MathWorks
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India

Scenario-Based Virtual Validation for ADAS Features

Munish Raj, MathWorks

Dr Rishu Gupta, MathWorks


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CONFERENCE 2023
India
Open Simulation Interface Using RoadRunner For Automated Driving Validation
Ananthesh Shet, Aptiv
Naga Pemmaraju, MathWorks
APTIV
MathWorks


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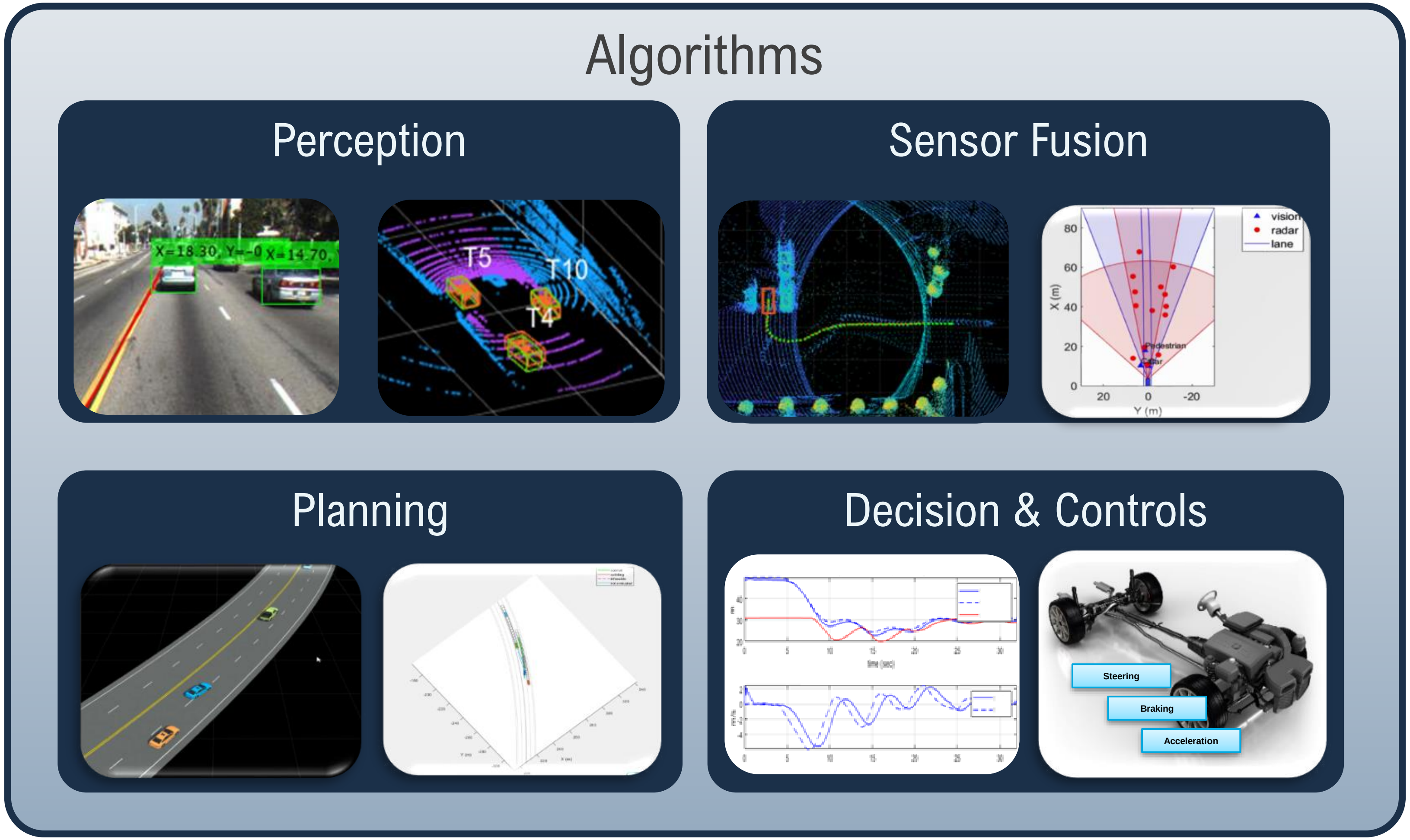
CONFERENCE 2023
India
Scenario Based Co-Simulation framework for Automated Driving Systems Validation using RoadRunner and Carmaker
Deva Hanuma Kishore Naidu Avisineni,
Bosch Global Software Technologies
Munish Raj, MathWorks
BOSCH
MathWorks

Automated Driving Algorithm



Key subsystems of an automated driving system

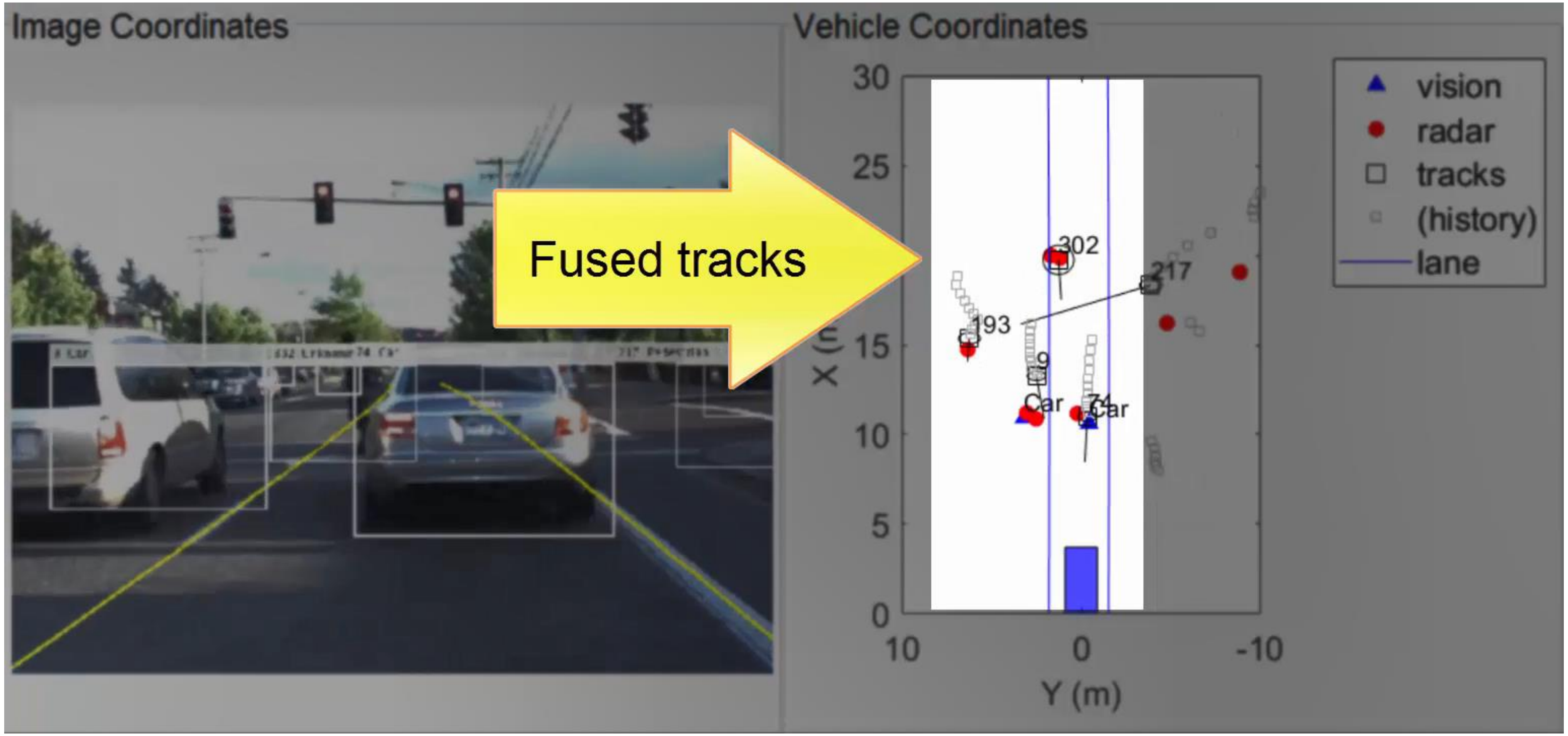
Perception

Key subsystems of an automated driving system

Perception

↓

Sensor Fusion

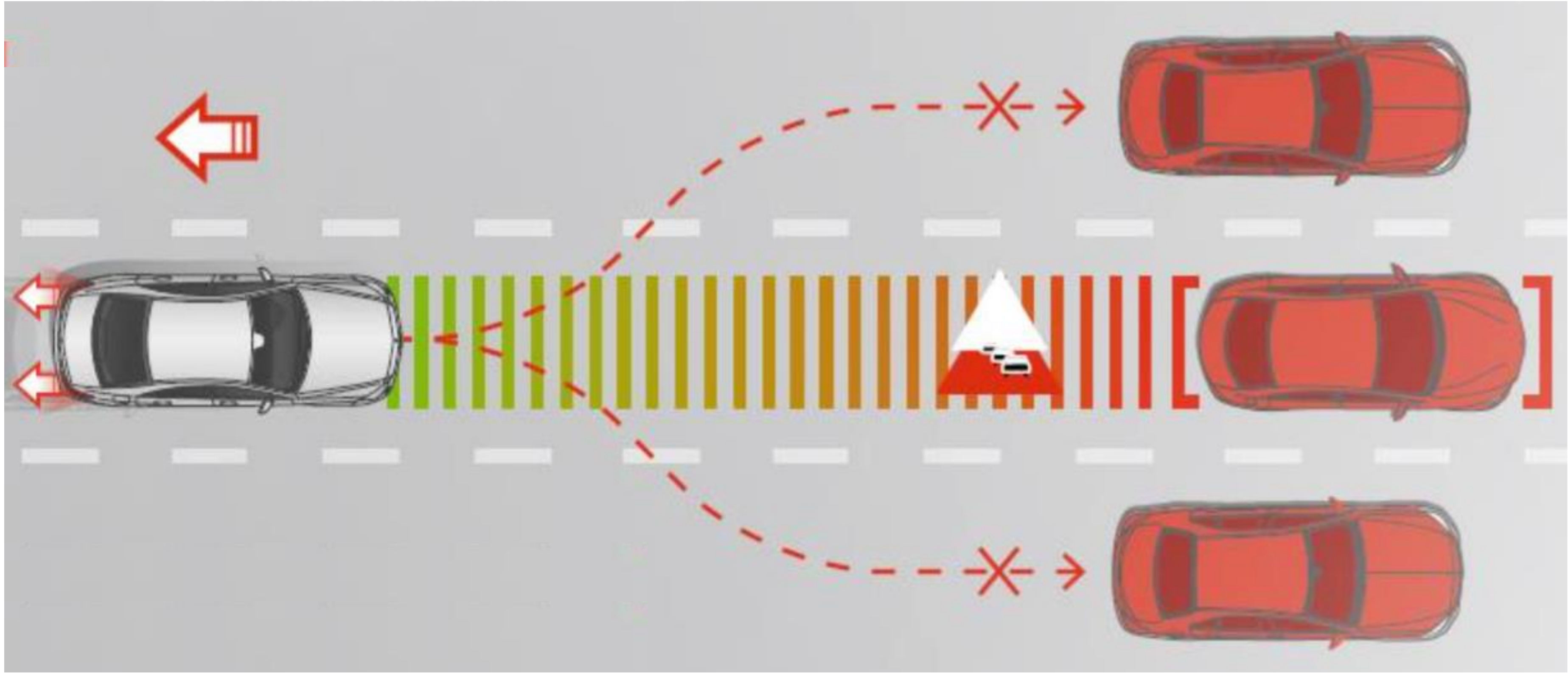


Key subsystems of an automated driving system

Perception

Sensor Fusion

Planning



Key subsystems of an automated driving system

Perception

↓

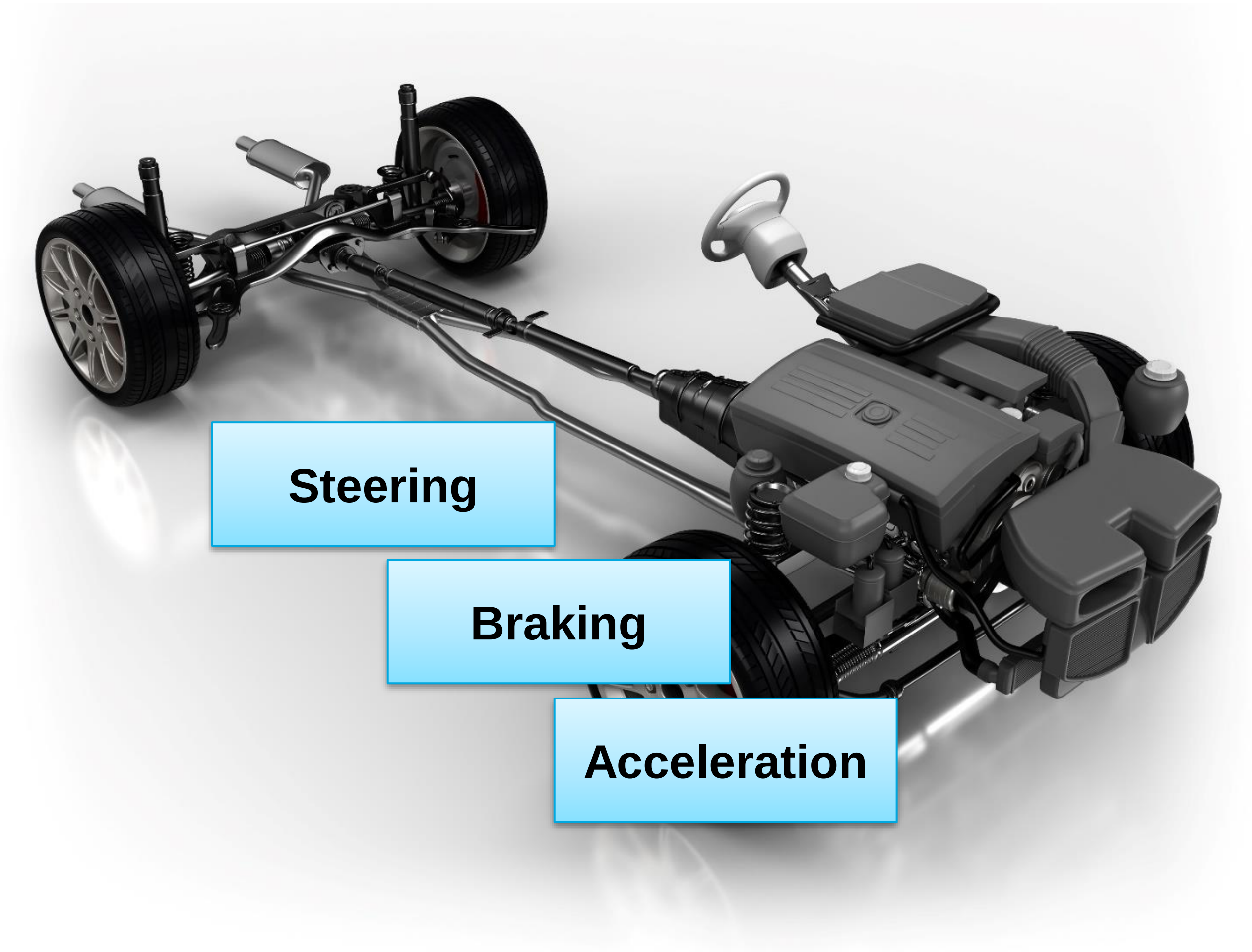
Sensor Fusion

↓

Planning

↓

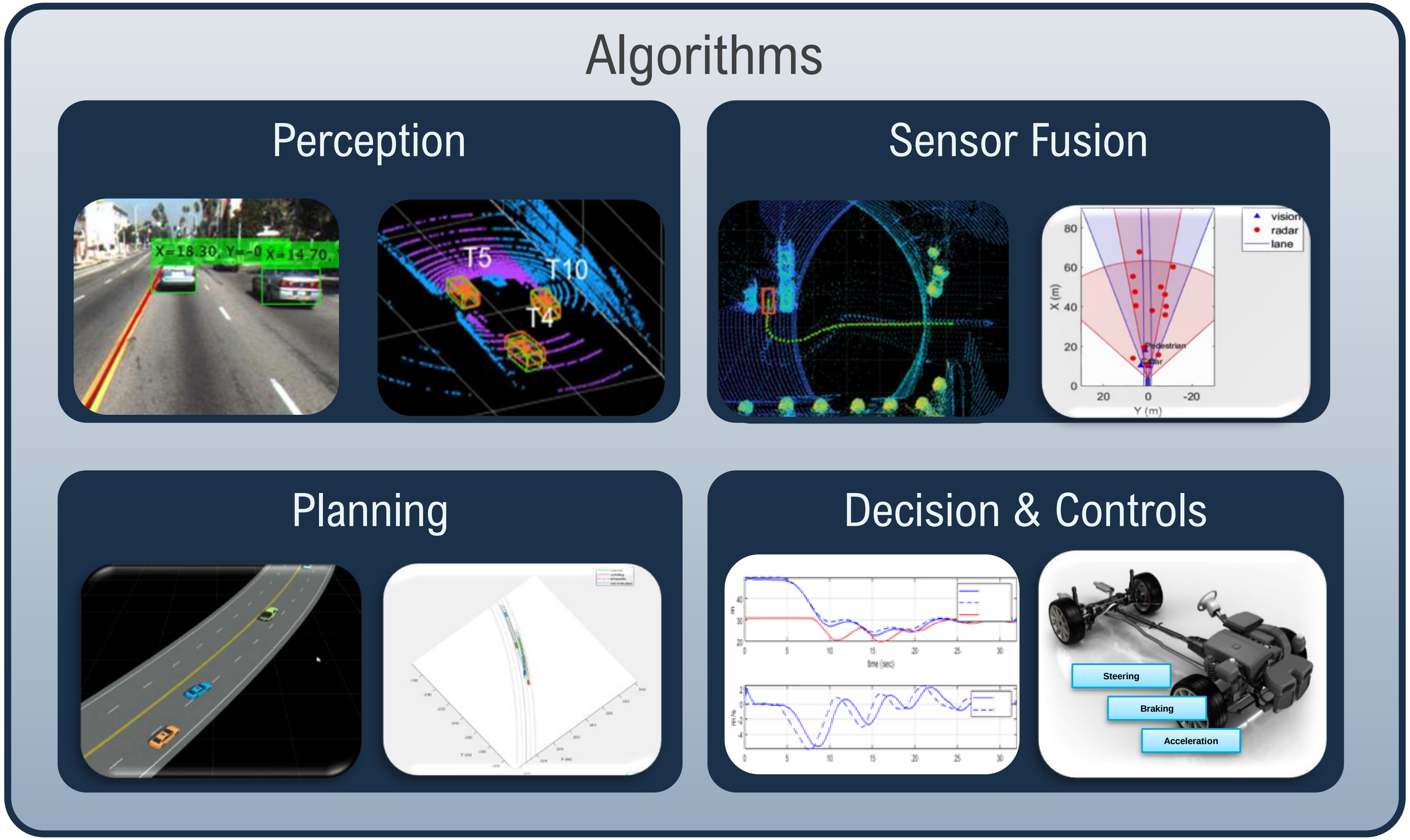
Controls



Key subsystems of an automated driving system

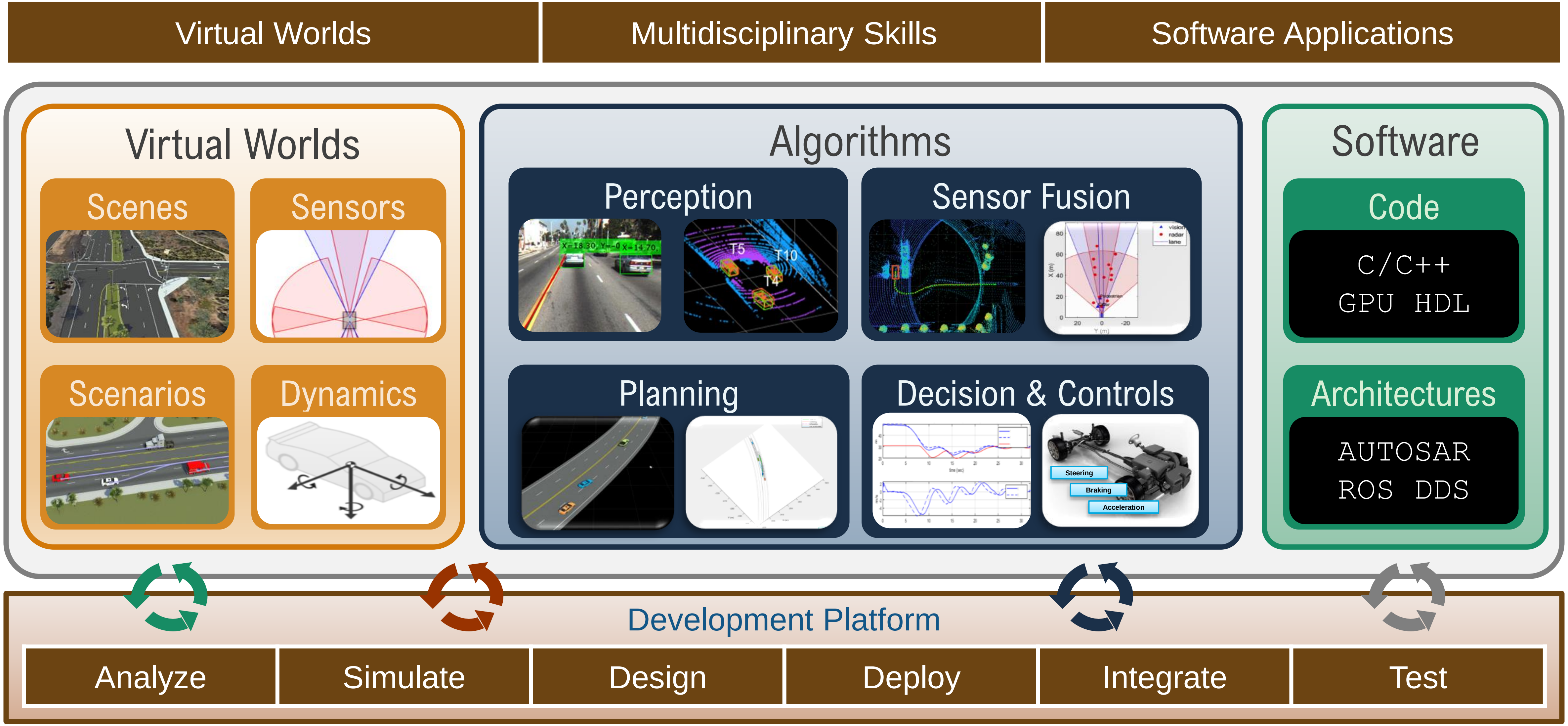
- Perception
- Sensor Fusion
- Planning
- Controls

Automated Driving Algorithm Development



Automated Driving Development and Validation

with MATLAB, Simulink, & RoadRunner



Introduction : EuroNCAP - ACC

- For each scenario and test speed, 1 point can be achieved where the ACC fully avoids the collision. Where the ACC intervenes and reduces the impact speed by more than 5 km/h before the AEB intervenes, 0.5 points are scored. Where the ACC does not reduce more than 5 km/h, no points are awarded

ACC CAR-TO-CAR		VUT	GVT/ SOV
CCRS – STATIONARY TARGET (straight and curved road)		70 km/h 80 km/h 90 km/h 100 km/h 110 km/h 120 km/h 130 km/h	
CCRM – MOVING TARGET		80 km/h 90 km/h 100 km/h 110 km/h 120 km/h 130 km/h	20 km/h 20 km/h 20 km/h 20 km/h 20 km/h 20 km/h
		80 km/h 90 km/h 100 km/h 110 km/h 120 km/h 130 km/h	60 km/h 60 km/h 60 km/h 60 km/h 60 km/h 60 km/h
CCRB – BRAKING TARGET @ -4m/s²	ACC-mode closest	55 km/h	50 km/h
CUT-IN	Cut-in @ TTC = 0.00	50 km/h	10 km/h
	Cut-in @ TTC = 1.50	120 km/h	70 km/h
CUT-OUT	Cut-out @ TTC = 3.00	70 km/h	50 km/h
	Cut-out @ TTC = 3.00	90 km/h	70 km/h

ACC EuroNCAP Document

Introduction : EuroNCAP - AEB

EUROPEAN NEW CAR ASSESSMENT PROGRAMME
(Euro NCAP)

TEST PROTOCOL – AEB VRU systems

[AEB EuroNCAP Document]

Coordinate system

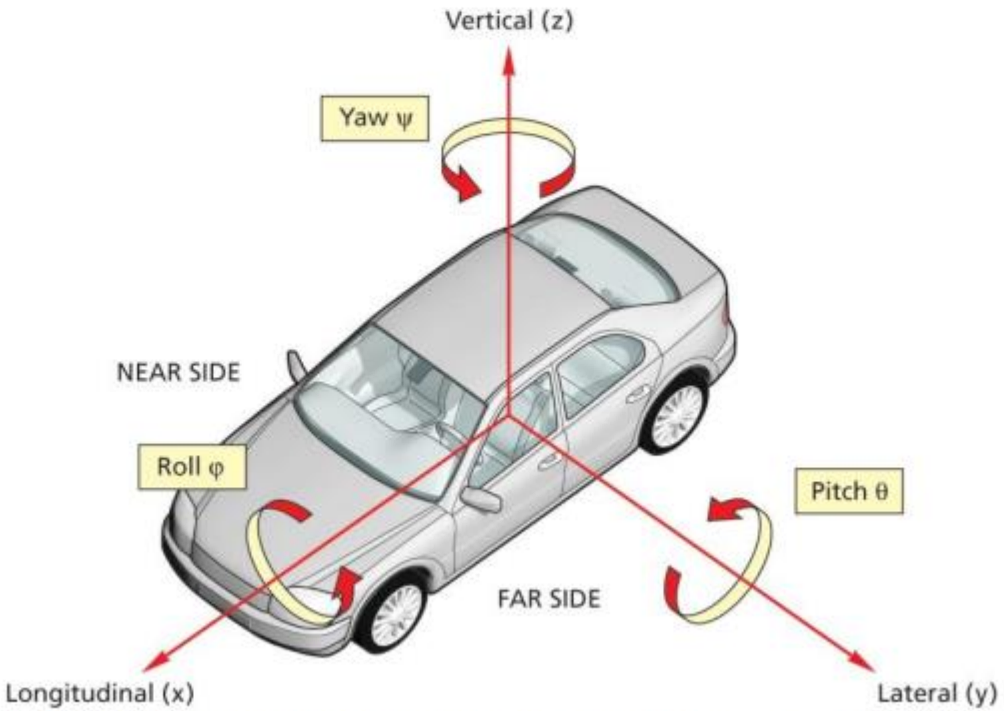


Figure 3-1: Coordinate system and notation (LHD & RHD) and nearside – farside for LHD vehicle

Scenario variants for test protocols

EURO NCAP car Assessment Programme

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	

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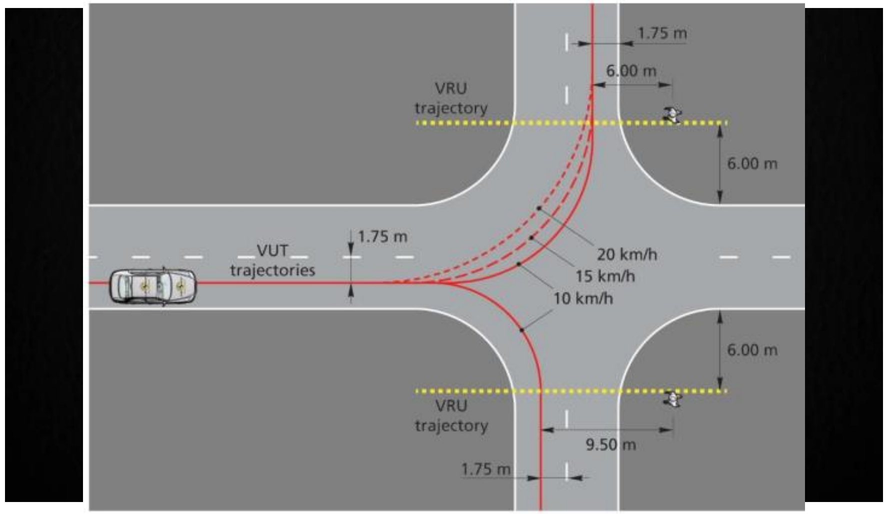


- Car-to-Pedestrian Farside Adult (CPFA)
- Car-to-Pedestrian Nearside Adult (CPNA)
- Car-to-Pedestrian Nearside Child (CPNC)

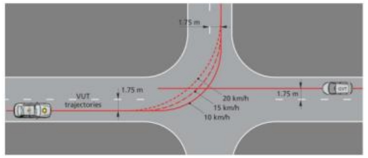
- Car-to-Pedestrian Turning Adult (CPTA)
- Car-to-Pedestrian Reverse Adult (CPRA)
- Car-to-Pedestrian Longitudinal Adult (CPLA)

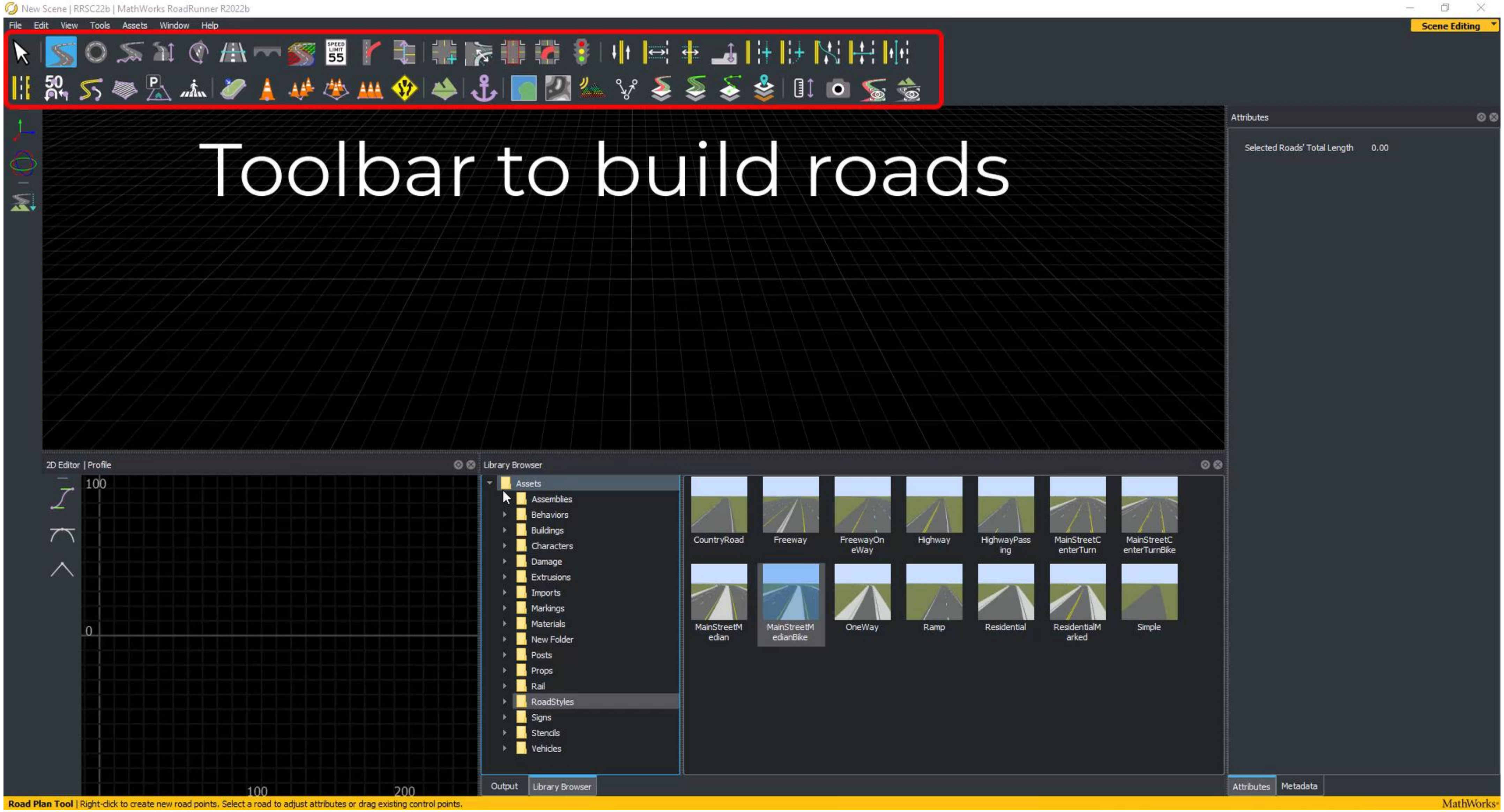
- Car-to-Bicyclist Nearside Adult (CBNA)
- Car-to-Bicyclist Farside Adult (CBFA)
- Car-to-Bicyclist Longitudinal Adult (CBLA)

Common notations

- Autonomous Emergency Braking (AEB)
- Forward Collision Warning (FCW)
- Vehicle under test (VUT)
- Global Vehicle Target (GVT)
- Secondary Other Vehicle (SOV)
- Time To Collision (TTC)
- Car-to-Car Crossing Straight Crossing Path (CCCscp)

RoadRunner enables Engineers to create Road networks





Design 3D scenes for automated driving applications with RoadRunner

Here HD Live Map
TomTom HD Maps
Apollo HD Maps
Custom HD Maps

OpenDRIVE
OpenStreetMap
OpenCRG
Zenrin SD Maps

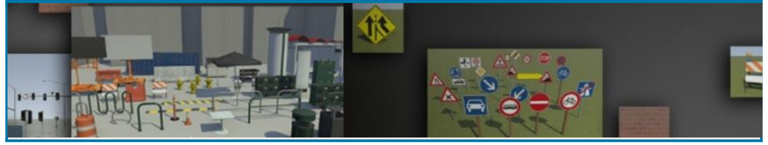
Geographic Information System (GIS) Files
- Point clouds
- Orthoimagery
- Vector data
- Elevation data

Custom Assets

RoadRunner Scene Builder

RoadRunner

RoadRunner Asset Library



OpenDRIVE

Filmbox

Third Party Simulators
- CARLA
- Unreal Engine®
- Unity®
- LGSVL
- VIRES Virtual Test Drive
- rFpro
- IPG Carmaker
- Cognata
- Baidu Apollo
- Tesis Dynaware
- Simcenter Prescan
- NVIDIA DRIVE Sim through Universal Scene Description (USD)

Create the Test track

6 **TEST CONDITIONS**

6.1 **Test Track**

6.1.1 Conduct tests on a dry (no visible moisture on the surface), uniform, solid-paved surface with a consistent slope between level and 1%. The test surface shall have a minimal peak braking coefficient (PBC) of 0.9.

6.1.2 The surface must be paved and may not contain any irregularities (e.g. large dips or cracks, manhole covers or reflective studs) that may give rise to abnormal sensor measurements within a lateral distance of 3.0m to either side of the test path and with a longitudinal distance of 30m ahead of the VUT when the test ends.

6.1.3 The presence of lane markings is allowed. However, testing may only be conducted in an area where typical road markings depicting a driving lane may not be parallel to the test path within 3.0m either side. Lines or markings may cross the test path, but may not be present in the area where AEB activation and/or braking after FCW is expected.

6.1.4 Junction and Lane Markings

6.1.4.1 The CPTA tests described in this document require use of a junction. The main approach lane where the VUT path starts, (horizontal lanes in Figure 6-1) will have a width of 3.5. The side lane (vertical lanes in Figure 6-1) will have a width of 3.25 to 3.5m. The lane markings on these lanes need to conform to one of the lane markings as defined in UNECE Regulation 130:

1. Dashed line starting at the same point where the radius transitions into a straight line with a width between 0.10 and 0.15m
2. Solid line with a width between 0.10 and 0.25m
3. Junction without any central markings

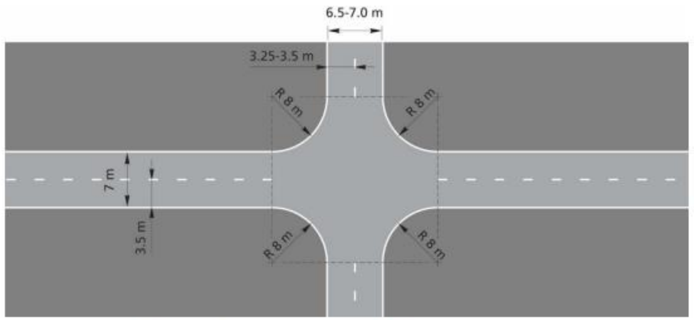
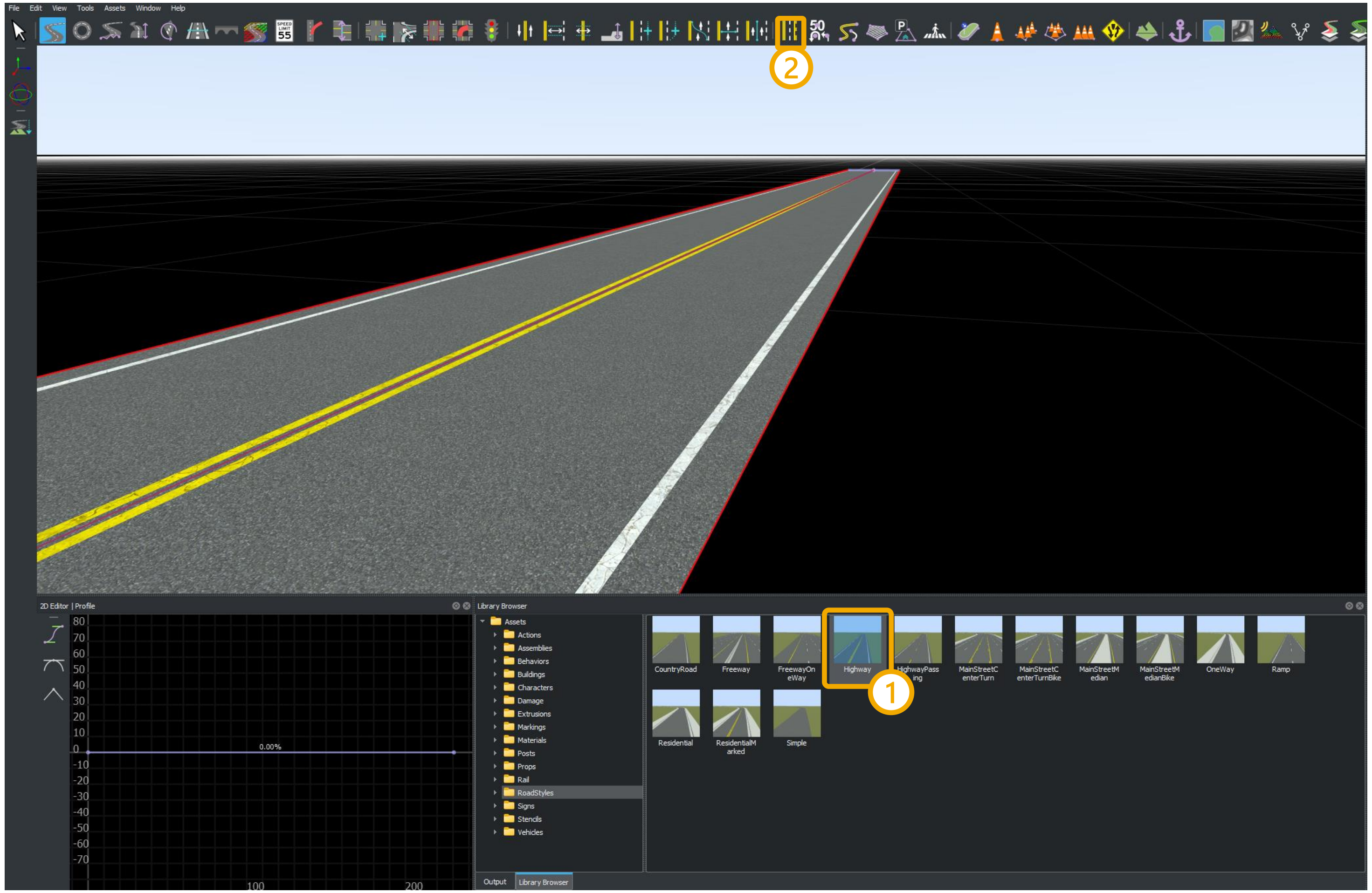
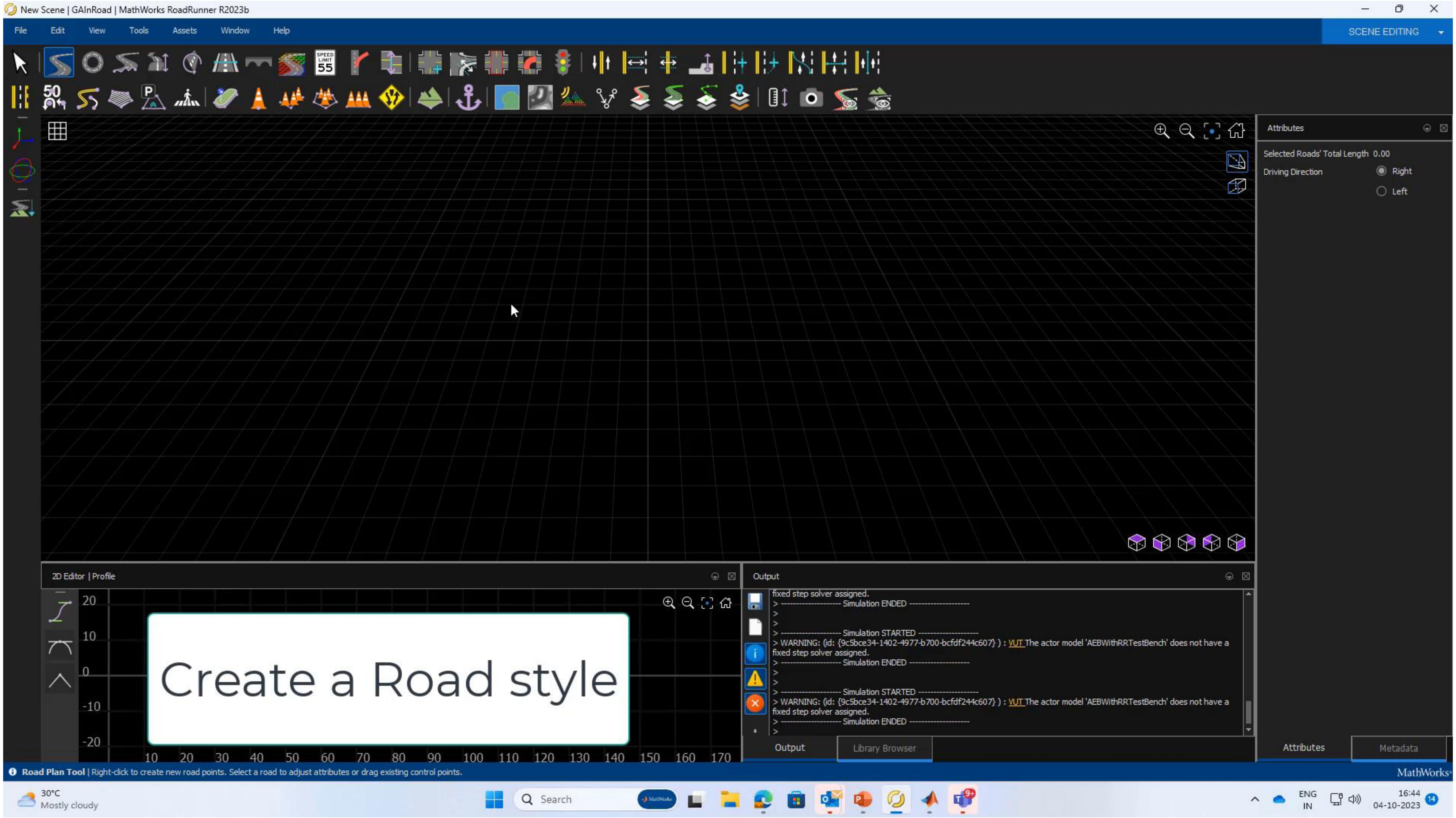


Figure 6-1: Layout of junction and the connecting lanes

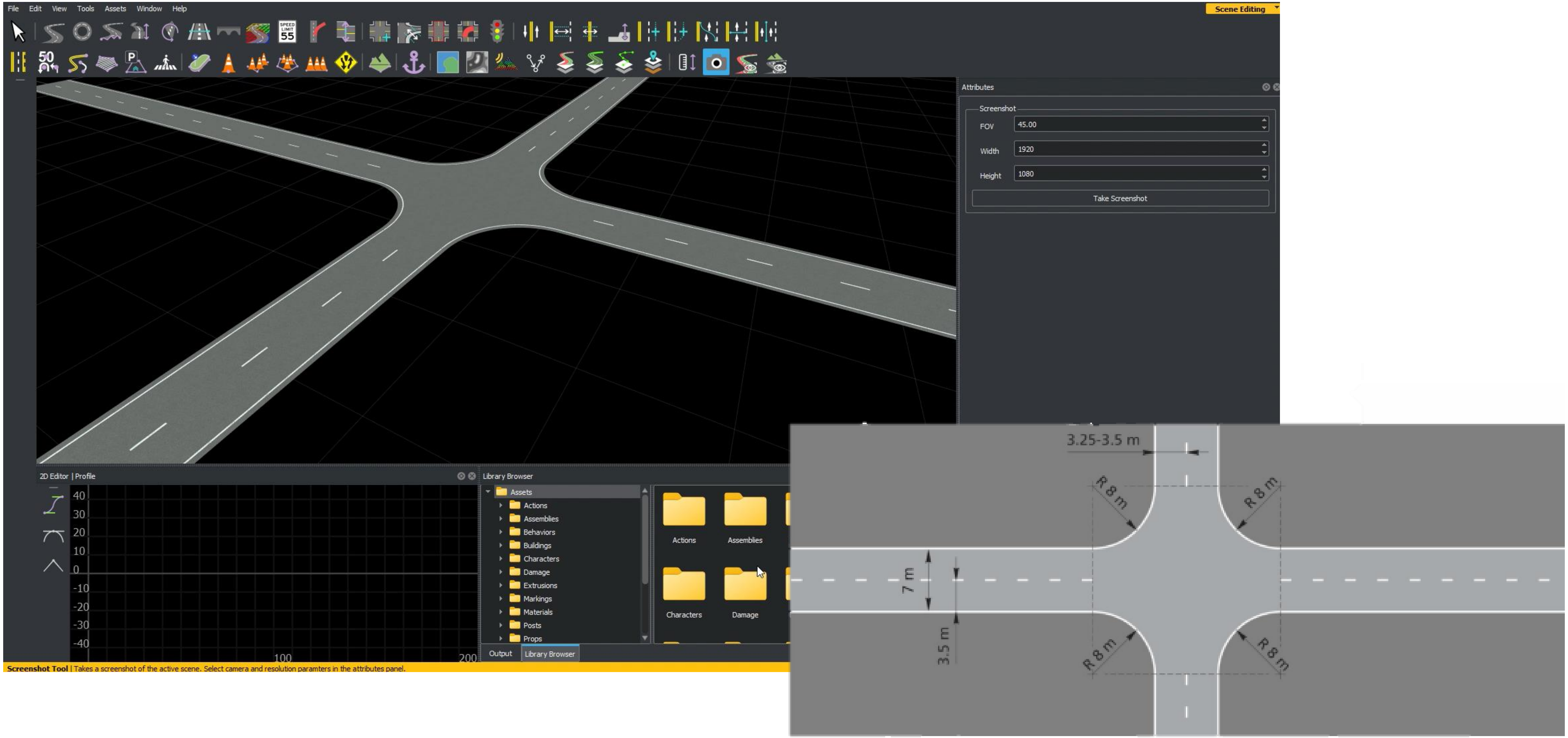
Create the required EuroNCAP road style

- Select Highway from Road Style
- Change the Marking type to Dashed line with a width of 0.25 – Using the Marking tool
- Change Corner Radius to 8
- Modify Lane markings
- Verify Lane widths

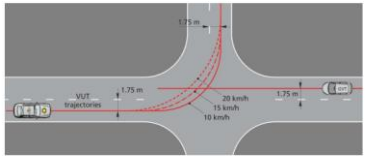



New Scene | GAInRoad | MathWorks RoadRunner R2023b
File
Edit
View
Tools
Assets
Window
Help
SCENE EDITING
Attributes
Selected Roads' Total Length 0.00
Driving Direction
Right
Left
2D Editor | Profile
Create a Road style
Output
Simulation STARTED
Simulation ENDED
WARNING: (id: {9c5bce34-1402-4977-b700-bcfdf244c607}) : VUT The actor model 'AEBWithRRTestBench' does not have a fixed step solver assigned.
Output
Library Browser
Attributes
Metadata
Road Plan Tool | Right-click to create new road points. Select a road to adjust attributes or drag existing control points.

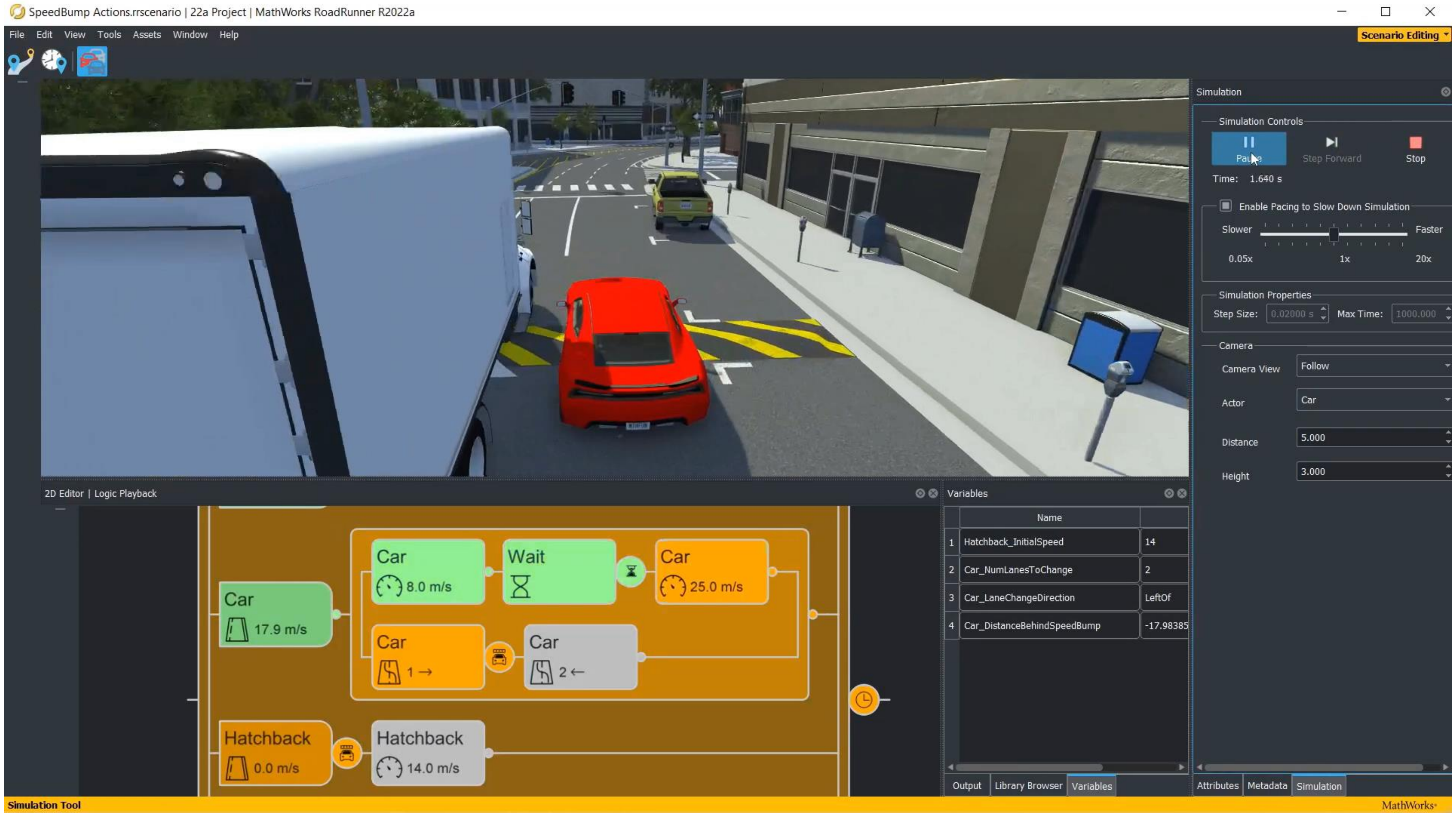
Test Track for this EuroNCAP test



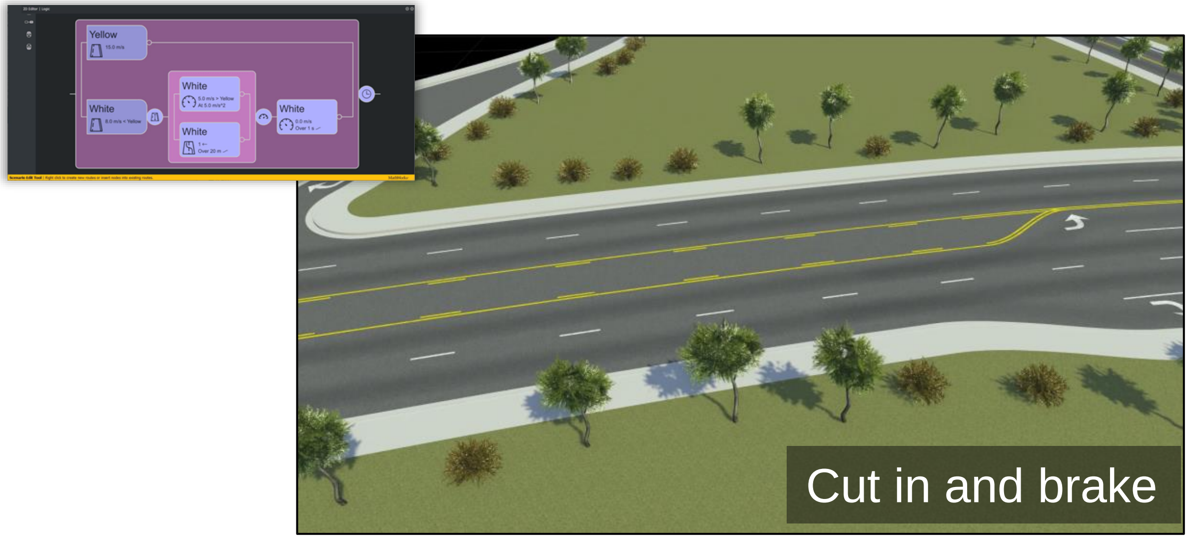
Interactively design Euro NCAP scenarios with RoadRunner Scenario



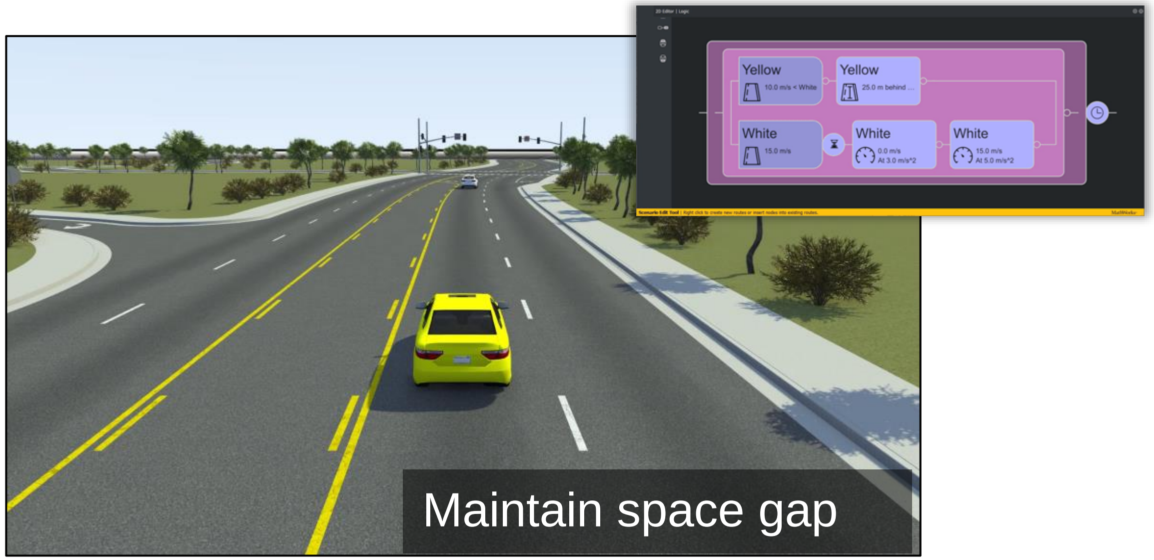
- Add various vehicles
- Author trajectories
- Specify actions and logic
- Parameterize variations



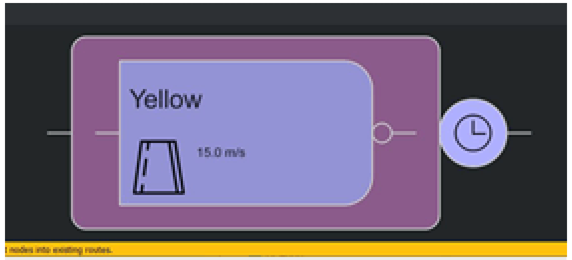
Utilize prebuilt sample scenarios



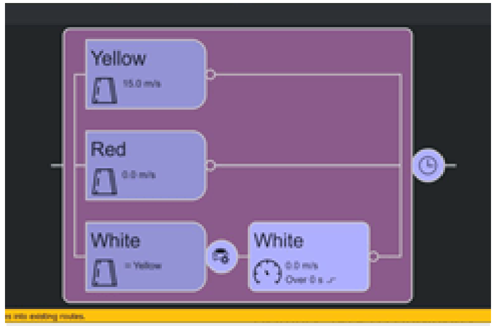
Cut in and brake



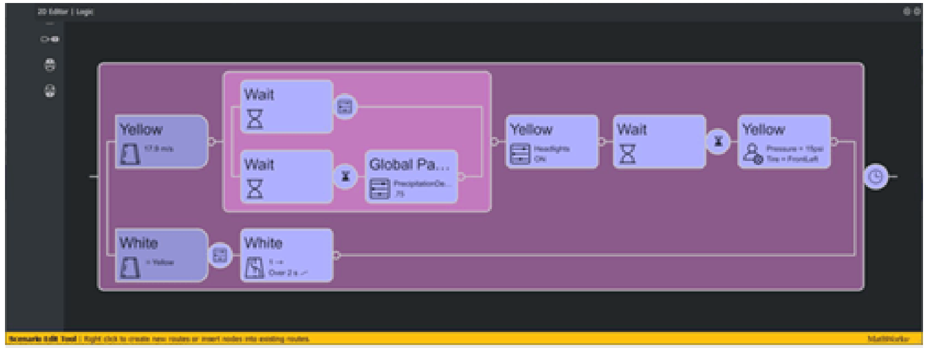
Maintain space gap



Free drive



Lead collision



User extensions

[Open and Explore Sample Scenarios]()

RoadRunner Scenario

R2022b

Develop scenarios for automated driving applications with RoadRunner Scenario

Trajectories
- CSV
- OpenSCENARIO 1.x

RoadRunner Scenario

Trajectories and logic
- OpenSCENARIO 1.x
- OpenSCENARIO 2.0

Automate Tasks
(import, export, set variables,…)

- MATLAB*
- C/C++
- Python
- Any gRPC supported language

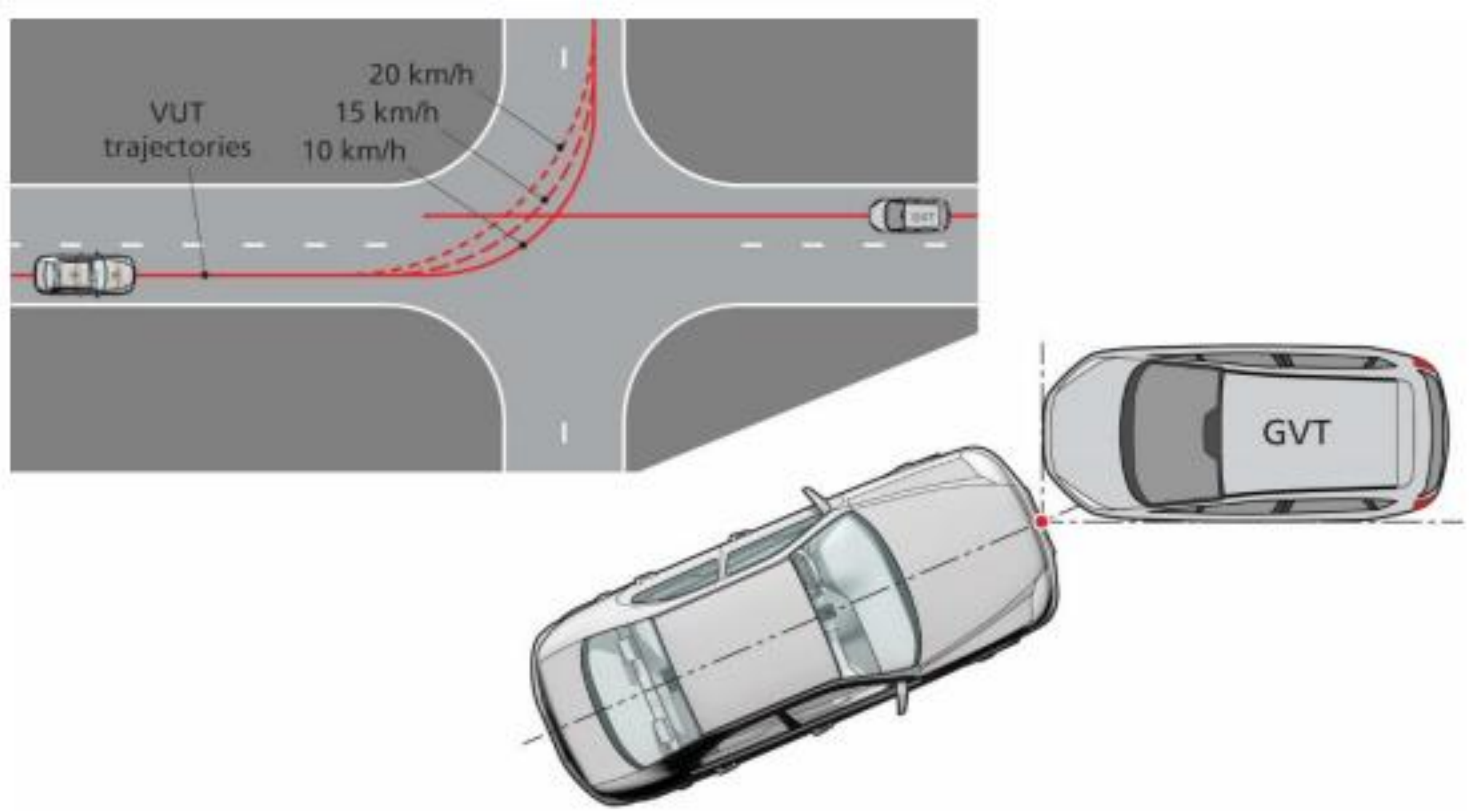
RoadRunner

Simulate Actor Behaviors

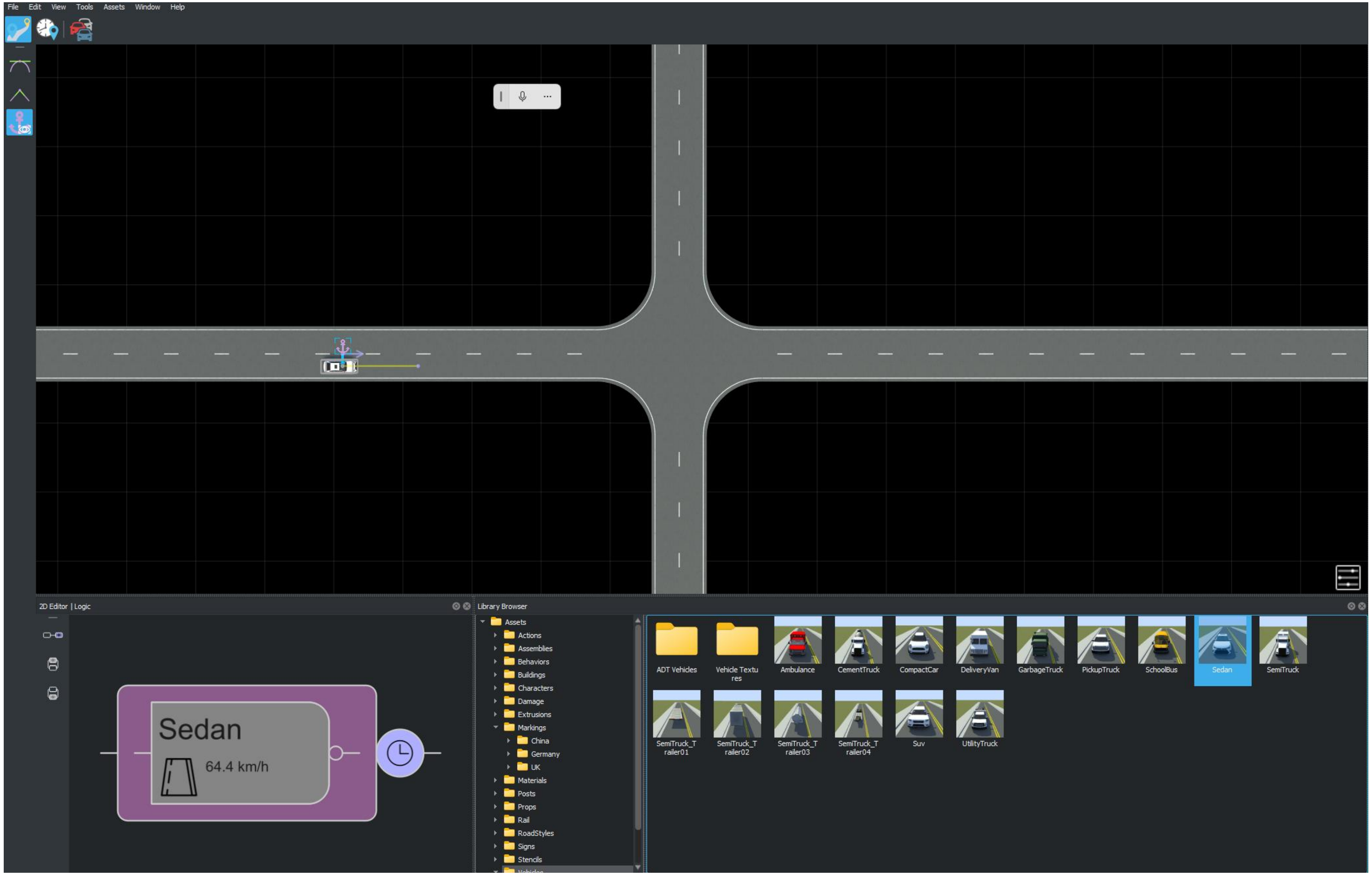
- MATLAB*
- Simulink*
- CARLA

* = Enabled through Automated Driving Toolbox

Car-to-Car Front turn-across-path (CCFtap)

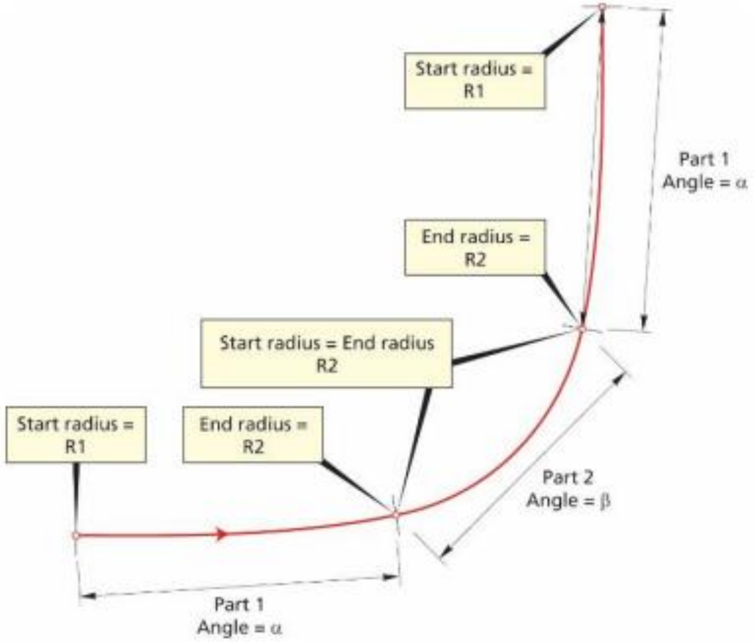


Add a Vehicle



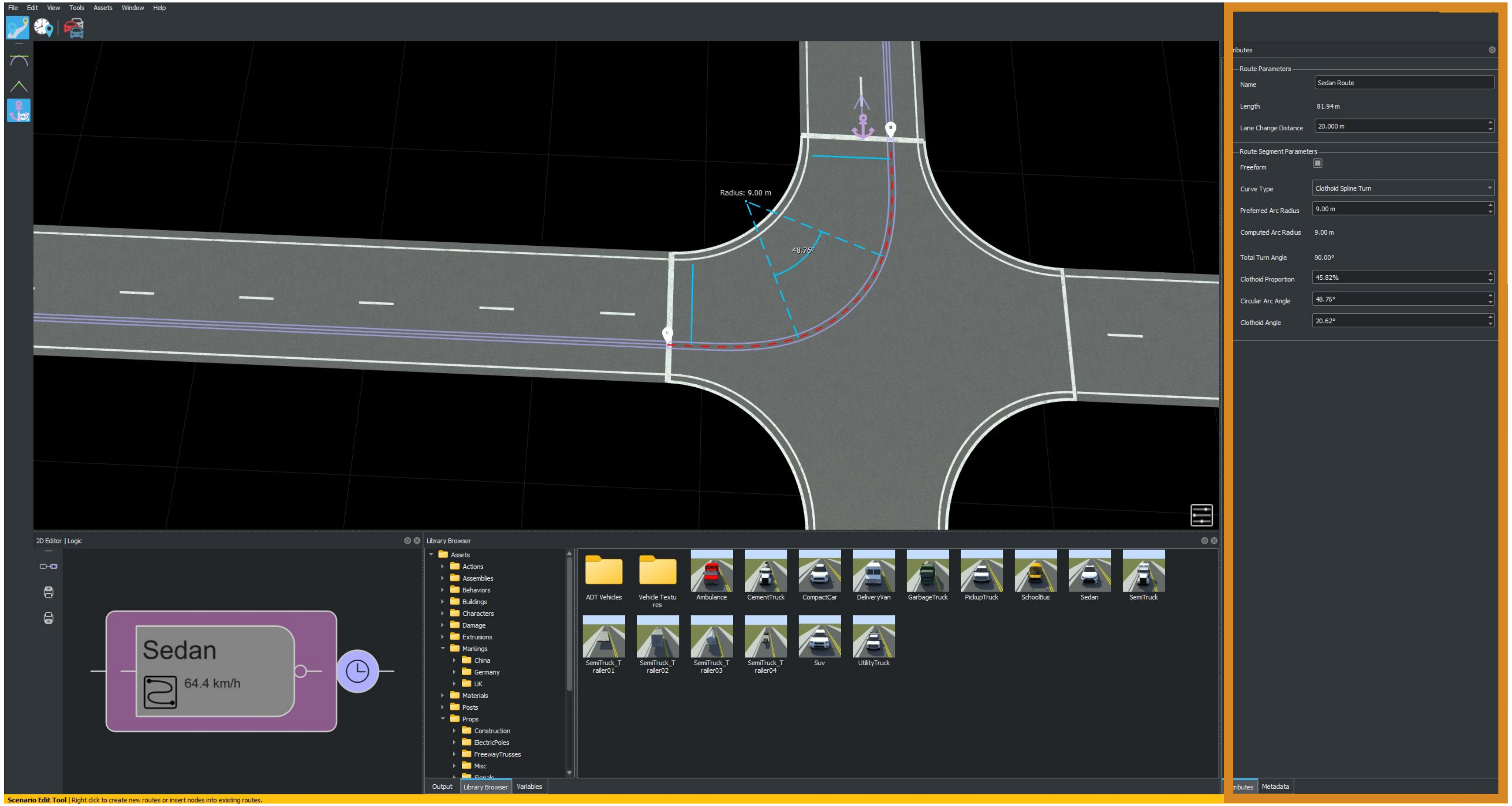
Clothoid Arc for Vehicle

7.2.8.1 The following parameters should be used to create the test paths. The tests are performed without using the turn signal:

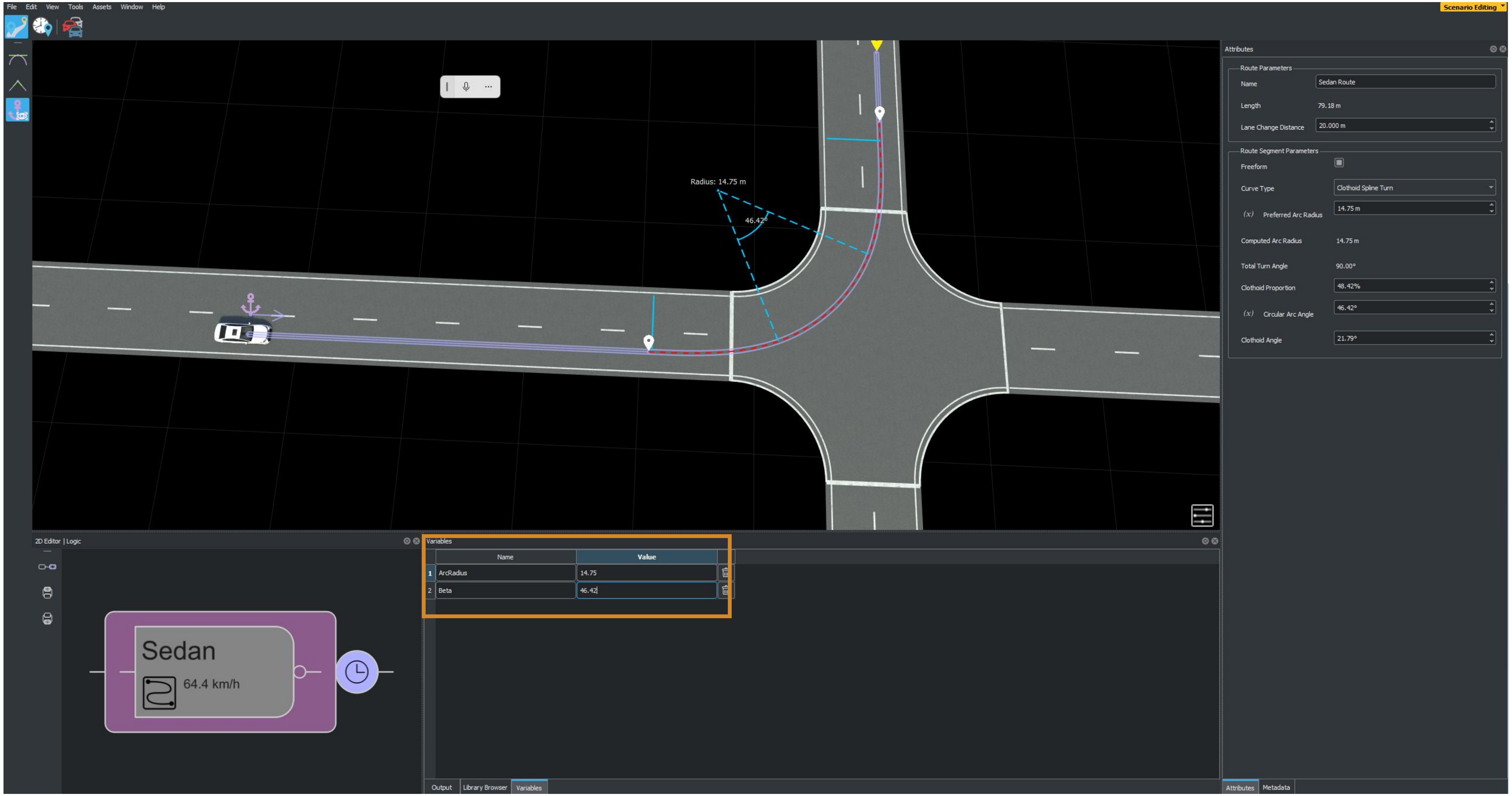


Test speed	Part 1 (clothoid)			Part 2 (constant radius)			Part 3 (clothoid)		
	Start Radius R1 [m]	End Radius R2 [m]	Angle α [deg]	Start Radius R2 [m]	End Radius R2 [m]	Angle β [deg]	Start Radius R2 [m]	End Radius R1 [m]	Angle α [deg]
10 km/h to Farside	1500	9.00	20.62	9.00	9.00	48.76	9.00	1500	20.62
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

Create a clothoid Arc in RoadRunner Scenario



Create Clothoid arcs for different Radii using variables



Add the GTV , Adjust variables to create collision

Simulate driving applications with Automated Driving Toolbox

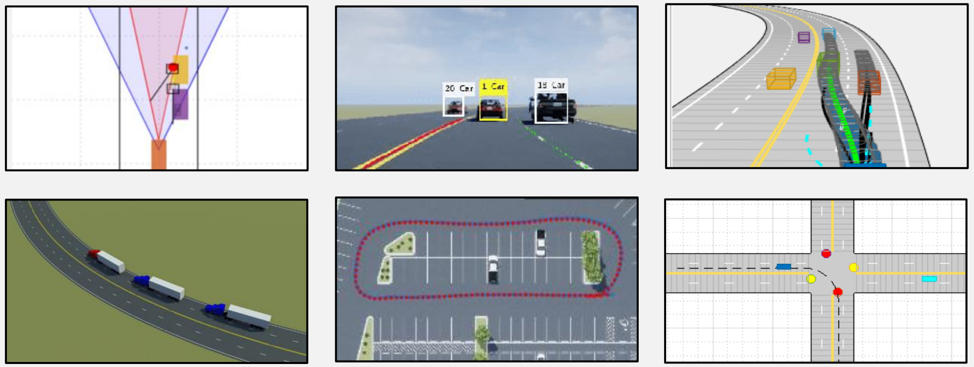
RoadRunner

RoadRunner Scenario

Vehicle Dynamics Blockset

Automated Driving Toolbox

Application Examples



Simulink Test

Simulink Requirements

Simulink Real-Time

Embedded Coder

GPU Coder

Lidar Toolbox

Computer Vision Toolbox

Sensor Fusion & Tracking Toolbox

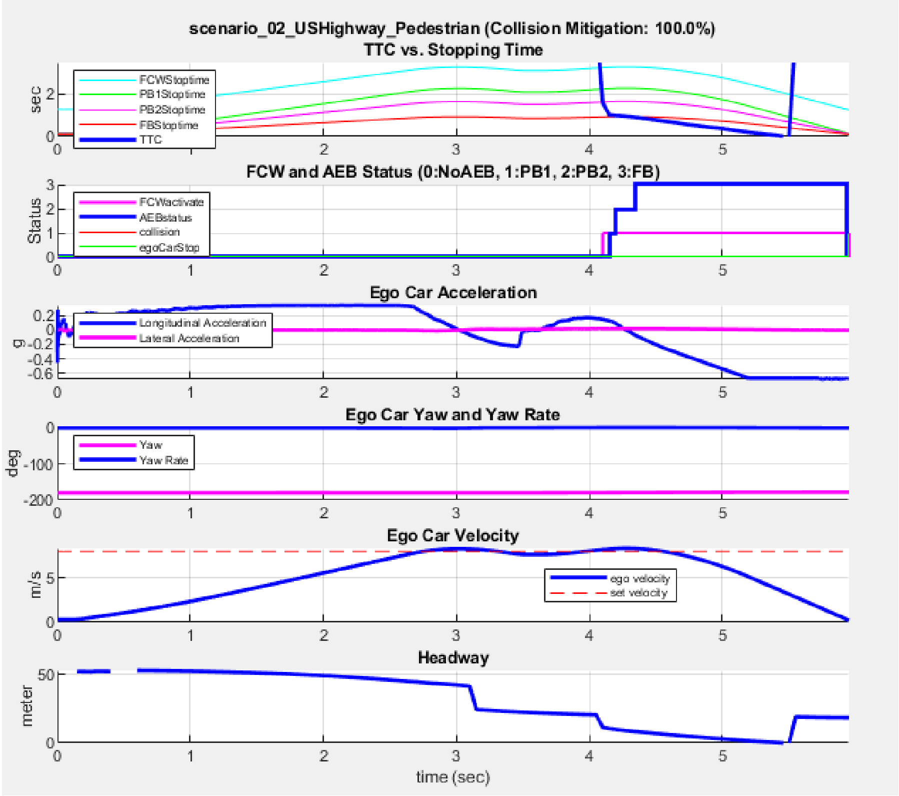
Navigation Toolbox

MPC Toolbox

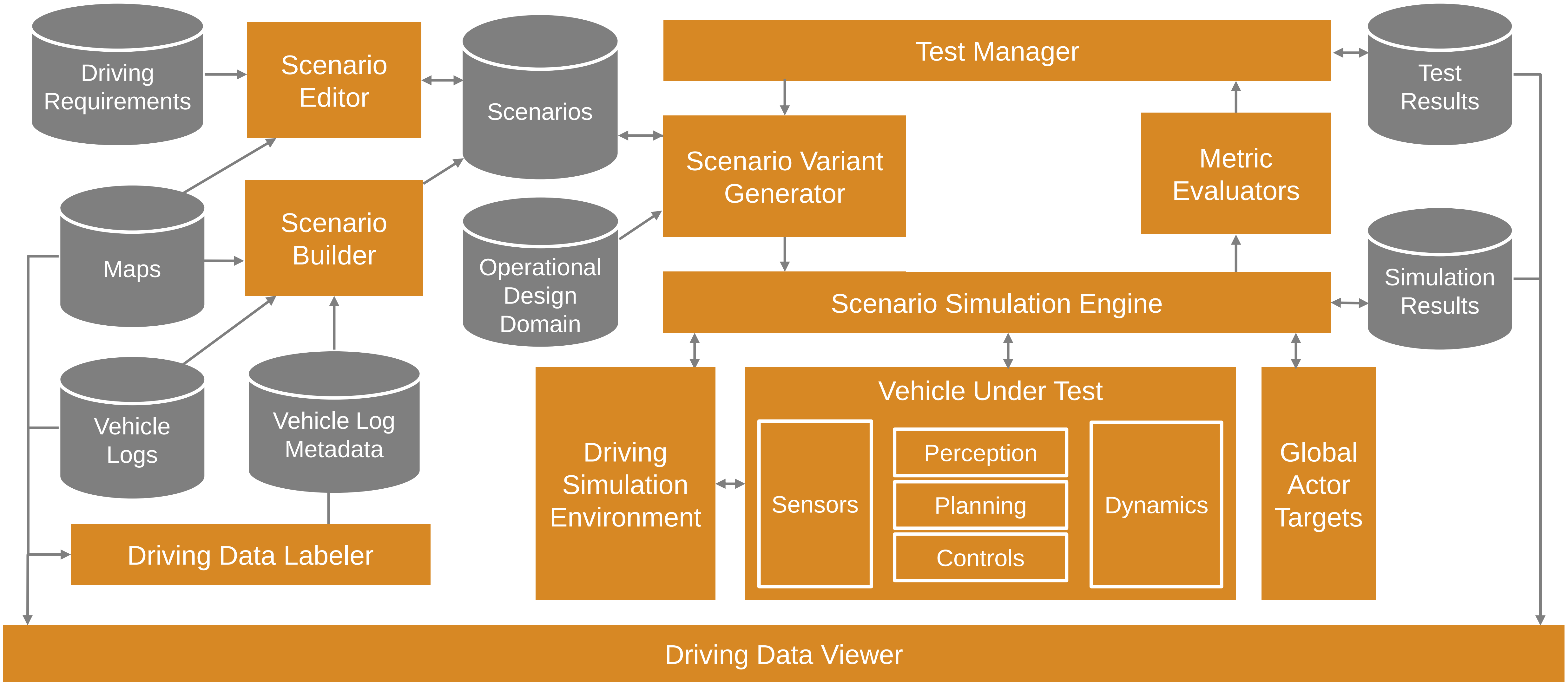
Simulate one scenario and analyze results

This example also provides an additional scenario, `scenario_02_USHighway_Pedestrian`, which is compatible with the `AEBWithHighFidelityDynamicsTestBench` model.

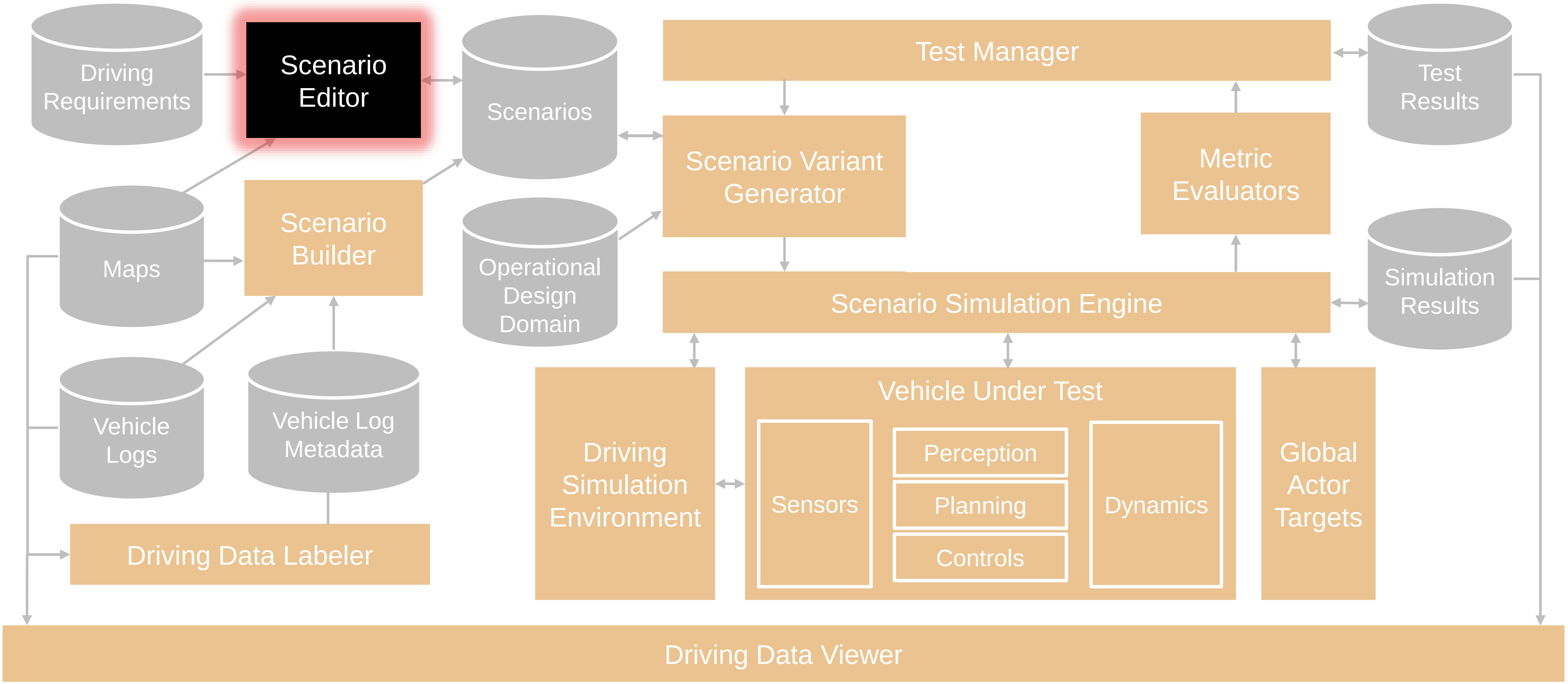
```
helperSLAEBWithHighFidelityDynamicsSetup(rrApp,rrSim,scenarioFileName="scenario_02_USHighway_Pedestrian");
```



The Auto industry is moving towards scenario based testing

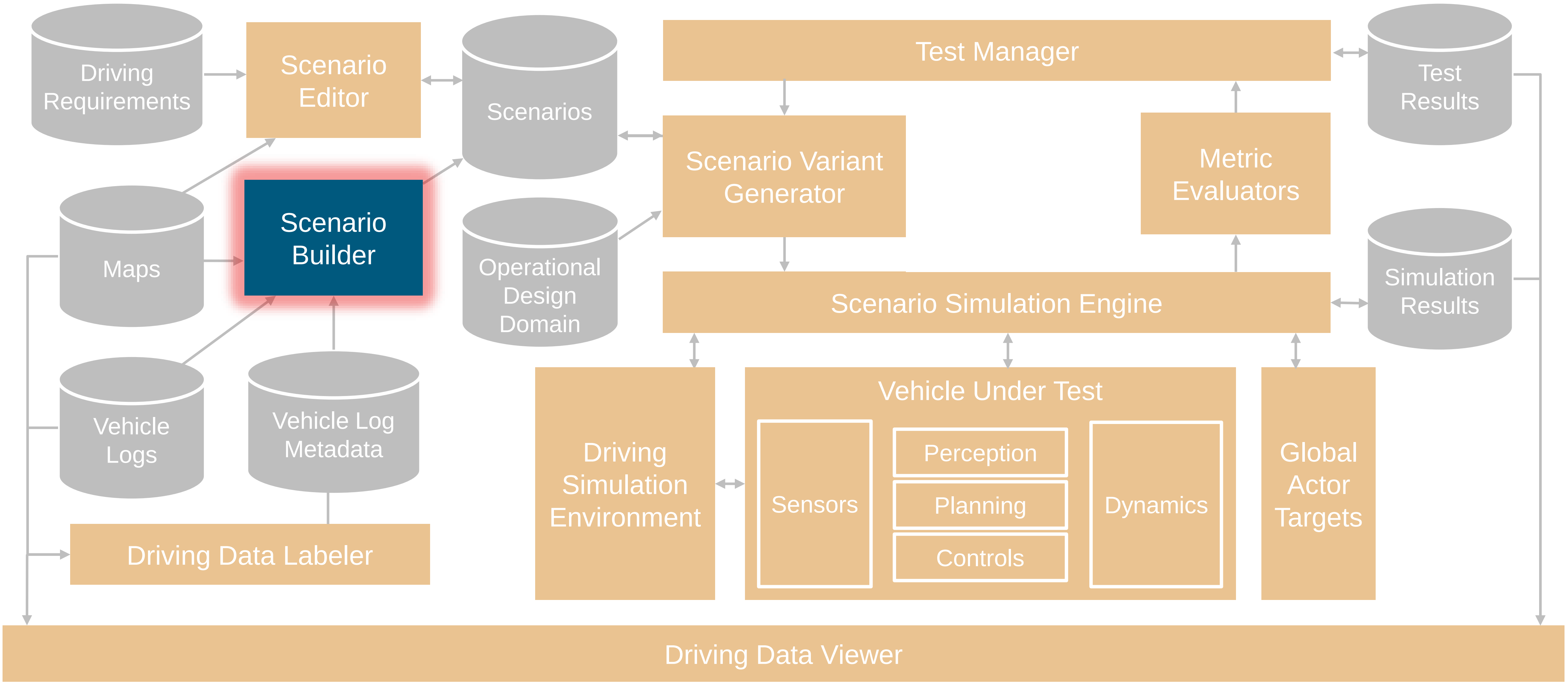


Simplified view of scenario-based testing trend in auto industry




Edit View Tools Assets Window Help
Scenario Editing
Simulation
Simulation Controls
Pause
Step Forward
Stop
Time: 1.460 s
Enable Pacing to Slow Down Simulation
Slower
Faster
0.05x
1x
20x
Simulation Properties
Step Size: 0.02000 s
Max Time: 1000.000 s
Camera
Camera View Follow
Actor CompactCar
Distance 5.000
Height 3.000
CarlaUE4
2D Editor | Logic Playback
CompactCar
17.9 m/s
Sedan
17.9 m/s
Library Browser
Assets
Assemblies
Behaviors
Buildings
Damage
Extrusions
Markings
Materials
Posts
Props
Rail
RoadStyles
Output
Library Browser
Variables
ulation Tool

Simplified view of scenario-based testing trend in auto industry



Scenario Builder for Automated Driving Toolbox

Add-on specialized for generating Scenes and Scenarios from recorded sensor data

MathWorks R2022b

Sensor data → Ego localization → Road reconstruction → Roadside objects reconstruction → Target actor trajectory reconstruction → RoadRunner Scenario

Scenario Builder

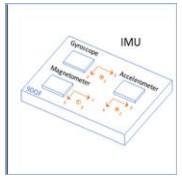
GPS
Camera
IMU
Lidar
Radar

ASAM OpenDRIVE®
ASAM OpenSCENARIO®

Scenario Builder - workflow

Sensor data → Ego localization → Road reconstruction → Roadside objects reconstruction → Target actor trajectory reconstruction → RoadRunner Scenario


GPS



IMU


Lanes


HD Map

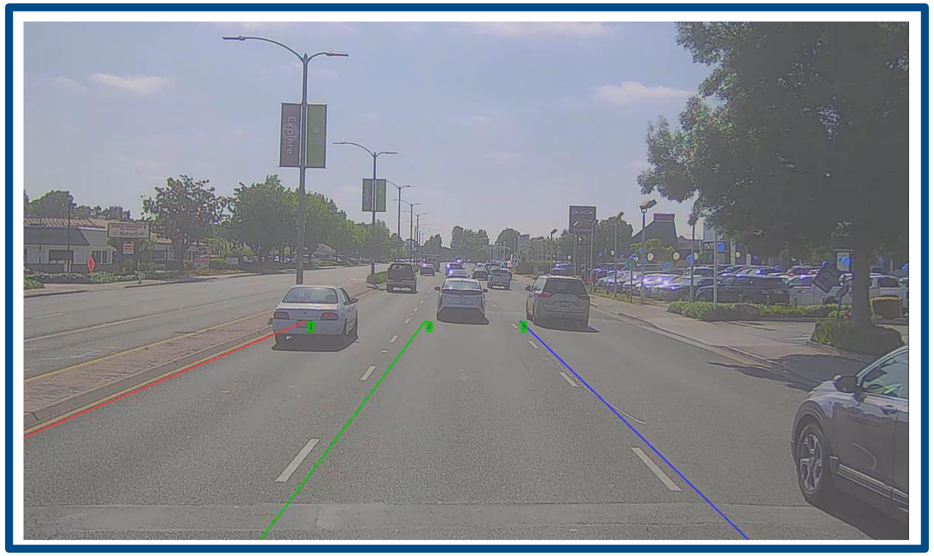
Pose correction

Offset correction

- Correct position and orientation of ego actor using GPS and IMU fusion
- Correct single/multi-lane level offsets using GPS, lane information and HD maps

Road reconstruction

Sensor data → Ego localization → Road reconstruction → Roadside objects reconstruction → Target actor trajectory reconstruction → RoadRunner Scenario



- Extract lanes, road boundaries from camera and lidar data
- Reconstruct road with lane add/drop, road curvature and junctions

Roadside objects reconstruction

Sensor data → Ego localization → Road reconstruction → Roadside objects reconstruction → Target actor trajectory reconstruction → RoadRunner Scenario

Lidar

- Labelled Lidar data is used to reconstruct trees, buildings and other roadside objects.
  - Labels supported: buildings, trees, bushes, traffic cones, pylons, barricades, and electric poles
- Automate assets (trees and buildings) labelling using pre-trained models
- Alternatively use Camera + GPS to get approximate scene with roadside objects.

Trajectory reconstruction

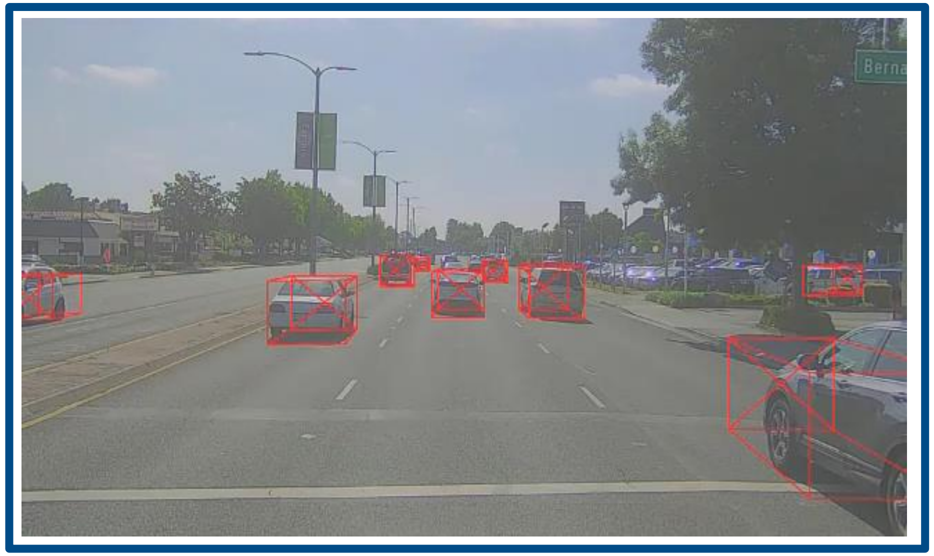
Sensor data → Ego localization → Road reconstruction → **Roadside objects reconstruction** → Target actor trajectory reconstruction → RoadRunner Scenario

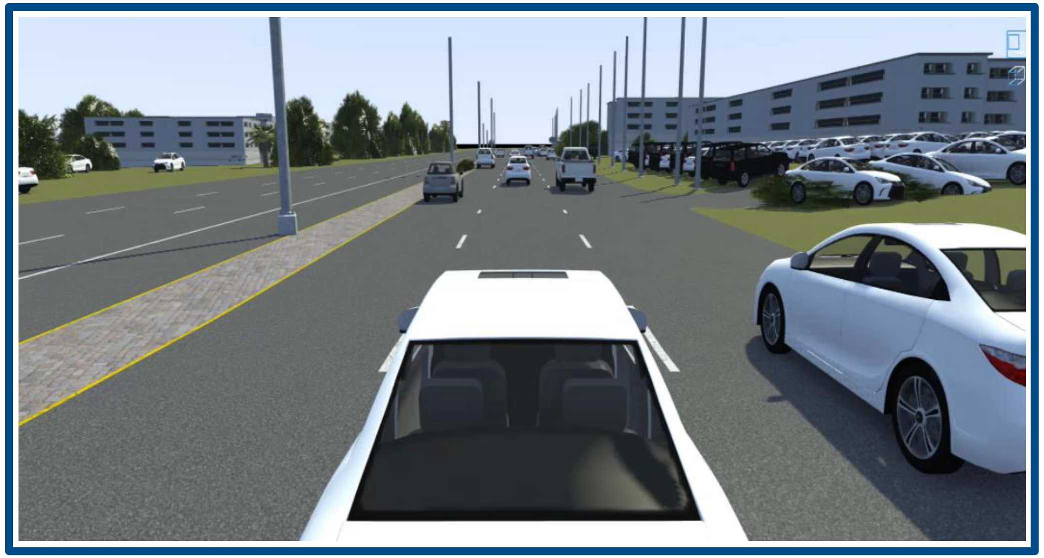
Object List

Camera

Lidar

Radar

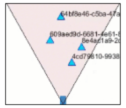




- Reconstruct dynamic actor tracklists, vehicles from camera or lidar or radar data and its combinations
- Lidar sensor data can enable extraction of objects from all the sides of the ego vehicle whereas Radar sensor data can enable farther objects.
- Camera sensor data can help identify object classes (car, truck etc.)

Trajectory reconstruction

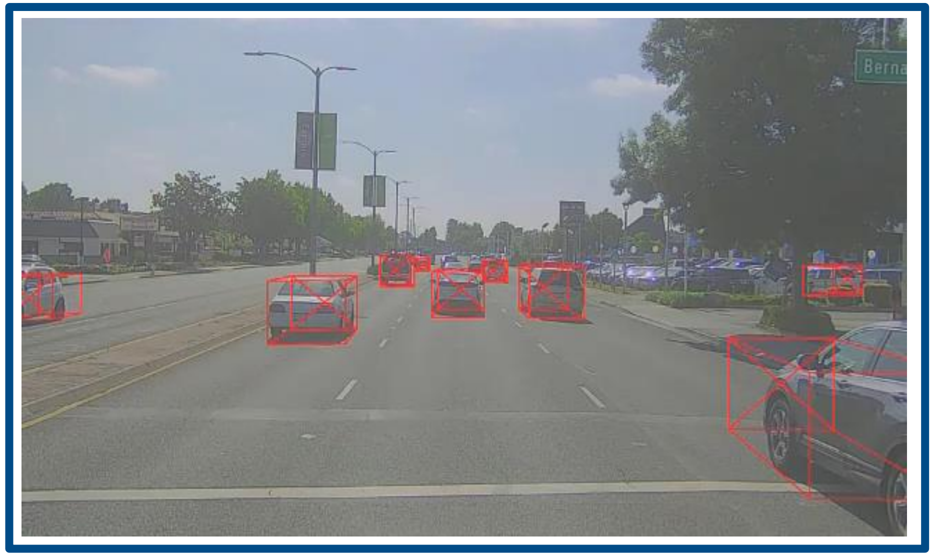
Sensor data → Ego localization → Road reconstruction → **Roadside objects reconstruction** → Target actor trajectory reconstruction → RoadRunner Scenario

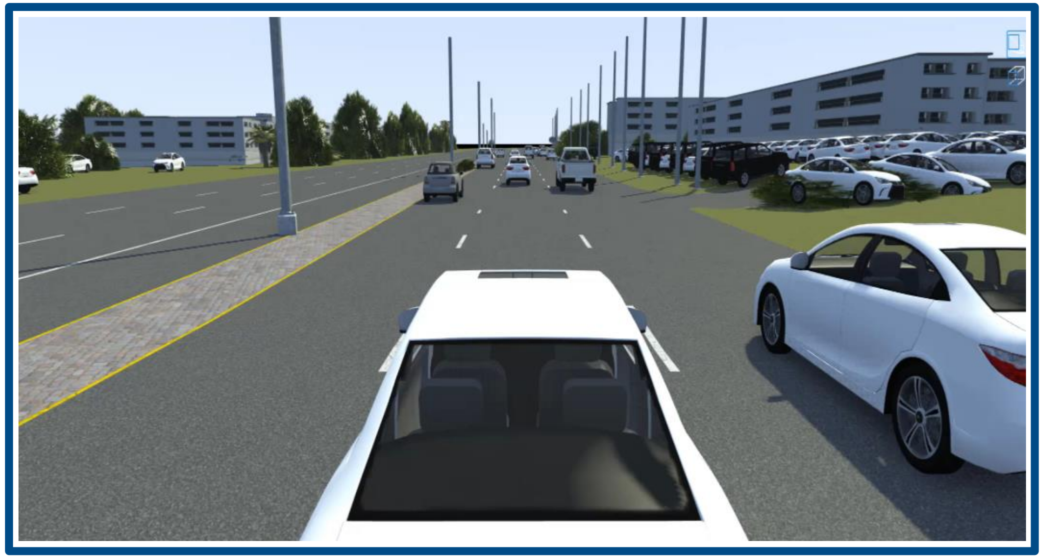

Object List


Camera


Lidar


Radar





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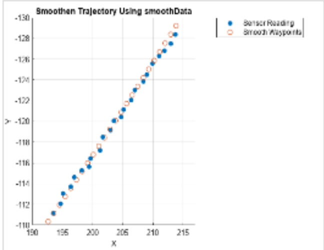
- Camera sensor data can help identify object classes (car, truck etc.)

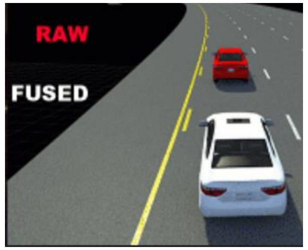
Shipping examples for you to get started

Ego localization



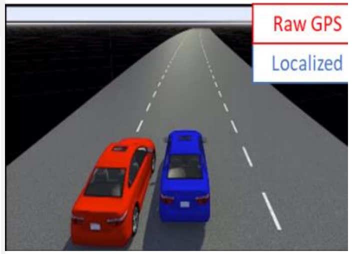
Smooth GPS Waypoints for Ego Localization

Ego pose smoothing



Ego vehicle localization using GPS and IMU fusion for Scenario Generation

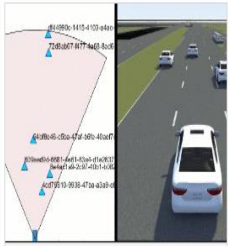
Pose correction using GPS & IMU



Ego Localization Using Lane Detections and HD Map for Scenario Generation

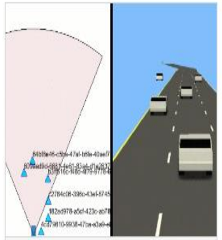
Drift correction using lanes

Target actor trajectory reconstruction



Generate RoadRunner Scenario from Recorded Sensor Data

RR Scenario from tracklist

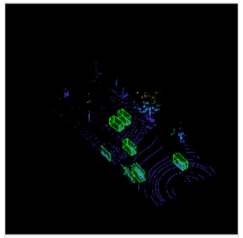


Generate Scenario from Actor Tracklist and GPS Data

Open-Scenario from tracklist

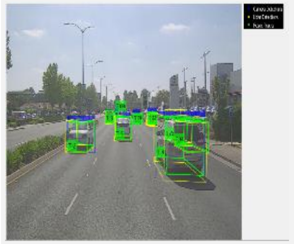
Extract Vehicle Tracklist from Recorded Camera Data for Scenario...

Vehicle tracklist from camera



Extract Vehicle Tracklist from Recorded Lidar Data for Scenario Generation

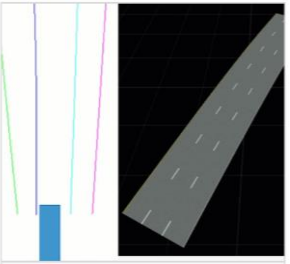
Vehicle tracklist from lidar



Fuse Recorded Lidar and Camera Data to Generate Vehicle Track List for Scenario Generation

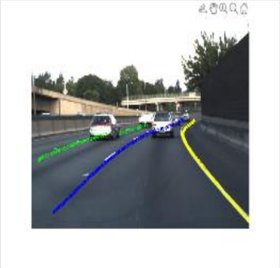
Vehicle tracklist from camera & Lidar

Road scene and roadside object reconstruction



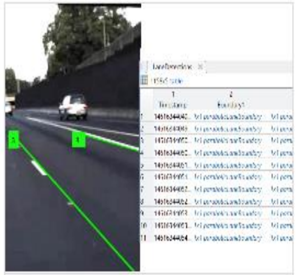
Generate High Definition Scene from Lane Detections

Augment OpenStreetMap with lanes



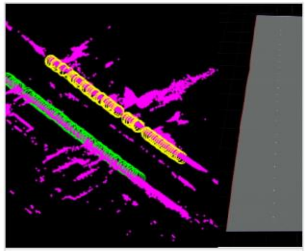
Extract Lane Information from Recorded Camera Data for Scene Generation

Extract lanes from camera



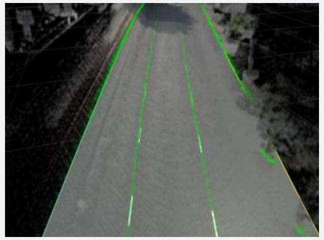
Preprocess Lane Detections for Scenario Generation

Extract labeled & Mobileye lanes



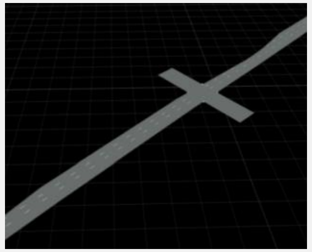
Generate RoadRunner Scene from Recorded Lidar Data

Generate road scene from lidar



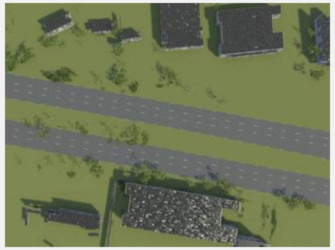
Generate road scene with lanes from labelled recorded data

Generate road lanes, junctions from Camera & Lidar



Generate RoadRunner Scene Using Labeled Camera Images and GPS Data

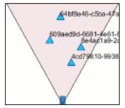
Generate road lanes, junctions from Camera & GPS



Generate Roadside trees and buildings from recorded Lidar data

Extract static objects using labelled lidar data

Scenario Builder can reconstruct roads, lanes and statics objects from raw sensor data or object list

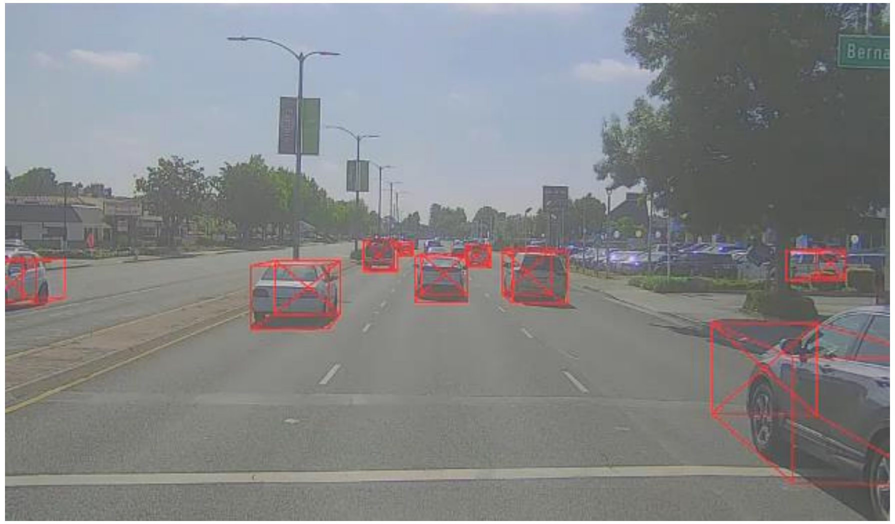


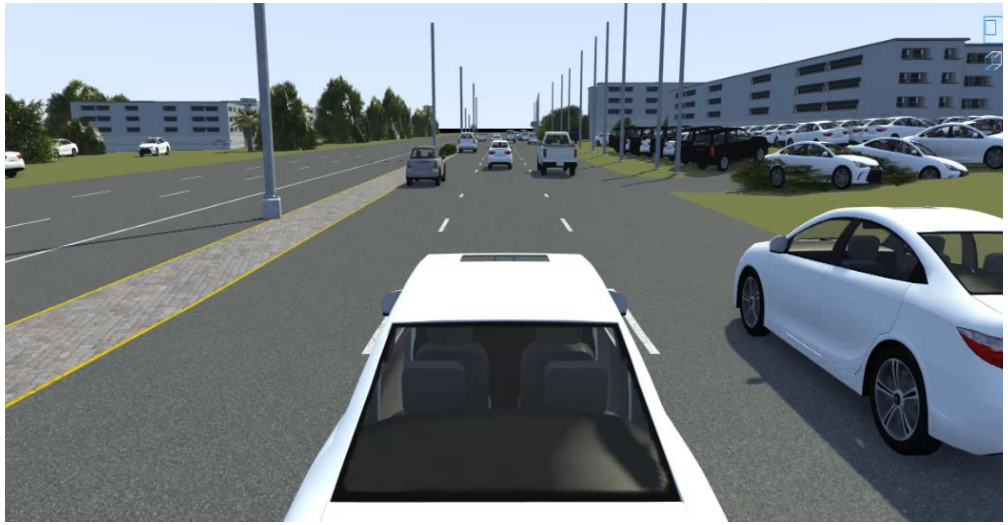
Object List

Camera

Lidar

GPS





Sensor data → Actor trajectory extraction (e.g. vehicles) → Scene objects extraction (e.g. lanes, signs, etc.) → RoadRunner Scenario composition → RoadRunner Scenario

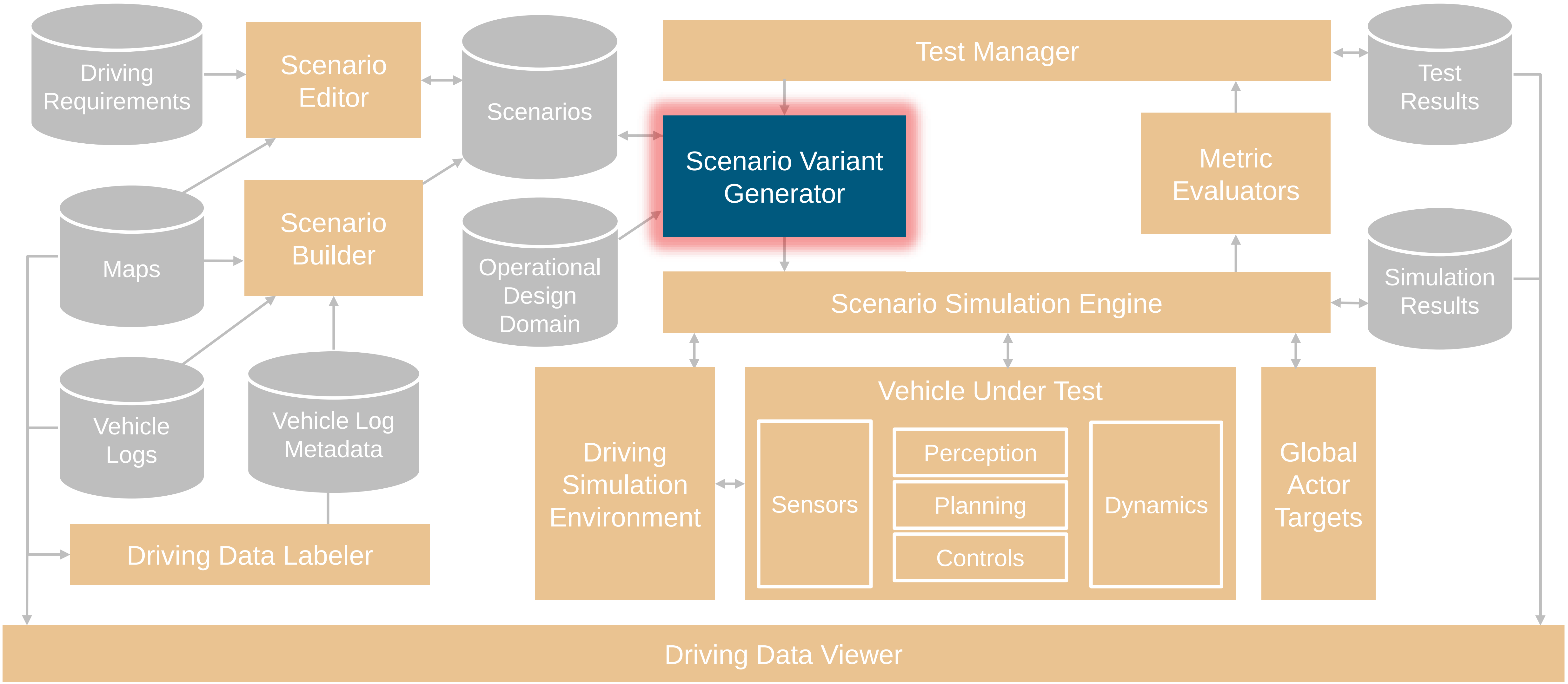
Analyse recorded data to extract key scenario events

Sensor data → Actor trajectory extraction → Segment trajectories for event extraction → Scene objects extraction → RoadRunner Scenario composition → RoadRunner Scenario

User → Scenario event description (E.g. Cut-in)

- Key scenario events include
  - cut-in,
  - turns,
  - accel/deceleration and
  - lane changes

Simplified view of scenario-based testing trend in auto industry



Scenario Variant Generator [ADT Add-on]

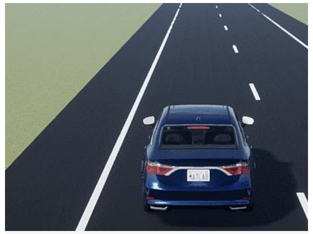
Scenario Variant Generator for Automated Driving Toolbox

- Read the seed scenario and extract its parameters
- Specify variation properties
- Generate variant scenarios

Generate Scenario Variants by Modifying Actor Dimensions

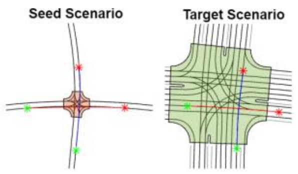
Generate Variants of ACC Target Cut-In Scenario

Generate Scenario Variants for Testing ACC Systems

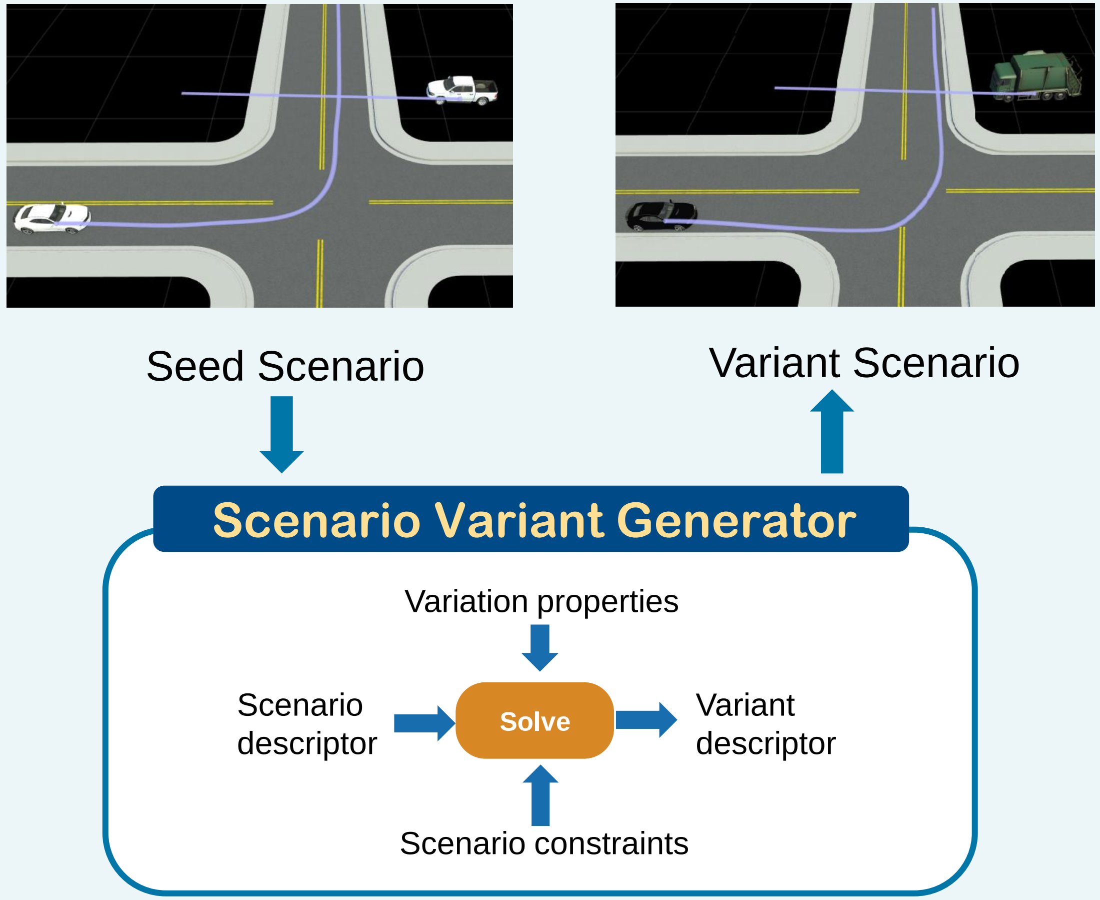


Generate Scenario Variants for Lane Keep Assist Testing

Generate Scenario Variants for Testing AEB Pedestrian Systems



Translocate Collision from Seed Scenario to Target Scene



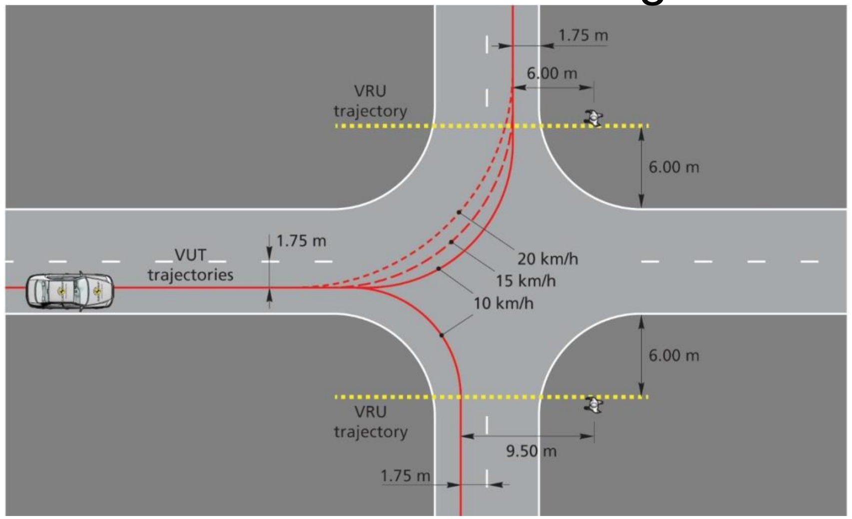
Generate variants from seed scenario

EURO NCAP – Variation table

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	

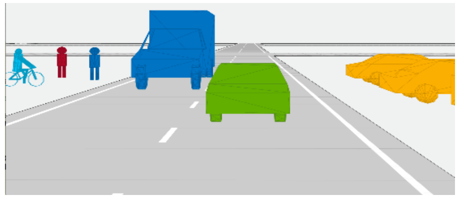
AEB Bicyclist	CBNA		CBFA	CBLA	
Type of test	AEB		AEB	AEB	FCW
VUT speed [km/h]	10-60		10-60	25-60	50-80
VUT direction	Forward		Forward	Forward	Forward
Obstruction	No	Yes	No	No	No
Target speed [km/h]	15	10	20	15	20
Impact location [%]	50		50	50	25
Lighting condition	Day		Day	Day	

Car-to-Pedestrian Turning Adult



Variant generation workflow from seed scenario data

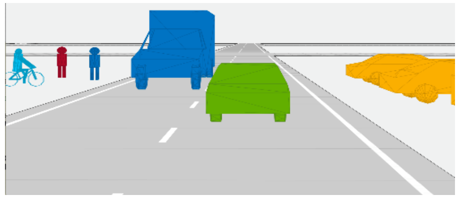
RoadRunner Scenario



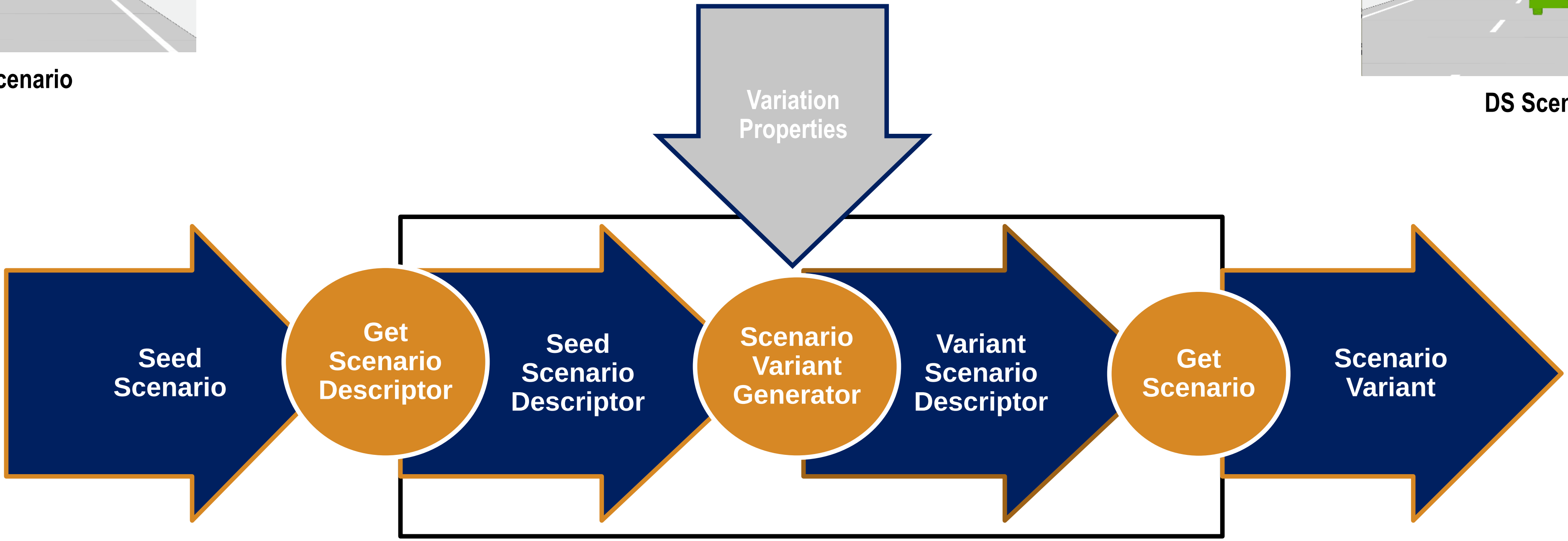
DS Scenario

Support both drivingScenario
and RoadRunner Scenario

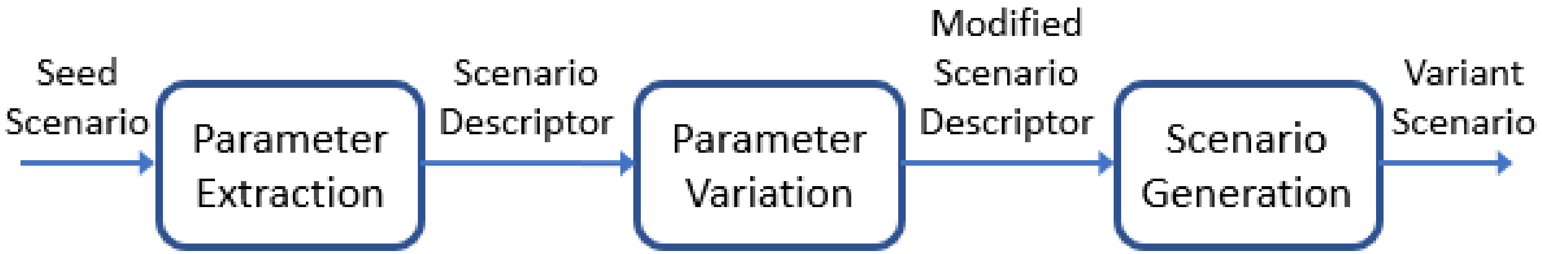
RoadRunner Scenario



DS Scenario



Scenario Variant Generator is built to enable customization



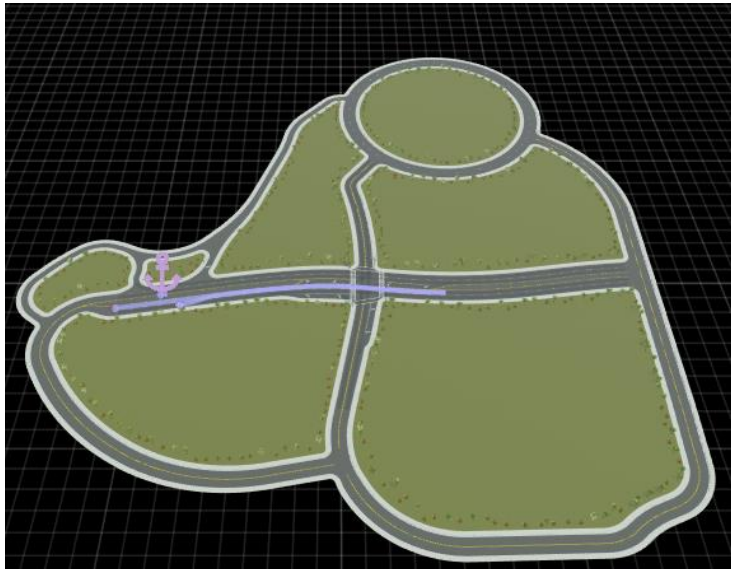
- Features
  - getScenario
  - getScenarioDescriptor
  - getCollisionData
  - varyActorProperties
  - varyCollisionProperties
  - generateVariants

- Examples
  - Generate Scenario Variants for Testing ACC Systems
  - Generate Variants of ACC Target Cut-In Scenario
  - Generate Scenario Variants for Lane Keep Assist Testing
  - Generate Scenario Variants for Testing AEB Pedestrian Systems
  - Generate Scenario Variants by Modifying Actor Dimensions
  - Automatic Scenario Generation
  - Translocate Collision from Seed Scenario to Target Scene

getScenarioDescriptor

- getScenarioDescriptor can now be used with “RoadRunner”.
- User can create scenario descriptor out of road runner scenario.

```
% Create RR Descriptor
RRScenarioDescriptor=getScenarioDescriptor(rrObjStruct,Simulator="RoadRunner");
```



RoadRunner Scenario “TrajectoryCutIn”

getScenarioDescriptor
Simulator=“RoadRunner”

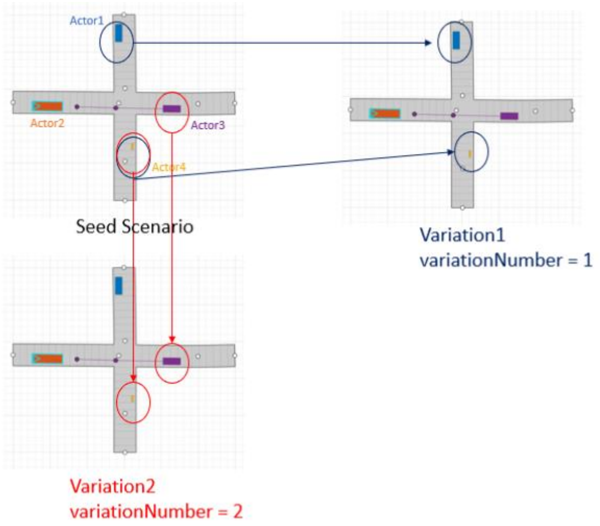
```
>> out = getScenarioData(RRScenarioDescriptor)

out =

  struct with fields:

          scene: [1×1 struct]
     SampleTime: 0.0200
       StopTime: 10
       entities: [1×1 struct]
      Simulator: "RoadRunner"
  StartTestTime: []
```

varyActorProperties

% Add and define actor variation
varyActorProperties(scenarioVariantObj, actorID, Speed=actorSpeed, Dimension=actorDimension, Waypoints = actorWaypoint, Yaw=actorYaw) ;

- Current Capabilities
  - Single and Multi-Actor Variations
  - Speed Variation, Waypoint Variation, Dimension Variation

Seed Scenario → Variation1 -> Actor1 -> Waypoint, Yaw, Speed, Dimension
-> Actor2 -> Waypoint, Yaw, Speed, Dimension
-> Actor3 -> Waypoint, Yaw, Speed, Dimension
-> Actor4 -> Waypoint, Yaw, Speed, Dimension
→ Variation2 -> Actor1 -> Waypoint, Yaw, Speed, Dimension
-> Actor2 -> Waypoint, Yaw, Speed, Dimension
-> Actor3 -> Waypoint, Yaw, Speed, Dimension
-> Actor4 -> Waypoint, Yaw, Speed, Dimension
→ Variation3 -> Actor1 -> Waypoint, Yaw, Speed, Dimension
-> Actor2 -> Waypoint, Yaw, Speed, Dimension
-> Actor3 -> Waypoint, Yaw, Speed, Dimension
-> Actor4 -> Waypoint, Yaw, Speed, Dimension



[varyActorProperties]

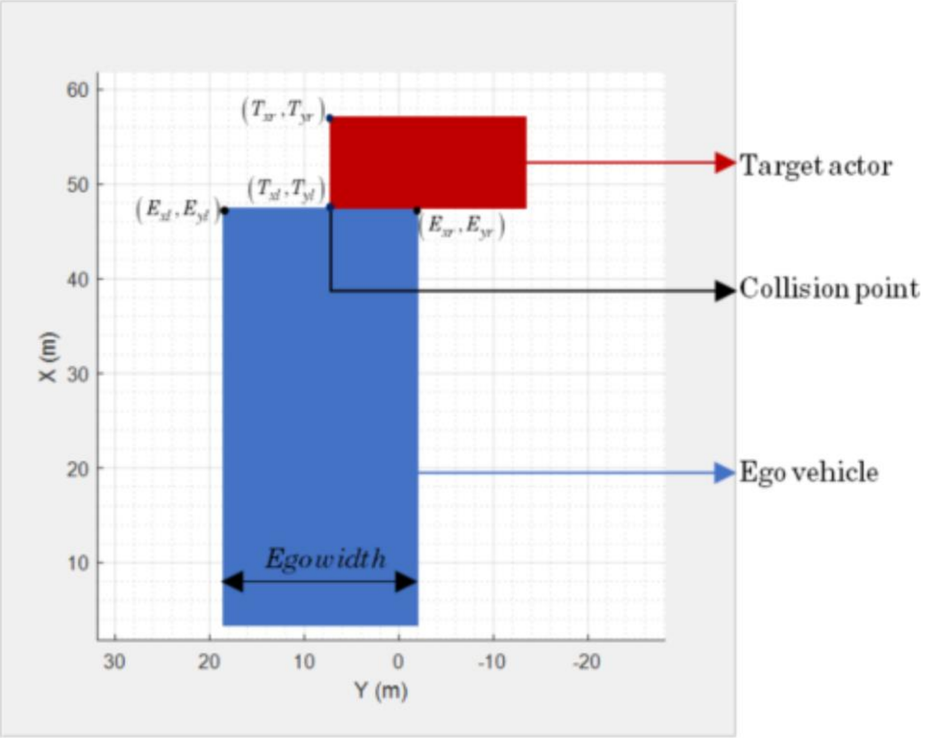
varyCollisionProperties

varyCollisionProperties(scenarioVariantObj, Actor1ID, Actor2ID, options);
varyCollisionProperties(scenarioVariantObj, CollisionObj, options);

Name-Value pairs:

- Actor1CollisionSide
- Actor1CollisionFraction
- Actor2CollisionSide
- Actor2CollisionFraction
- VariationType

- Create collision variations based on user input



Collision Point

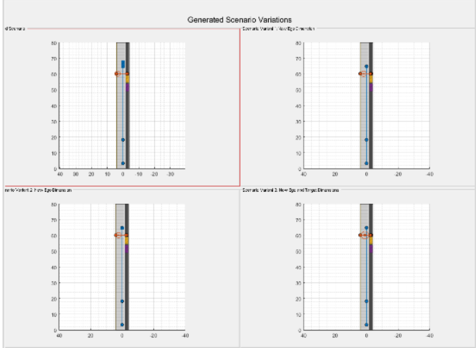
Scenario Variation Generation for a Euro NCAP scenario

Scenario Variant Generator for Automated Driving Toolbox

by MathWorks Automated Driving Toolbox Team STAFF

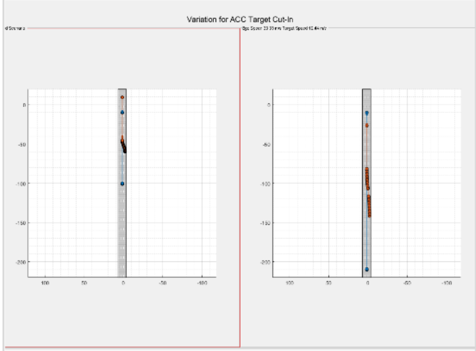
Generate multiple variants from a seed scenario that is either manually created or generated from recorded sensor data

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



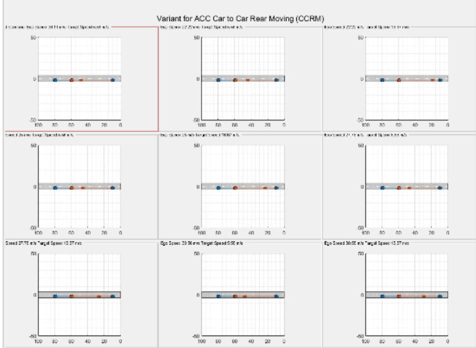
Generate Scenario Variants by Modifying Actor Dimensions

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

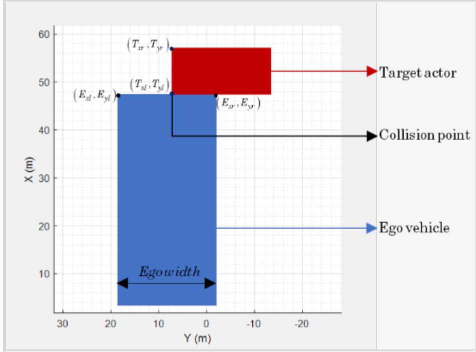


Generate Scenario Variants for Testing ACC Systems

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

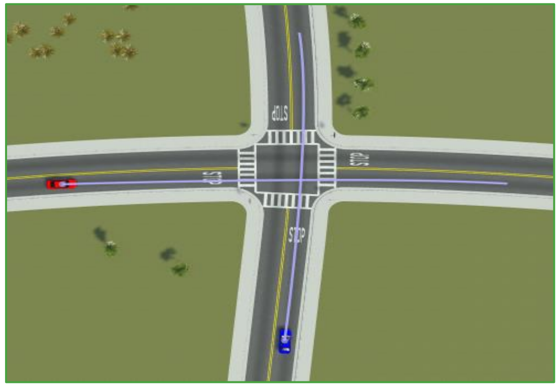
Generate scenario variants to test lane keep assist (LKA) system using European New Car Assessment Programme (Euro NCAP) test



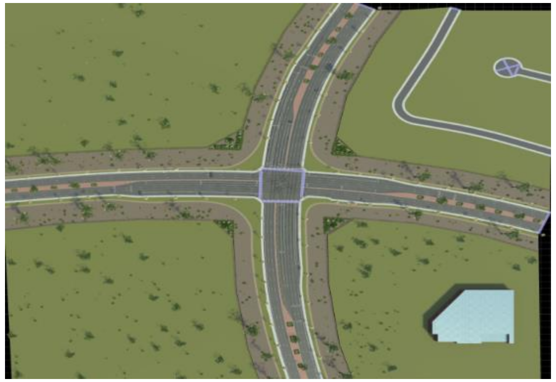
Generate Scenario Variants for Testing AEB Pedestrian Systems

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

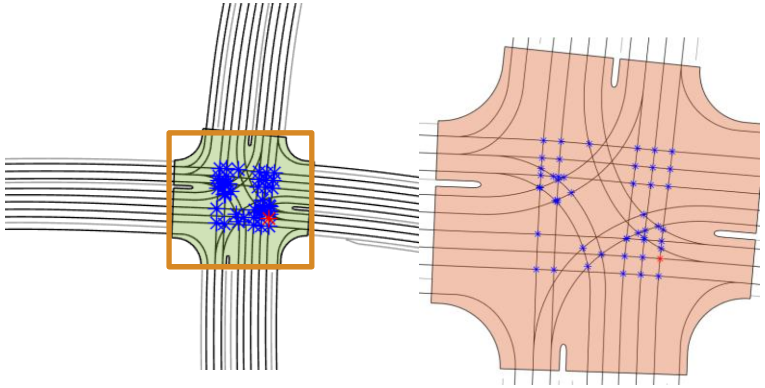
Translocate Collision Scenario to Selected Scene – We do not want your simulations to break



Seed Scenario

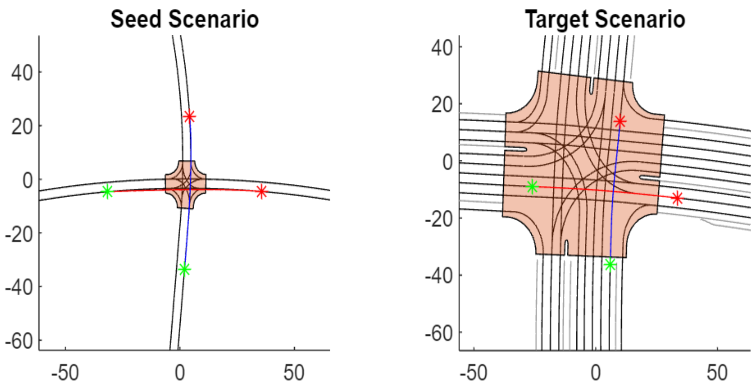


Target scene

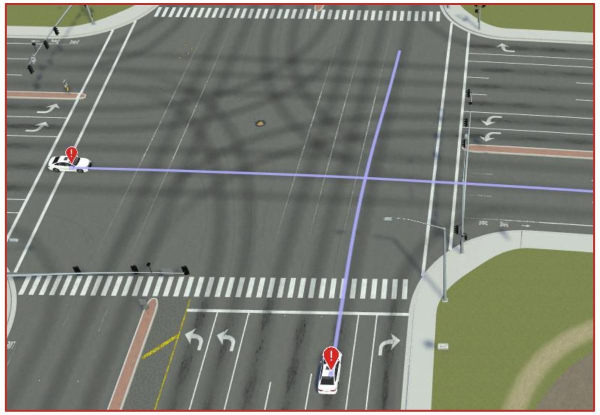


Lane Intersections

Filtering infeasible Lane Intersections

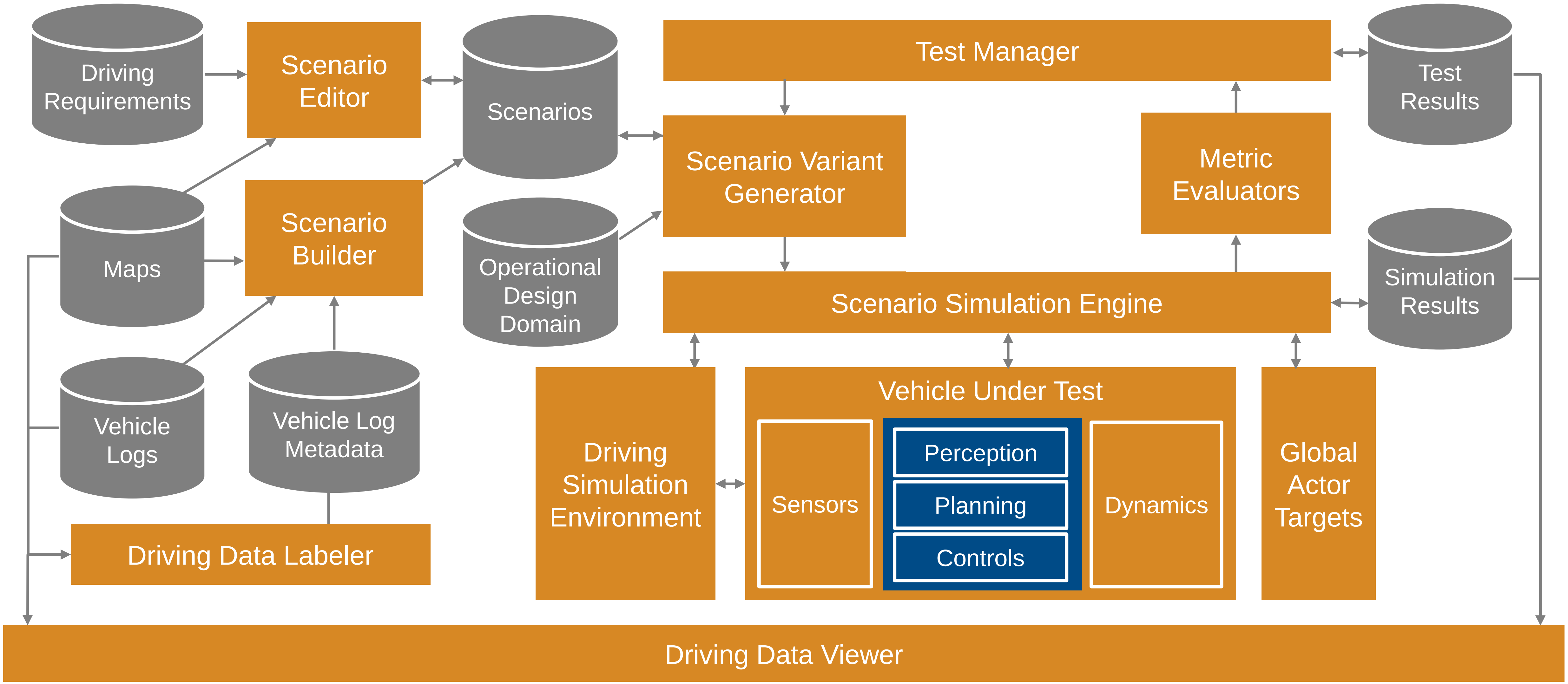


Translocation Maintaining Collision



Translocated Scenario in RR

The Auto industry is moving towards scenario based testing

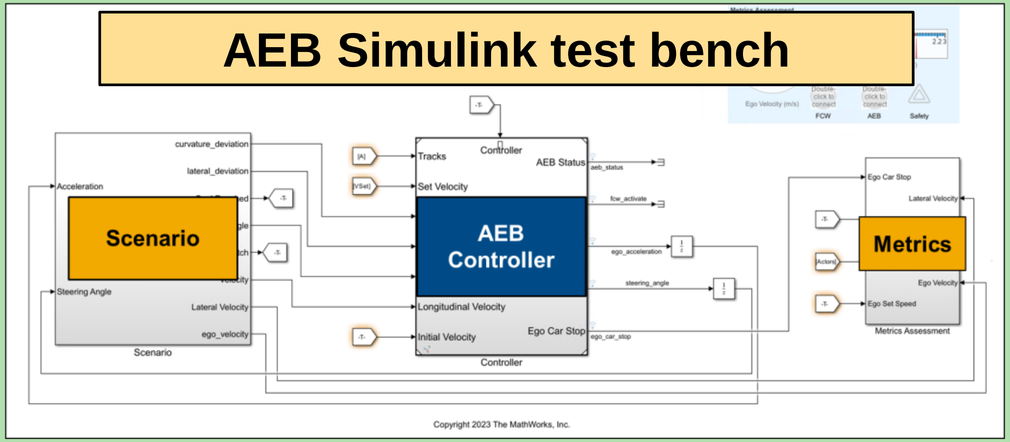


Euro NCAP workflow with RoadRunner Scenario & Simulink

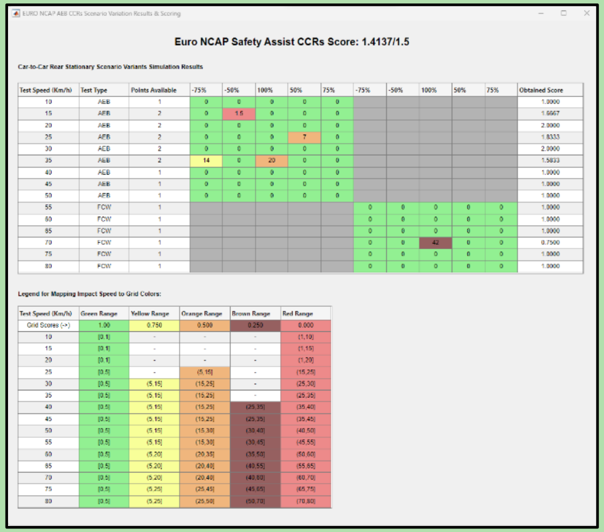
Automated Driving Toolbox™ Test Suite for Euro NCAP® Protocols

Euro NCAP scenario variants

AEB Simulink test bench

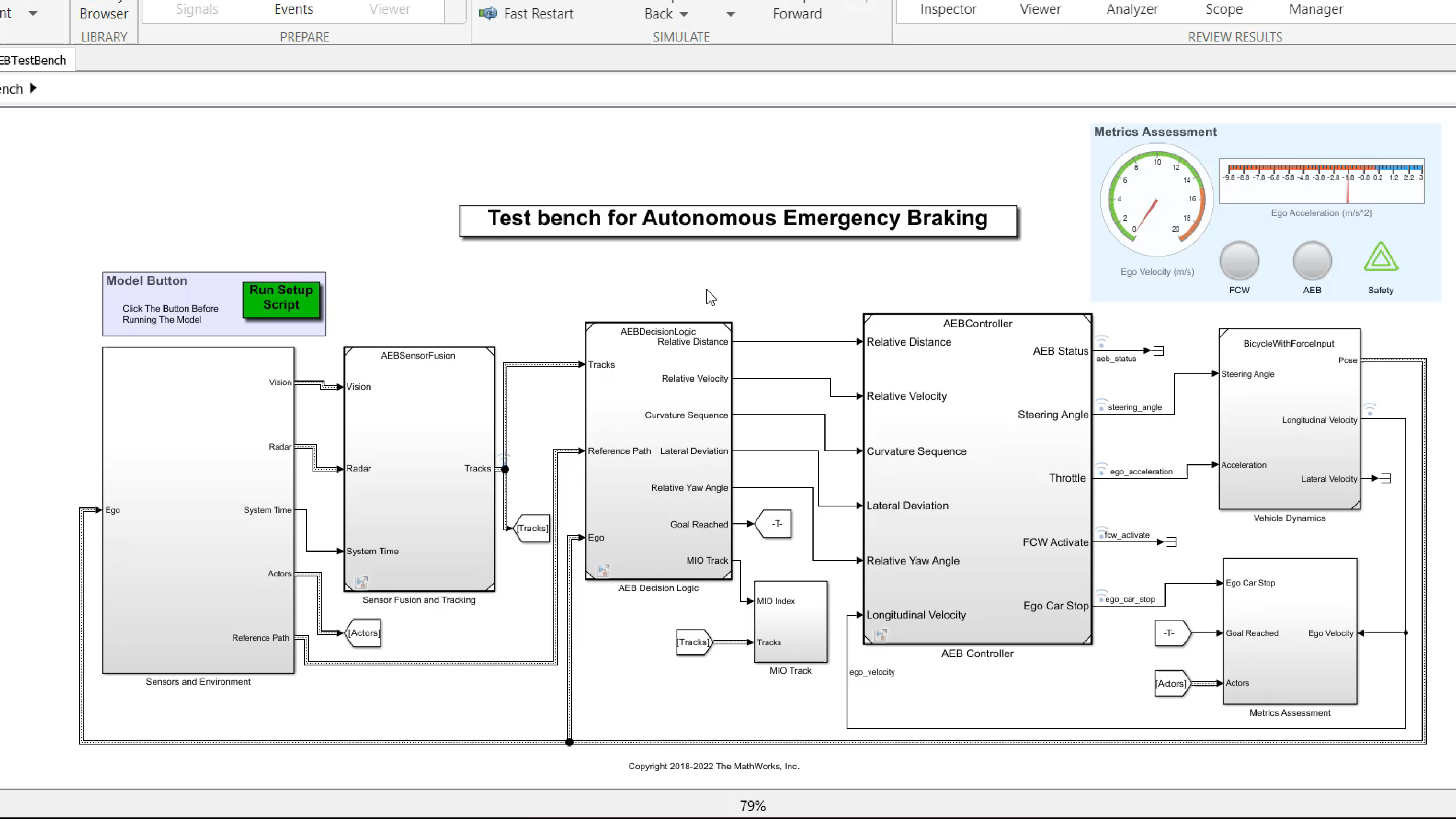


Euro NCAP score and rating



Scenario

Simulink Test manager



Browser
Signals
Events
Viewer
Fast Restart
Back
Forward
Inspector
Viewer
Analyzer
Scope
Manager
LIBRARY
PREPARE
SIMULATE
REVIEW RESULTS
EBTestBench
ench
Test bench for Autonomous Emergency Braking
Metrics Assessment
Ego Velocity (m/s)
Ego Acceleration (m/s^2)
FCW
AEB
Safety
Model Button
Click The Button Before Running The Model
Run Setup Script
Sensors and Environment
Ego
Vision
Radar
System Time
Actors
Reference Path
AEBSensorFusion
Tracks
Sensor Fusion and Tracking
[Tracks]
[Actors]
AEBDecisionLogic
Relative Distance
Relative Velocity
Curvature Sequence
Lateral Deviation
Relative Yaw Angle
Goal Reached
MIO Track
AEB Decision Logic
-T-
MIO Index
MIO Track
AEBController
AEB Status
Steering Angle
Throttle
FCW Activate
Ego Car Stop
Longitudinal Velocity
AEB Controller
aeb_status
steering_angle
ego_acceleration
fcw_activate
ego_car_stop
ego_velocity
BicycleWithForceInput
Pose
Acceleration
Lateral Velocity
Vehicle Dynamics
Ego Velocity
Metrics Assessment
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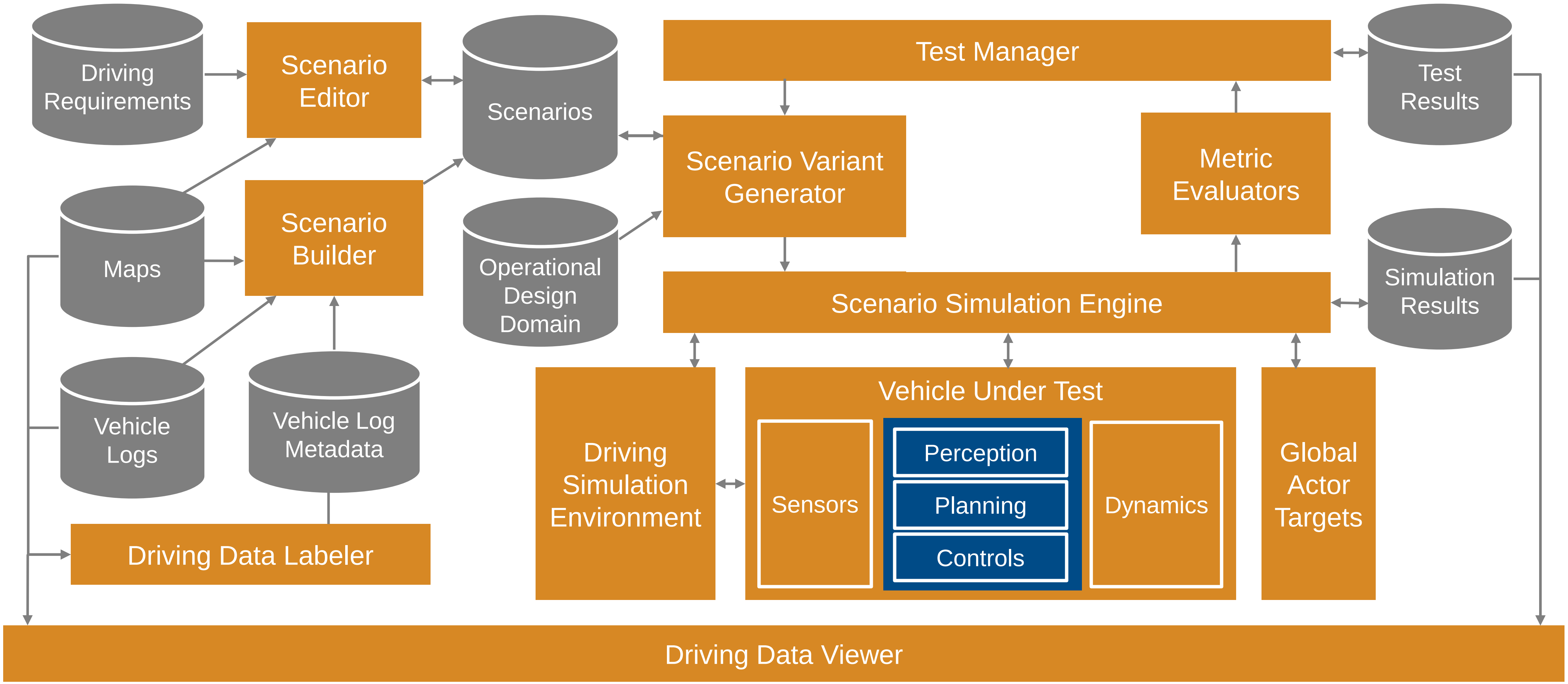
79%

The Auto industry is moving towards scenario based testing

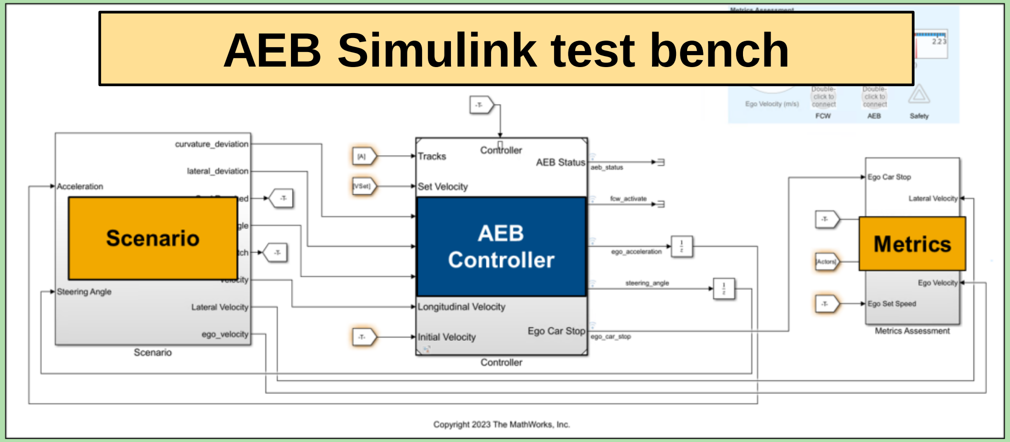


Euro NCAP workflow with RoadRunner Scenario & Simulink

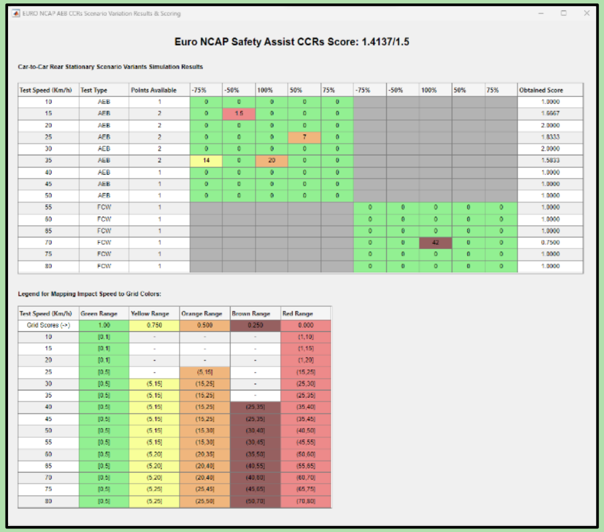
Automated Driving Toolbox™ Test Suite for Euro NCAP® Protocols

Euro NCAP scenario variants

AEB Simulink test bench



Euro NCAP score and rating



Scenario

Simulink Test manager

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- **we would be happy to brainstorm and help you on same**
- MathWorks would be happy to collaborate on your journey of Automated Driving

MathWorks

Accelerating the pace of engineering and science

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