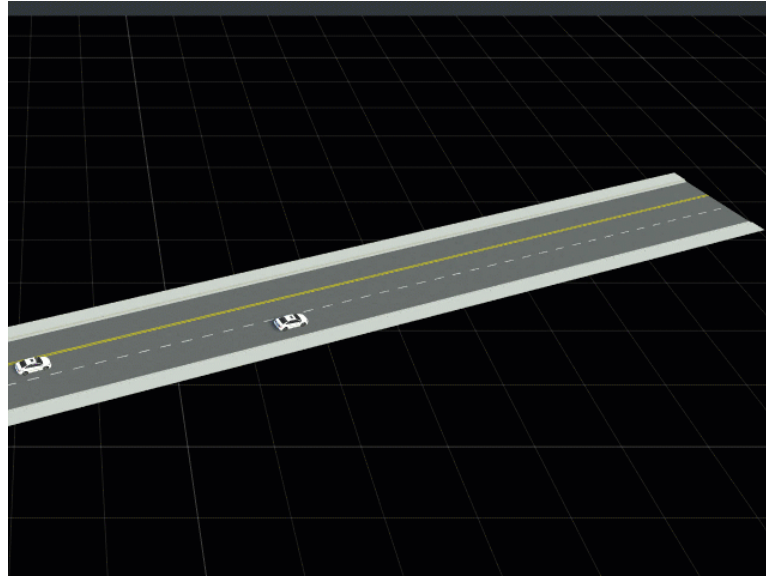
RoadRunner Scenario

R2022a

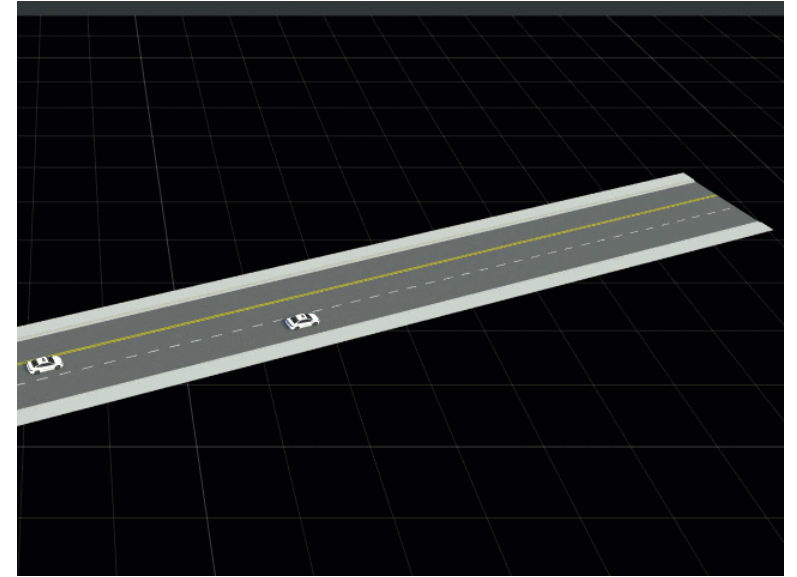
Adjusting Scenario Variables with MATLAB Programs



```
rrApp = roadrunner(rrProj);  
rrApp.setScenarioVariable('Threshold','5');
```

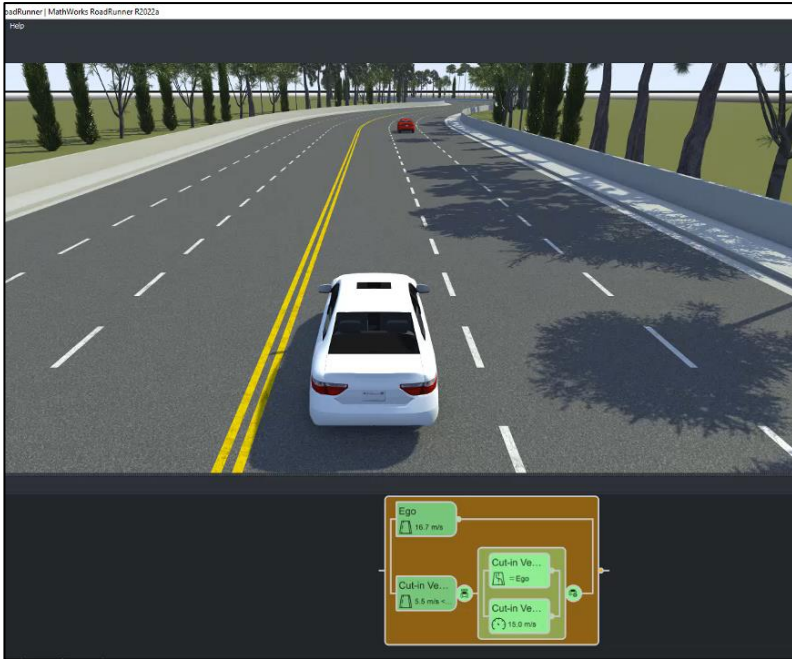


```
rrApp = roadrunner(rrProj);  
rrApp.setScenarioVariable('Threshold','15');
```



```
rrApp = roadrunner(rrProj);  
rrApp.setScenarioVariable('Threshold','25');
```

Export scenarios to OpenSCENARIO V1.x and V2.0

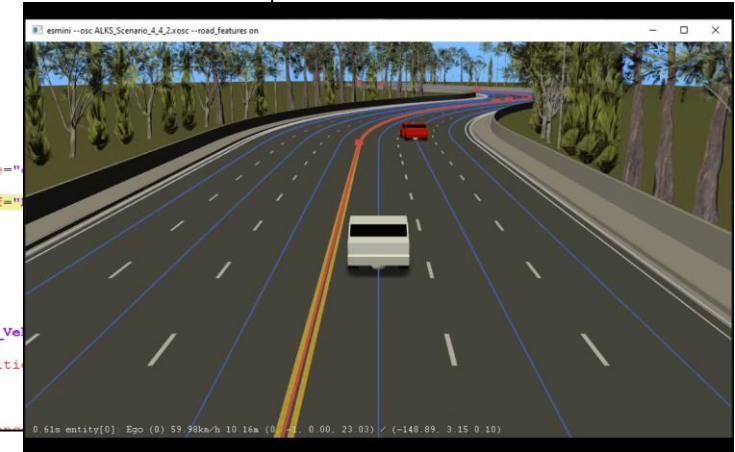


OpenSCENARIO
V1.x

```

<Condition name="Start Condition of Event_Vehicle2" conditionEdge="none"
  <ByValueCondition>
    <SimulationTimeCondition value="0" rule="greaterThan"/>
  </ByValueCondition>
</Condition>
</ConditionGroup>
</StartTrigger>
</Event>
<Event name="Event_Vehicle2_2" priority="overwrite">
  <Action name="Speed_Action_Vehicle2_2">
    <LongitudinalAction>
      <SpeedAction>
        <SpeedActionDynamics dynamicsShape="
        <SpeedActionTarget>
          <RelativeTargetSpeed entityRef="
        </SpeedActionTarget>
        </SpeedAction>
      </LongitudinalAction>
    </PrivateAction>
  </Action>
  <StartTrigger>
    <ConditionGroup>
      <Condition name="Start Condition of Event_Ve
        <ByEntityCondition>
          <TriggeringEntities triggeringEntiti
            <EntityRef entityRef="Ego"/>
          </TriggeringEntities>
          <EntityCondition>
            <SpeedRelativeCondition value="
  </ConditionGroup>
  </StartTrigger>
  </Event>

```



<https://github.com/esmini/esmini>

OpenSCENARIO
V2.0

```

81 do parallel:
82   ego.drive() with:
83     along(sedan__route)
84     speed(16.66mps, at: start)
85   serial:
86     cut-in_vehicle.drive() with:
87       along(sedan2__route)
88       speed(5.5mps, slow)
89       until (cut-in_v
90   parallel:
91     cut-in_vehicle.
92     cut-in_vehicle.
93     speed(15mps,
94   with:
95     until (ego.time
96

```

MathWorks is an ASAM Member and actively participates in the **OpenSCENARIO 2.0 Implementers Forum**

[Export to ASAM OpenSCENARIO](#)
RoadRunner Scenario

R2022a

RoadRunner Scenario's simulation engine enables simulation with agents in multiple simulators

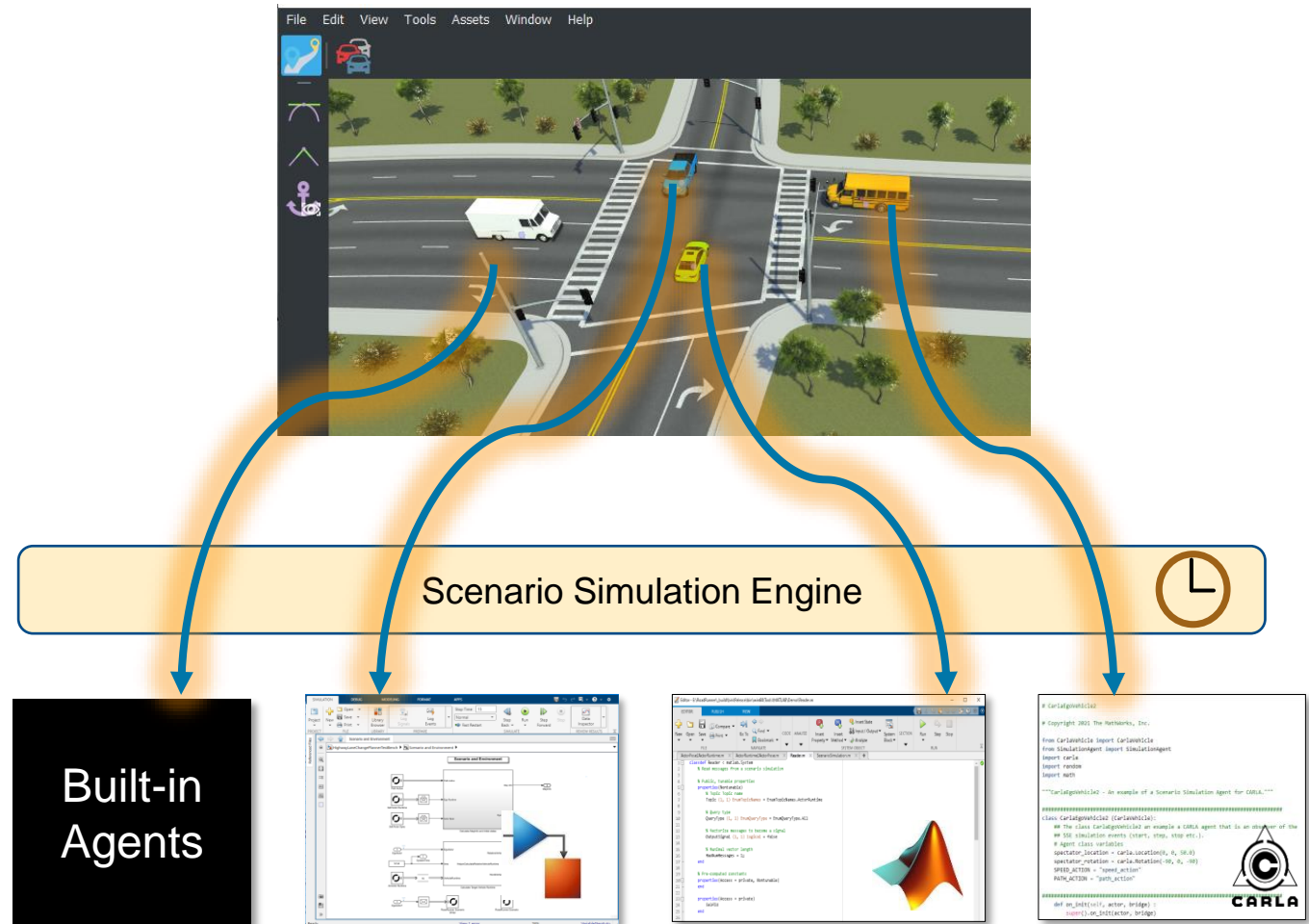
RoadRunner Scenario connects Agents in MATLAB, Simulink, and CARLA through a Scenario Simulation Engine (SSE)

Agents write scenario states

- Their pose and velocity for each scenario simulation step

Agents can read scenario states

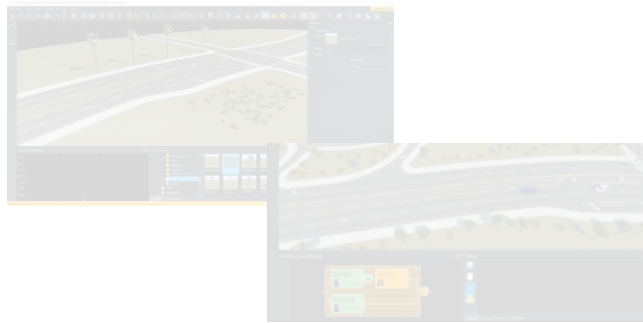
- Action commands (path, speed, lane change, lateral offset)
- Pose and velocity of all actors in the scenario
- Dimensions of all actors
- Map lanes and lane boundaries



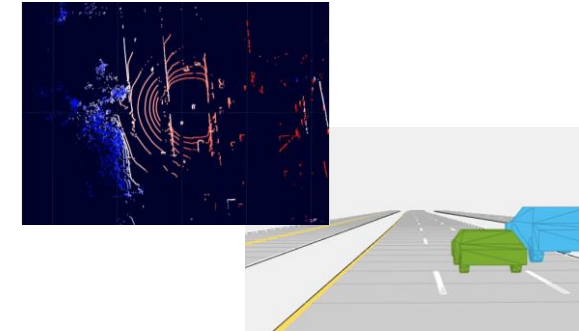
Today's Agenda

ENVIRONMENT MODELLING

Create Virtual Scenes and Scenarios

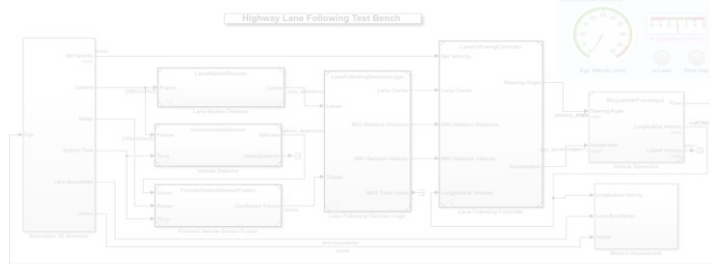


Recreating real world for virtual simulation



VIRTUAL VALIDATION

Testing highway lane following application



Copyright 2019-2021 The MathWorks, Inc.

Setting up Test Automation framework for

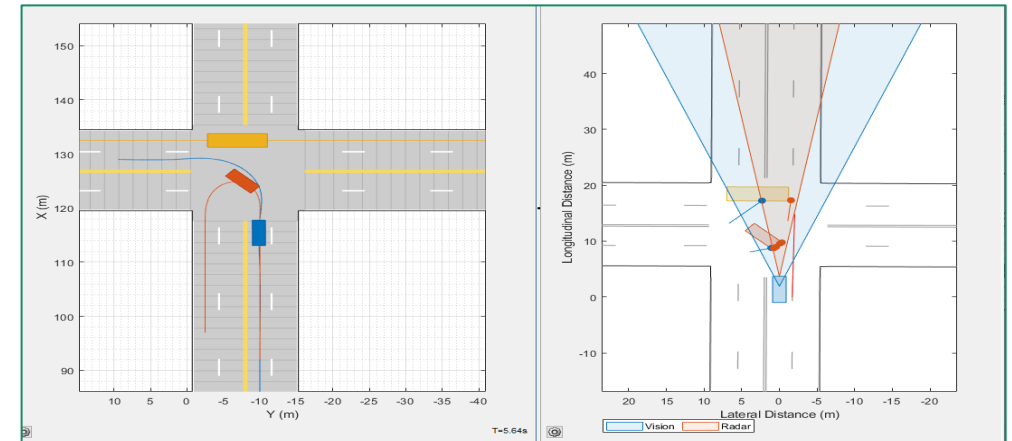


Design Scenes for Simulating Virtual Worlds

3D



Cuboid



Use Case

- Controls, Sensor Fusion, Planning, *Perception*

Scene Authoring Tool

- RoadRunner

Use Case

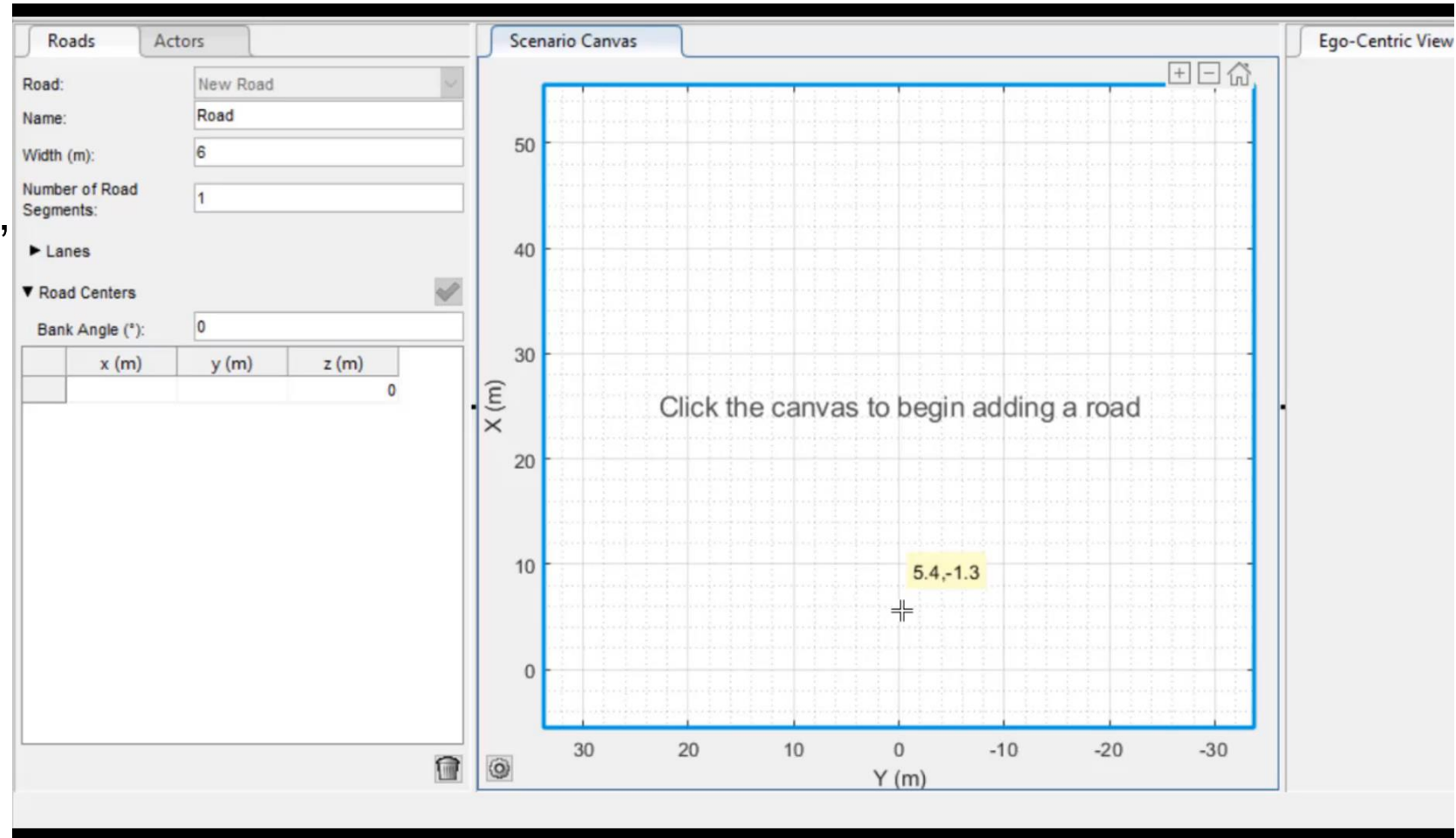
- Controls, Sensor Fusion, Planning

Scene Authoring Tools

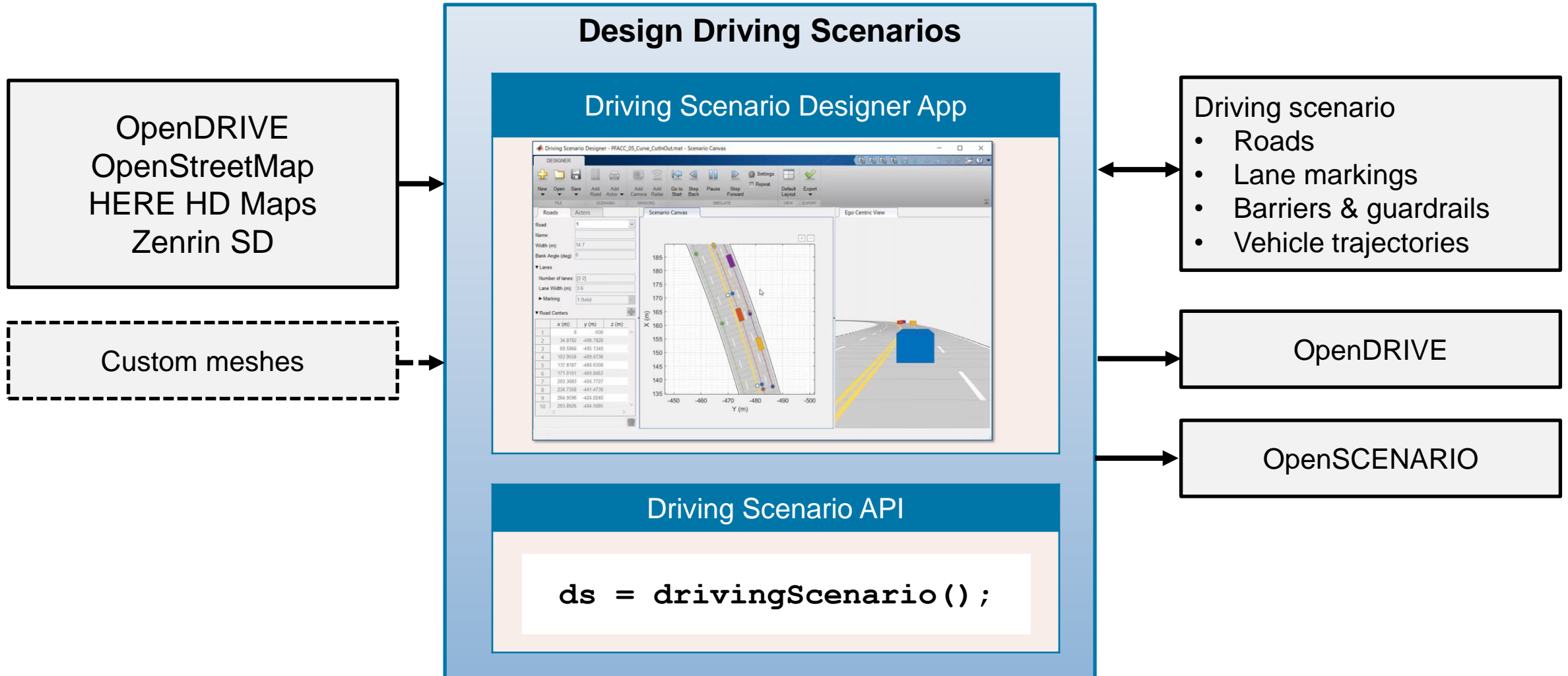
- Driving Scenario Designer
- Programmatic API (drivingScenario)

Driving Scenario Designer and API (MATLAB)

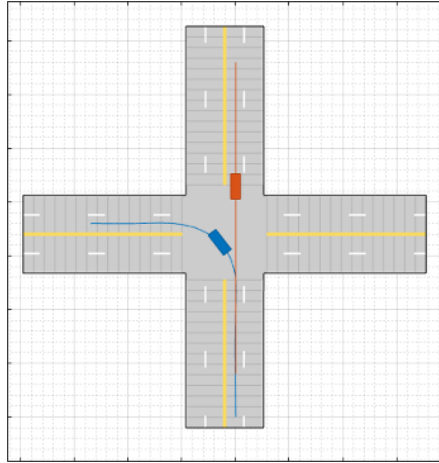
1. Create a new driving scenario
 - Add roads, lanes, vehicles, trajectories, pedestrians, sensors
2. Generate synthetic detections
 - Bird's eye plot
 - Run Scenario
 - Export scenario to MATLAB/Simulink



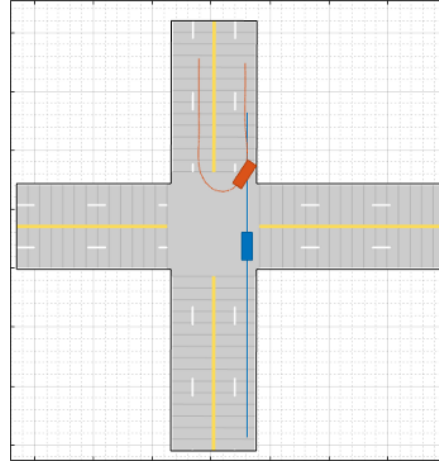
Design scenes and scenarios for automated driving



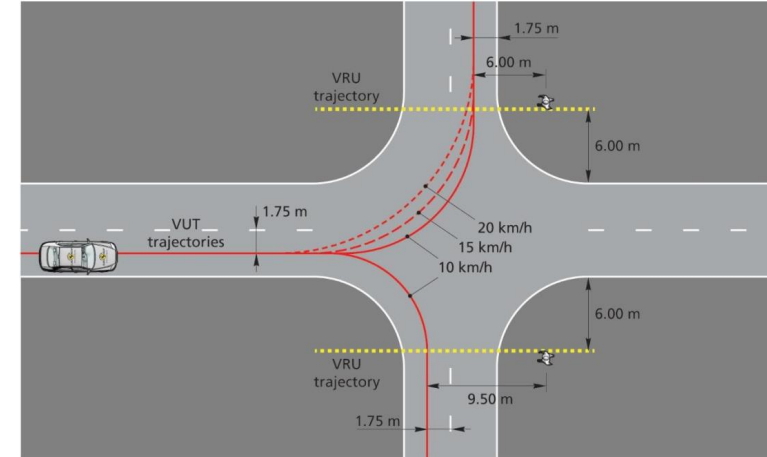
Pre-Build Scenarios Available



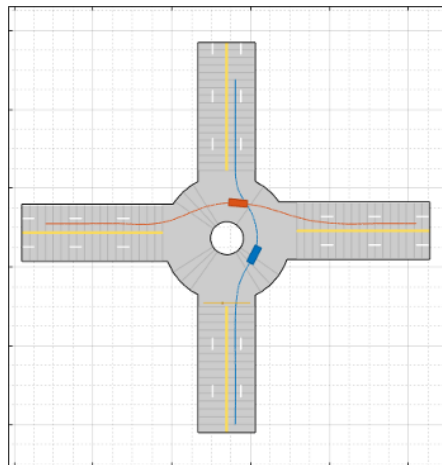
Turns



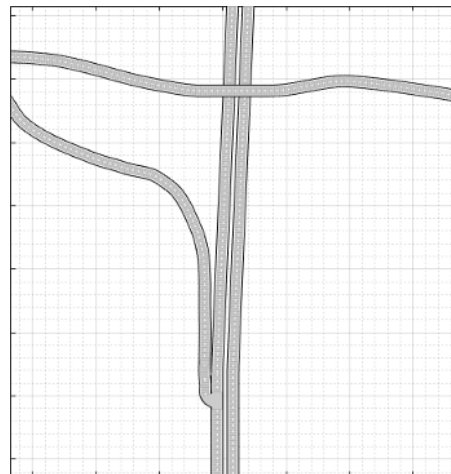
U-Turns



Euro NCAP



Intersections



Cuboid replicas of 3D simulation scenes

Migrate paths from Driving Scenario Designer (DSD) to RoadRunner Scenario

Introduction

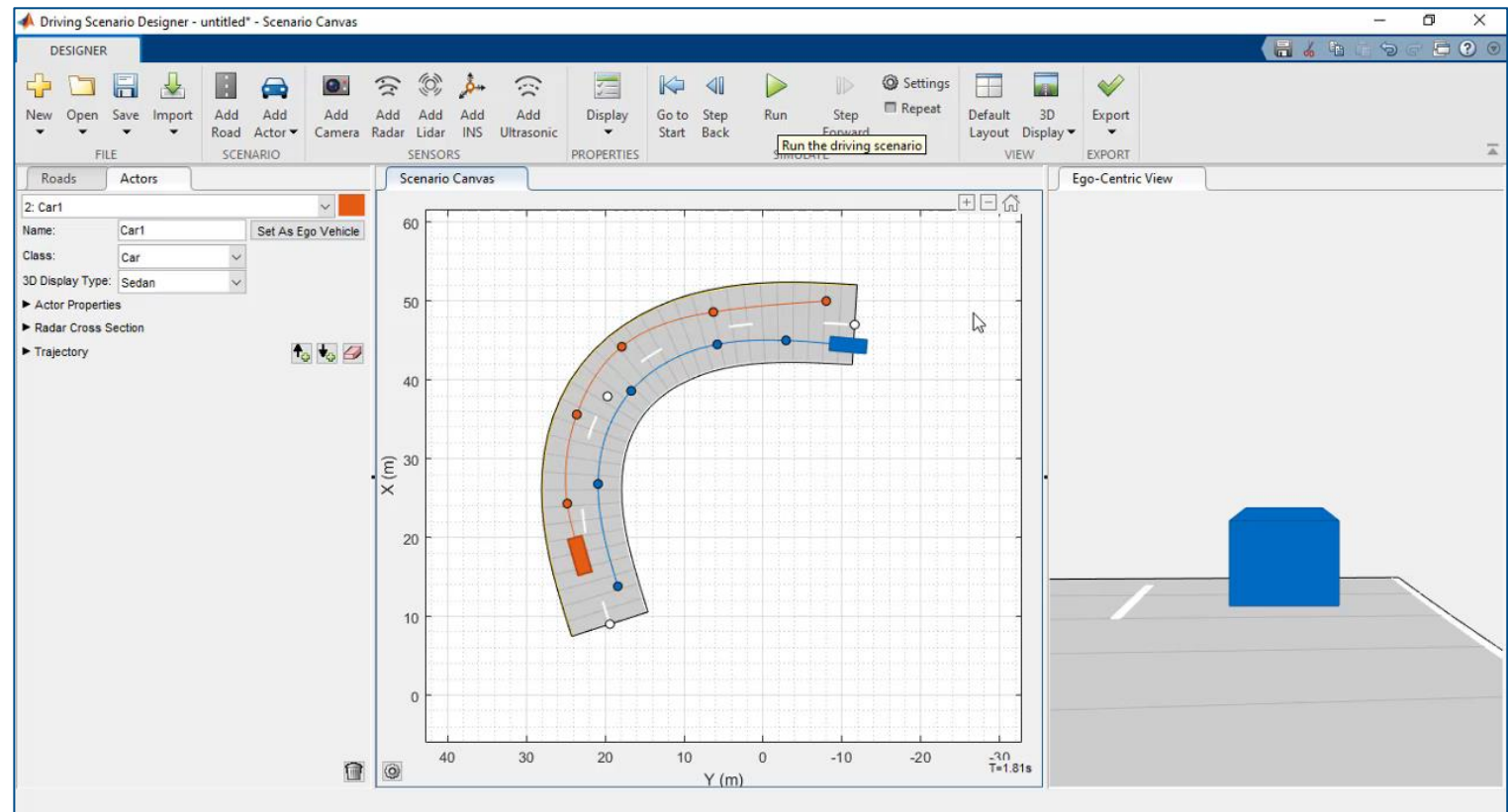
Design trajectories in DSD

Export OpenSCENARIO from DSD

Import OpenSCENARIO to RoadRunner Scenario

Edit trajectories in RoadRunner Scenario

RoadRunner Scenario can import paths and initial velocities from OpenSCENARIO 1.0 files. You can leverage this to migrate paths designed in Driving Scenario Designer into RoadRunner Scenario.



Simulating real world environment for virtual testing in ADAS

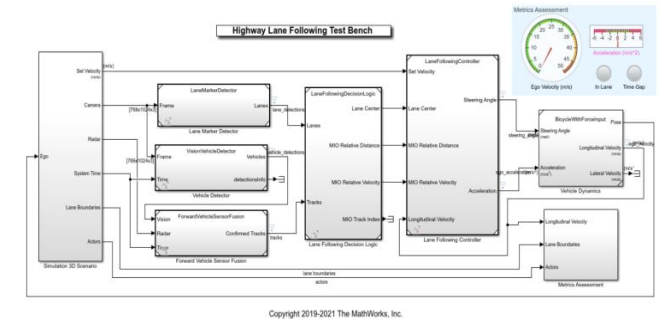
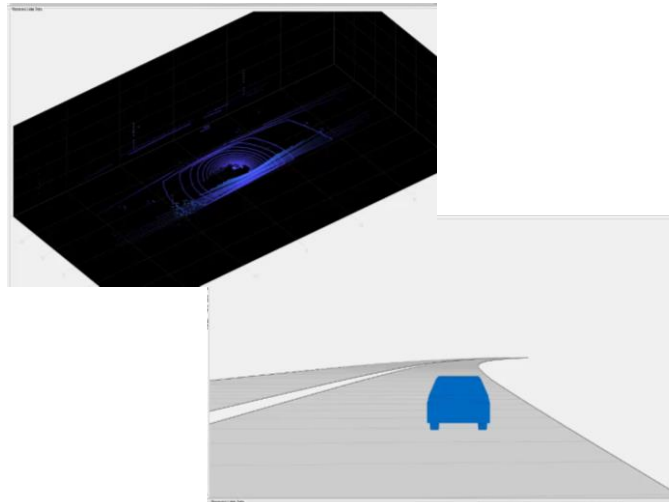
Vehicle sensor data collection



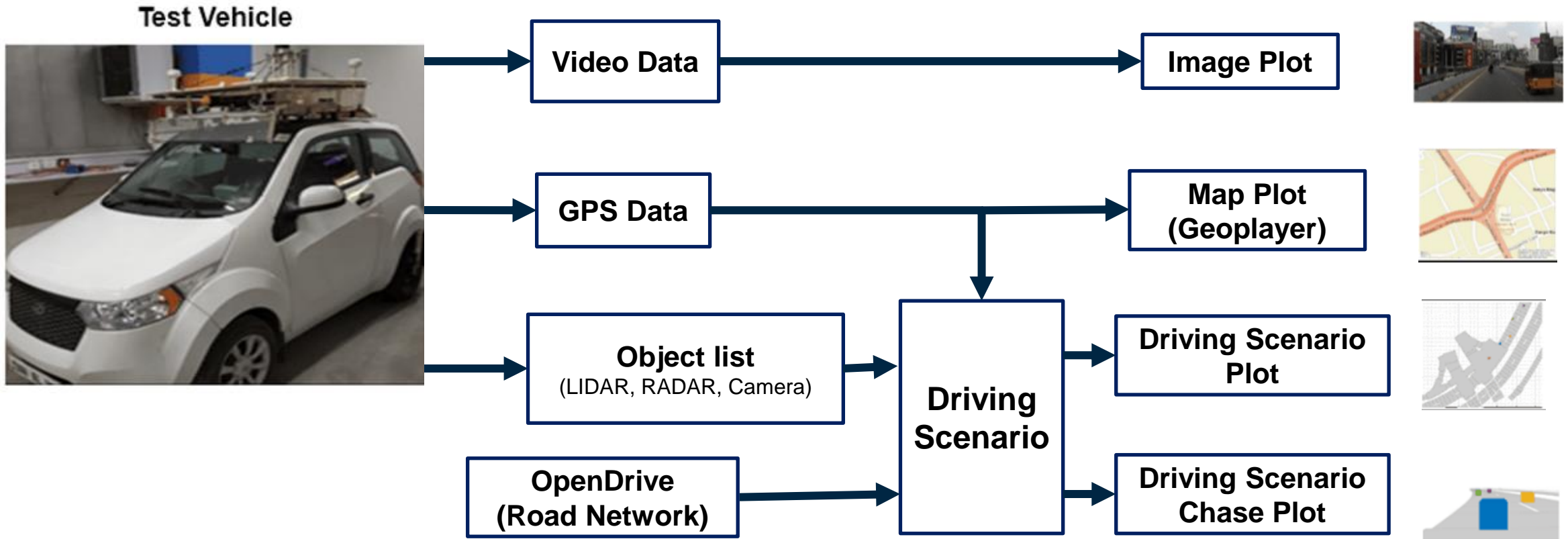
Recreating real world in simulation



Virtual testing for ADAS

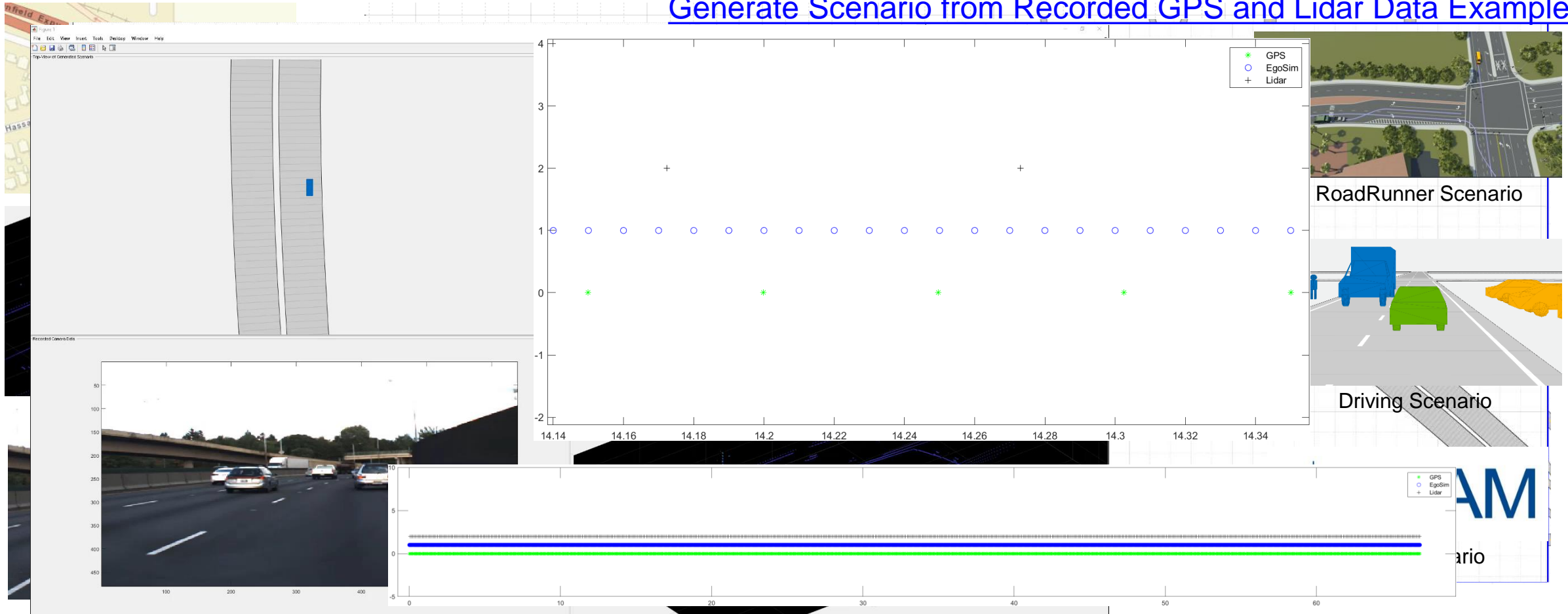


Creating scenario from real world sensor data



Creating scenario from real world sensor data

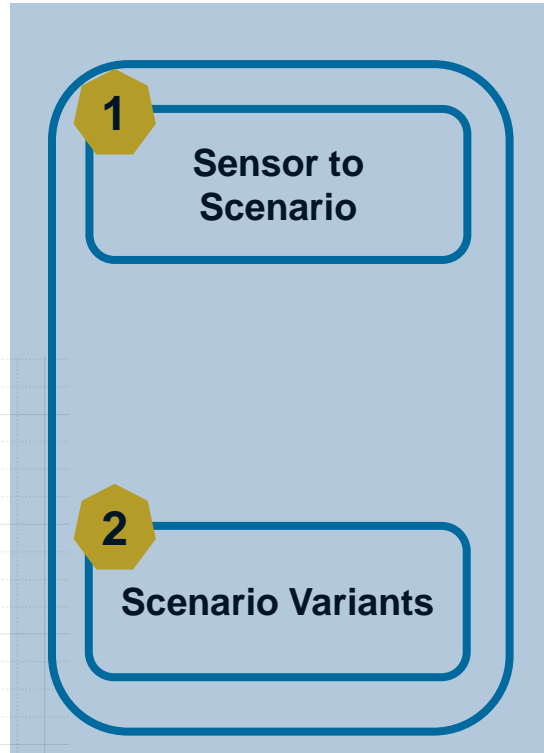
Generate Lane Information from Recorded Data Example Generate Scenario from Recorded GPS and Lidar Data Example



Recorded time stamped data

SCENARIO VARIANT GENERATION- can generate many scenarios from the scenario

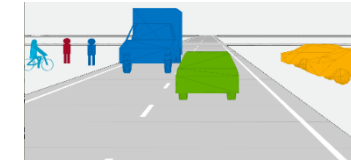
Recorded time stamped data



Generate Scenario



RoadRunner Scenario

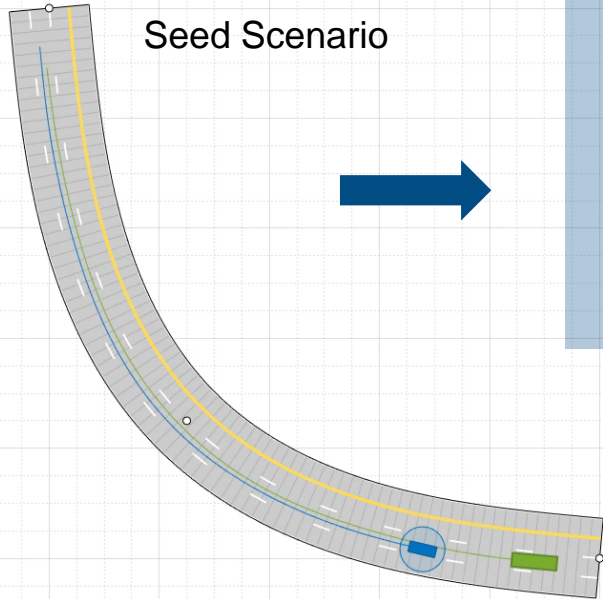


DS Scenario



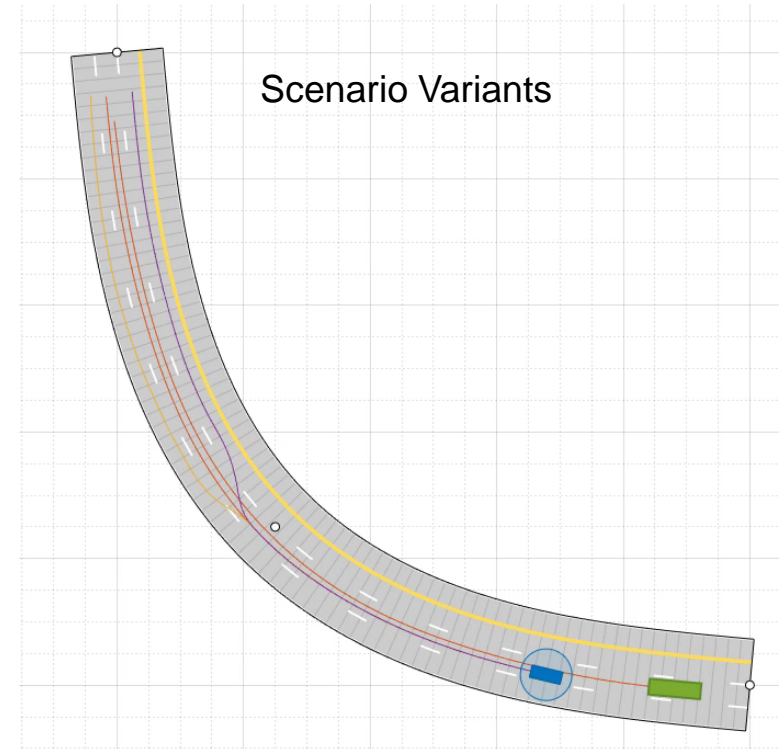
Open Scenario

Seed Scenario



Generate Variants

Scenario Variants



Learn about generating scenes and scenarios from recorded sensor data

Featured Examples

<p>Generate Scenario from Actor Tracklist and GPS Data Generate ASAM OpenSCENARIO® v1.0 file using recorded actor tracklist and GPS data.</p> <p>Open Live Script</p>	<p>Generate RoadRunner Scenario from Recorded Sensor Data Generate RoadRunner Scenario from recorded GPS data and preprocessed actor track list.</p> <p>Open Live Script</p>	<p>Generate RoadRunner HD Scene from Recorded Lidar Data Generate RoadRunner HD map from recorded lidar data using pretrained deep learning model.</p> <p>Open Live Script</p>	<p>Generate High Definition Scene from Lane Detections Generate HD road scene using recorded lane detections, GPS data, and OpenStreetMap® data.</p> <p>Open Live Script</p>	<p>Extract Lane Information from Recorded Camera Data for Scene Generation Extract lane information from raw camera data to generate ASAM OpenDRIVE® scene or RoadRunner scene.</p> <p>Open Live Script</p>
<p>Extract Vehicle Tracklist from Recorded Lidar Data for Scenario Generation Extract actor track list from recorded lidar data using pretrained vehicle detection model and JPDA tracker.</p> <p>Open Live Script</p>	<p>Extract Vehicle Tracklist from Recorded Camera Data for Scenario Generation... Extract actor track list from raw camera data for scenario generation.</p> <p>Open Live Script</p>	<p>Improve Ego Vehicle Localization Improve ego vehicle localization by fusing GPS and IMU sensor data and generate virtual driving scenario from recorded sensor data.</p> <p>Open Live Script</p>	<p>Smooth GPS Waypoints for Ego Localization Create jitter-limited ego trajectory by smoothing GPS and IMU sensor data.</p> <p>Open Live Script</p>	<p>Preprocess Lane Detections for Scenario Generation Format lane detection data to update lane specifications for scenario generation.</p> <p>Open Live Script</p>

- ✓ Actor Tracklist
- ✓ Lane Detections
- ✓ GPS, IMU
- ✓ Camera
- ✓ Lidar

- ✓ ASAM OpenDRIVE & OpenSCENARIO
- ✓ RoadRunner Scene & Scenario
- ✓ drivingScenario

Parameters fueling scenario variant generation



<https://wiki.unece.org/download/attachments/78741915/VMAD-02-05%20Japan.pptx>

- Actor Parameters
 - Speed, waypoint, yaw
 - Actor dimension and type
 - Other properties
 - Driving behavior
 - Aggressive / Safe

- Event Parameters
 - Collision
 - Driving manoeuvres
 - Lead, Follow, Lane keep, Lane change, Overtake, Merge, Exit
 - Road object interaction

- Scene Parameters
 - Road Network
 - Lane marking
 - Roadside details
 - Traffic density
 - Lighting or Weather
 - Sensor coverage

EURO NCAP – Parameter table

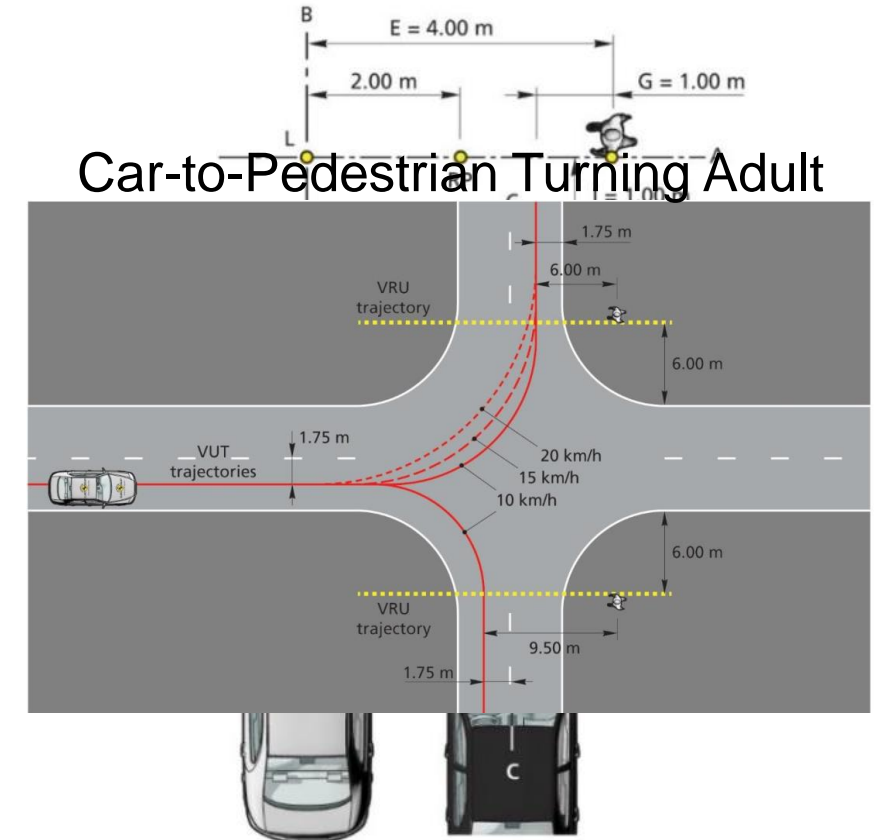
Simulation is becoming important for homologation

AEB Pedestrian	CPFA	CPNA	CPNC	CPTA		CPRA		CPLA	
Type of test	AEB			AEB		AEB		AEB	FCW
VUT speed [km/h]	10-60			10,15,20	10	4,8		20-60	50-80
VUT direction	Forward			Farside turn	Nearside turn	Rearward		Forward	Forward
Target speed [km/h]	8	5		5		0	5	5	5
Impact location [%]	50	25,75	50	50		25,50,75	50	50	25
Lighting condition	Day	Day/Night	Day	Day		Day		Day/Night	
Vehicle lights (night)		Low beam						High beam	
Streetlights (night)		Streetlights						No streetlights	

AEB Bicyclist	CBNA		CBFA	CBLA	
Type of test	AEB		AEB	AEB	FCW
VUT speed [km/h]	10-60		10-60	25-60	50-80
VUT direction	Forward		Forward	Forward	Forward
Obstruction	No	Yes	No	No	No
Target speed [km/h]	15	10	20	15	20
Impact location [%]	50		50	50	25
Lighting condition	Day		Day	Day	

Car-to-Pedestrian Nearside Child

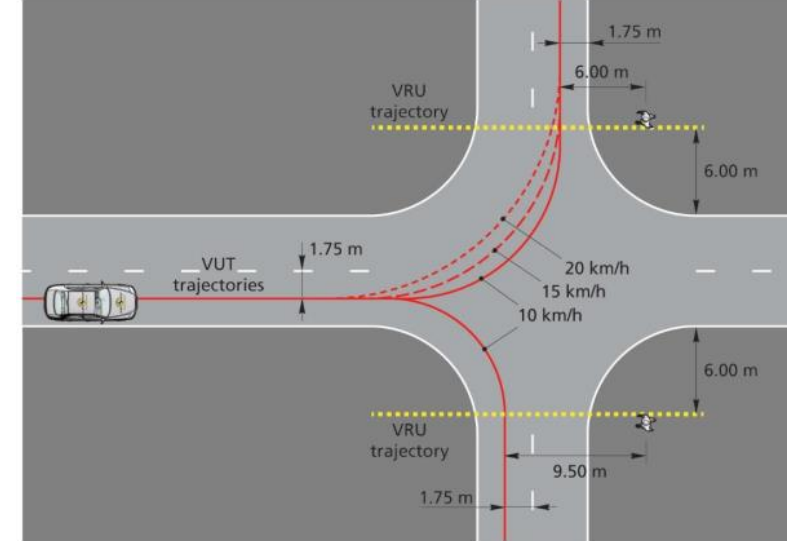
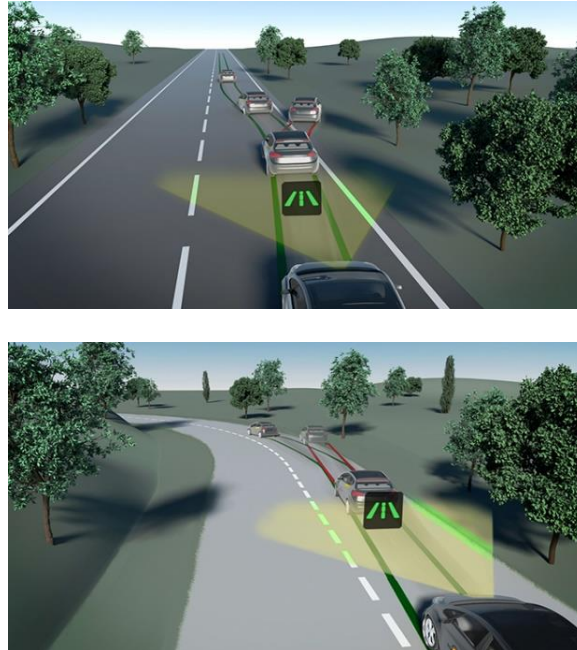
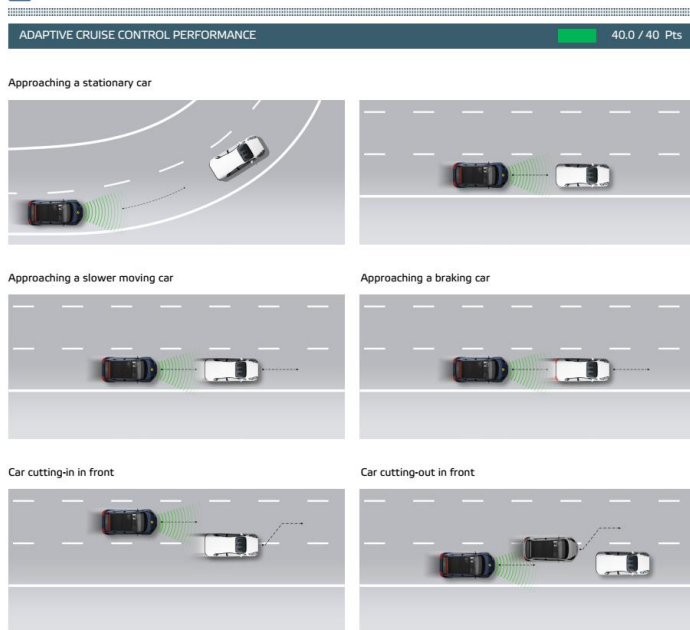
Car-to-Pedestrian Turning Adult



Scenario Variants support many AD Workflows

	Variation parameters ->	Actor					Event				Scene			Perception		
Test Scenario Categories	Workflow v	Speed	Dimension	Waypoint	Acceleration /breaking	Driving behavior	Collision	Driving maneuvers	Rerouting	Translocate	Road	Roadside Articles	Count of actors	Lighting	Weather	Sensor types
Crash	Adaptive Cruise Control	✓	✓	✓	✓		✓				✓					✓
	AEB test on straight roads	✓	✓		✓		✓				✓	✓		✓		
	AEB test on turns	✓	✓	✓	✓		✓				✓	✓		✓		
Other ADAS	Lane Keep Assist	✓		✓							✓					
	Lane change, Overtaking	✓		✓				✓	✓		✓					
	Traffic Jam Assist	✓	✓	✓		✓	✓	✓	✓		✓		✓			
	Parking helper L1/L2	✓	✓	✓												✓
Sensor	Sensor coverage	✓	✓	✓	✓			✓	✓	✓	✓		✓		✓	✓
	Object detection	✓	✓	✓	✓			✓				✓	✓		✓	✓
	V2X test	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓		✓
AD stack	Urban, rural, highway	✓		✓	✓	✓	✓	✓			✓	✓		✓	✓	
	Auto parking valet	✓	✓	✓												✓
	Increase traffic density	✓	✓	✓		✓		✓	✓				✓			
	Complete self driving	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Euro NCAP driven Portfolio to test scenarios for ACC LKA AEB



Variant parameters for testing ACC

- Ego speed
- Non-ego Trajectory (cut-in)
- Road Variation

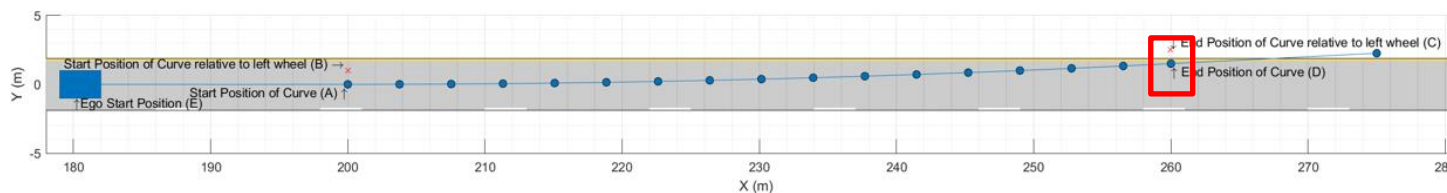
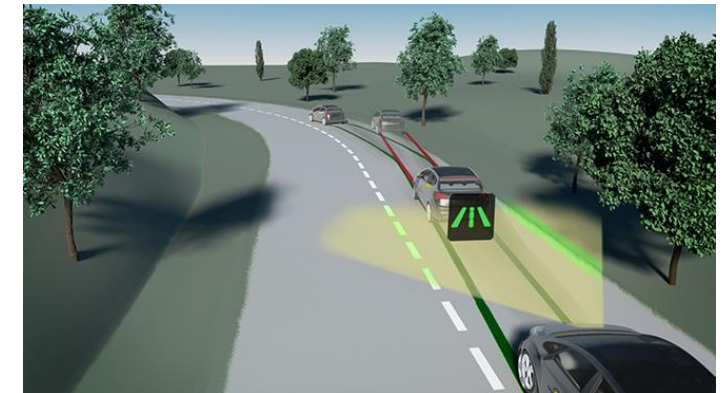
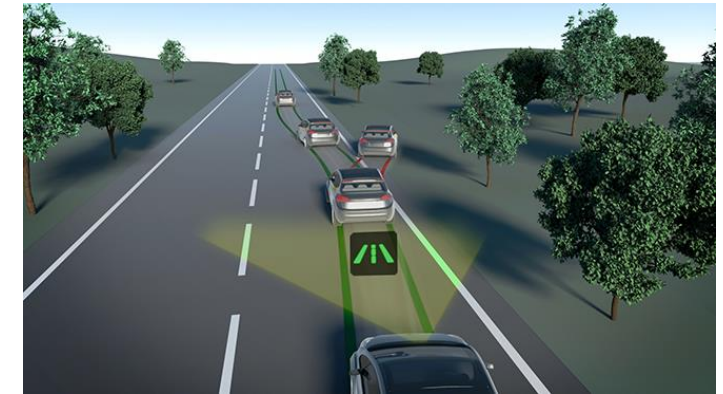
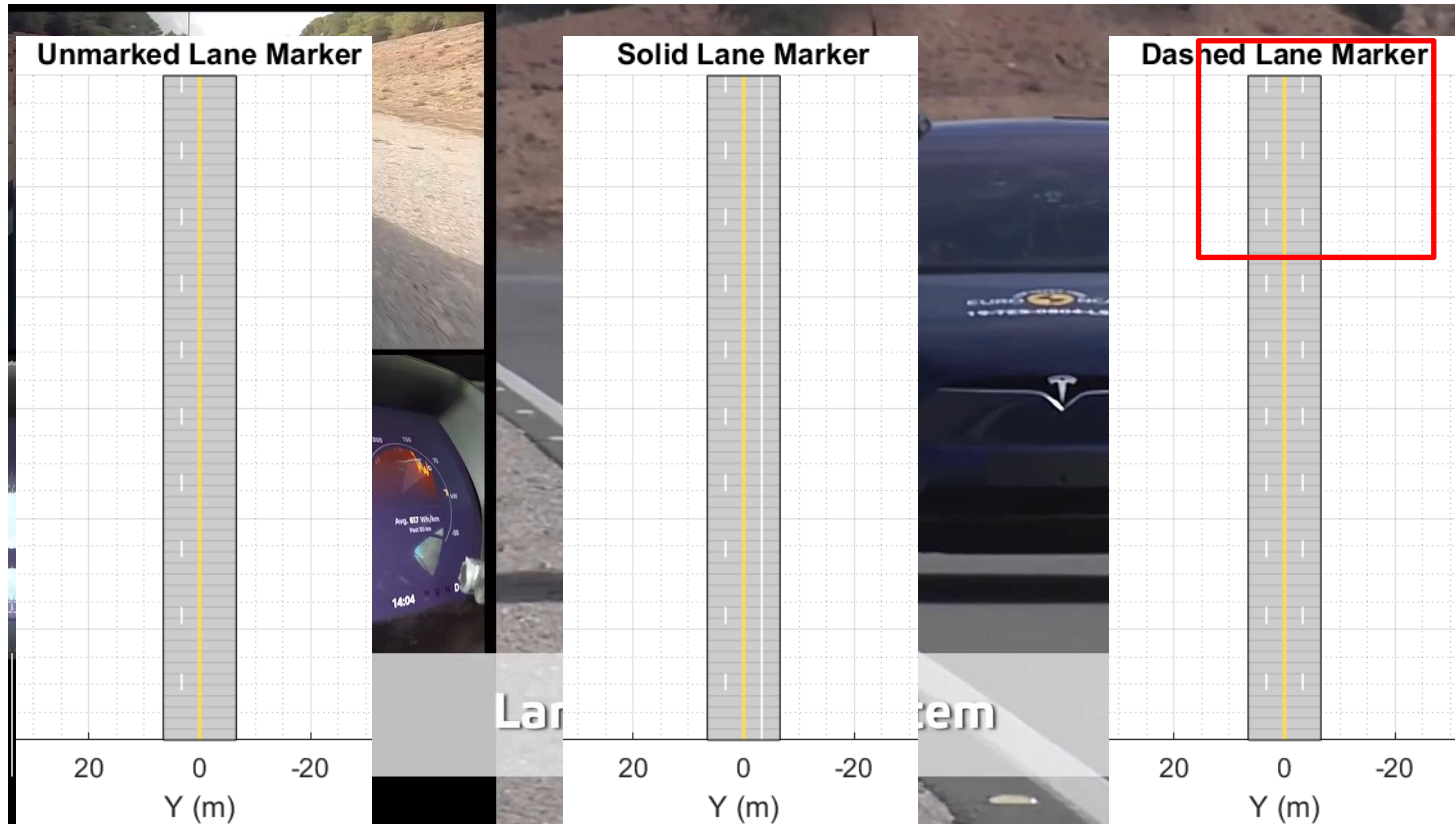
Variant parameters for testing LKA

- Ego speed
- Target Trajectory
- Road Variation

Variant parameters for testing AEB

- Ego speed variation
- Ego trajectory variation on turns
- Actor dimension variation
- Impact location variation

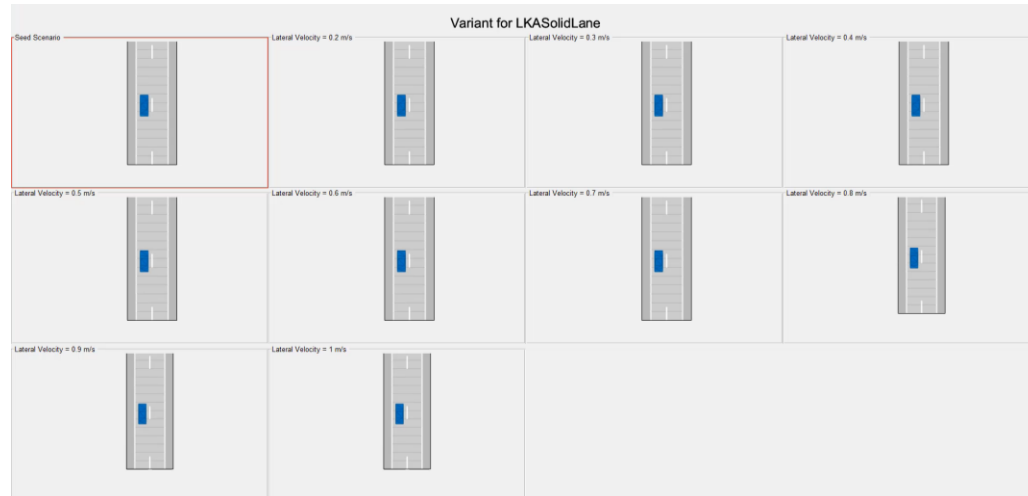
Test scenario variant generation for LKA



Parameters for LKA Variants

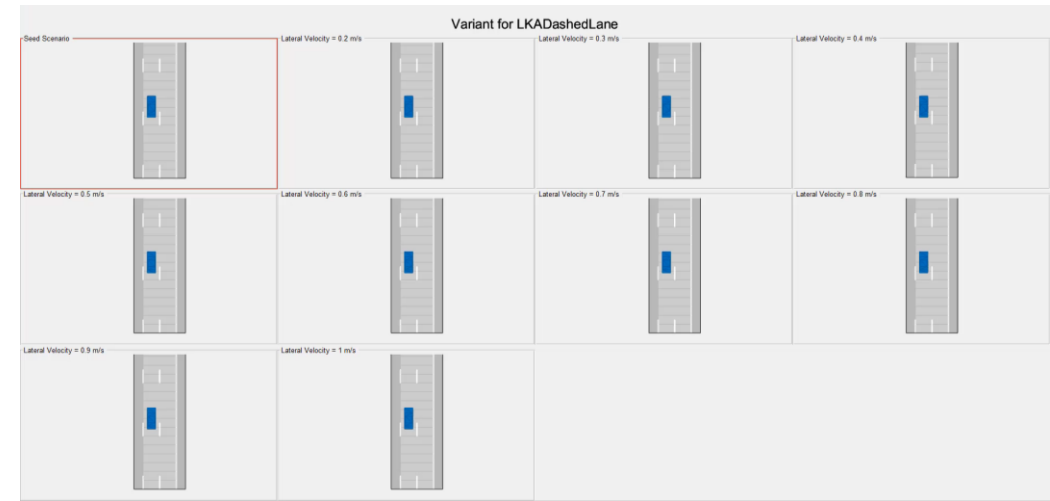
- Ego speed
- Road Variation

Test scenario variant for Lane Keep Assist Testing (LKA)

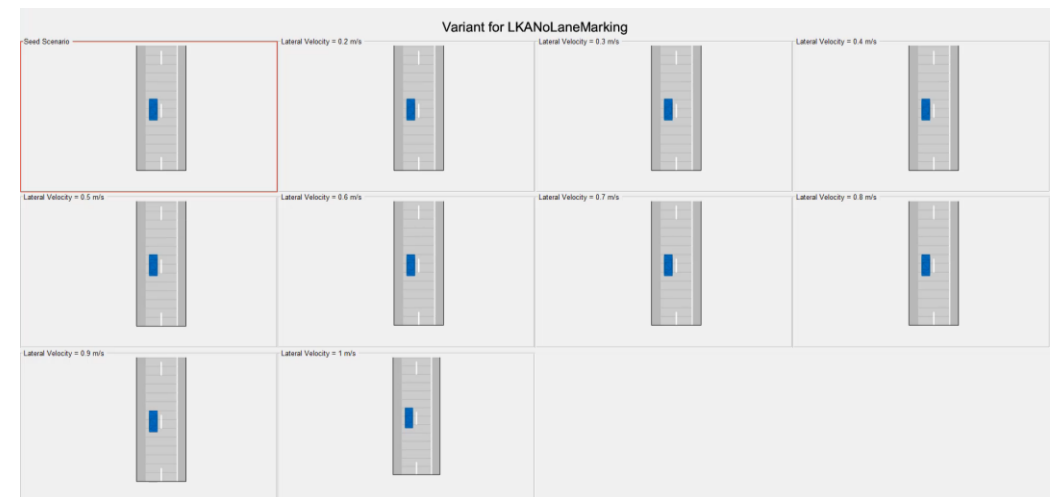


LKASolidLane

[Generate Scenario Variants for Lane Keep Assist Testing](#)



LKADashedLane



LKANoLaneMarking

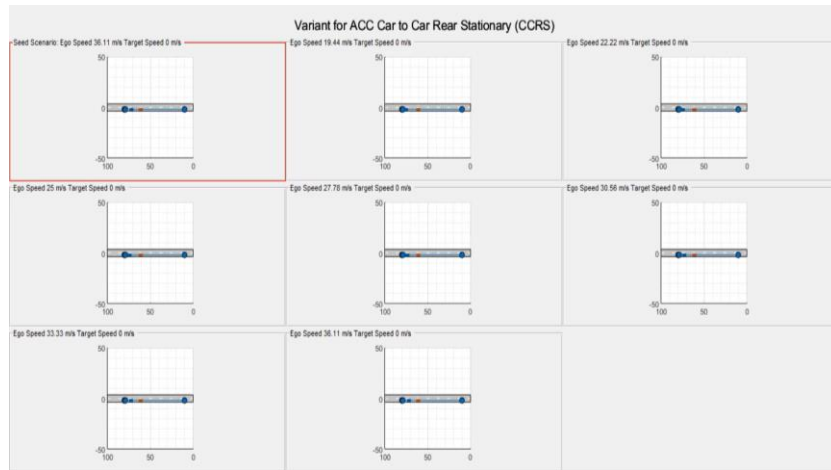
Test scenario variant for AEB and dimension variation



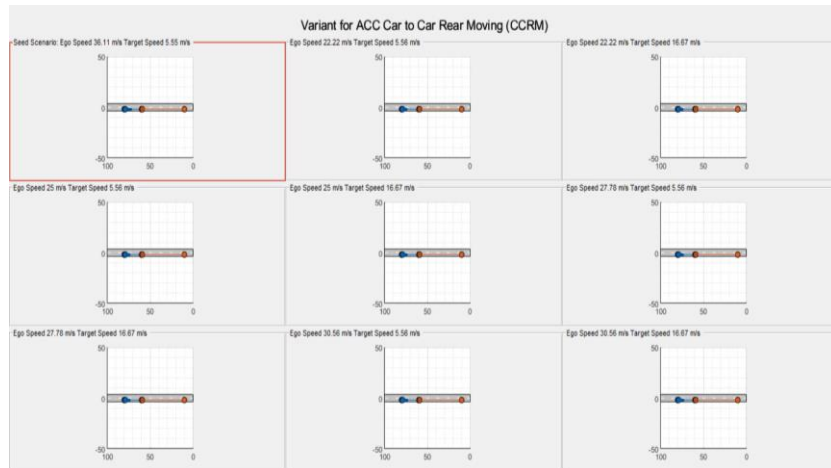
[Generate Scenario Variants for Testing AEB Pedestrian Systems](#)

[Generate Scenario Variants by Modifying Actor Dimensions](#)

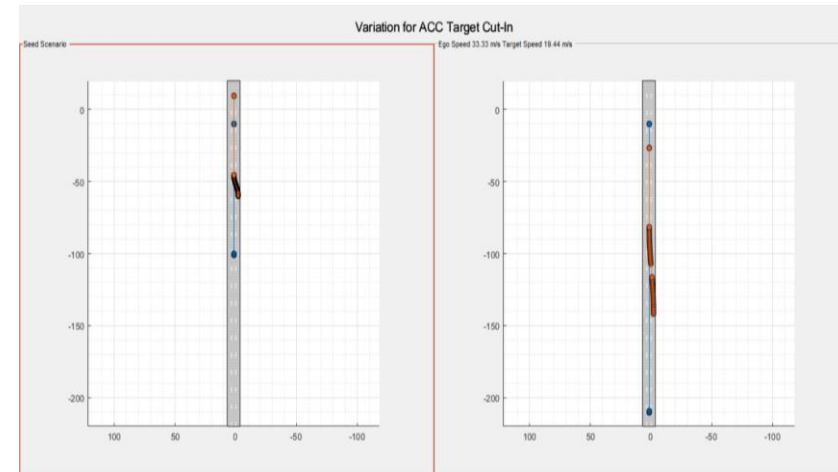
Test scenario variant for Adaptive Cruise Control (ACC)



Car-to-car rear stationary (CCRs)



Car-to-car rear moving (CCRM)



Generate Variants of ACC Target Cut-In Scenario

Generate Scenario Variants for Testing ACC Systems

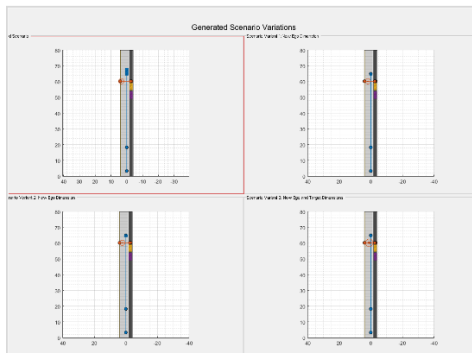
Scenario Variation Generation

Scenario Variant Generator for Automated Driving Toolbox

by MathWorks Automated Driving Toolbox Team **STAFF**

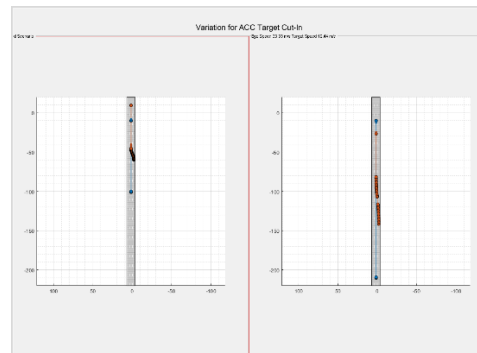
Generate multiple variants from a seed scenario that is either manually created or generated from recorded sensor data

- Read the seed scenario and extract its parameters
- Modify static/dynamic parameters of the seed scenario
- Generate variant scenarios



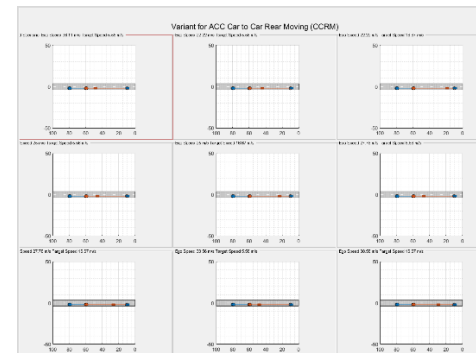
Generate Scenario Variants by Modifying Actor Dimensions

Generate scenario variants from seed scenario by modifying actor dimensions.



Generate Variants of ACC Target Cut-In Scenario

Generate scenario variants to test adaptive cruise control (ACC) application using European New Car Assessment Programme (Euro



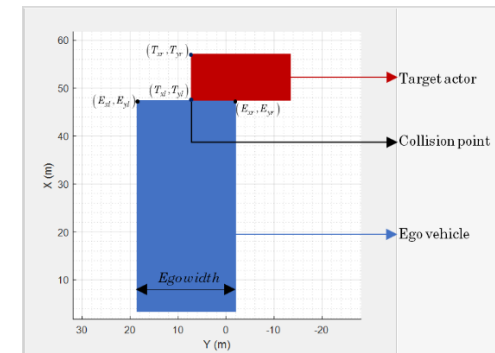
Generate Scenario Variants for Testing ACC Systems

Modify speeds of the ego and target vehicles to generate scenario variants for testing adaptive cruise control (ACC) application using



Generate Scenario Variants for Lane Keep Assist Testing

Generate scenario variants to test lane keep assist (LKA) system using European New Car Assessment Programme (Euro NCAP) test

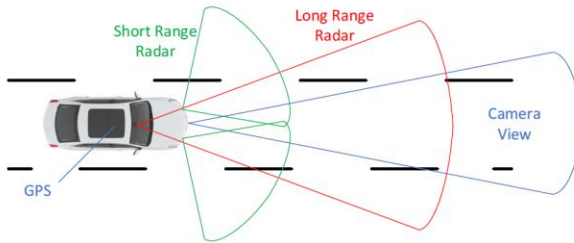


Generate Scenario Variants for Testing AEB Pedestrian Systems

Generate scenario variants to test automated emergency braking (AEB) system using car-to-pedestrian European New Car Assessment

GM synthesizes scenarios from recorded data to validate lane centering system

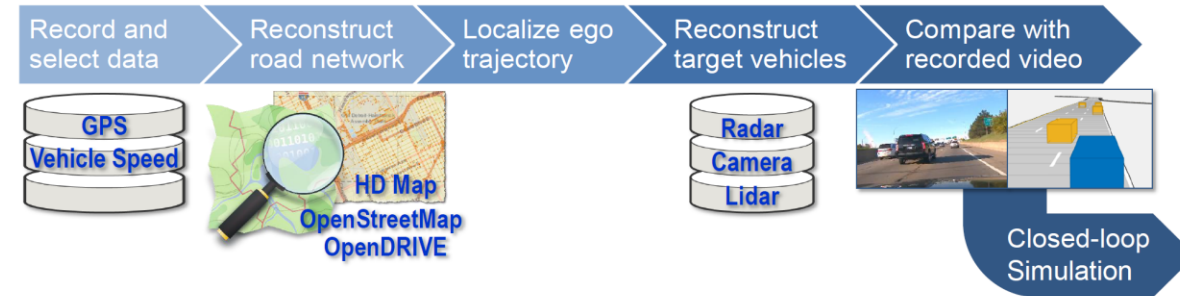
Lane Centering with Super Cruise on Cadillac CT6



- **Sensors**
 - Pre-Scanned High Definition Map
 - Map matching with GPS
 - Camera
 - Long Range Radar
 - Short Range Radars
- **Actuation**
 - Electric Power Steering
- **Driver Monitoring System for Safety**
 - Infra-red Face Recognition
 - Steering Wheel Touch Sensor
 - Chime and Vibration Seat

Conclusion

- Created virtual driving scenario from recorded data

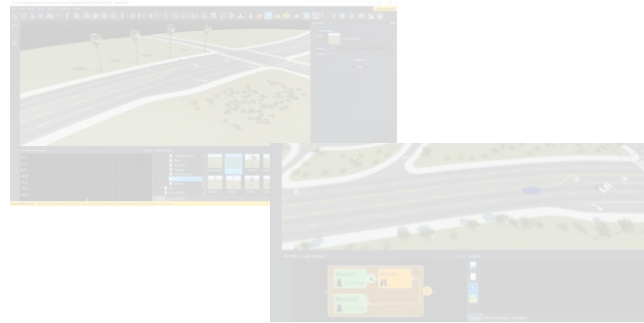


- Reproduced real-world driving scenario in the virtual simulation environment
 - Assess functional behavior and identify root cause for problem cases
 - Reduce development time with limited resources
 - Enable repetitive tests for hazardous scenarios

Today's Agenda

ENVIRONMENT MODELLING

Create Virtual Scenes and Scenarios

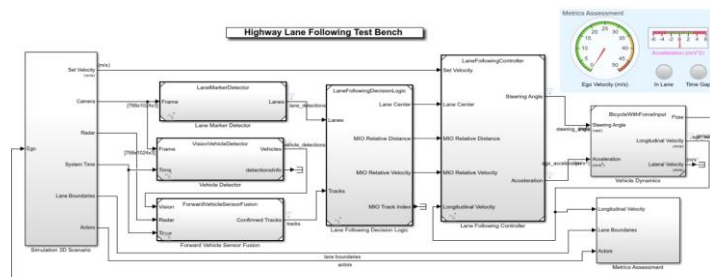


Recreating real world for virtual simulation



VIRTUAL VALIDATION

Testing highway lane following application



Copyright 2019-2021 The MathWorks, Inc.

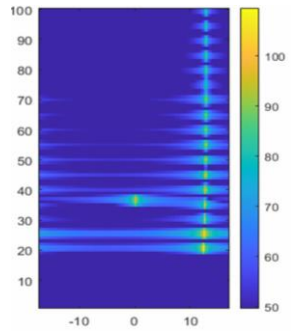
Setting up Test Automation framework for



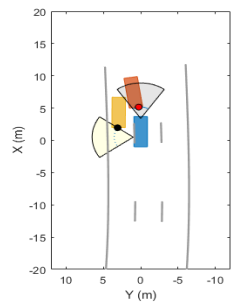
Simulate sensors for automated driving applications

Cuboid Sensors

Radar IQ Signals

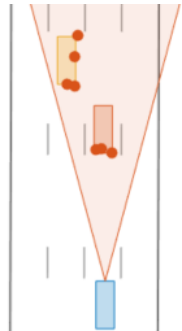


Ultrasonic Detections

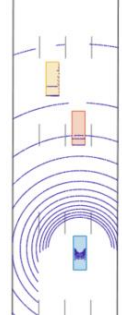


Cuboid & Unreal Engine

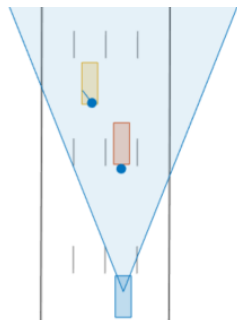
Radar Detections



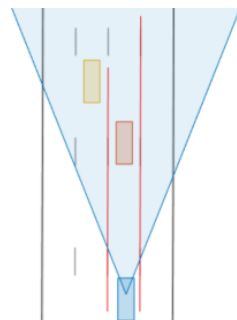
Lidar



Vision Detections



Lane Detections

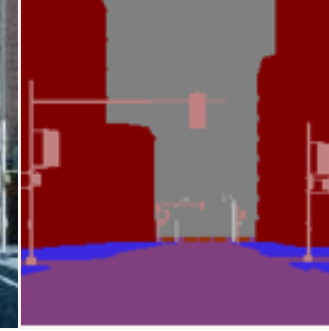


Unreal Engine Sensors

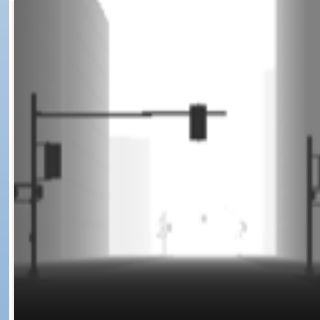
Monocular Camera



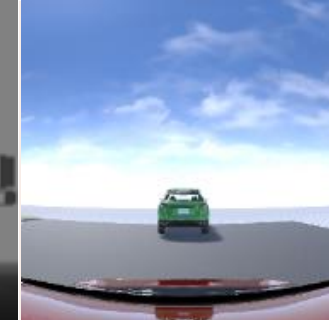
Semantic Segmentation



Depth



Fisheye Camera



Positional Sensors

Wheel Encoder

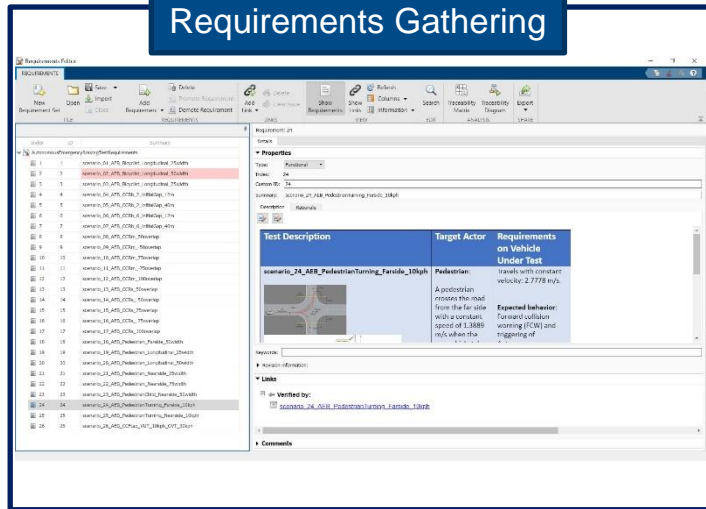
Global Positioning System (GPS)

Inertial Measurement Unit (IMU)

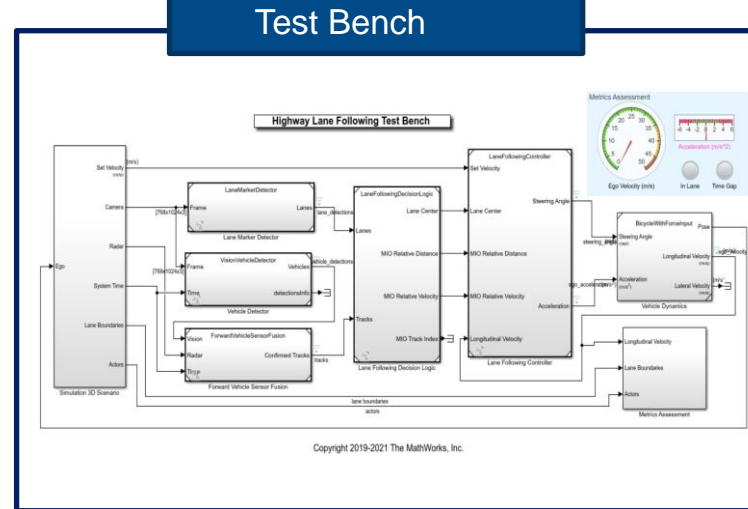
Inertial Navigation System (INS)

Virtual Validation

Requirements Gathering



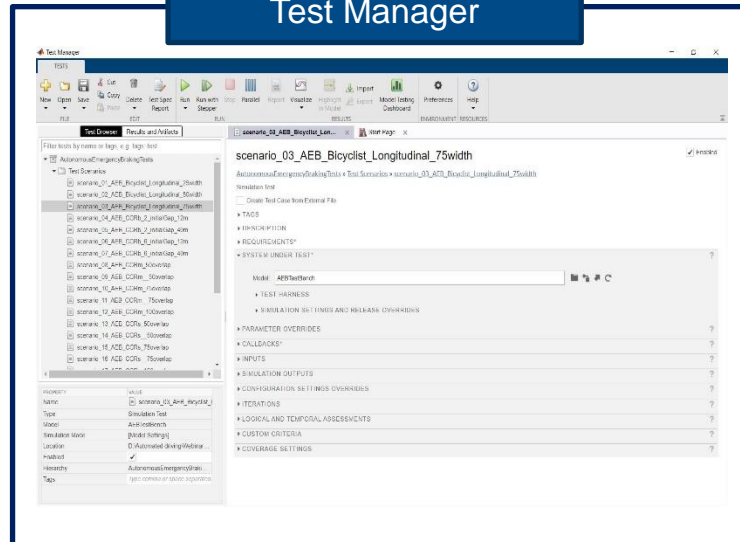
Test Bench



Scenarios to Test

Index	ID	Summary
1	1	scenario_01_AEB_Bicyclist_Longitudinal_25width
2	2	scenario_02_AEB_Bicyclist_Longitudinal_50width
3	3	scenario_03_AEB_Bicyclist_Longitudinal_75width
4	4	scenario_04_AEB_CCRb_2_initialGap_12m
5	5	scenario_05_AEB_CCRb_2_initialGap_40m
6	6	scenario_06_AEB_CCRb_6_initialGap_12m
7	7	scenario_07_AEB_CCRb_6_initialGap_40m
8	8	scenario_08_AEB_CCRm_50overlap
9	9	scenario_09_AEB_CCRm_50overlap
10	10	scenario_10_AEB_CCRm_75overlap
11	11	scenario_11_AEB_CCRm_75overlap
12	12	scenario_12_AEB_CCRb_100overlap
13	13	scenario_13_AEB_CCRs_50overlap
14	14	scenario_14_AEB_CCRs_50overlap
15	15	scenario_15_AEB_CCRs_75overlap
16	16	scenario_16_AEB_CCRs_75overlap
17	17	scenario_17_AEB_CCRs_100overlap
18	18	scenario_18_AEB_Pedestrian_FarSide_50width
19	19	scenario_19_AEB_Pedestrian_Longitudinal_25width

Test Manager



Report Generation

Report Generated by Test Manager

Title: Autonomous Emergency Braking Test Results

Author: MATLAB
Date: 10-Dec-2021 13:52:37

Test Environment

Platform: PCWIN64
MATLAB: (R2021b)

Sensor fusion algorithm test bench for Open Loop Testing

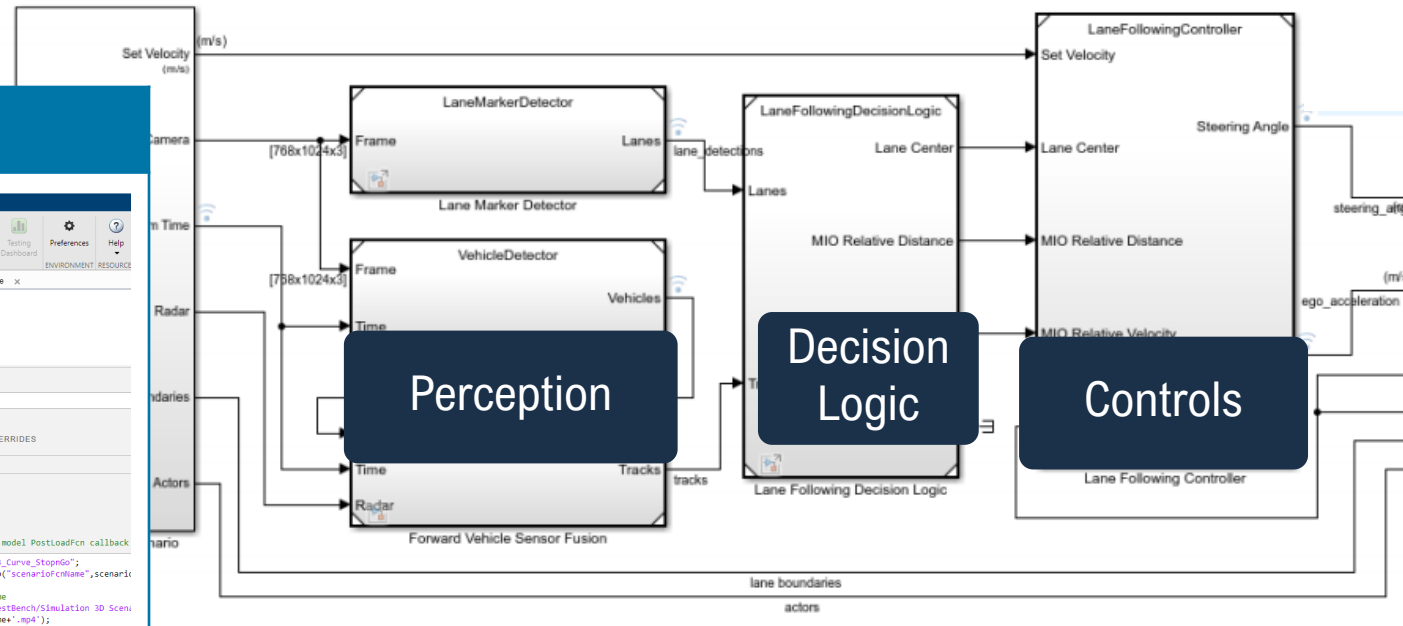
The screenshot shows the MATLAB R2022a environment. The current folder is `D:\Automated driving\Demos\FVSensorFusion\FVSensorFusion`. The workspace contains the following variables:

Name	Value
<code>alpha</code>	<code>2</code>
<code>assessment</code>	<code>1x1 struct</code>
<code>assigThresh</code>	<code>400</code>
<code>BusActors1</code>	<code>1x1 Bus</code>
<code>BusLaneDetecti...</code>	<code>1x1 Bus</code>
<code>BusLaneDetecti...</code>	<code>1x1 Bus</code>
<code>BusObjectDetec...</code>	<code>1x1 Bus</code>
<code>BusObjectDetec...</code>	<code>1x1 Bus</code>
<code>BusObjectDetec...</code>	<code>1x1 Bus</code>
<code>BusRadar</code>	<code>1x1 Bus</code>
<code>BusSimulation3...</code>	<code>1x1 Bus</code>
<code>BusSimulation3...</code>	<code>1x1 Bus</code>
<code>BusSimulation3...</code>	<code>1x1 Bus</code>
<code>BusSimulation3...</code>	<code>1x1 Bus</code>
<code>BusSimulation3...</code>	<code>1x1 Bus</code>
<code>BusSimulation3...</code>	<code>1x1 Bus</code>
<code>BusTrackerJPDA</code>	<code>1x1 Bus</code>
<code>BusTrackerJPDA...</code>	<code>1x1 Bus</code>
<code>BusVehiclePose</code>	<code>1x1 Bus</code>
<code>BusVision</code>	<code>1x1 Bus</code>
<code>BusVisionDetect...</code>	<code>1x1 Bus</code>
<code>BusVisionDetect...</code>	<code>1x1 Bus</code>
<code>BusVisionDetect...</code>	<code>1x1 Bus</code>
<code>camera</code>	<code>1x1 struct</code>
<code>cutOffDistance</code>	<code>30</code>
<code>Epsilon</code>	<code>2.5000</code>
<code>M</code>	<code>3</code>
<code>MinNumPoints</code>	<code>2</code>

AEB with sensor fusion test bench- Closed loop testing

[Reference Examples](#)

Highway Lane Following Test Bench



Copyright 2019-2020 The MathWorks, Inc.

Manage Tests

The screenshot shows the Test Manager software interface. On the left, there is a 'Test Scenarios' list with various scenarios like 'scenario_LFACC_01_Curve_DecelTarget' and 'scenario_LFACC_03_Curve_StopnGo'. The right pane shows configuration options for a selected test, including 'TAGS', 'DESCRIPTION', 'REQUIREMENTS', 'SYSTEM UNDER TEST' (set to 'HighwayLaneFollowingTestBench'), 'TEST HARNESS', 'SIMULATION SETTINGS AND RELEASE OVERRIDES', 'PARAMETER OVERRIDES', and 'CALLBACKS'. A 'PRE-LOAD' section contains a script snippet for setting up the simulation.

Report Results

Summary Name	Outcome
HighwayLaneFollowingMetricAssessments	10
Test Scenarios	10
scenario LFACC 01 Curve DecelTarget	
scenario LFACC 02 Curve AutoRetarget	
scenario LFACC 03 Curve StopnGo	
scenario LFACC 04 Curve CutInOut	
scenario LFACC 05 Curve CutInOut TooClose	
scenario LFACC 06 Straight StopandGoLea	
scenario LF 01 Straight RightLane	
scenario LF 02 Straight LeftLane	
scenario LF 03 Curve LeftLane	
scenario LF 04 Curve RightLane	

Automate testing for the closed loop AEB testbench

The screenshot displays the MATLAB R2021b environment. The main window shows a script titled 'AutomateTestingForHighwayLaneFollowingExample.m'. The script contains the following code:

```

17 % Transfer Learning in lane vehicle automation
42 % external reviewers.
43 % # 'Automate testing with generated code:' The lane detection, sensor
44 % fusion, decision logic, and controls components are configured to
45 % generate C++ code. The automated testing is run on the generated code to
46 % verify expected behavior.
47 % # 'Automate testing in parallel:' Overall execution time for running the
48 % tests is reduced using parallel computing on a multi-core computer.
49 %
50 % Testing the system-level model requires a photorealistic simulation
51 % environment. In this example, you enable system-level simulation through
52 % integration with the Unreal Engine from Epic Games®; the 3D
53 % simulation environment requires a Windows®; 64-bit platform.
54 %
55 % if ~ispc
56 %     error('The 3D simulation environment requires a Windows 64-bit platform');
57 % end
58 %%
59 % To ensure reproducibility of the simulation results, set the random seed.
60 rng(0);
61
62 %% Review Requirements
63 % Simulink RequirementsStrade; lets you author, analyze, and manage requirements
64 % within Simulink. This example contains ten test scenarios, with
65 % high-level testing requirements defined for each scenario. Open the
66 % requirement set.
67 %
68 % To explore the test requirements and test bench model, open a working
69 % copy of the project example files. MATLAB copies the files to an example
70 % folder so that you can edit them. The |TestAutomation| folder contains
71 % the files that enables the automate testing.
72
73 addpath(fullfile(matlabroot, 'toolbox', 'driving', 'drivingdemos'));
74 helperDrivingProjectSetup('HighwayLaneFollowing.zip', 'workDir', pwd);
75
76 %%
77 open('HighwayLaneFollowingTestRequirements.sirepx')
78 %%
79

```

The workspace window shows the following variables:

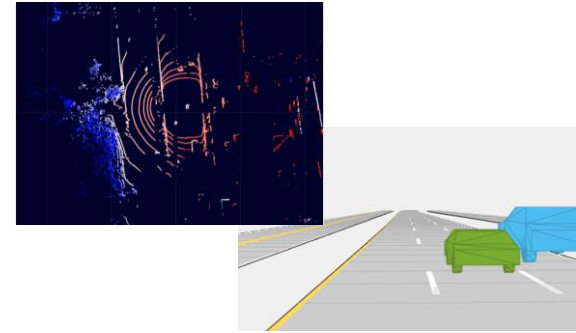
Name	Value
assessment	1x1 struct
msg_thresh	400
BusActors1	1x1 Bus
BusDetectionCon...	1x1 Bus
BusDetectionCon...	1x1 Bus
BusDetectionCon...	1x1 Bus
BusLaneBoundari...	1x1 Bus
BusLaneBoundari...	1x1 Bus
BusLaneCenter	1x1 Bus
BusLadar	1x1 Bus
BusRadarDetections	1x1 Bus
BusRadarDetectio...	1x1 Bus
BusRadarDetectio...	1x1 Bus
BusTrackerPDA	1x1 Bus
BusTrackerPDATr...	1x1 Bus
BusVehiclePose	1x1 Bus
BusVision	1x1 Bus
BusVisionDetectio...	1x1 Bus
BusVisionDetectio...	1x1 Bus
BusVisionDetectio...	1x1 Bus
BusVisionInfo	1x1 Bus
camera	1x1 struct
cameraOutputFile...	1x1 struct

ENVIRONMENT MODELLING

Create Virtual Scenes and Scenarios

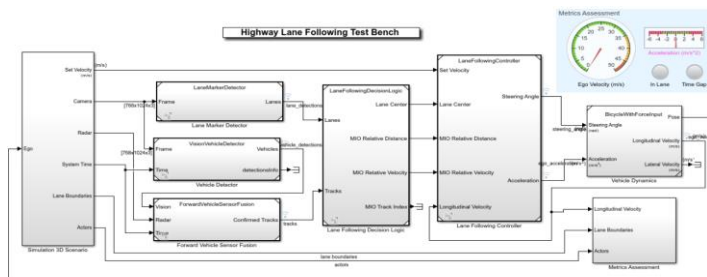


Recreating real world for virtual simulation



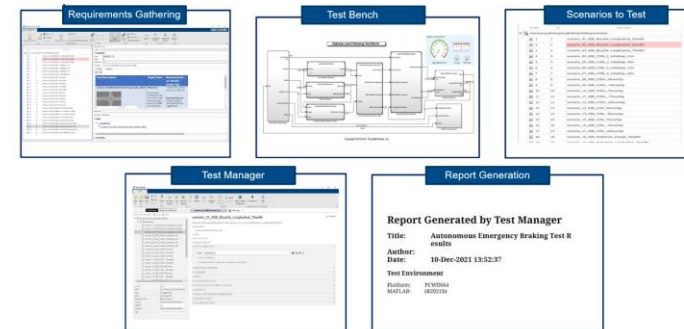
VIRTUAL VALIDATION

Open/ Closed loop testing



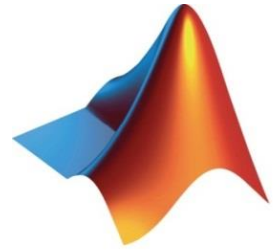
Copyright 2019-2021 The MathWorks, Inc.

Test Automation for AD/ADAS



Call to Action

- Visit us at our demo booth, outside the seminar hall
- Let us know the challenges you face in your AD/ADAS workflow
- MathWorks would be happy to collaborate with you for developing your AD/ADAS workflow



MathWorks®

Accelerating the pace of engineering and science

Thank you



For further details, Q&A and feedback kindly reach out to



Munish Raj

Email id: mraj@mathworks.com
LinkedIn



Dr Rishu Gupta

Email id: rishug@mathworks.com
[LinkedIn](#)

Please provide your Feedback for this Session.
You will also receive a Feedback Link via SMS on your registered Mobile Number



<https://tinyurl.com/ypr9z7rx>

