What's New in MATLAB, Simulink, and RoadRunner for Automated Driving Development

October 20, 2022 | Stuttgart
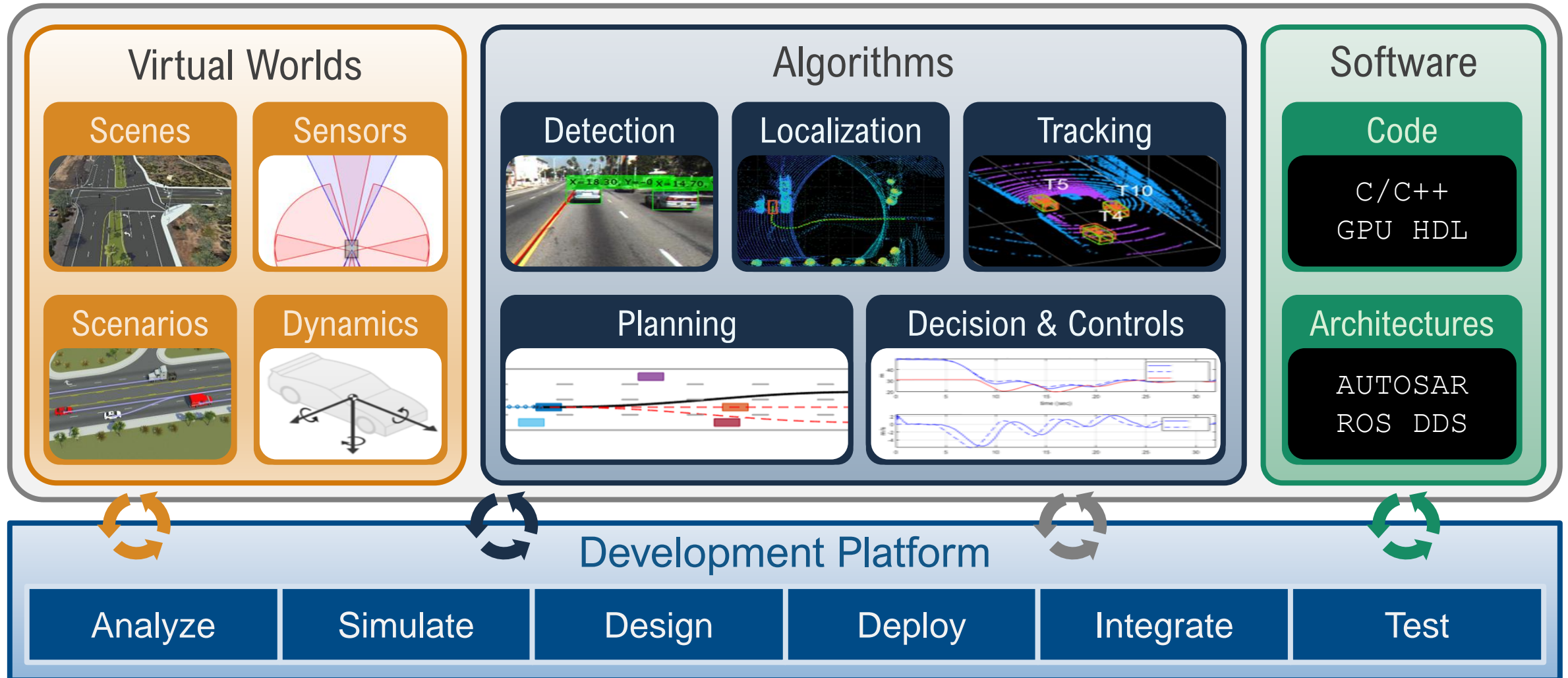
Simone Hämmerle

Dimitri Hamidi
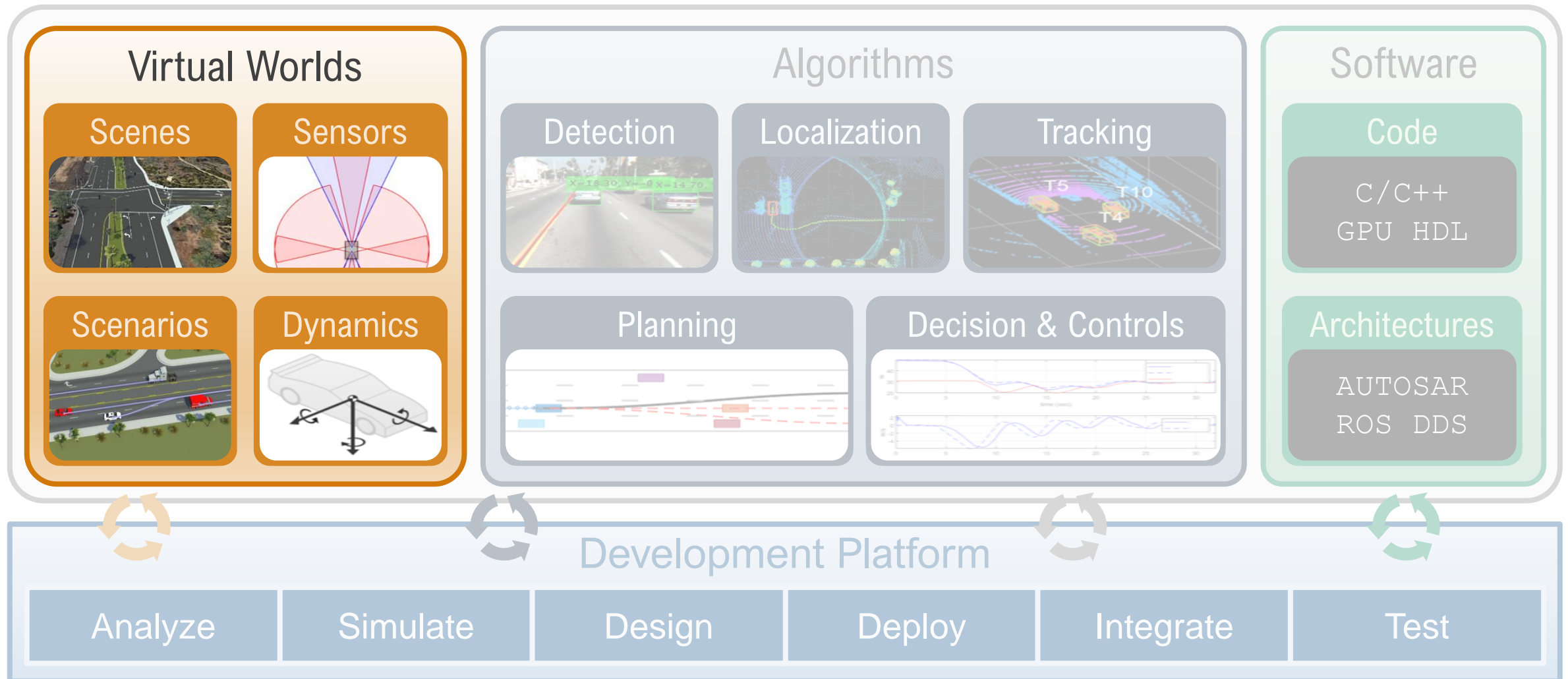
MathWorks®

Develop automated driving applications
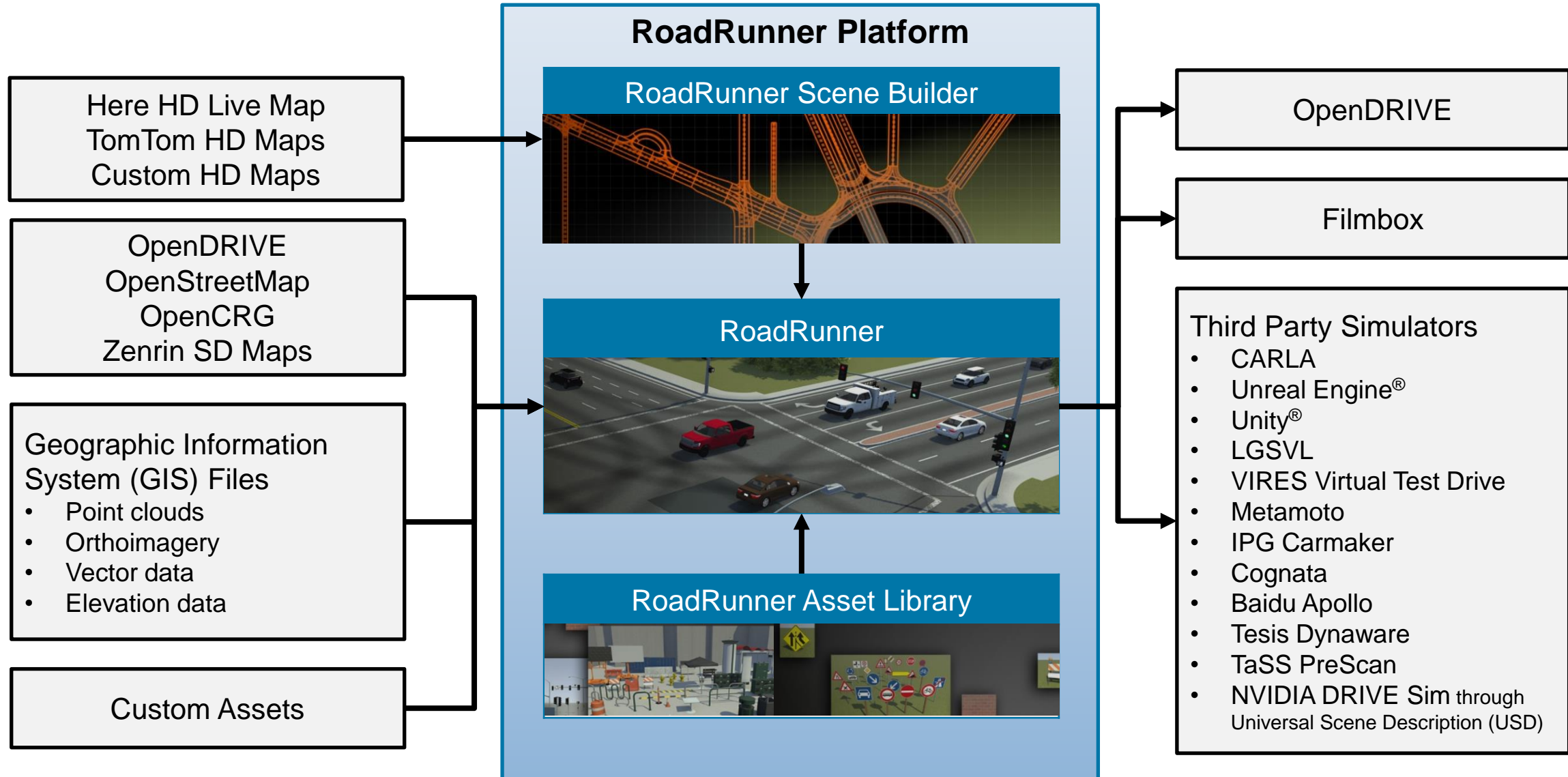## with MATLAB, Simulink, & RoadRunner

Develop automated driving applications
with MATLAB, Simulink, & RoadRunner

Design 3D scenes for automated driving applications
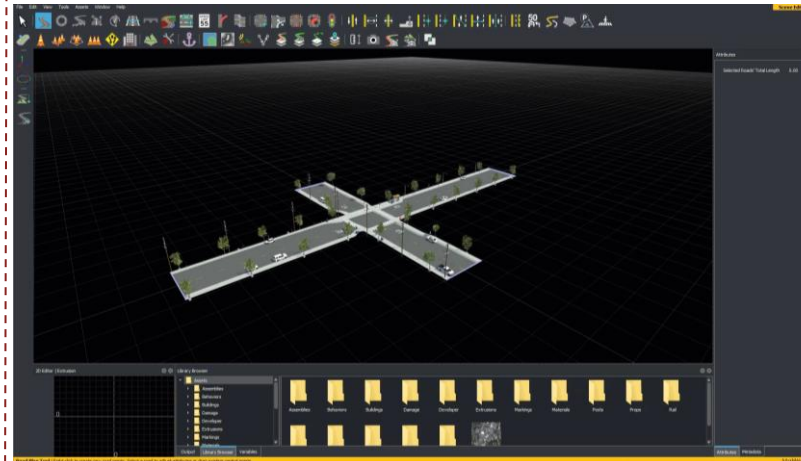
Learn about new features to author 3D scenes

Traffic Island Tool	Scene Merge	Import OpenCRG
Traffic Island Tool *RoadRunner*	Merge Multiple Scenes *RoadRunner*	Road CRG Tool *RoadRunner*
R2022**b**	**R**2022**b**	**R**2021**b**
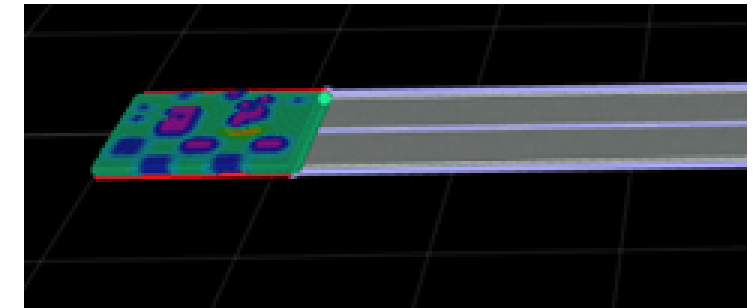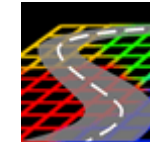
Learn about new features to author 3D scenes

RoadRunner API

```
% Open a RoadRunner project
rrApp = roadrunner("C:\RR\MyScenario");

% Open a scenario in the project
openScenario(rrApp,"FourWayStop.rrscenario");

% Save scenario to a new name
saveScenario(rrApp,"FourWayStop1.rrscenario");

% Set a scenario variable
setScenarioVariable(rrApp,"ActorID","7");

% Options for exporting scene to OpenSCENARIO
options = openScenarioExportOptions(...
    "SceneGraphFormatName",'OpenSceneGraph');
```

[RoadRunner API](#)
RoadRunner

R2022**a**

Console Mode

[Control RoadRunner Programmatically Using Terminal](#)
RoadRunner

R2022**b**

Custom HD Map
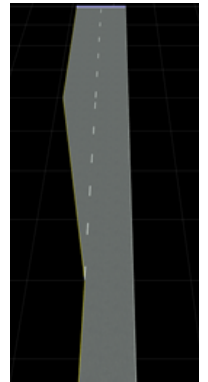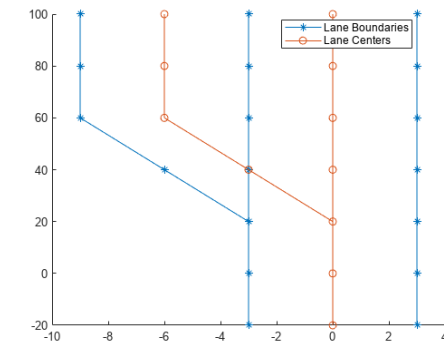
[Build Roads Programmatically Using RoadRunner HD Map](#)
Automated Driving Toolbox, RoadRunner Scene Builder

R2022**b**

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Build custom 3D scenes using RoadRunner HD Map
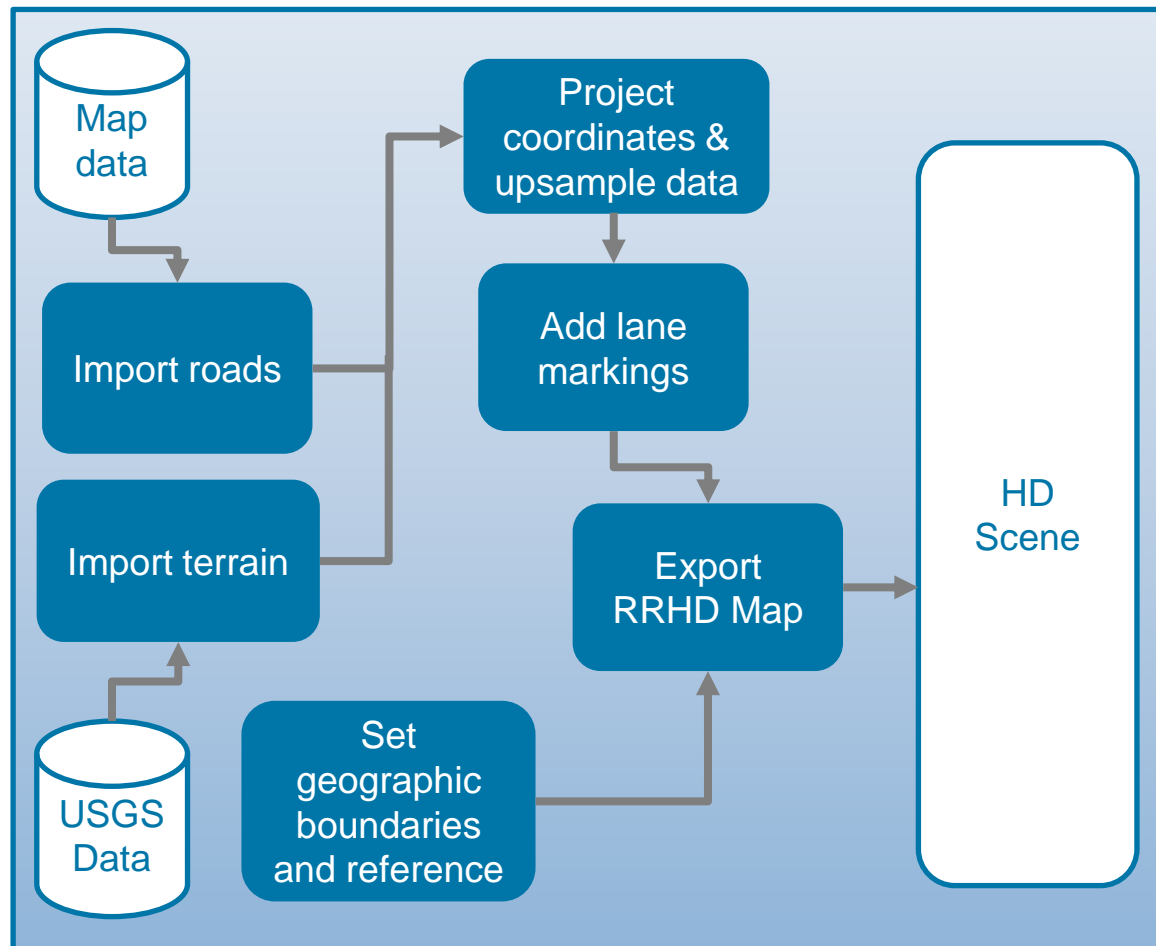
- Import map and elevation data into MATLAB
- Upsample data and create RoadRunner HD Map
- Import into RoadRunner

Build Pikes Peak RoadRunner 3D Scene

Automated Driving Toolbox, Mapping Toolbox

R2022b

Develop <u>scenarios</u> for automated driving applications with RoadRunner Scenario
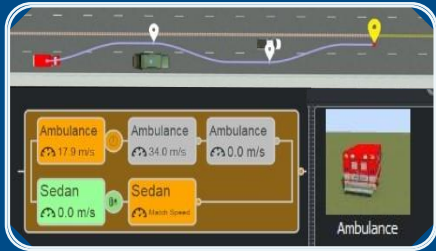
Design and Simulate Scenarios

- Design paths and scenario logic
- Relocate scenarios to different scenes
- Programmatically vary parameters
- Utilize prebuilt sample scenarios
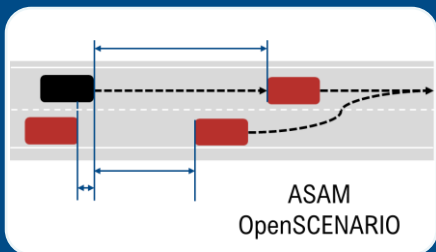
Interface with OpenSCENARIO

- Export to OpenSCENARIO v2.0
- Export to OpenSCENARIO v1.x
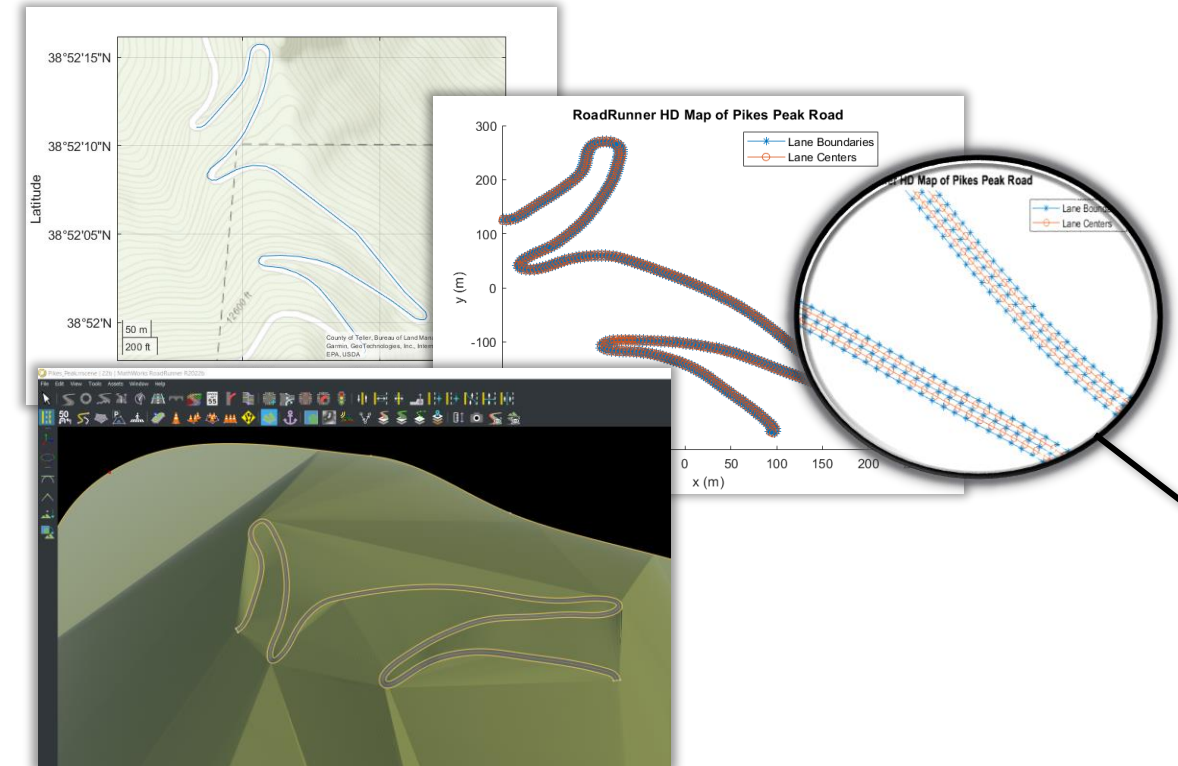- Import trajectories from OpenSCENARIO v1.0

Simulate with MATLAB, Simulink, and CARLA

- Author actor behaviors in MATLAB
- Author actor behaviors in Simulink
- Author actor behaviors in CARLA

Learn about new features to design scenarios

Pedestrian Actors	Actor Groups	User-Defined Actions

Character Assets
RoadRunner Scenario

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Truck & Trailer Scenario
RoadRunner Scenario
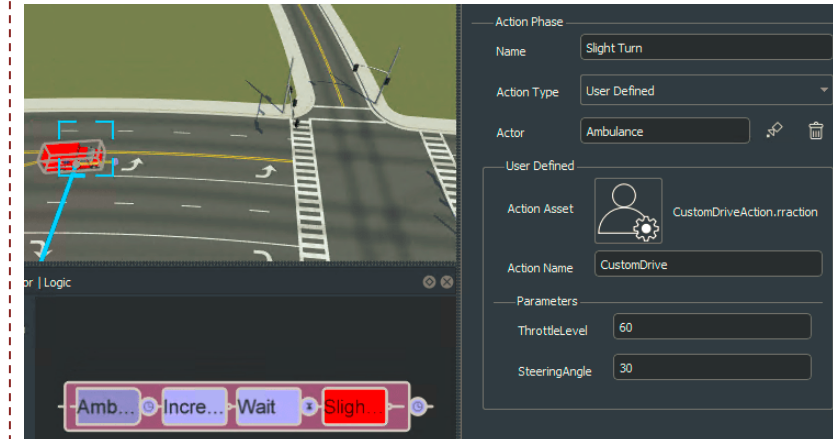
R2022**b**

Design Vehicle Following User-Defined Actions Scenario
RoadRunner Scenario

R2022**b**

Simulate sensors for automated driving applications
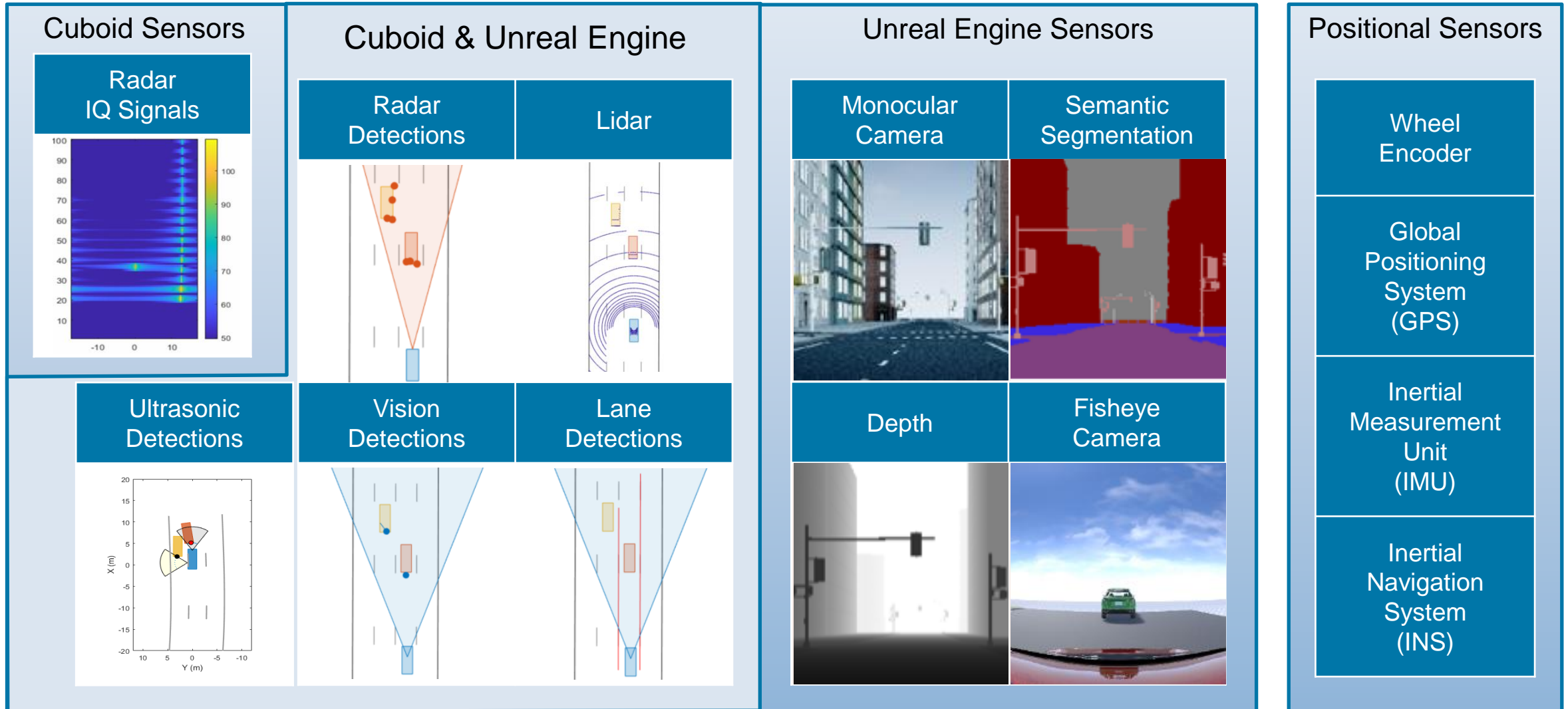
Commonly used tools: Automated Driving Toolbox™, Radar Toolbox, Navigation Toolbox™

Learn about new features to simulate sensors

Lidar Reflectivity (Unreal)	Ultrasonic Sensor (Unreal)	Ultrasonic Sensor (Cuboid)
Simulation 3D Lidar *Automated Driving Toolbox*	Simulation 3D Ultrasonic *Automated Driving Toolbox*	Ultrasonic Detection Generator *Automated Driving Toolbox*
R2022a	R2022b	R2022a
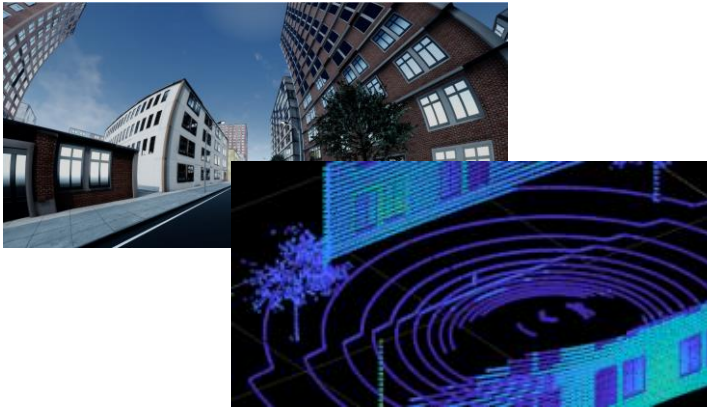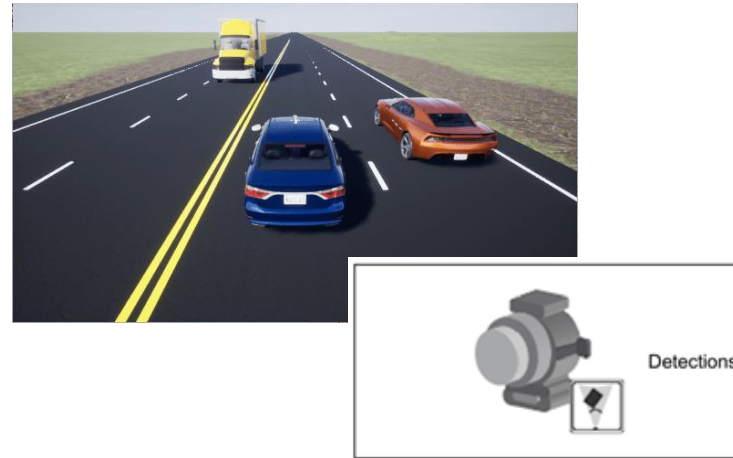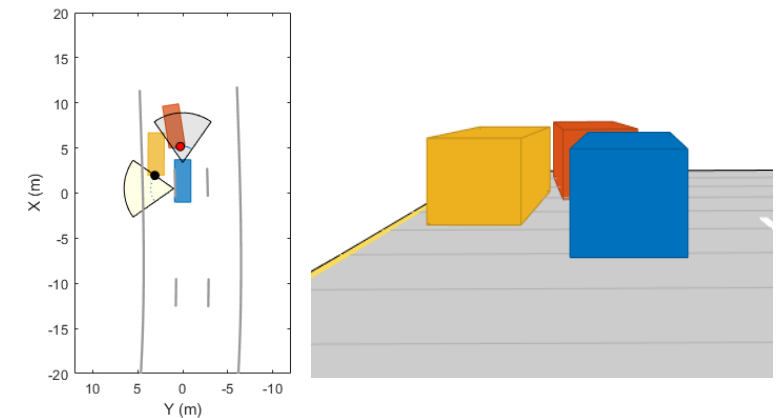
Integrate Unreal Engine sensors with RoadRunner Scenario
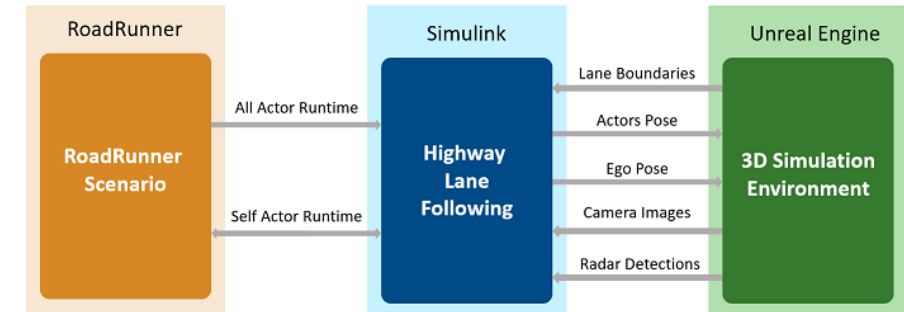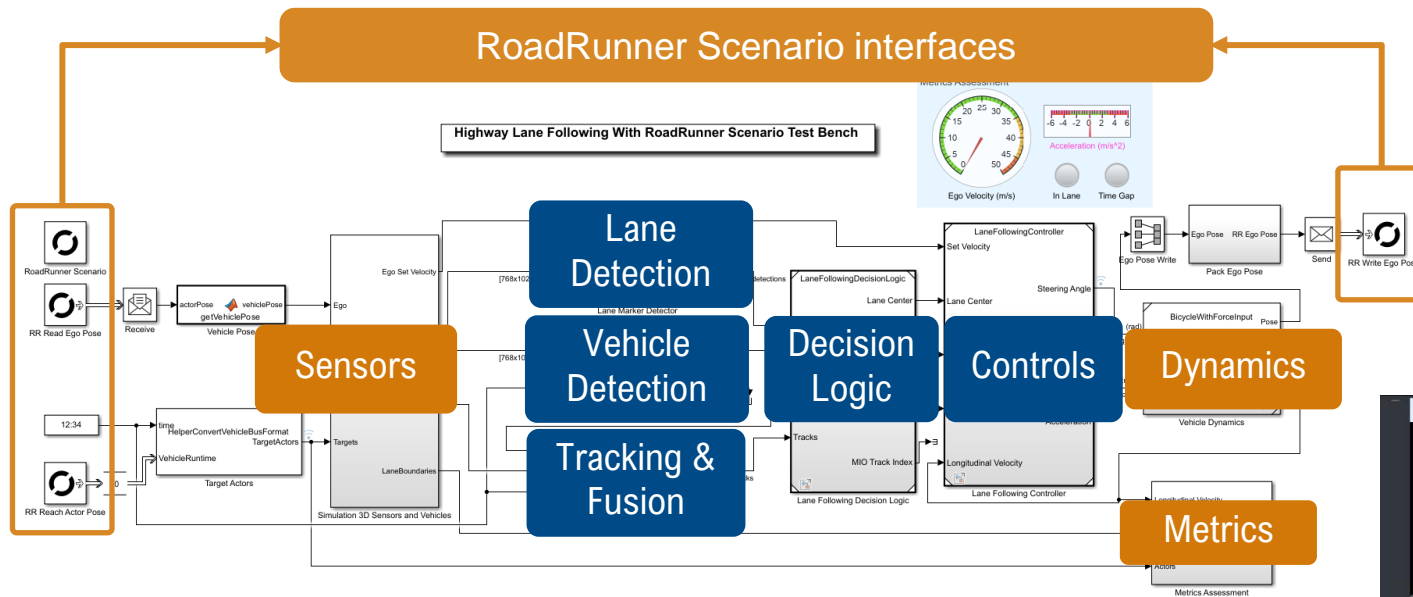
- Simulate Highway Lane Following with RoadRunner Scenario
- Monocular camera sensor
- Radar detections sensor

Highway Lane Following with RoadRunner Scenario

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

R2022b

Integrate cuboid sensors with RoadRunner Scenario

R2022b
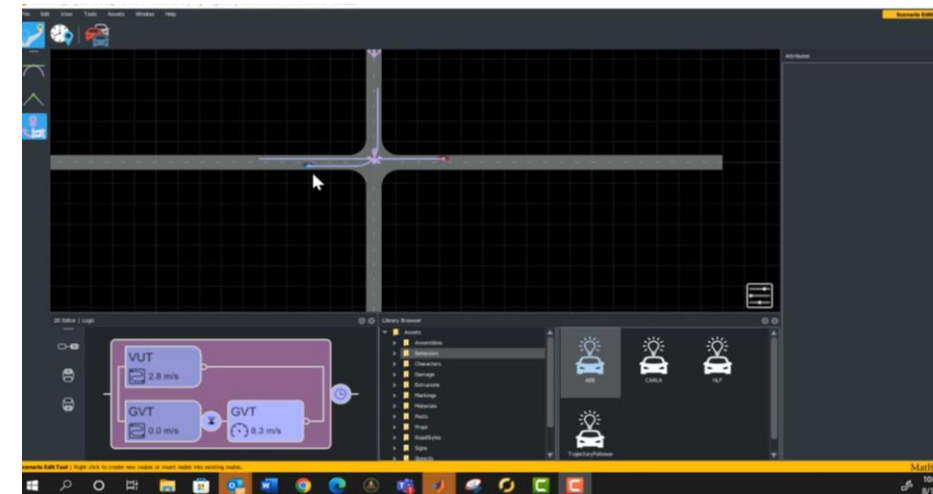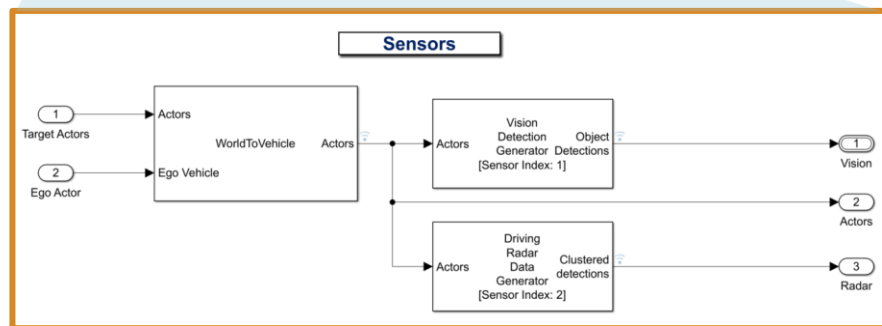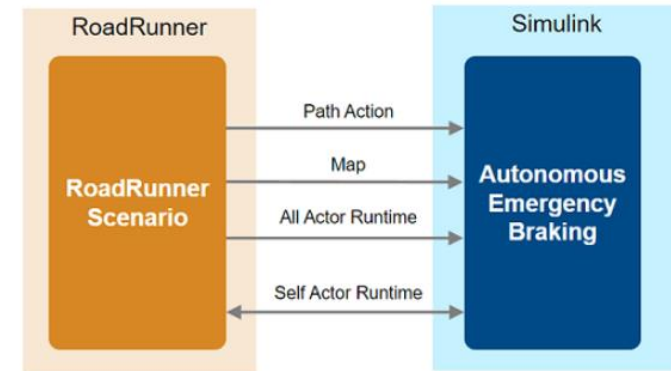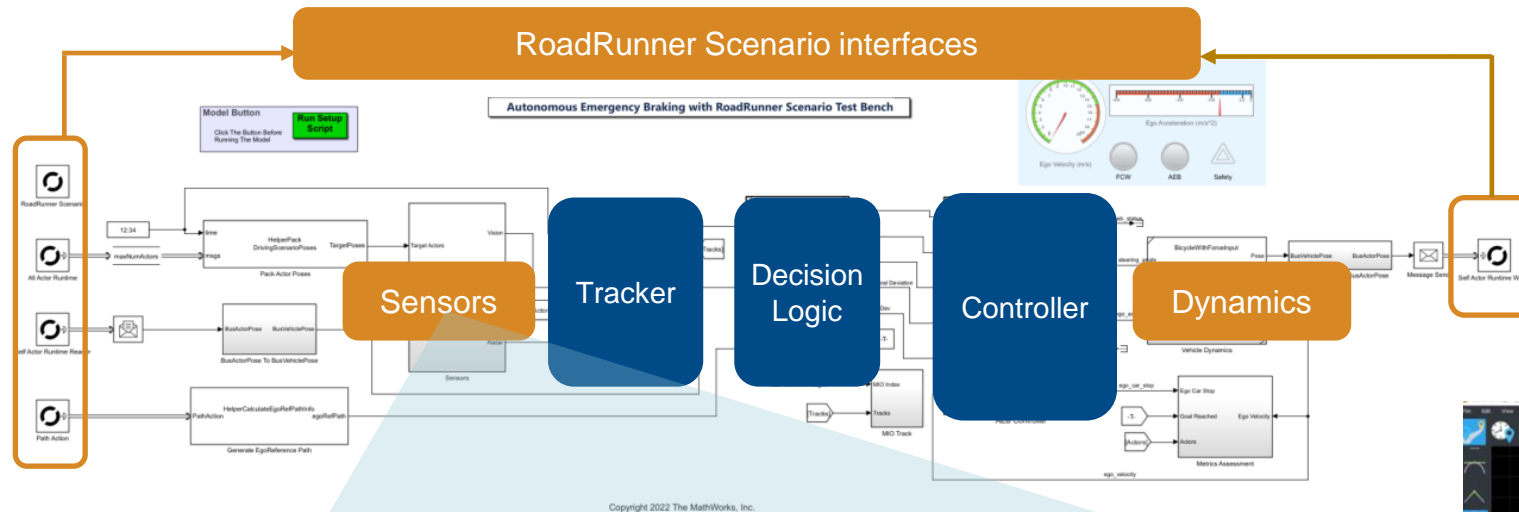
- Interface and co-simulate Automated Emergency Braking with RoadRunner Scenario
- Simulate Scenario Variants with speed variations for the Vehicle Under Test (VUT) and Global Vehicle Target (GVT)

Autonomous Emergency Braking with RoadRunner Scenario

Automated Driving Toolbox, RoadRunner Scenario, Simulink
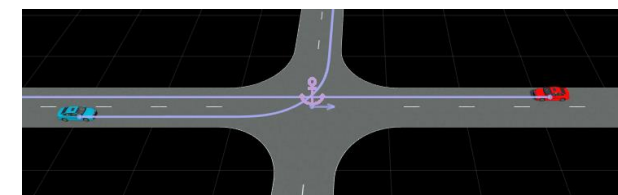
Car-to-**C**ar **F**ront **T**urn-**A**cross-**P**ath **50**%
(CCFTAP-50)

Generate RoadRunner Scenario from Recorded Sensor Data
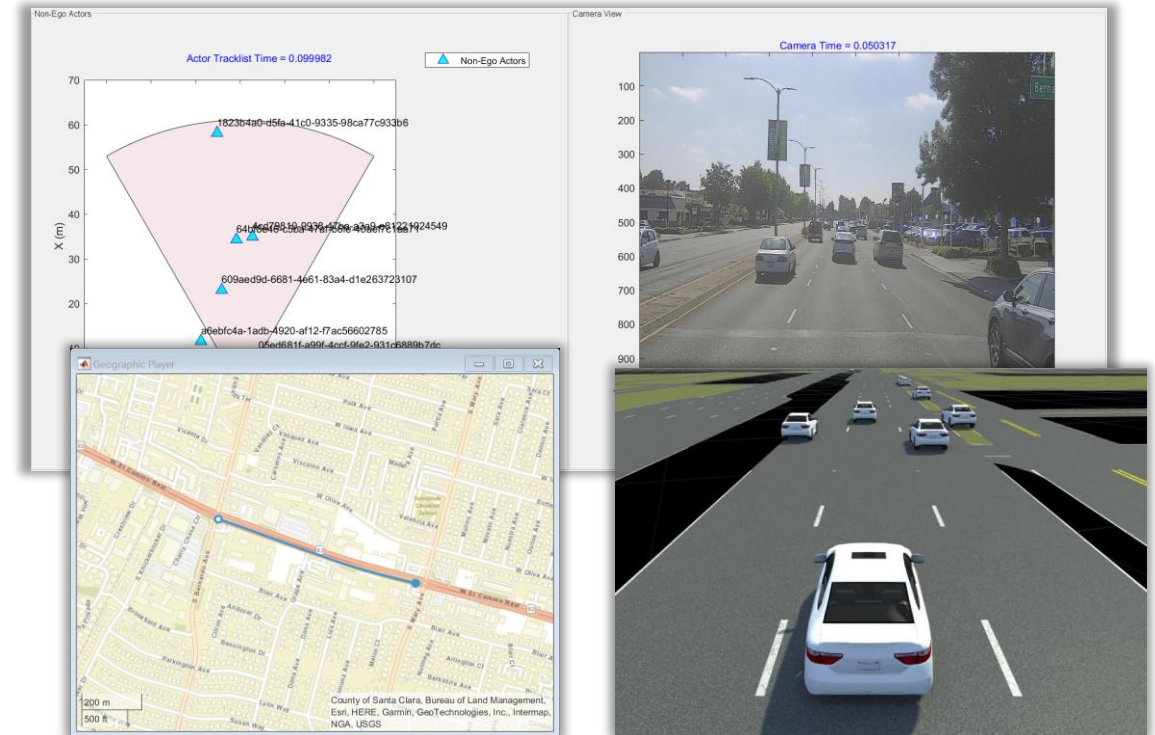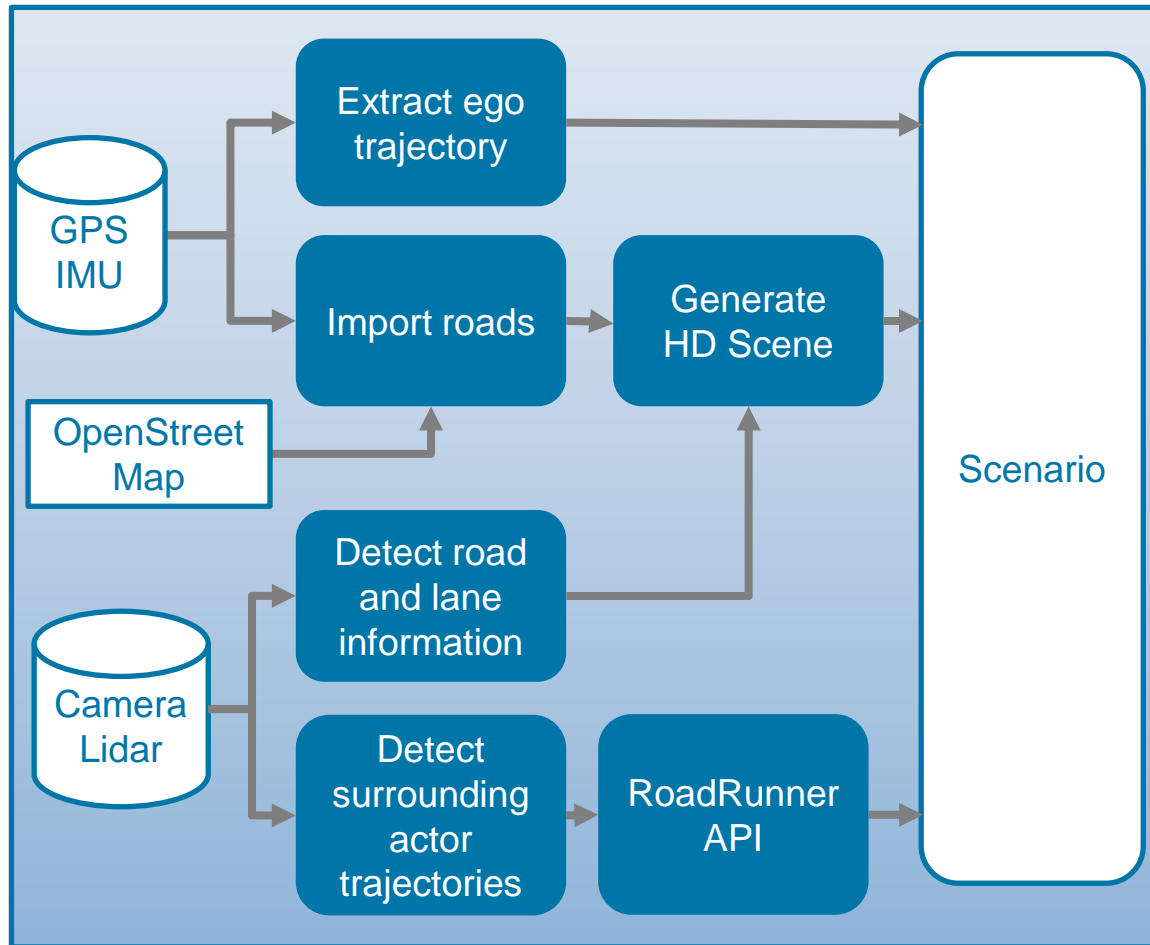
- Ego trajectories are extracted from GPS
- Non-Ego trajectories are extracted from Camera or Lidar
- Simulation is run in RoadRunner Scenario

Generate RoadRunner Scenario from Recorded Sensor Data

Automated Driving Toolbox, Scenario Builder support package, RoadRunner

R2022b

Learn about generating scenes and scenarios from recorded sensor data

R2022b

Featured Examples

Generate Scenario from Actor Tracklist and GPS Data

Generate ASAM OpenSCENARIO® v1.0 file using recorded actor tracklist and GPS data.

Open Live Script

Generate RoadRunner Scenario from Recorded Sensor Data

Generate RoadRunner Scenario from recorded GPS data and preprocessed actor track list.

Open Live Script

Generate RoadRunner Scene from Recorded Lidar Data

Generate RoadRunner HD map from recorded lidar data using pretrained deep learning model.

Open Live Script

Generate High Definition Scene from Lane Detections

Generate HD road scene using recorded lane detections, GPS data, and OpenStreetMap® data.

Open Live Script

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.

Open Live Script

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.

Open Live Script

Extract Vehicle Tracklist from Recorded Camera Data for Scenario…

Extract actor track list from raw camera data for scenario generation.

Open Live Script

Improve Ego Vehicle Localization

Improve ego vehicle localization by fusing GPS and IMU sensor data and generate virtual driving scenario from recorded sensor data.

Open Live Script

Smooth GPS Waypoints for Ego Localization

Create jitter-limited ego trajectory by smoothing GPS and IMU sensor data.

Open Live Script

Preprocess Lane Detections for Scenario Generation

Format lane detection data to update lane specifications for scenario generation.

Open Live Script

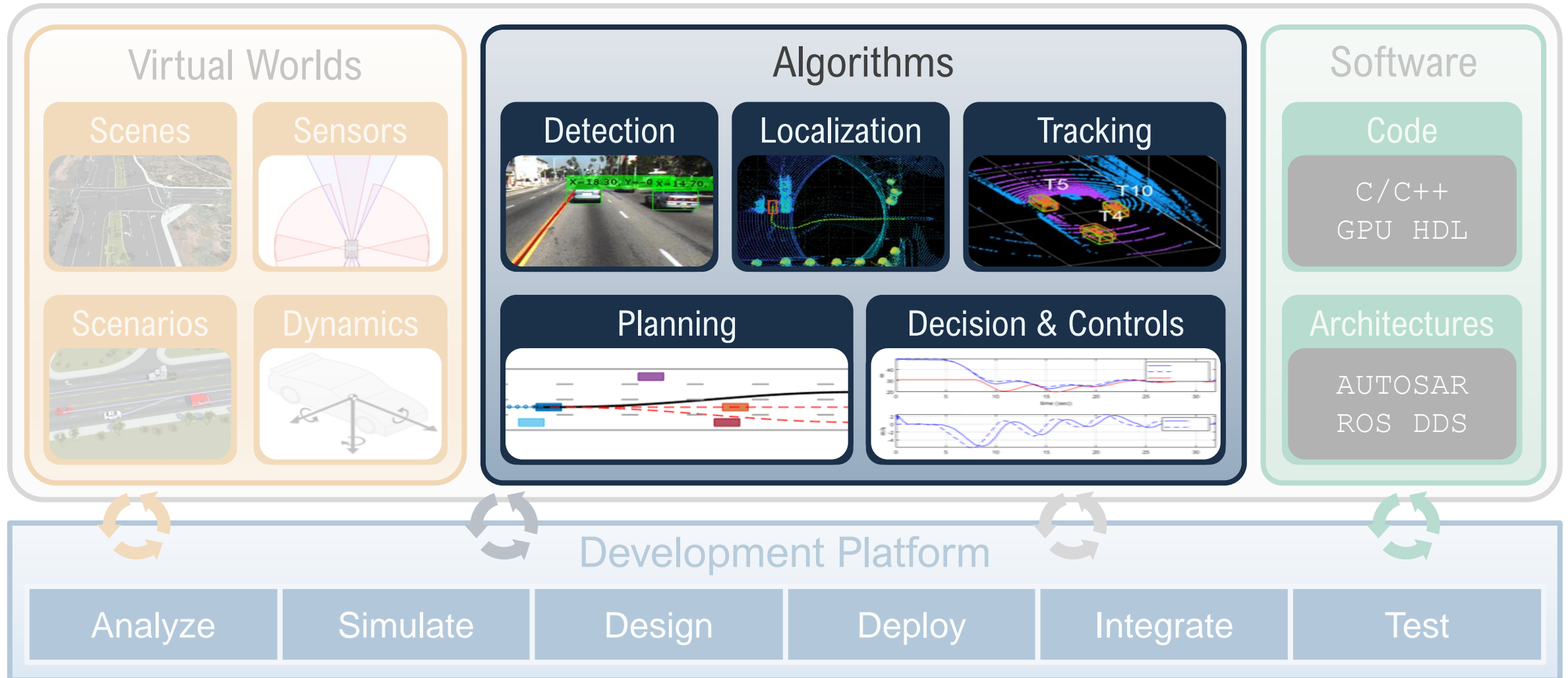Actor Tracklist

Lane Detections

GPS, IMU

Camera

Lidar

ASAM OpenDRIVE & OpenSCENARIO

RoadRunner Scene & Scenario

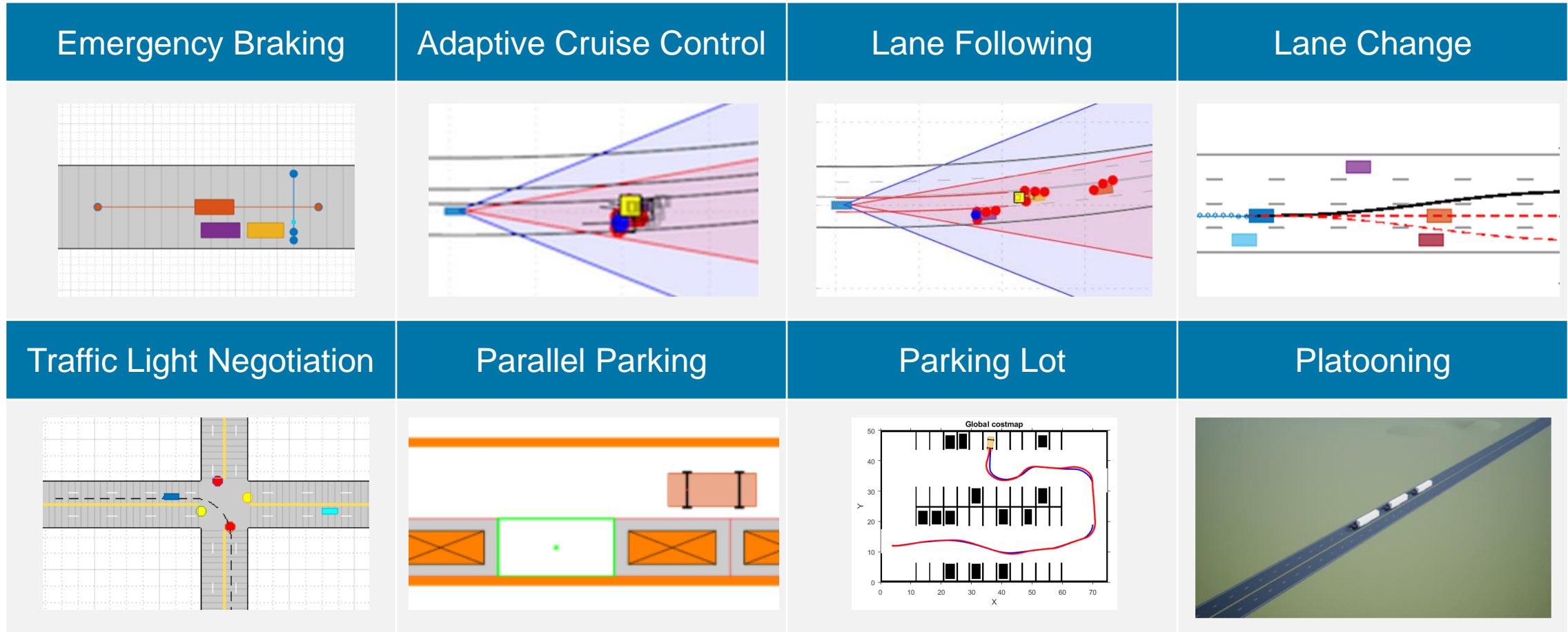drivingScenario

Scenario Builder support package

Automated Driving Toolbox

Develop Automated Driving Applications
with MATLAB, Simulink, & RoadRunner

Design planning and control algorithms for automated driving

Emergency Braking	Adaptive Cruise Control	Lane Following	Lane Change

Traffic Light Negotiation	Parallel Parking	Parking Lot	Platooning

Commonly used tools: Automated Driving Toolbox, Model Predictive Control Toolbox, Stateflow, Navigation Toolbox, Reinforcement Learning, Robotics System Toolbox
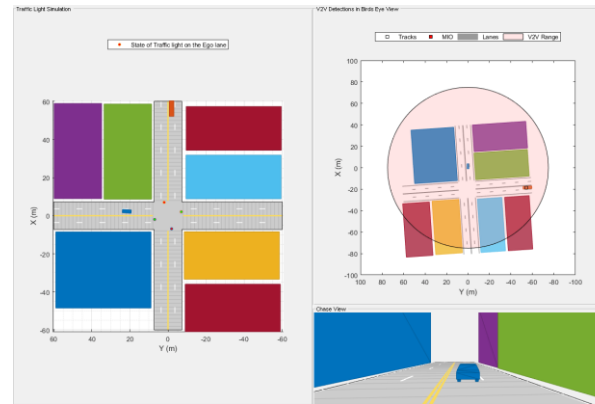
Learn about new features for planning and controls

Truck Trailer Parking
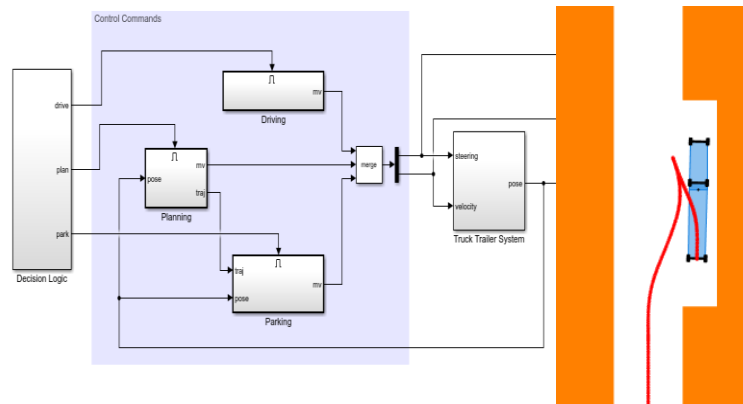
Parallel Parking of Truck Trailer Using Multistage Nonlinear MPC
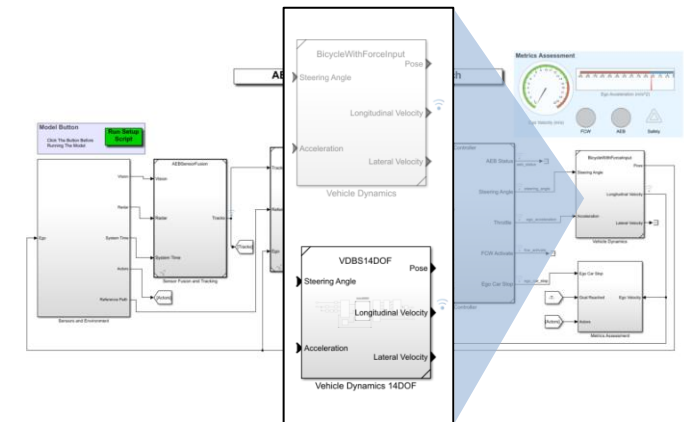*Model Predictive Control Toolbox, Optimization Toolbox*

V2X

Traffic Light Negotiation Using Vehicle-to-Everything Communication
Automated Driving Toolbox, Stateflow, Model Predictive Control Toolbox
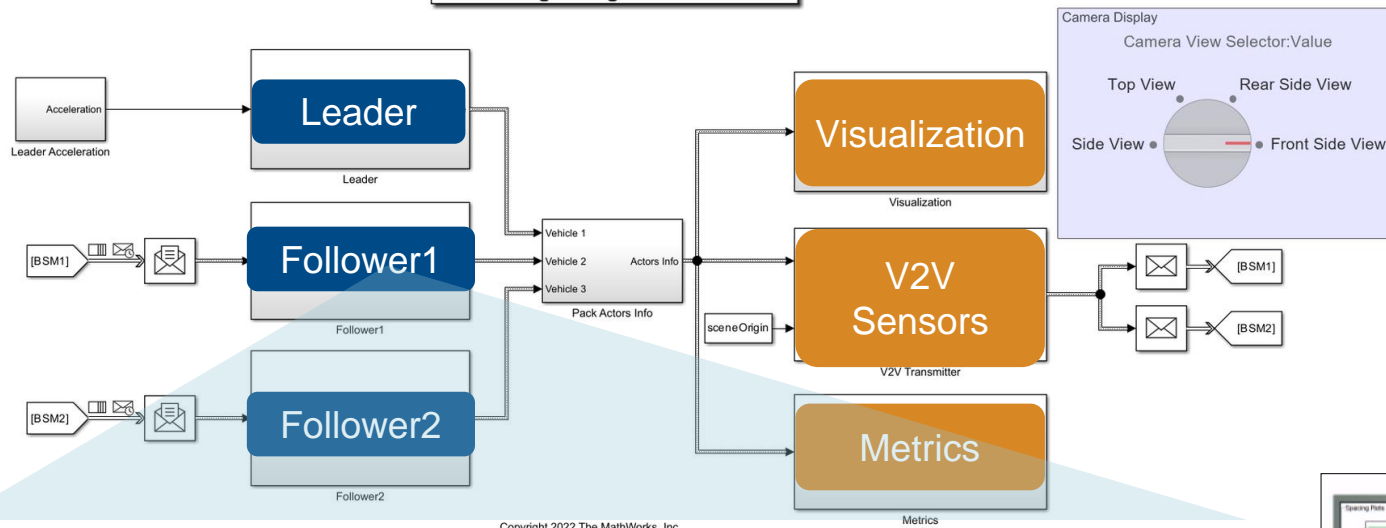
14 DOF Vehicle Dynamics in AEB

Autonomous Emergency Braking with Vehicle Variants
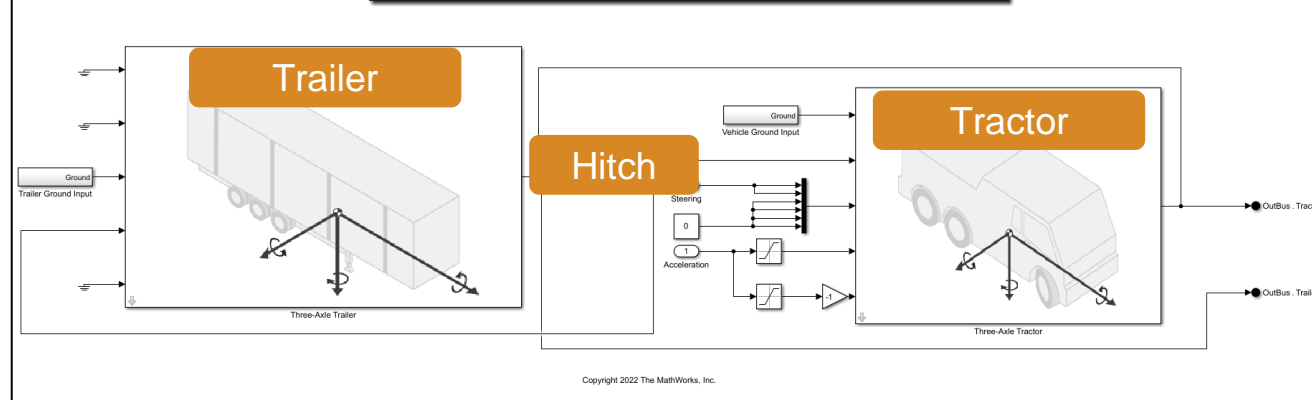*Automated Driving Toolbox, Vehicle Dynamics Blockset*

Design Platooning Controls with V2V Communication
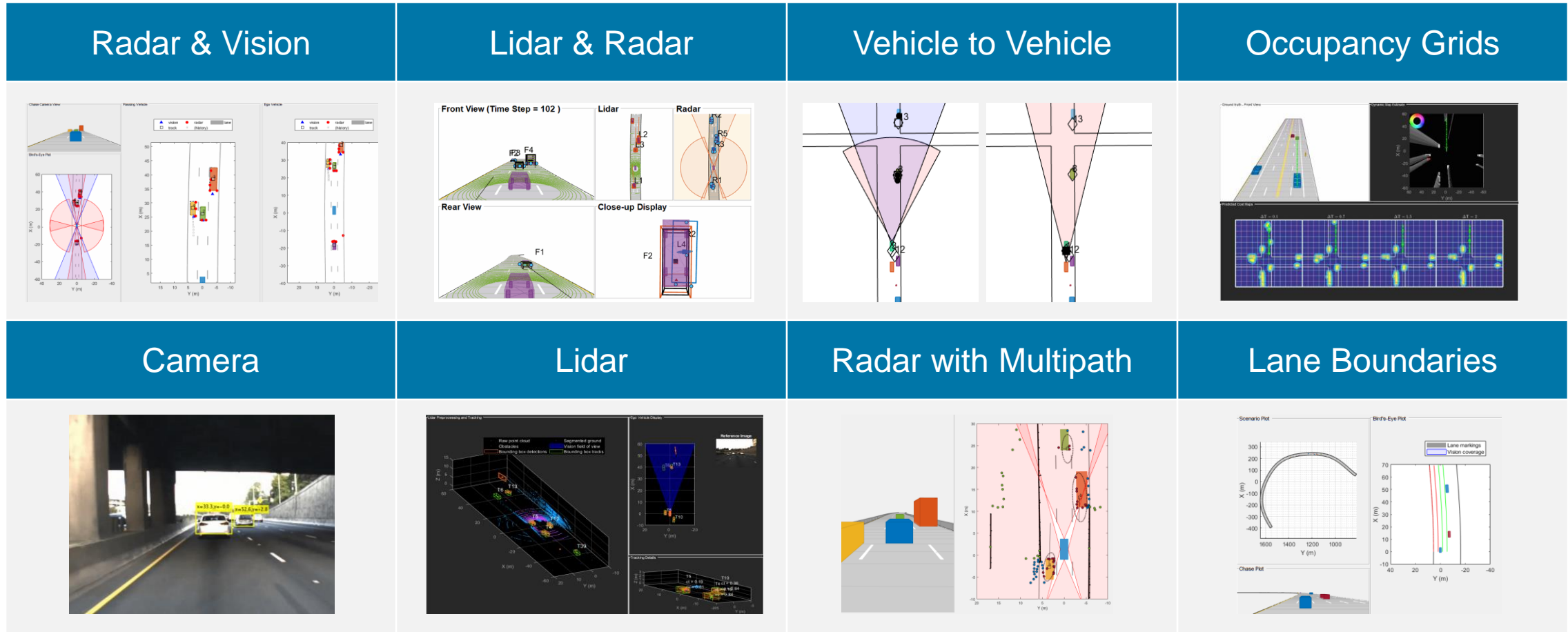
R2022**b**

Platooning Using V2V Test Bench

- Design Leader and Followers to form platoon using V2V
- Provide acceleration profile to leader
- Followers receive BSM messages and follow the leader
- Maintains safety space between vehicles
- Integrate followers with 6DoF Tractor and Trailer Dynamics

Three-Axle Tractor Towing Three-Axle Trailer

Trailer

Hitch

Tractor

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[Truck Platooning Using Vehicle-to-Vehicle Communication](#)

Automated Driving Toolbox, Simulink, Vehicle Dynamics Blockset

Design tracking and fusion algorithms for automated driving

Radar & Vision	Lidar & Radar	Vehicle to Vehicle	Occupancy Grids

Camera	Lidar	Radar with Multipath	Lane Boundaries

Commonly used tools: Automated Driving Toolbox, Tracking and Fusion Toolbox, Radar Toolbox

Design detection and localization algorithms for automated driving

Lanes	Objects	Semantic Segmentation

SLAM	Maps	Inertial Fusion

Commonly used tools: Automated Driving Toolbox, Computer Vision, Lidar Toolbox, Radar Toolbox, Deep Learning Toolbox, Navigation Toolbox
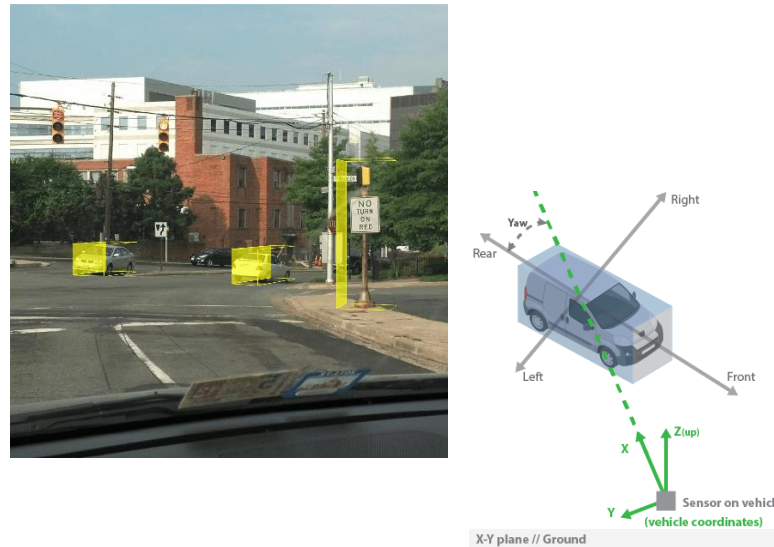
Learn about new features for algorithms

Improve tracking performance

3D Object Detection and Cuboid Computation

Depth Image to Point Cloud
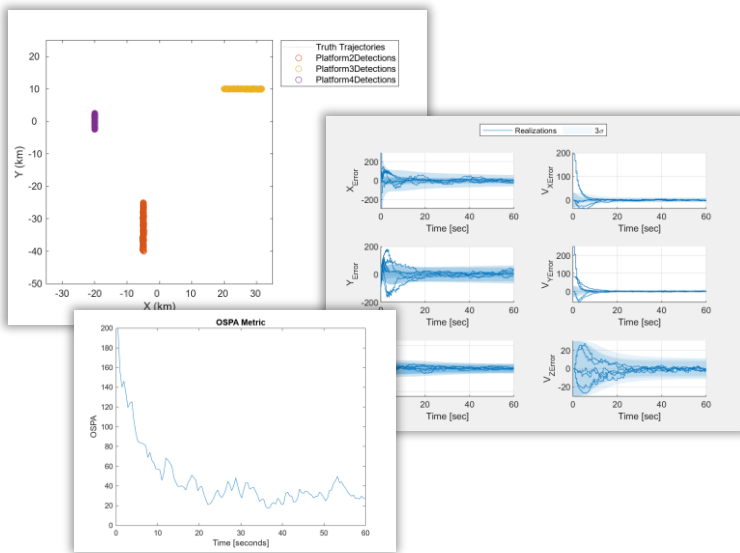
Automatically Tune Tracking Filter for Multi-Object Tracker
Sensor Fusion and Tracking Toolbox, Optimization Toolbox

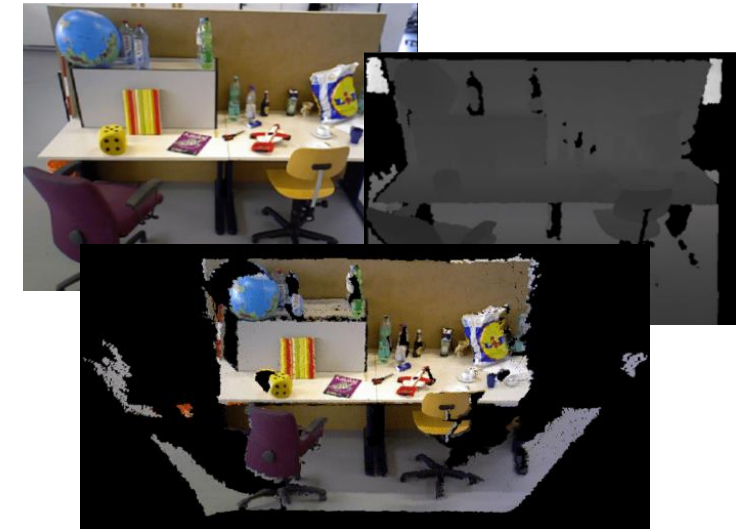Project Cuboids from 3-D World Coordinates to 2-D Image Coordinates
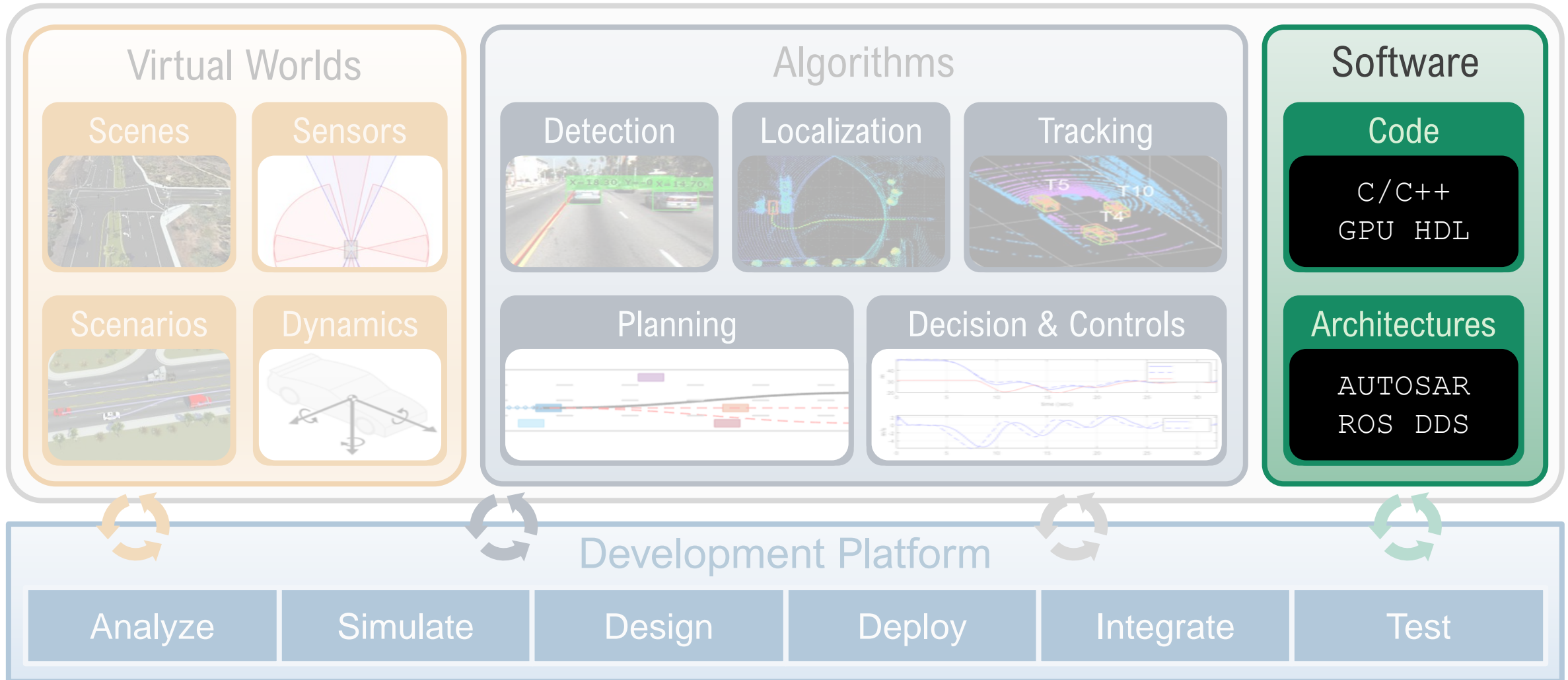*Automated Driving Toolbox, Computer Vision Toolbox*

Visual SLAM with an RGB-D Camera
Computer Vision Toolbox
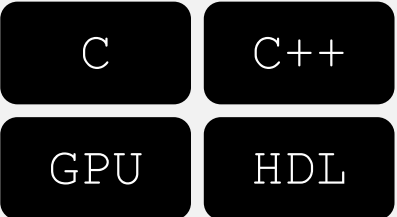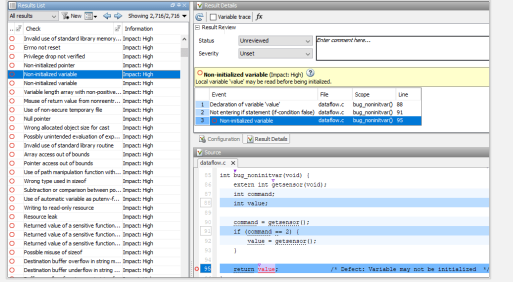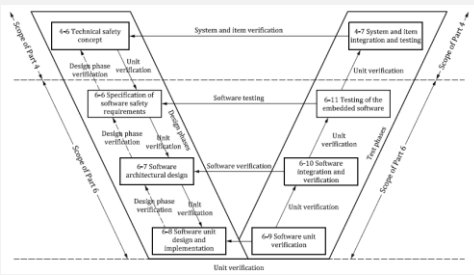
R2022b

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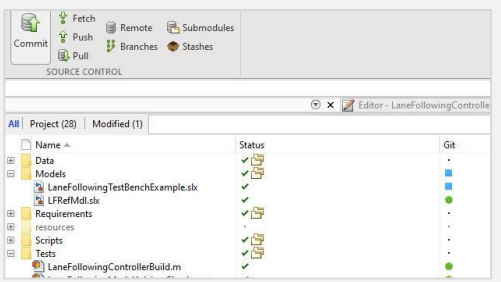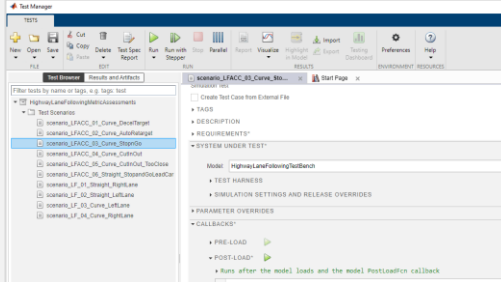# Develop Automated Driving Applications
with MATLAB, Simulink, & RoadRunner

Develop software applications for automated driving

Code	ROS / ROS 2.0	AUTOSAR	DDS

Continuous Integration	Automated Testing	Code Analysis	ISO 26262

Commonly used tools: MATLAB Coder, Embedded Coder, GPU Coder, HDL Coder,
ROS Toolbox, AUTOSAR Blockset, DDS Blockset,
Simulink Test, Simulink Coverage, Polyspace, IEC Certification Kit,

Learn about new examples for developing software applications

Sensor Fusion PIL Example	Real-Time Hardware Examples	SOA C++ Code Generation Example

Automate PIL Testing for Forward Vehicle Sensor Fusion
Simulink, Simulink Test, Embedded Coder
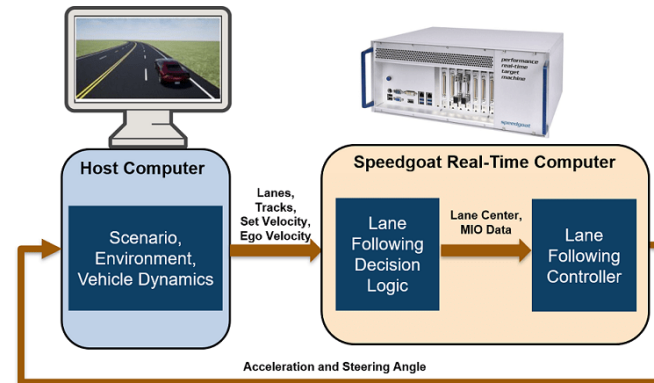
Automate Real-Time Testing for Highway Lane Following Controller
Automated Driving Toolbox, Simulink Real-TIme

Generate C++ code for Message Interfaces in Lane Following Controls & Sensor Fusion
ROS Toolbox, AUTOSAR Blockset, DDS Blockset

R2022b   R2022a   R2021b
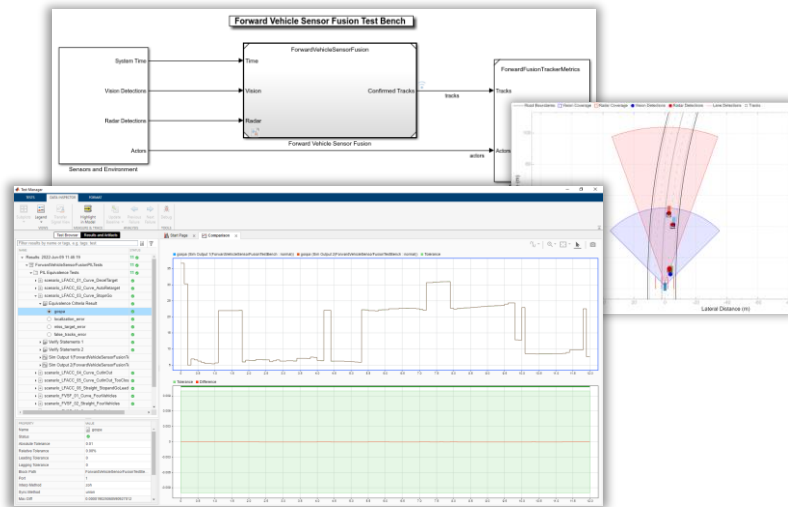
Develop Automated Driving Applications
with MATLAB, Simulink, & RoadRunner

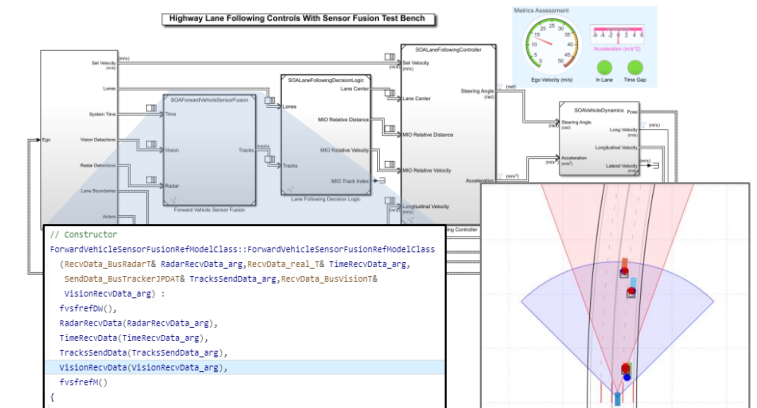# Partner with MathWorks to adopt algorithm development workflows

Ford manages scenario descriptions

[Converting Spreadsheet-Based Scenario Definitions to OpenSCENARIO Files](#)
MathWorks Automotive Conference 2022

Bosch develops lidar sensor classifier

[Designing a Lidar Sensor Classifier Using a MATLAB Framework](#)
MATLAB EXPO 2022

Denso deploys production ADAS software

[ADAS Control Unit Development and Continuous Integration Practice](#)
MATLAB EXPO 2022 - China