



## RoadRunner : Editeur de scènes et scénarios pour la conduite autonome

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# Develop Automated Driving Applications

Verify & Validate



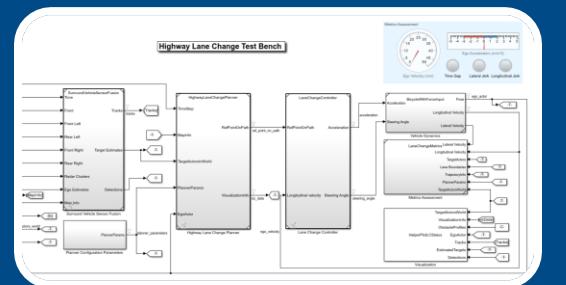
Analyze Recorded Data



Design Virtual Worlds



Design Algorithms & Systems



Deploy Software

C/C++  
GPU, ROS,  
AUTOSAR

Integrate with External Tools and Software

# Develop Automated Driving Applications

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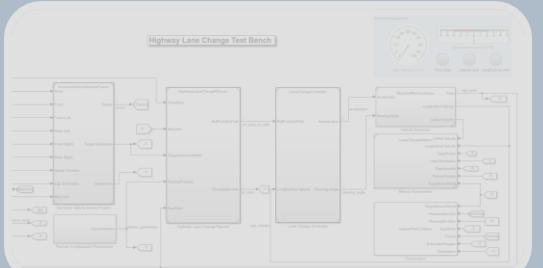
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# Develop Automated Driving Applications

Analyze Recorded Data

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Design Virtual Worlds



Design Algorithms & Systems

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Representative scenes & scenarios



Increase automation



Interactive and engineering-oriented tools



Adherence to the standards, interoperability, reproducibility

## Design 3D scenes

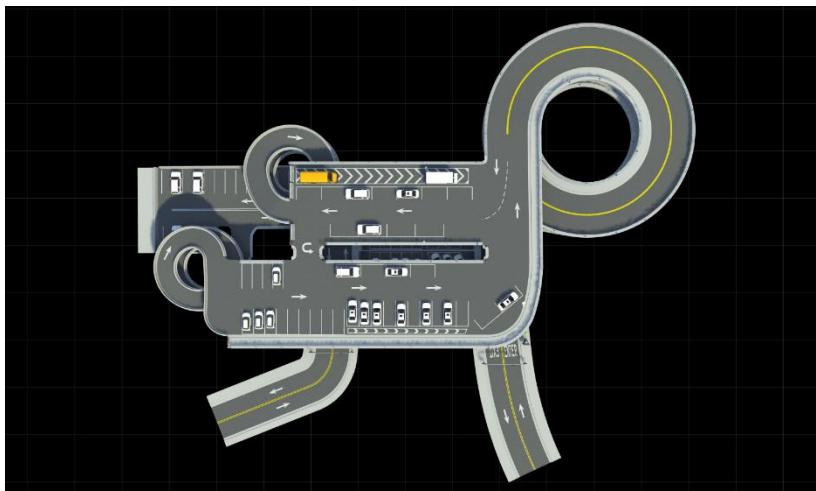
## Design scenarios

## Build scenarios from recorded data

## Simulate driving applications

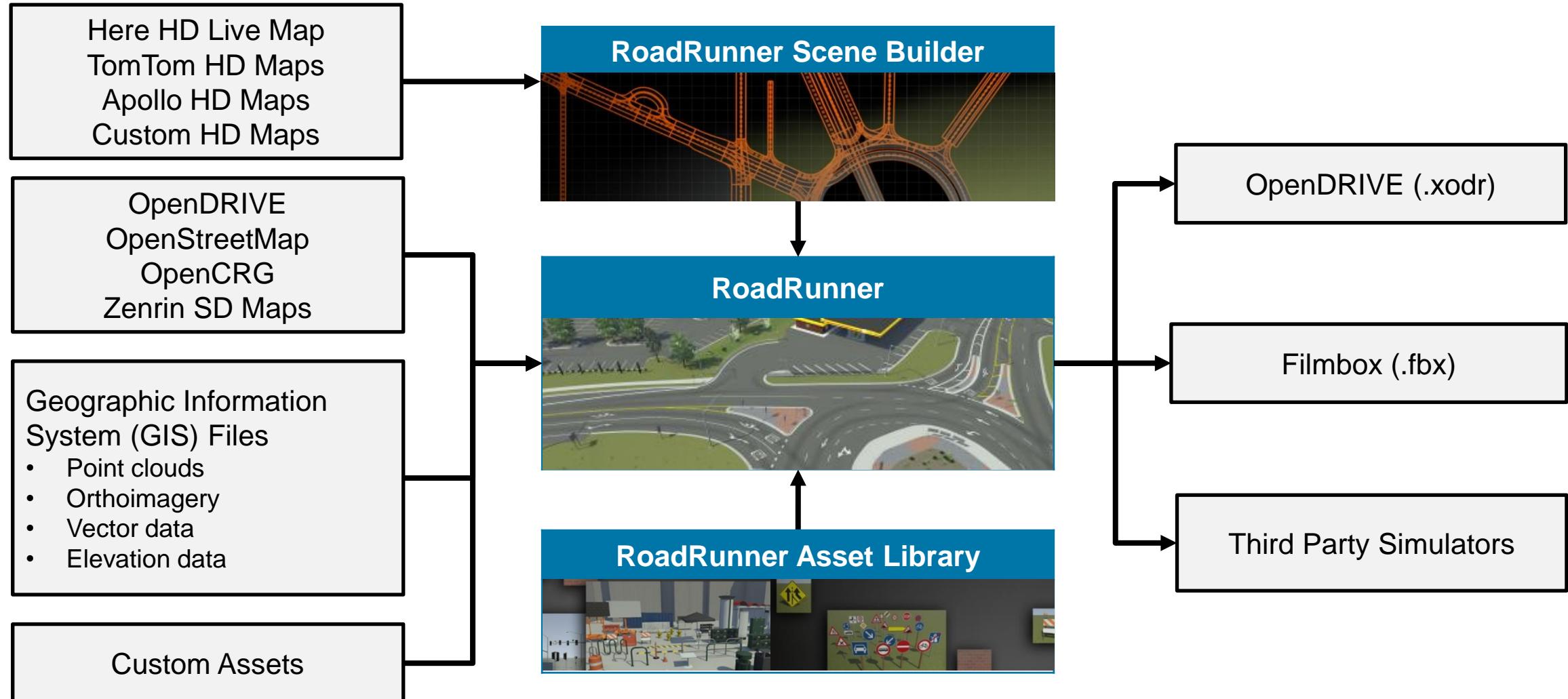


# Design 3D scenes for automated driving applications with RoadRunner



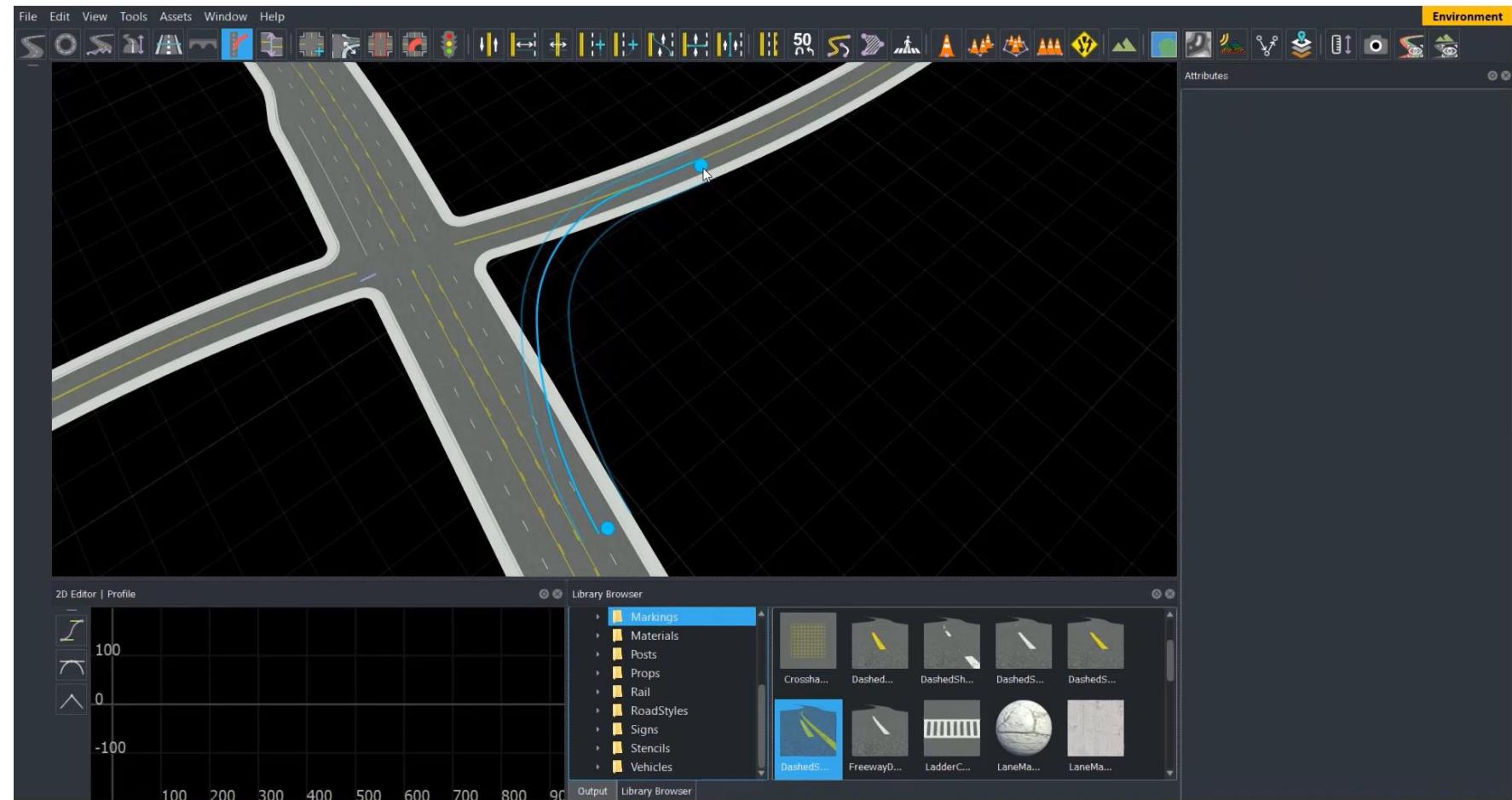
RoadRunner offers an **intuitive** user-friendly interface for creating complex functional road networks and environments for automotive and urban simulation.

# Design 3D scenes for automated driving applications with RoadRunner

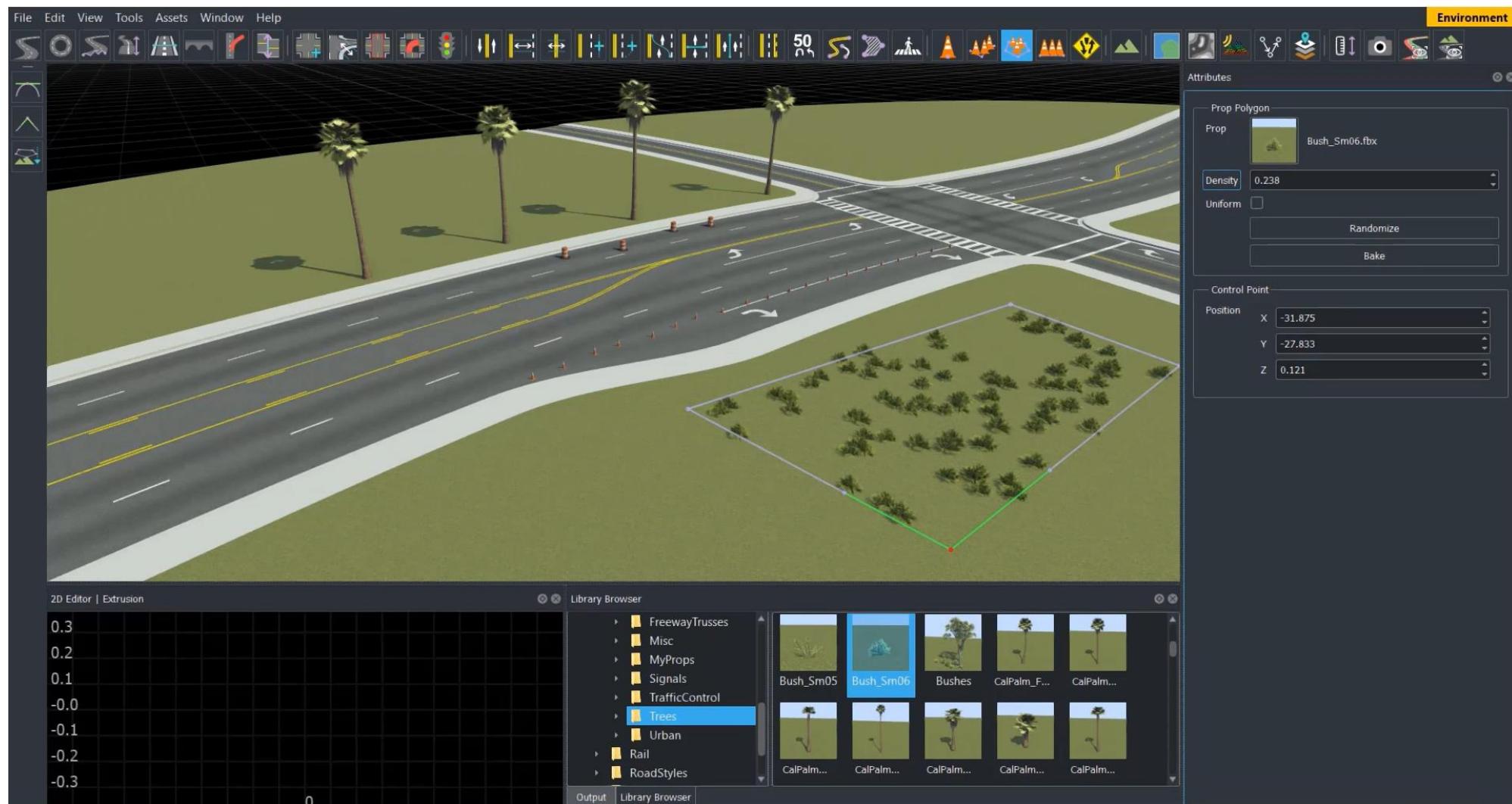


# Interactively design scenes with RoadRunner

- Author realistic roads and intersections
- Import/export OpenDRIVE
- Import HD maps
- Import Geographic Information System (GIS) files
- Export to common driving simulation environments

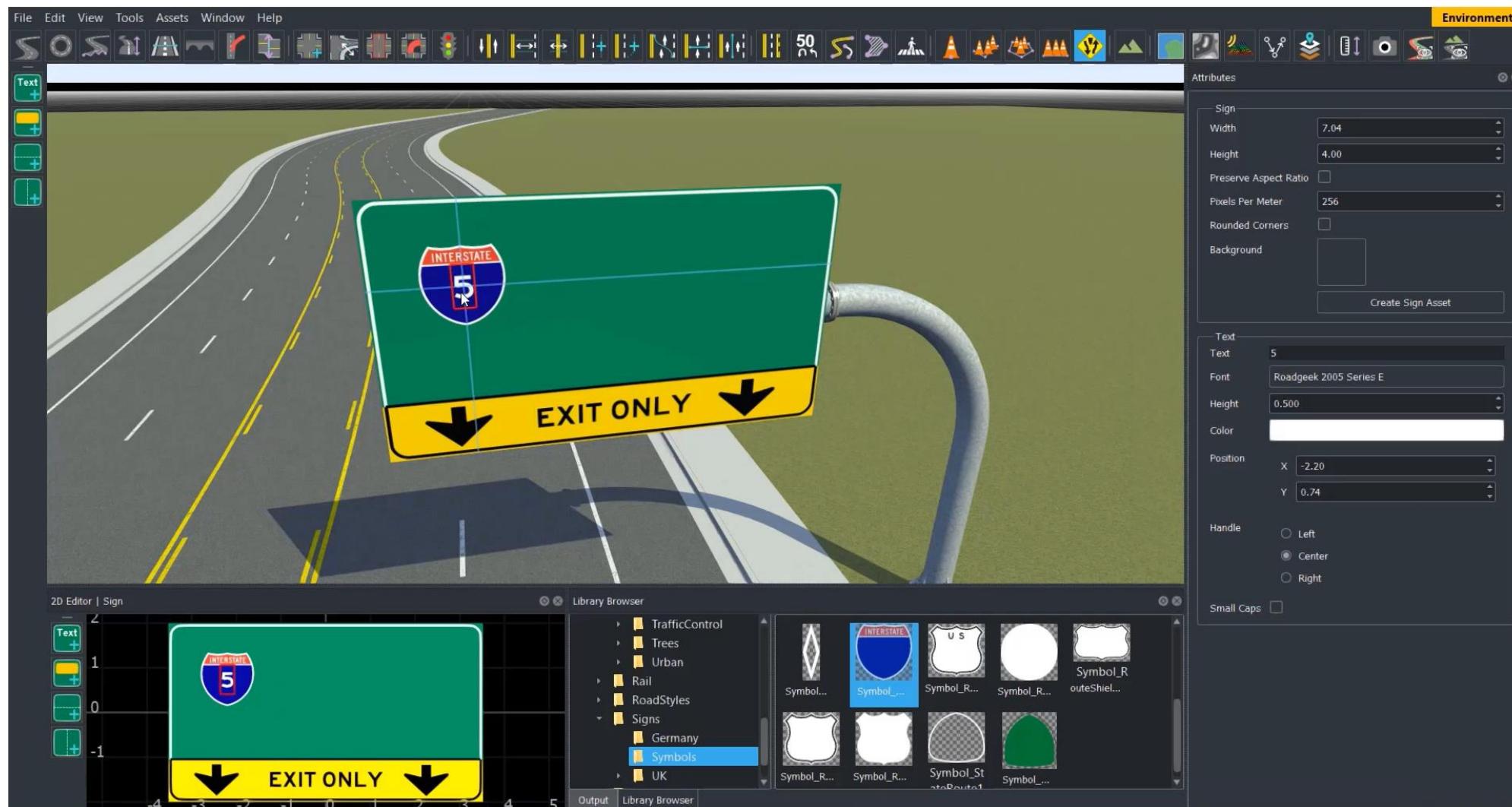


# Interactively design 3D scenes in RoadRunner

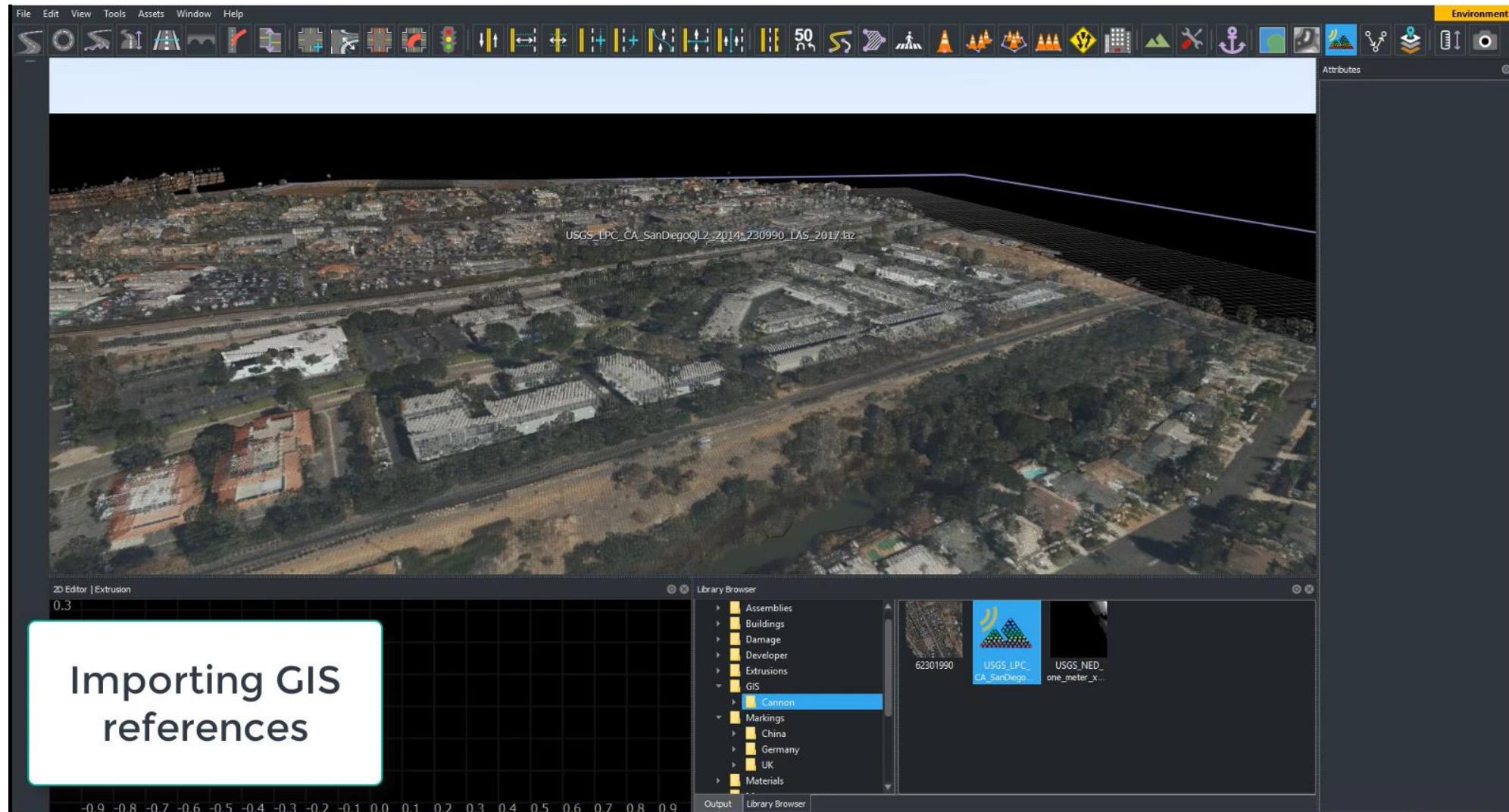


[Add 3D objects to the scene](#)

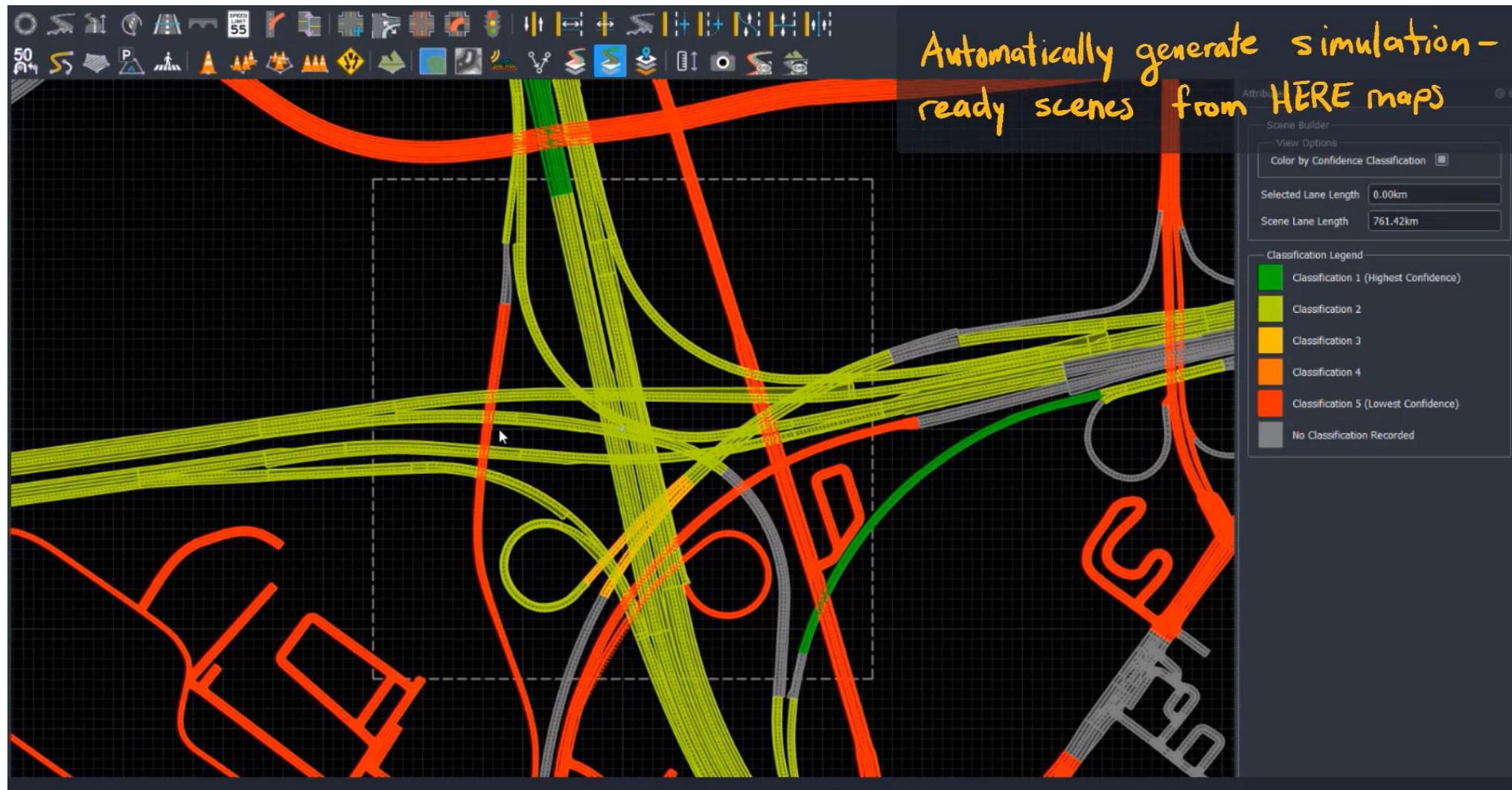
# Interactively design 3D scenes in RoadRunner



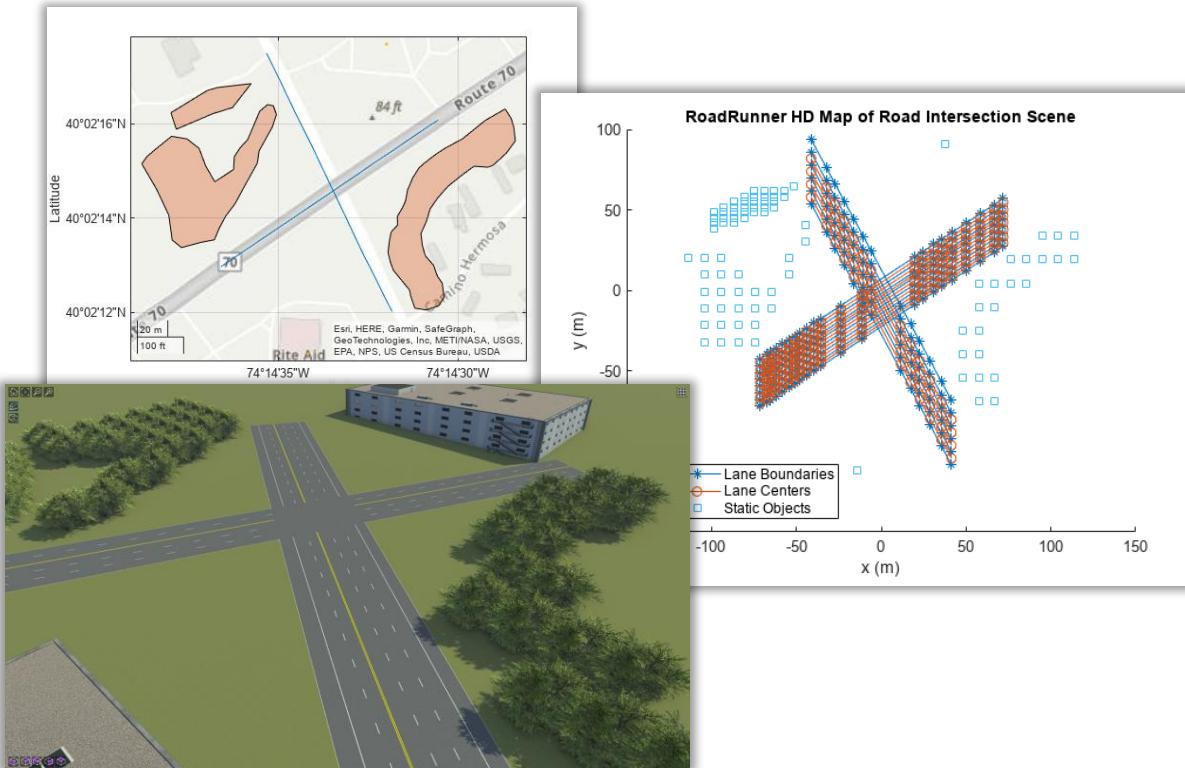
# Interactively design 3D scenes in RoadRunner



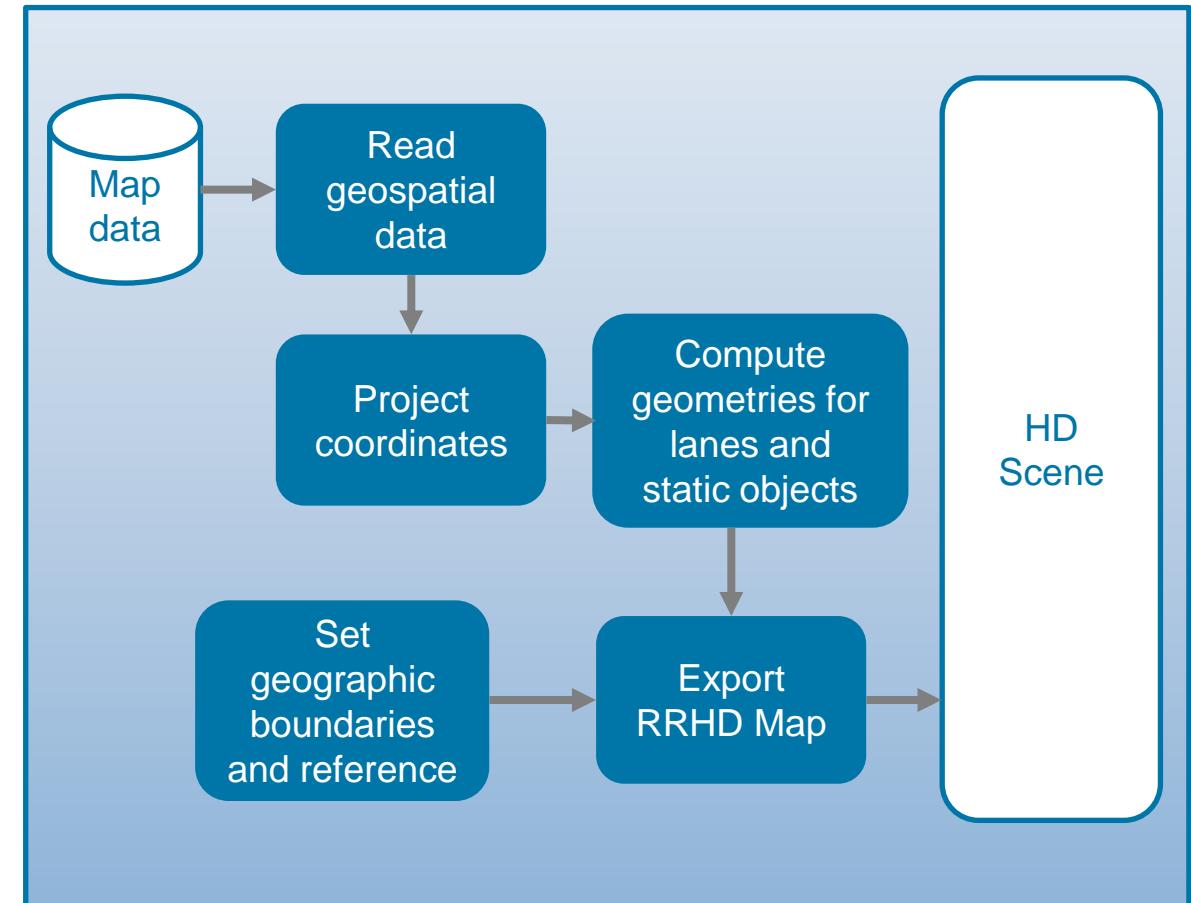
# Import HD maps in RoadRunner



# Build Custom 3D Scenes Using RoadRunner HD Map



- Import map data into MATLAB
- Programmatically specify lanes and static objects into a RoadRunner HD Map file
- Import into RoadRunner



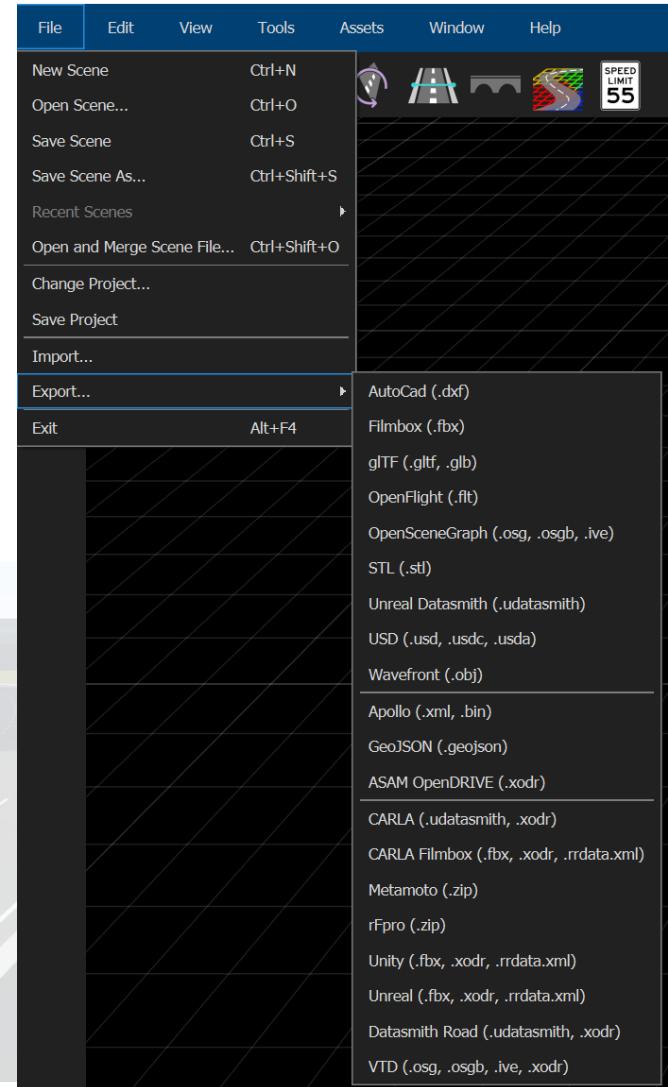
[Build RoadRunner Scene with Intersection and Static Objects Using RoadRunner HD Map](#)

*Automated Driving Toolbox, Mapping Toolbox, RoadRunner Scene Builder*

## Some example scenes with RoadRunner



# Export scenes to your favorite simulator



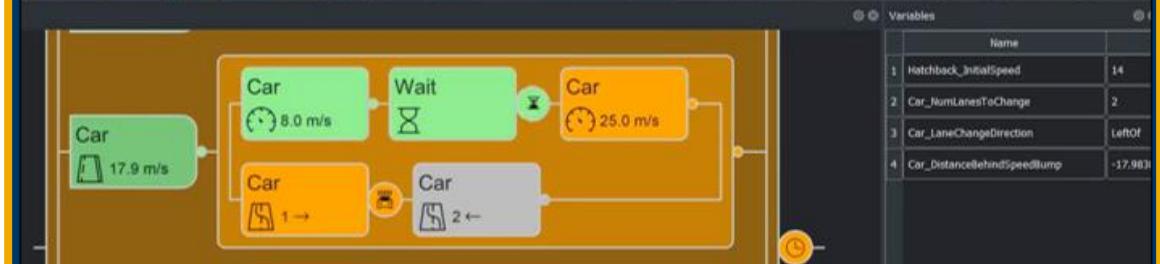
Design 3D scenes

Design scenarios

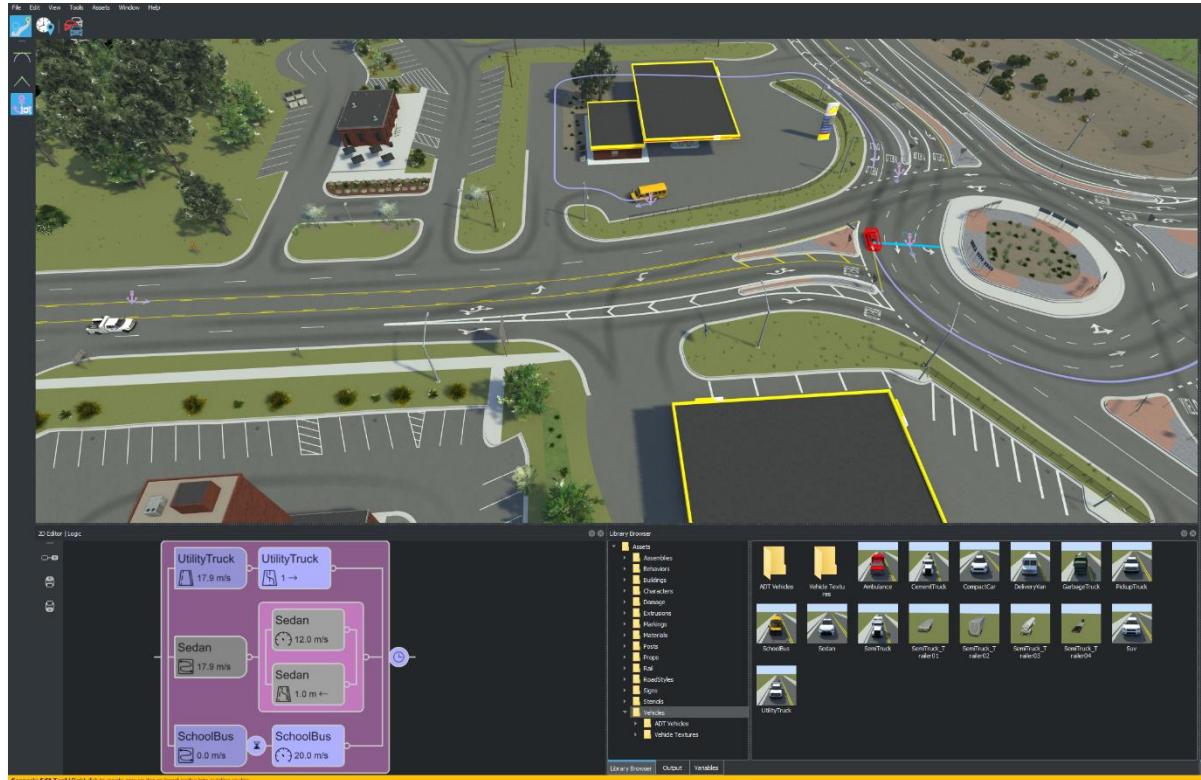
Build scenarios from recorded data

Simulate driving applications

RoadRunner Scenario

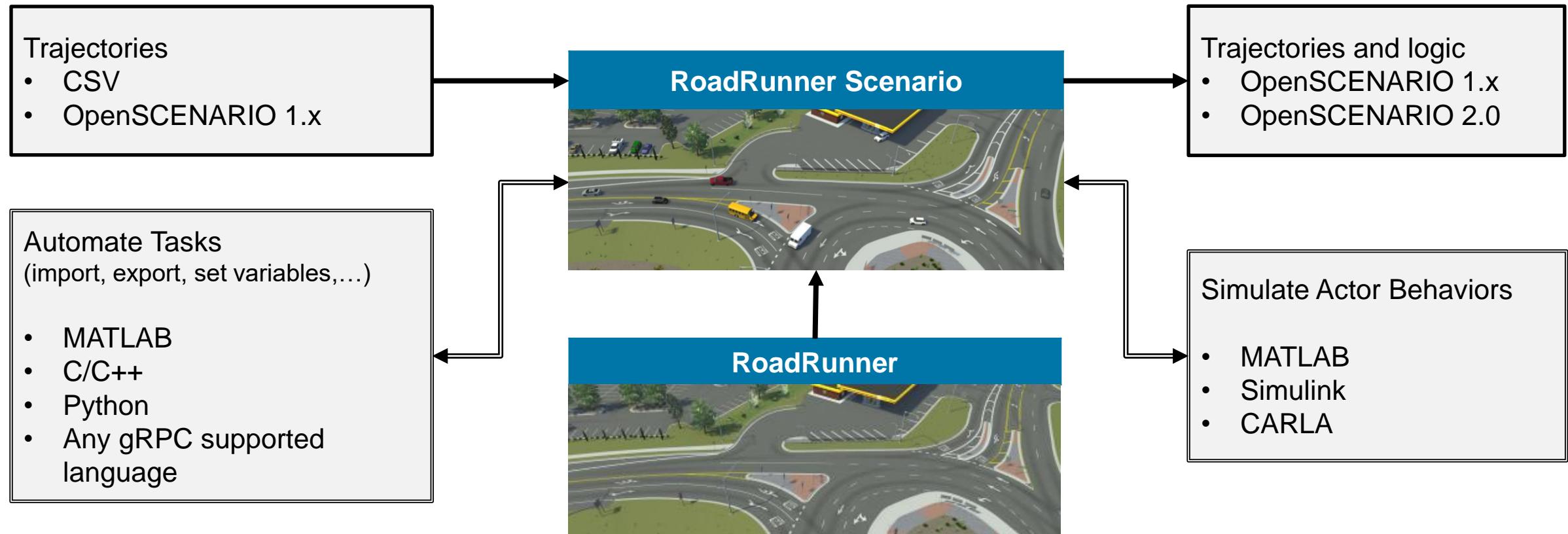


# Design Scenarios with RoadRunner Scenario



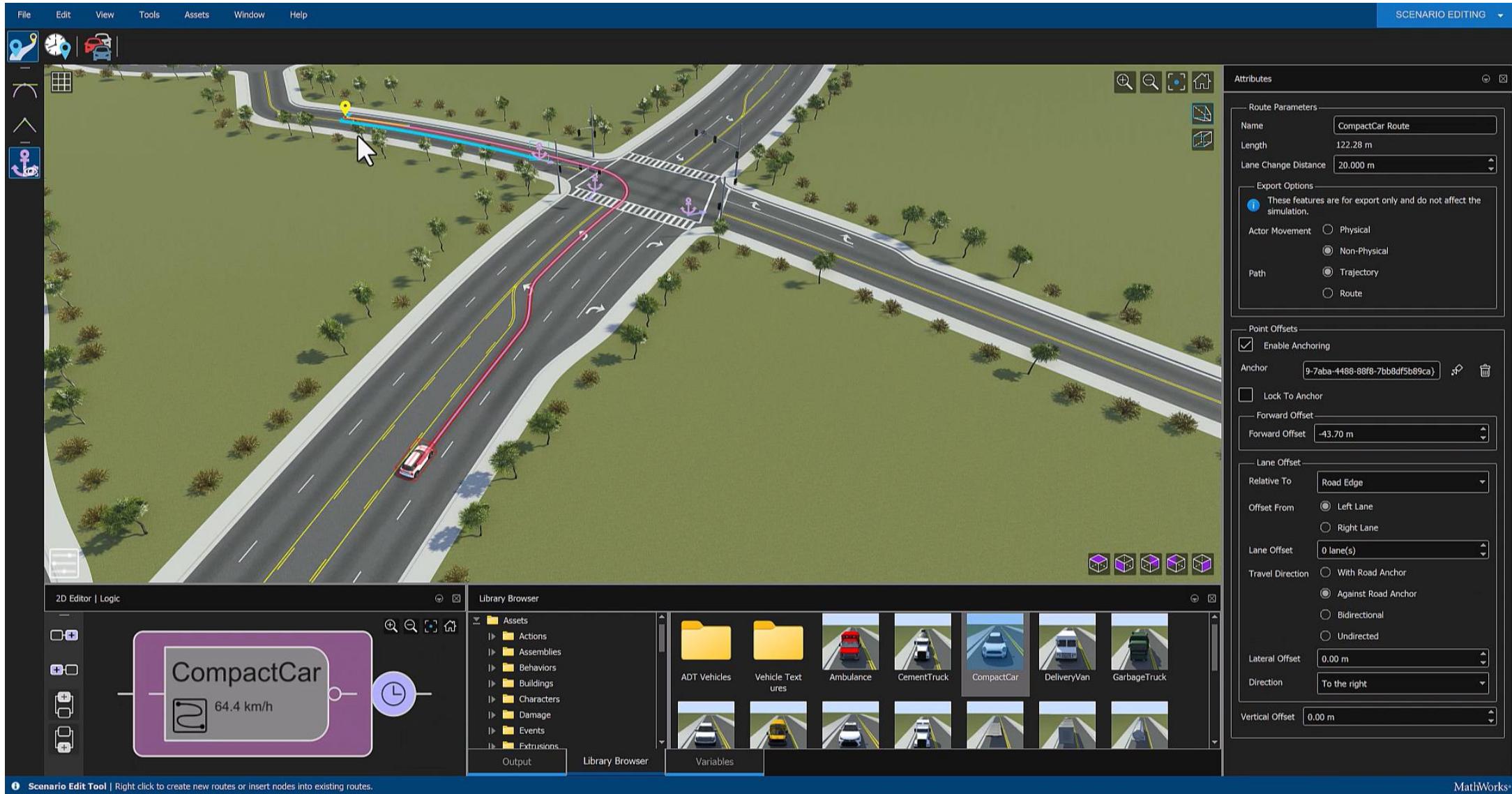
RoadRunner Scenario is an interactive editor that lets you design scenarios for simulating and testing automated driving systems. Place vehicles and paths, define logic, and parameterize scenarios. You can then simulate the scenario in the editor.

# Develop scenarios for automated driving applications with RoadRunner Scenario



# Interactively design scenarios with RoadRunner Scenario

## Vehicles | Trajectories | Actions and logic | Variations



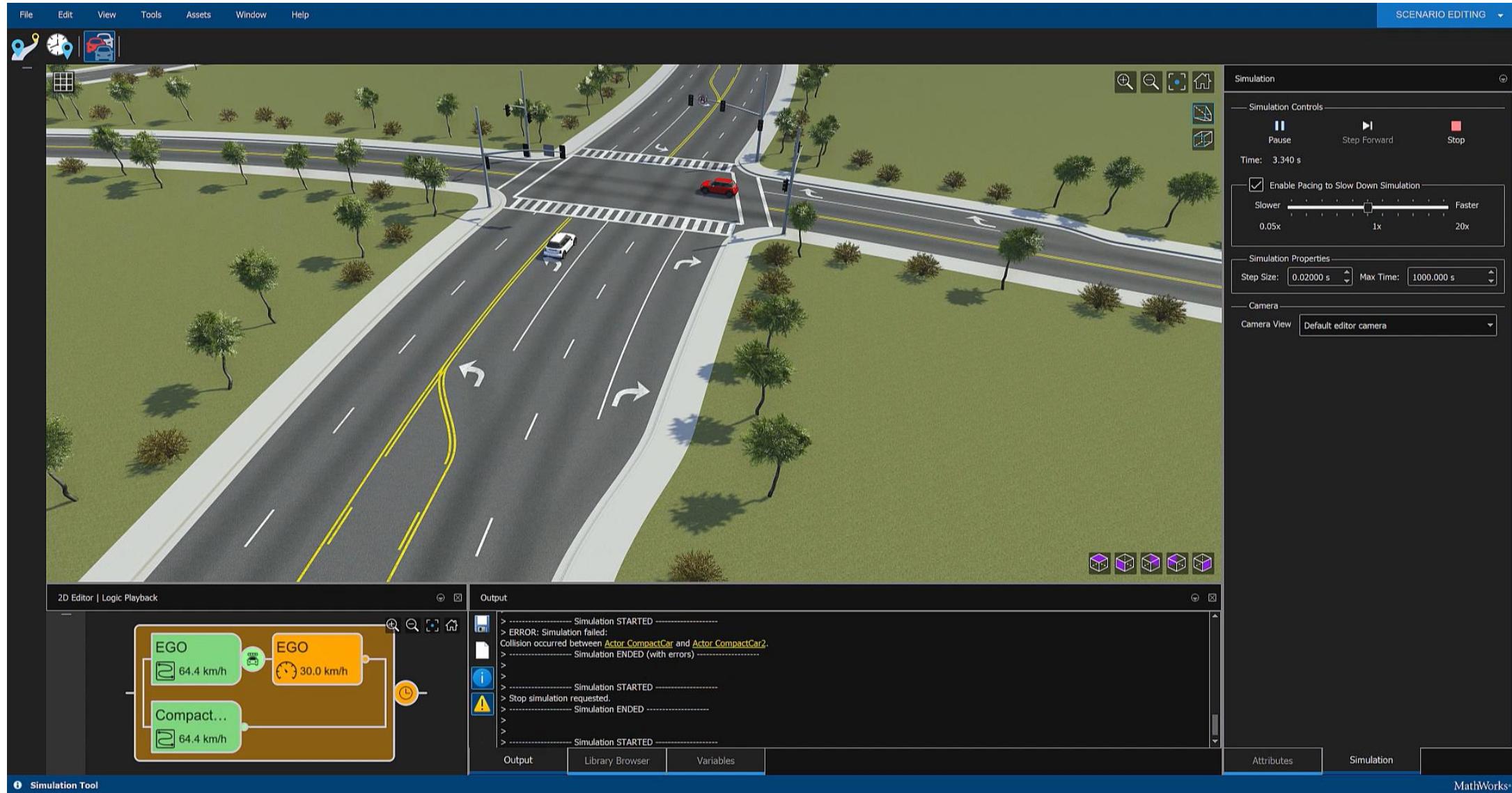
# Interactively design scenarios with RoadRunner Scenario

## Vehicles | Trajectories | Actions and logic | Variations



# Interactively design scenarios with RoadRunner Scenario

## Vehicles | Trajectories | Actions and logic | Variations



# Interactively design scenarios with RoadRunner Scenario

## Add pedestrians to the scenario



# Testing variations of your scenario



Changes to actions, positions, speed

Changes to roads and lanes

Changes to props and traffic



## Simulate scenarios with actor behaviors in multiple simulators

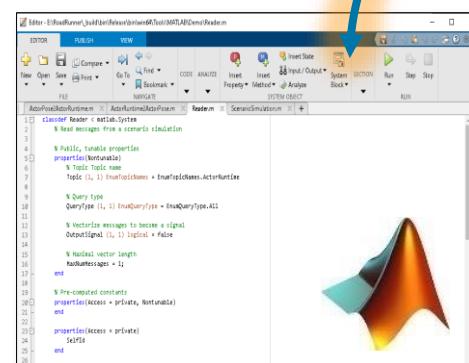
## Develop actor's behaviors using **MATLAB, Simulink or CARLA.**

Actors can **read** scenario states

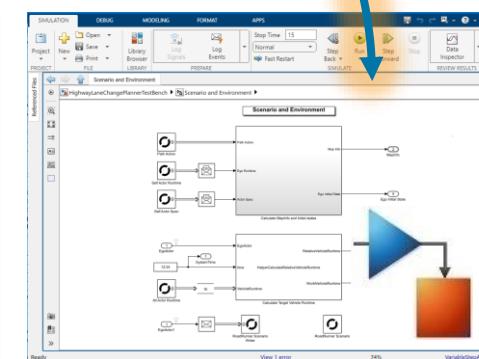
- **Action commands**
  - **Pose and velocity** of all actors
  - **Dimensions** of all actors
  - **Map lanes and lane boundaries**

## Actors **write** scenario states

- Their **pose** and **velocity** for each scenario simulation step



MATLAB



Simulink

```
# CarlaigoVehicle2

# Copyright 2021 The MathWorks, Inc.

from CarlaVehicle import CarlaVehicle
from SimulationAgent import SimulationAgent
import carla
import random
import math

"""CarlaigoVehicle2 - An example of a Scenario Simulation Agent for CARLA."""

#####
##### Class Definition #####
#####

class CarlaigoVehicle2(CarlaVehicle):
    """The class CarlaigoVehicle2 is an example a CARLA agent that is an observer of the
    # SSE simulation events (start, step, stop etc.)."""

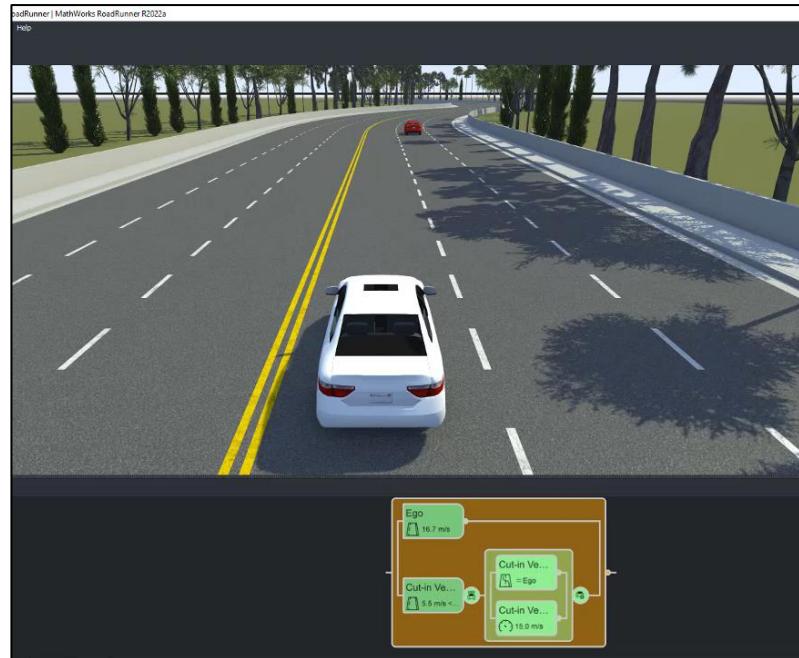
    # Agent class variables
    spectator_location = carla.Location(0, 0, 50.0)
    spectator_rotation = carla.Rotation(-90, 0, -90)
    SPEED_ACTION = "speed_action"
    PATH_ACTION = "path_action"

#####
##### Implementation #####
#####

def __init__(self, actor, bridge):
    super().__init__(actor, bridge)
```

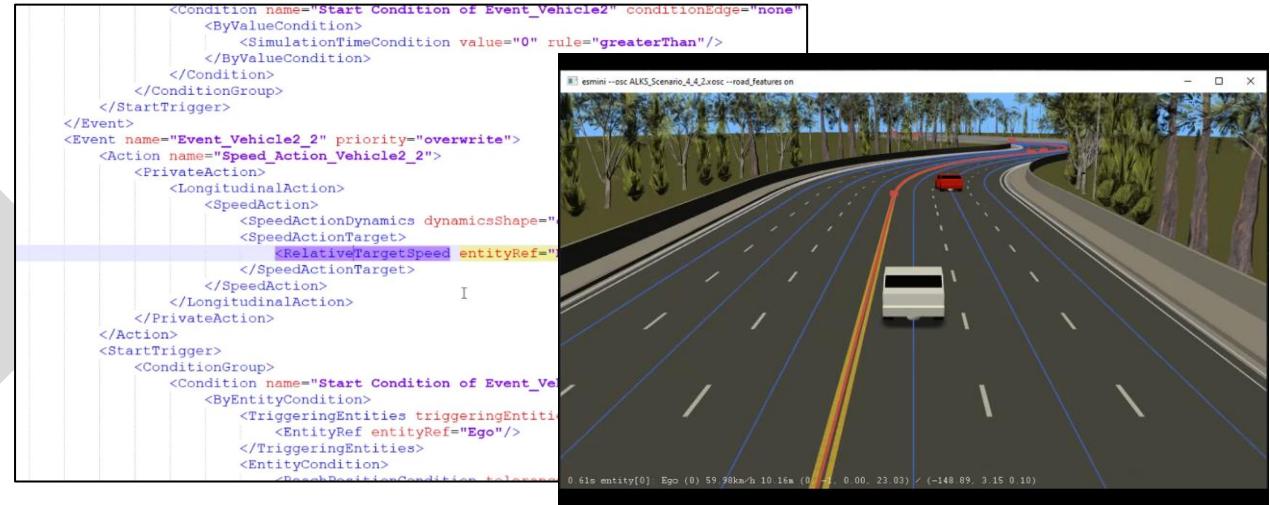
CARLA

# Export scenarios to OpenSCENARIO V1.x and V2.0



OpenSCENARIO  
V1.x

OpenSCENARIO  
V2.0



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

```
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_vehicle.time > 10.0s)
90     parallel:
91         cut-in_vehicle.
92         cut-in_vehicle.
93         speed(15mps,
94             until (ego.time > 10.0s))
95     with:
96         until (ego.time > 10.0s)
```

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

[Export to ASAM OpenSCENARIO](#)  
RoadRunner Scenario

Design 3D scenes

Design scenarios

Build scenarios from recorded data

Simulate driving applications

### Scenario Builder for Automated Driving Toolbox

Reconstruct  
Road & Static  
Objects

Localize  
Ego Vehicle

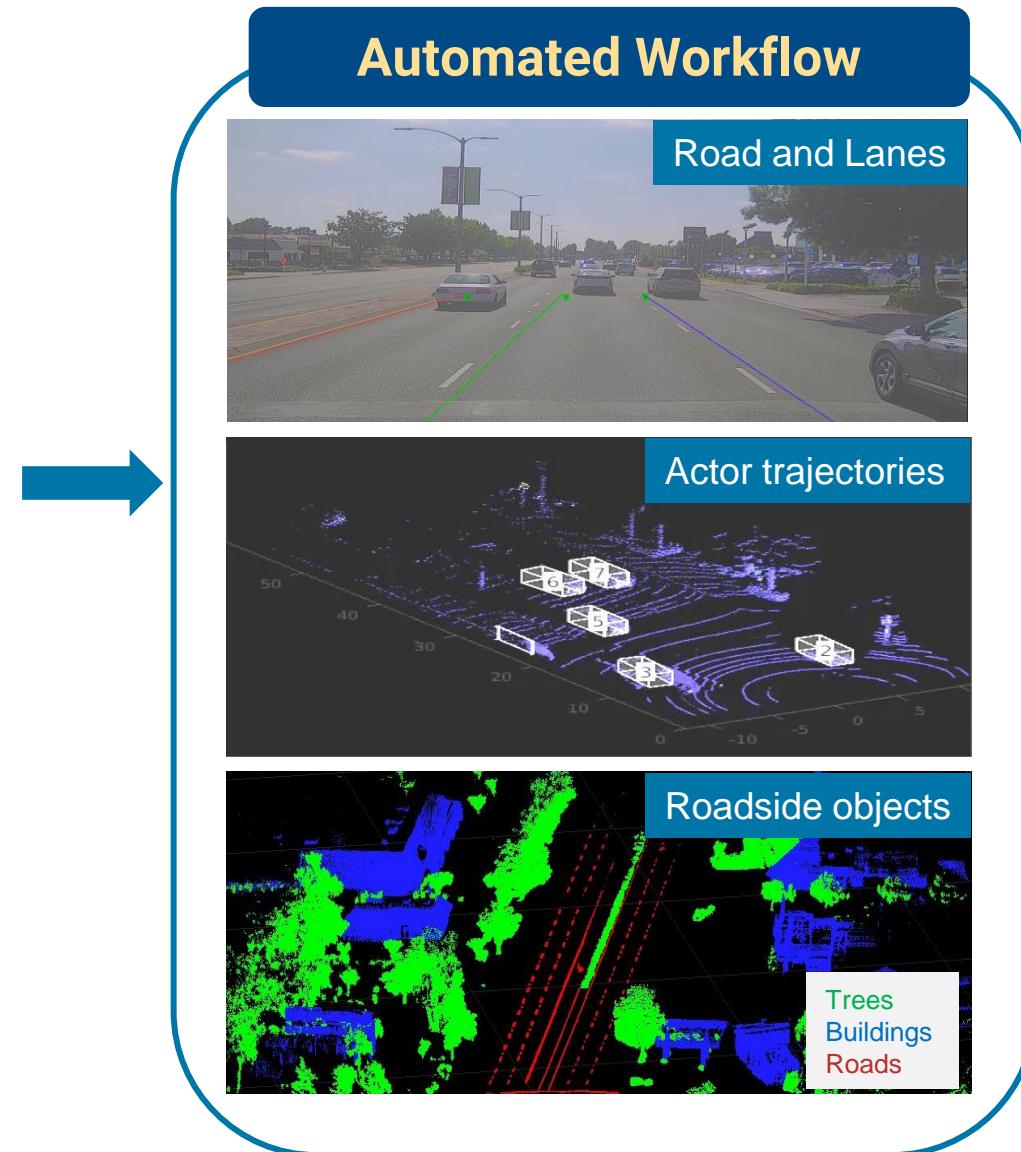
Reconstruct  
Targets



# Automation – representative actors from real-world sensor data



Using recorded sensor data:



## Scenario Builder

Add-on to Automated Driving Toolbox

Design 3D scenes

Design scenarios

Build scenarios from recorded data

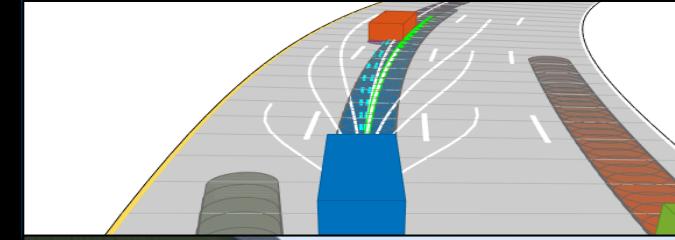
Simulate driving applications

### Scenario Builder for Automated Driving Toolbox

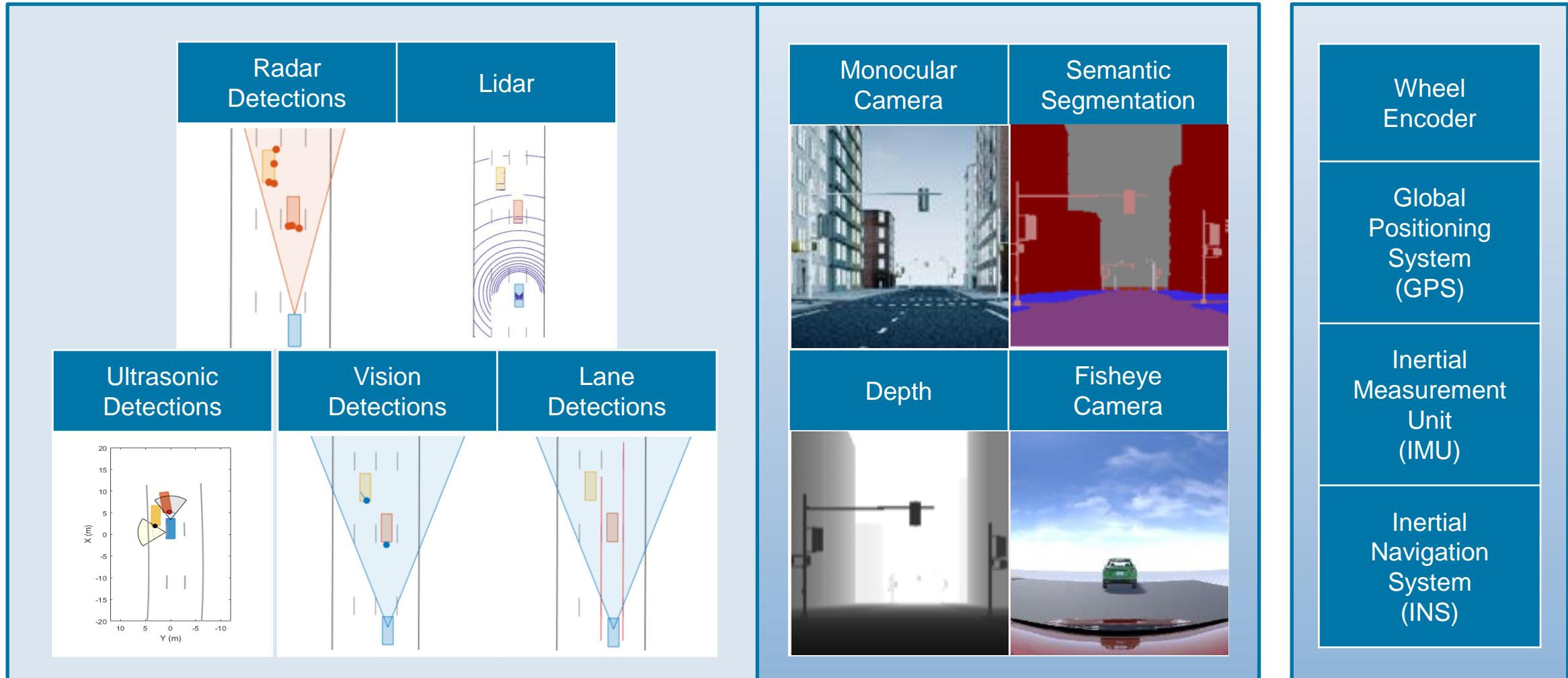
Lane  
Change

Emergency  
Braking

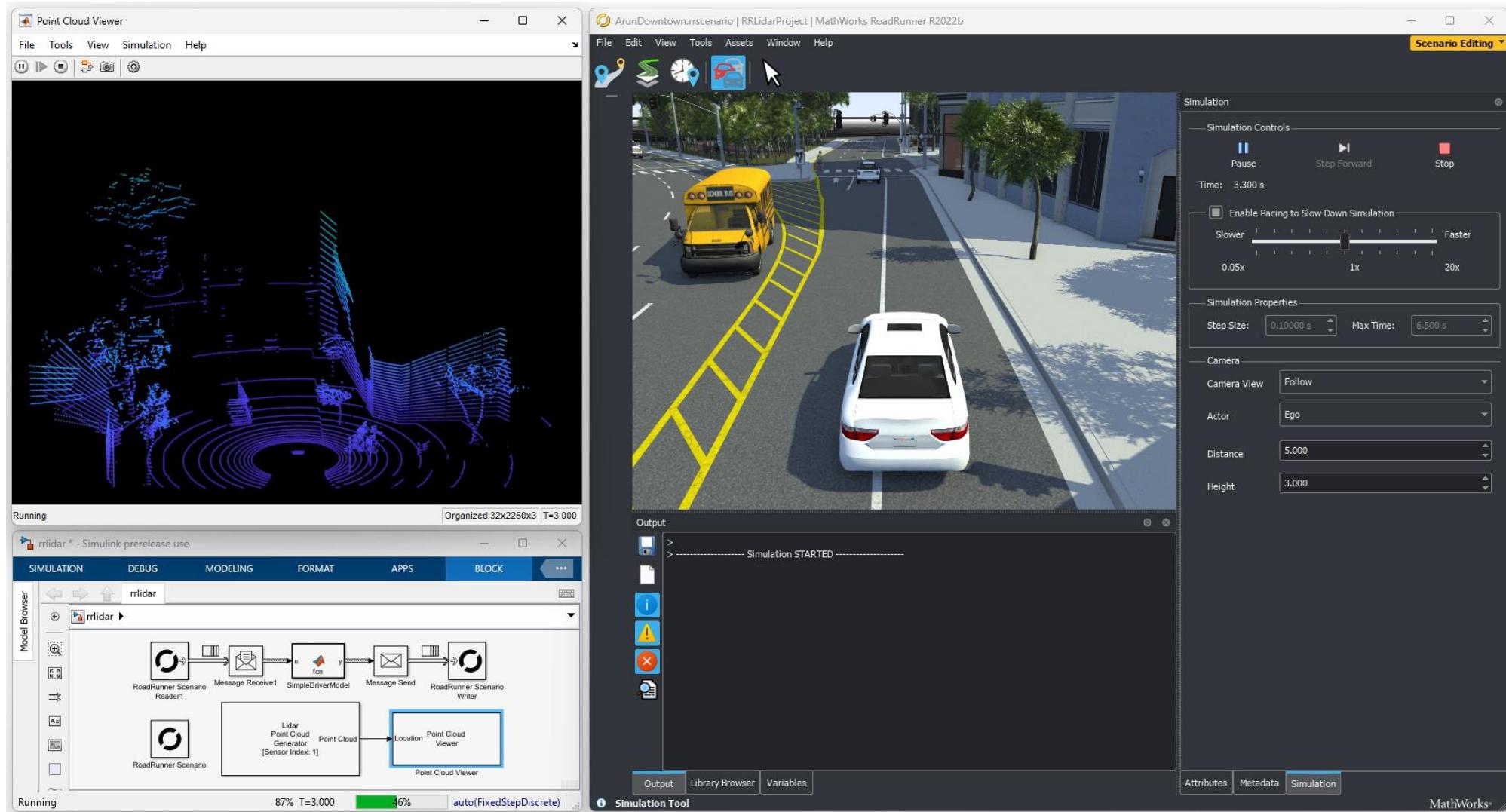
Platooning



# Simulate sensors for automated driving applications

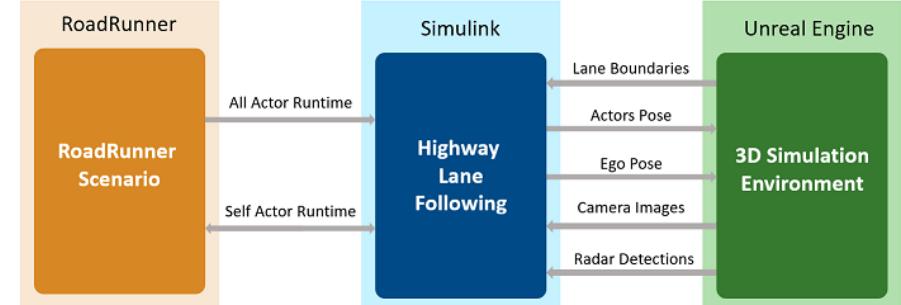
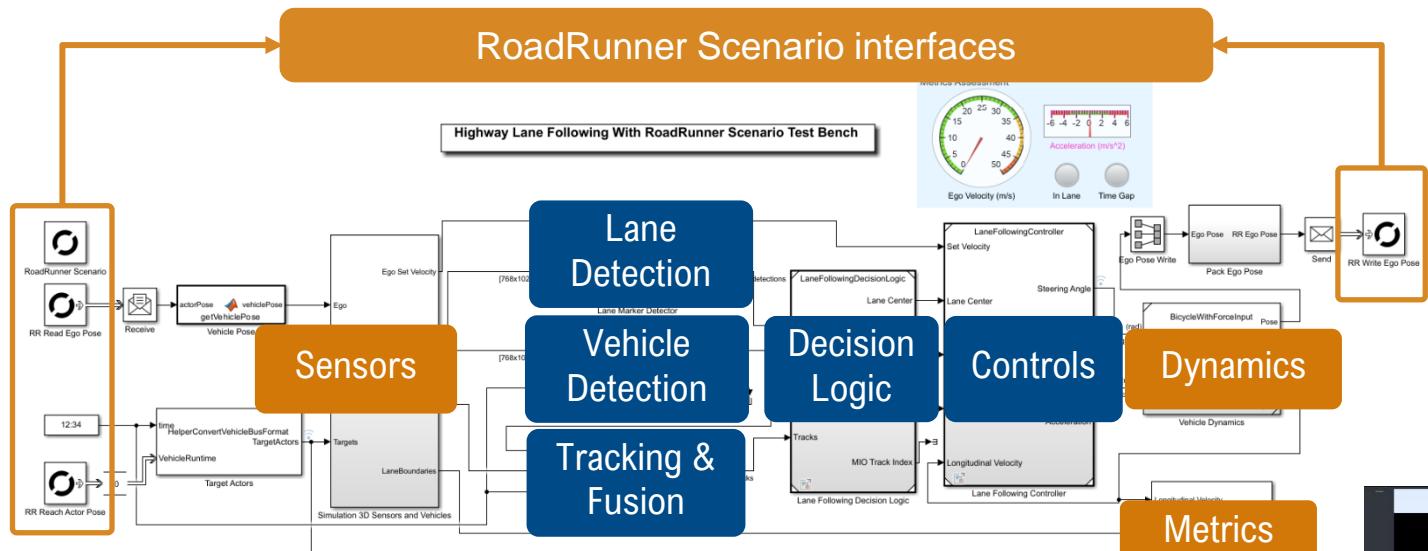


# Simulate sensors within RoadRunner Scenario



Add sensors and access sensor data from scenario simulation

# Integrate Unreal Engine sensors with RoadRunner Scenario



- Simulate Highway Lane Following with RoadRunner Scenario
- Monocular camera sensor
- Radar detections sensor

## Highway Lane Following with RoadRunner Scenario

Automated Driving Toolbox, Model Predictive Control Toolbox,  
Sensor Fusion and Tracking Toolbox, RoadRunner Scenario

# Cosimulating RoadRunner with CARLA

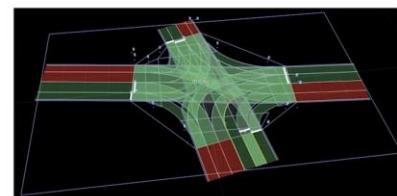


# Success Stories from the Industry

## BMW creates road scenes

### USING ROADRUNNER TO CREATE ROAD NETWORKS

- Remodelling of real life road networks and junctions
- Export to OpenDrive for driving simulation usage



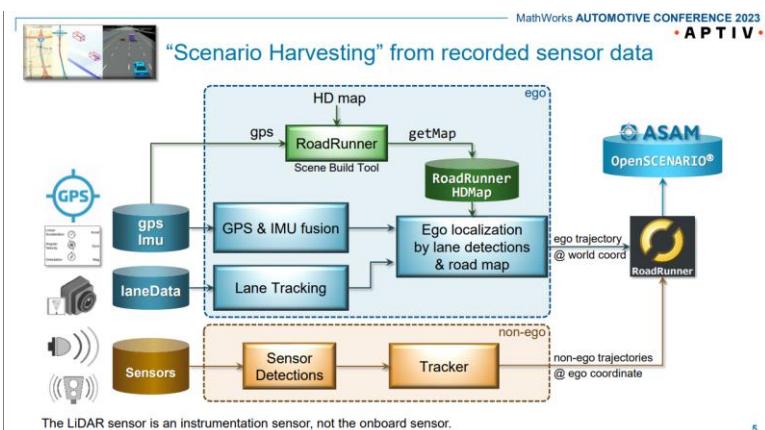
Hubert Cao | Mathworks Automotive Conference 2023

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### Virtual World Generation for BMW Driving Simulation

MathWorks Automotive Conference  
2023 - Europe

## APTIV generates scenarios from sensor data

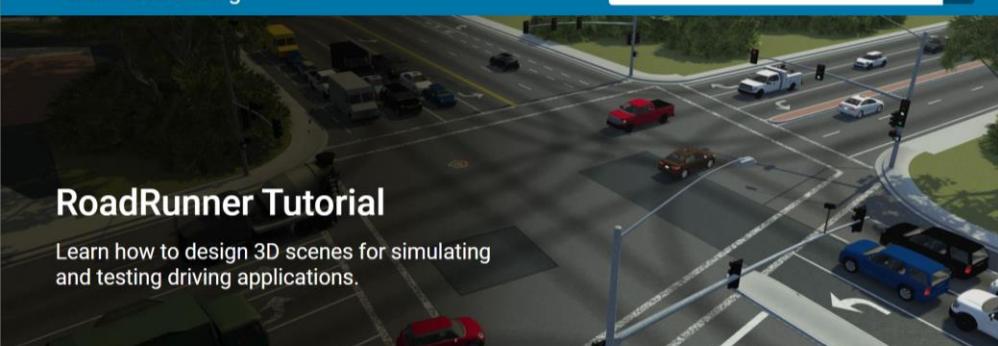


### Scenario Harvesting Using Automated Driving Toolbox and RoadRunner Scenario

MathWorks Automotive Conference  
2023 - NA

# Learn how to design 3D scenes using the new RoadRunner Tutorial

Automated Driving Search MathWorks.com



**RoadRunner Tutorial**  
Learn how to design 3D scenes for simulating and testing driving applications.

1. Launching RoadRunner    5. Customizing Lanes  
2. Using Camera Controls    6. Creating Junctions  
3. Exporting Scenes to Simulators    7. Adding Terrains and Props  
4. Creating Roads    8. Conclusion

**How to Use This Tutorial**  
Each module includes the following sections:

**Watch**  **Try**  **Training**  **Resources** 

Video demonstration of [Watch](#) Practice what you learned [Try](#) Access to the RoadRunner [Training](#) Links to related [Resources](#)

**RoadRunner Tutorial**  
*RoadRunner, RoadRunner Asset Library*

- Seven modules with a short (~3 minute) video each
- Takes 1-2 hours in total
- Sample scene below is built incrementally





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