MathWorks
AUTOMOTIVE CONFERENCE 2022
North America

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

Pitambar Dayal, MathWorks

MathWorks®

Develop Automated Driving Applications

with MATLAB, Simulink, & RoadRunner

Virtual Worlds

- Scenes
- Sensors
- Scenarios
- Dynamics

Algorithms

- Detection
- Localization
- Tracking
- Planning
- Decision & Controls

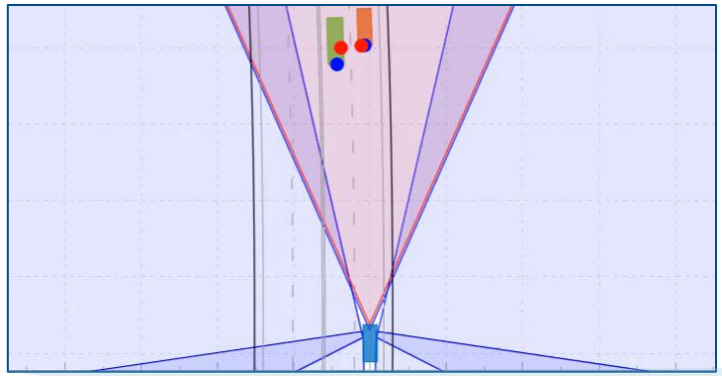
Software

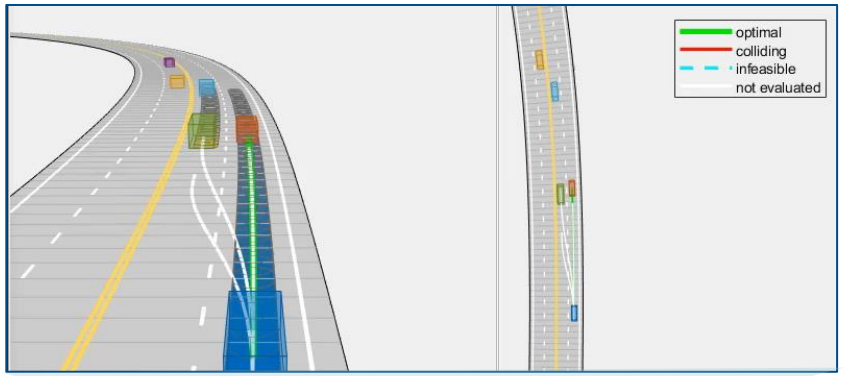
- Code: C/C++, GPU, HDL
- Architectures: AUTOSAR, ROS, DDS

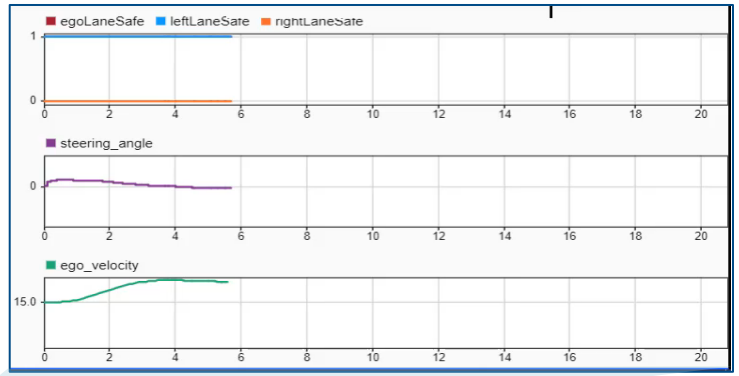
Development Platform

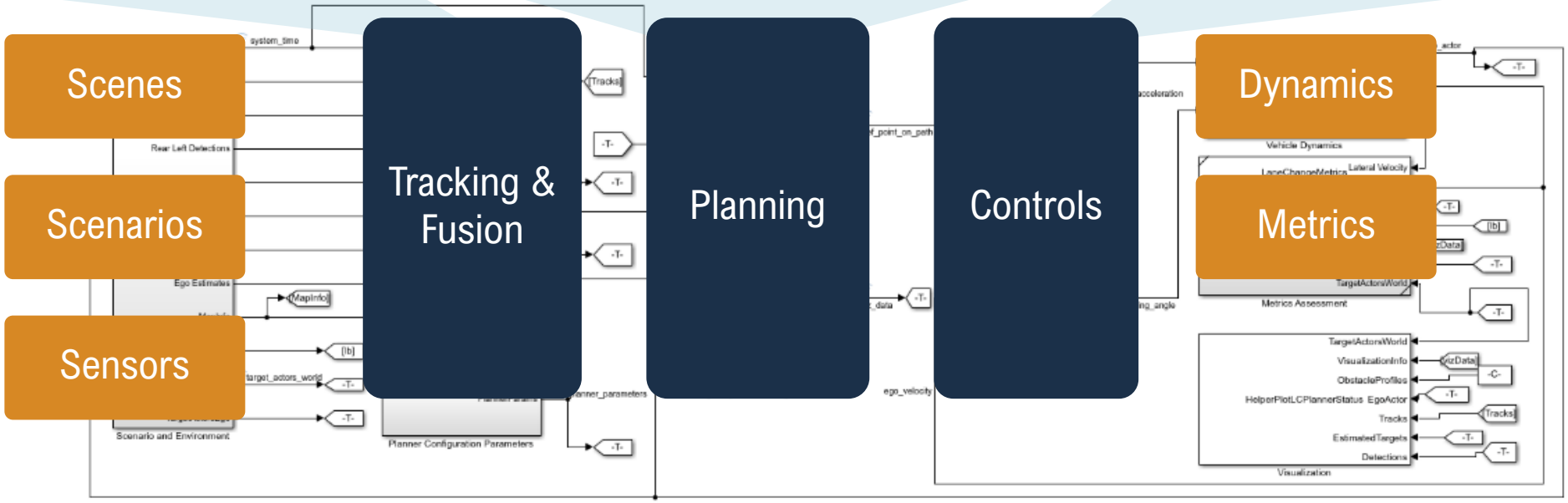
Analyze | Simulate | Design | Deploy | Integrate | Test

Develop virtual worlds for automated driving applications



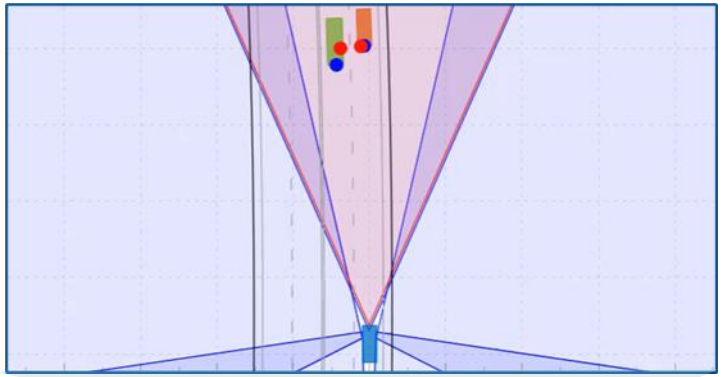


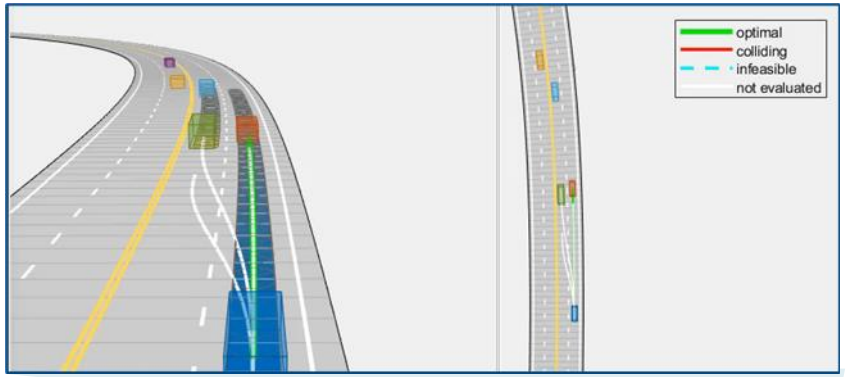


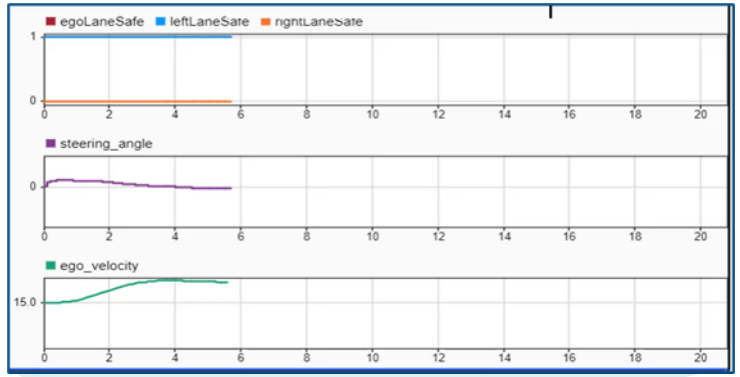


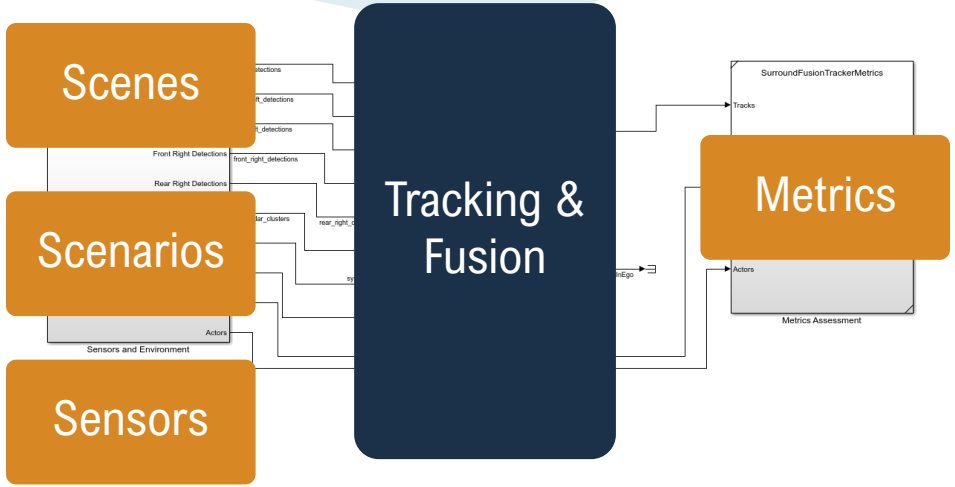
[Highway Lane Change](#) Updated R2022a

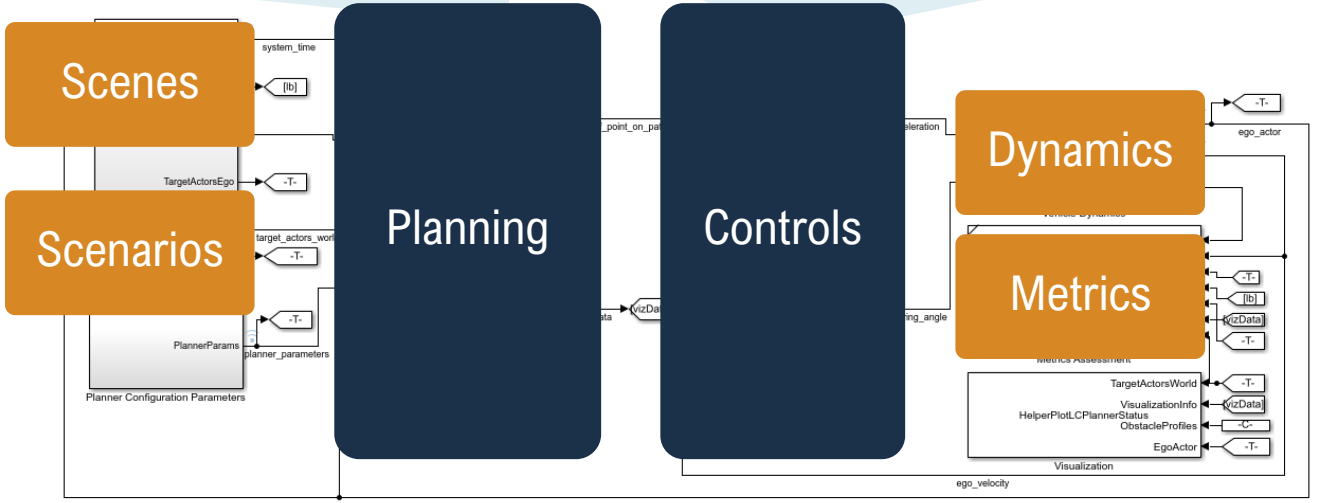
Develop algorithms for automated driving applications







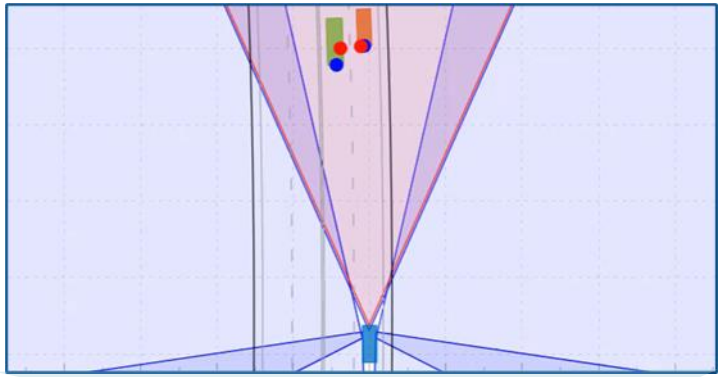


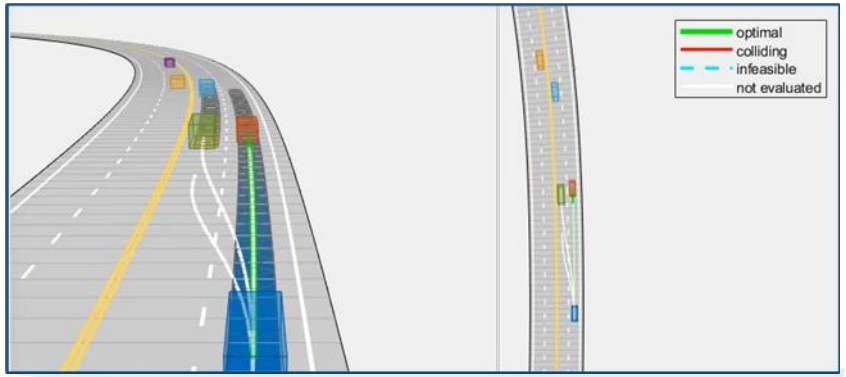


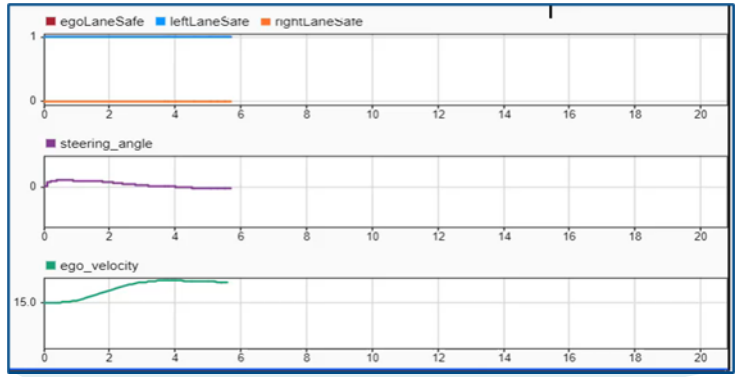
Surround Vehicle Sensor Fusion R2021a

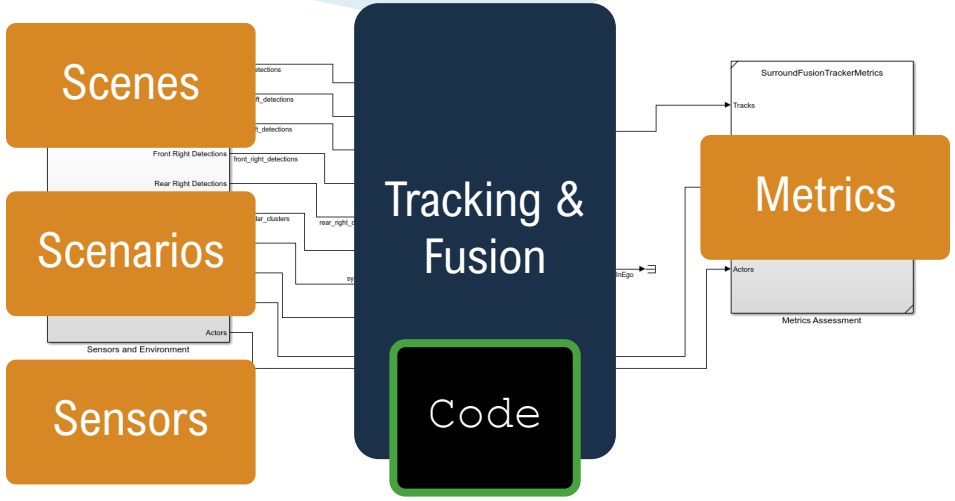
Highway Lane Change Planner and Controller R2022a

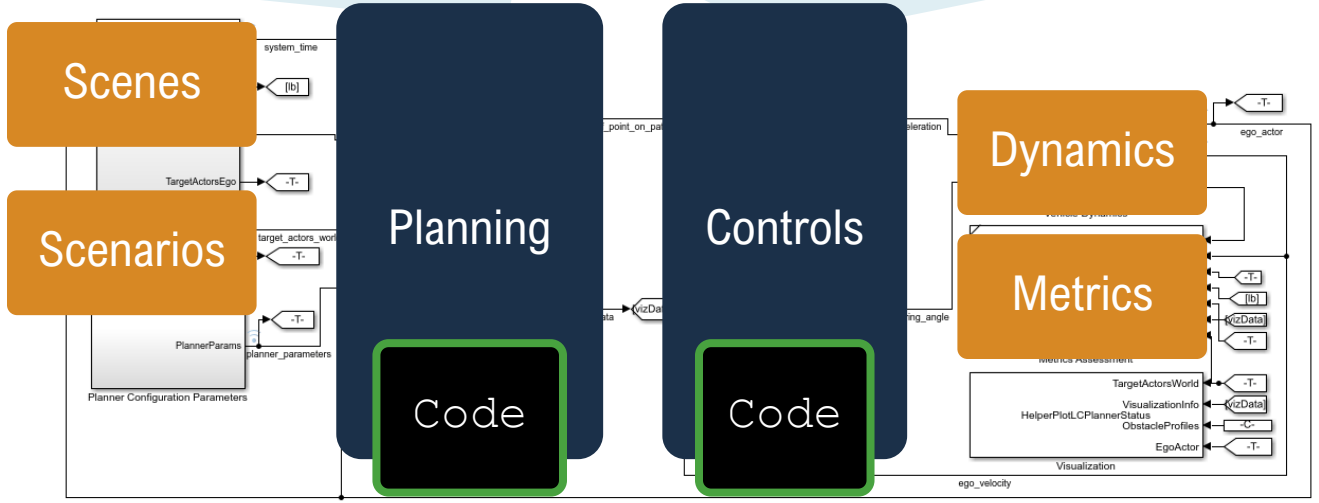
Develop software for automated driving applications







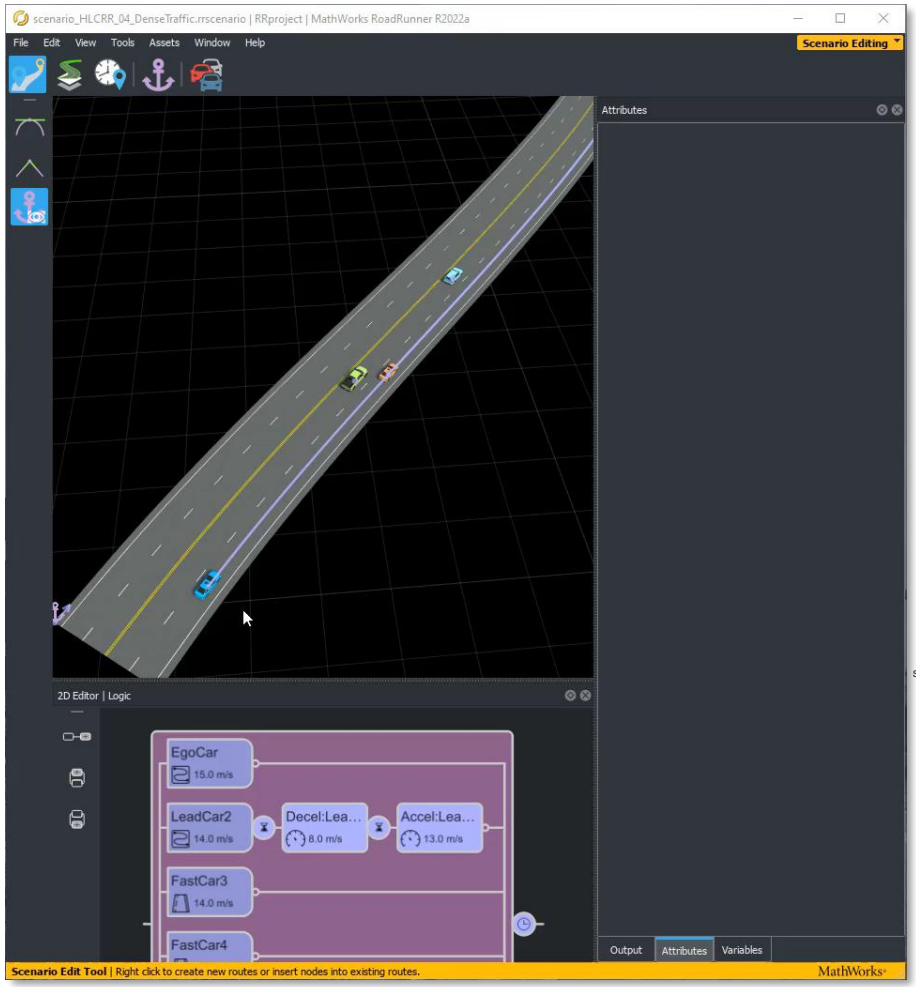


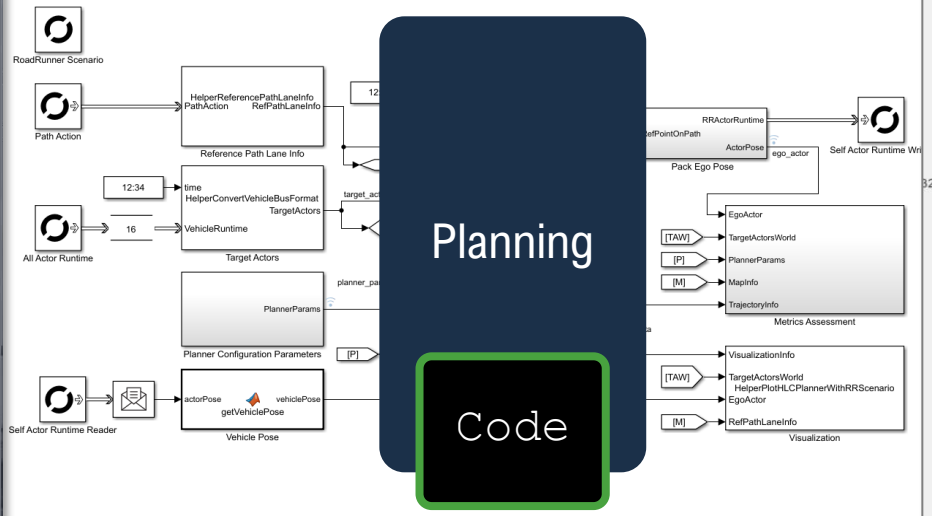


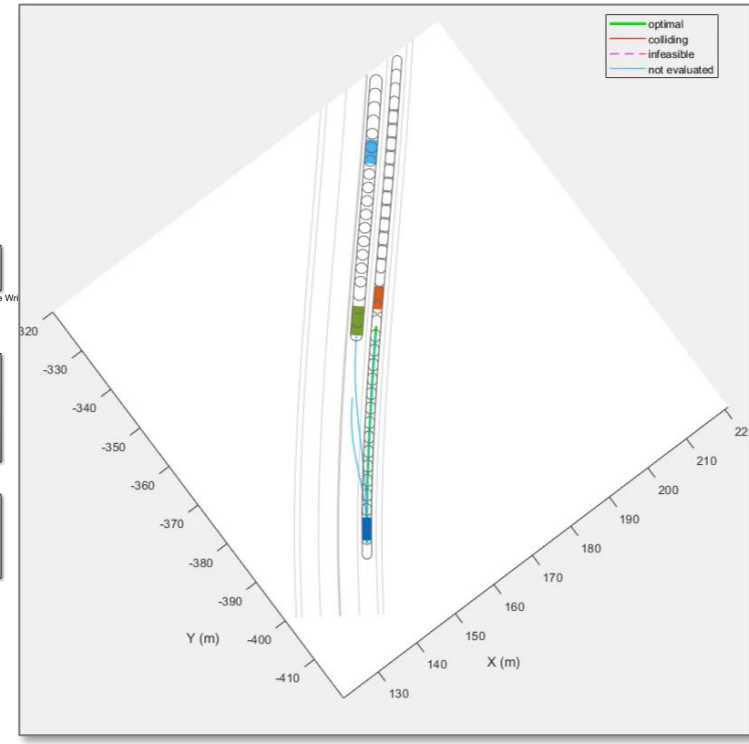
[Surround Vehicle Sensor Fusion](#) R2021a

[Highway Lane Change Planner and Controller](#) R2022a

Develop scenarios for automated driving applications







Set map-aware vehicle paths, scenario logic, conditions and goals

[Highway Lane Change Planner with RoadRunner Scenario]

R2022a

Develop Automated Driving Applications

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Design 3D scenes for automated driving applications

Here HD Live Map
Tom Tom HD Maps
Custom HD Maps

OpenDRIVE
OpenStreetMap
OpenCRG
Zenrin SD Maps

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

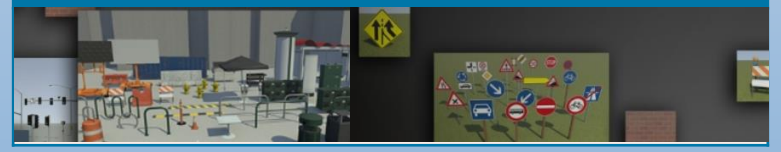
Custom Assets

RoadRunner Platform

RoadRunner Scene Builder

RoadRunner

RoadRunner Asset Library



OpenDRIVE

Filmbox

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

Learn about new features to author 3D scenes

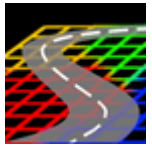
RoadRunner API

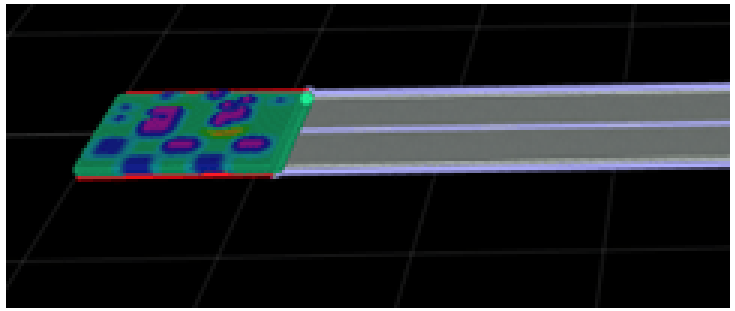
```
% Open a RoadRunner project
rrApp = roadrunner("C:\RR\MyScenario");

% 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

R2021b

Import OpenCRG

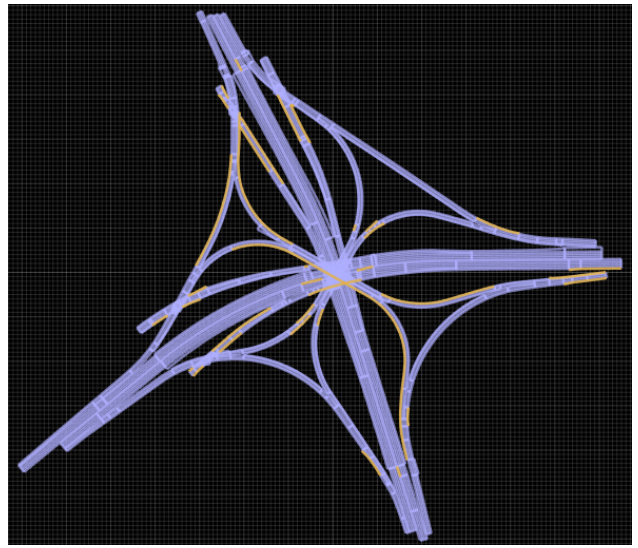




[Road CRG Tool](#)
RoadRunner

R2021b

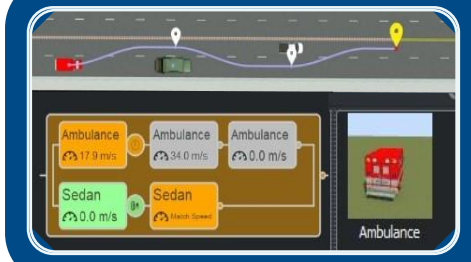
Import Custom HD Maps



[Build Scenes Using TomTom HD Map Data](#)
RoadRunner Scene Builder

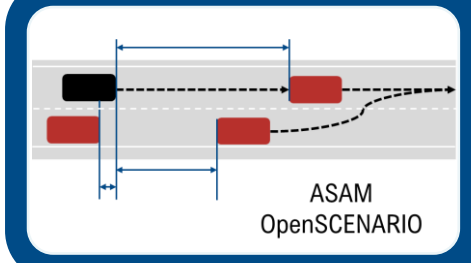
R2021b

Develop Scenarios for Automated Driving Applications with RoadRunner Scenario



Design and Simulate Scenarios

- Design paths and scenario logic
- Relocate scenarios to different scenes
- Programmatically vary parameters



Interface with OpenSCENARIO

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

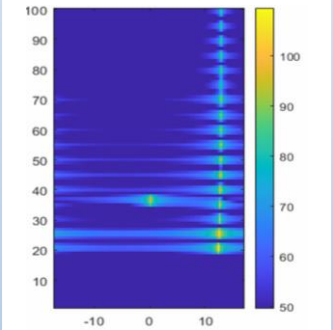
Simulate with MATLAB, Simulink, and CARLA

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

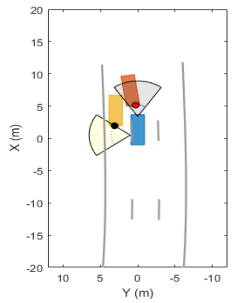
Simulate sensors for automated driving applications

Cuboid Sensors

- Radar IQ Signals

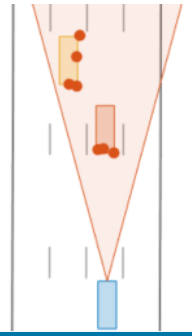


- Ultrasonic Detections

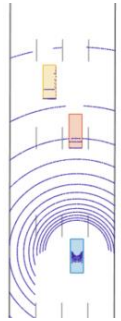


Cuboid & Unreal Engine

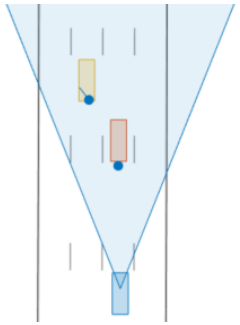
- Radar Detections



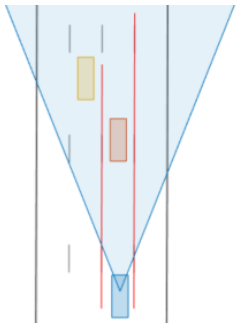
- Lidar



- Vision Detections



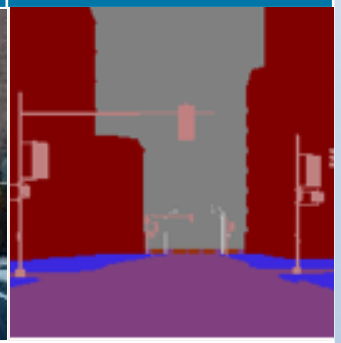
- Lane Detections



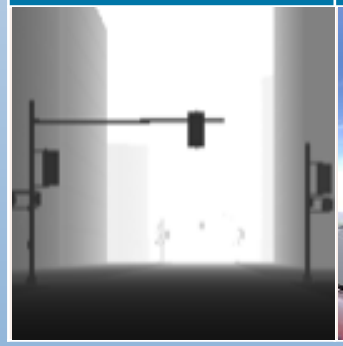
Unreal Engine Sensors

- Monocular Camera

- Semantic Segmentation



- Depth



- Fisheye Camera

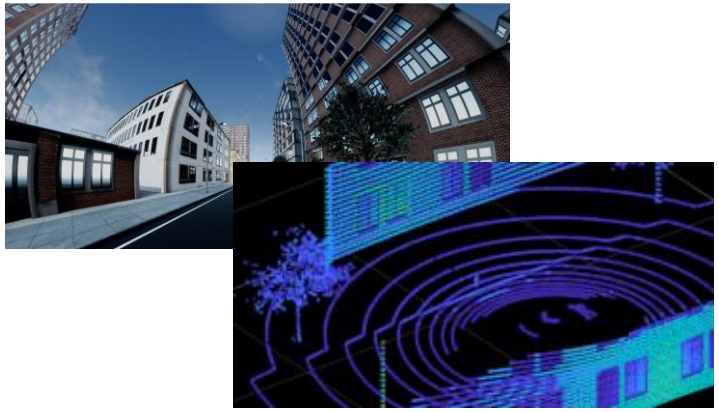
Positional Sensors

- Wheel Encoder
- Global Positioning System (GPS)
- Inertial Measurement Unit (IMU)
- Inertial Navigation System (INS)

Commonly used tools: Automated Driving Toolbox™, Radar Toolbox, Navigation Toolbox™

Learn about new features to simulate sensors

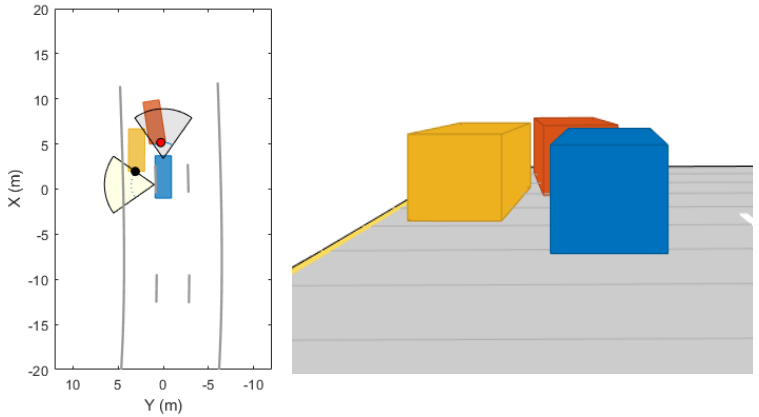
Lidar Reflectivity (Unreal)



[Simulation 3D Lidar](#)
Automated Driving Toolbox

R2022a

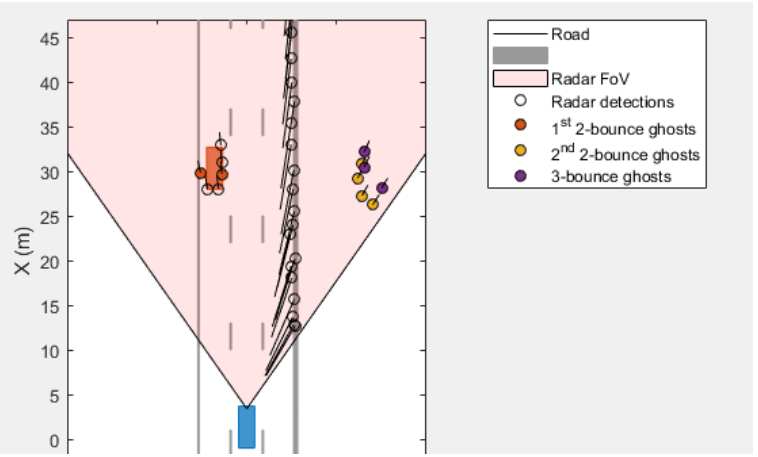
Ultrasonic Sensor (Cuboid)



[Ultrasonic Detection Generator](#)
Automated Driving Toolbox

R2022a

Radar Reflection (Cuboid)



[Simulate Radar Ghosts due to Multipath Return](#)
Radar Toolbox, Automated Driving Toolbox

R2021b

Develop Automated Driving Applications

with MATLAB, Simulink, & RoadRunner

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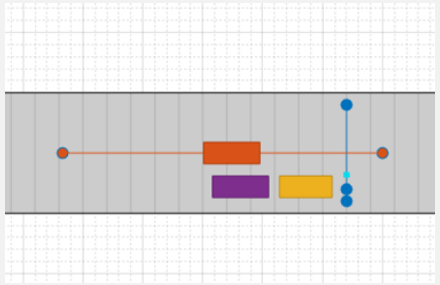
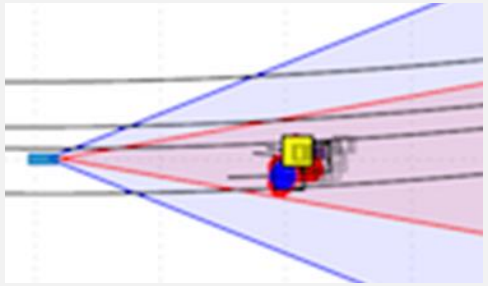
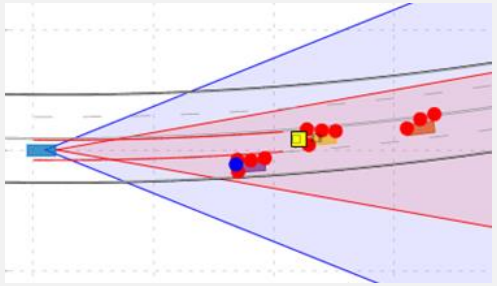
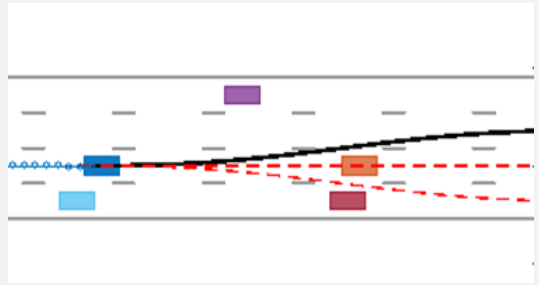
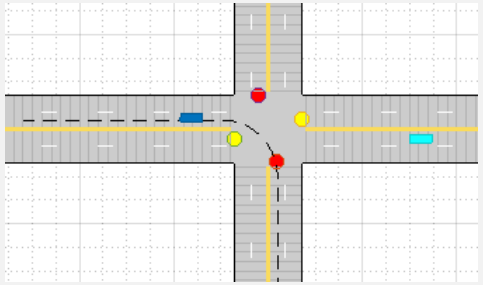
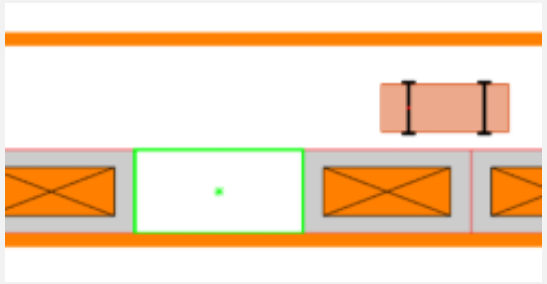
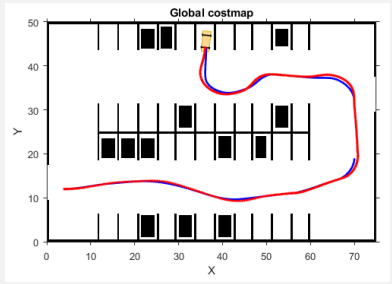
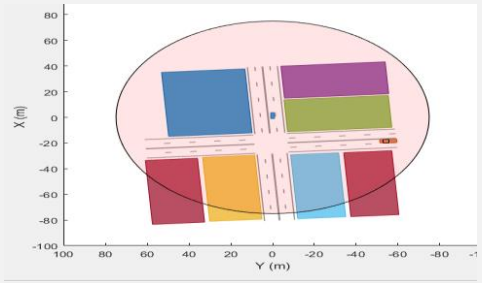
Software

- Code
  - C/C++
  - GPU HDL
- Architectures
  - AUTOSAR
  - ROS DDS

Development Platform

Analyze | Simulate | Design | Deploy | Integrate | Test

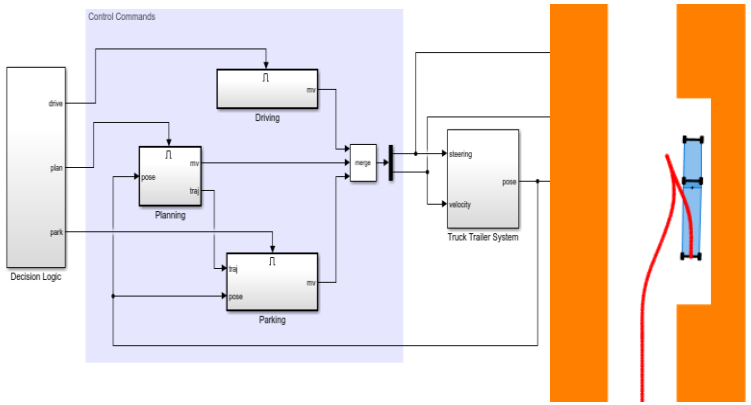
Design planning and control algorithms for automated driving

Emergency Braking	Adaptive Cruise Control	Lane Following	Lane Change
			
Traffic Light Negotiation	**Parallel Parking**	**Parking Lot**	**V2X**
			

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

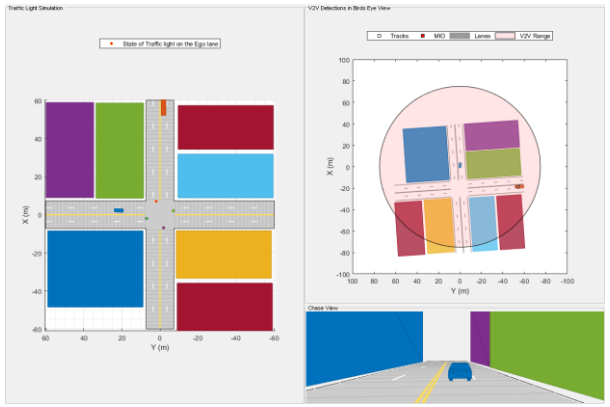


[Parallel Parking of Truck Trailer Using Multistage Nonlinear MPC]

Model Predictive Control Toolbox, Optimization Toolbox

R2022a

V2X

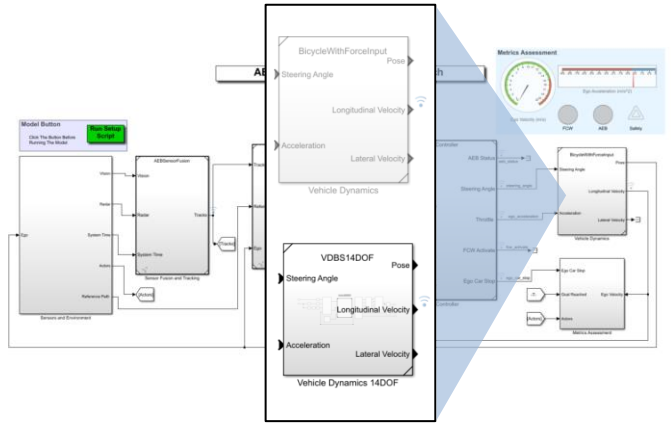


[Traffic Light Negotiation Using Vehicle-to-Everything Communication]

Automated Driving Toolbox, Stateflow, Model Predictive Control Toolbox

R2022a

14 DOF Vehicle Dynamics in AEB

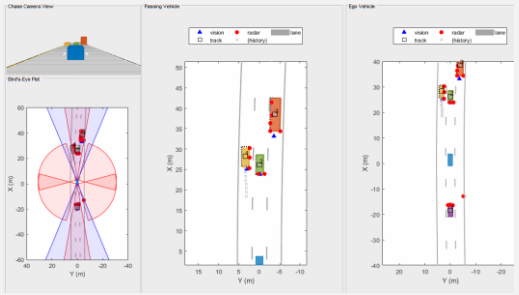
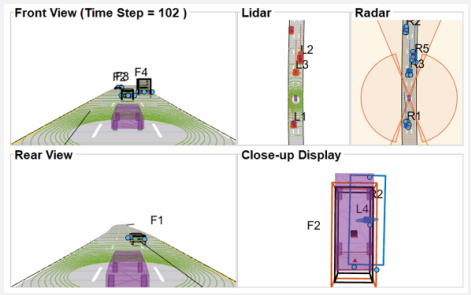
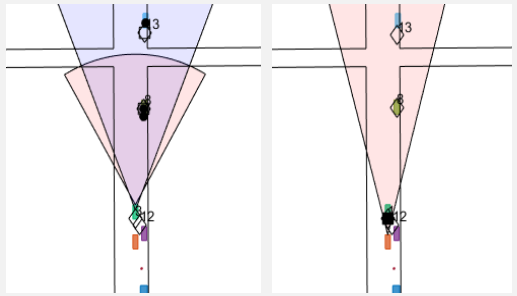
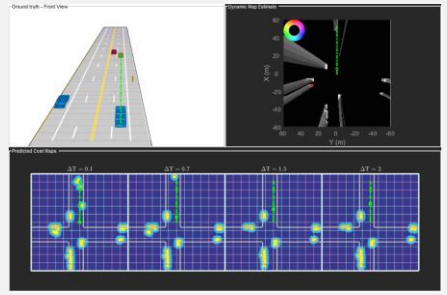
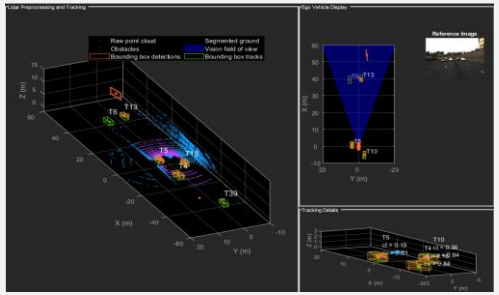
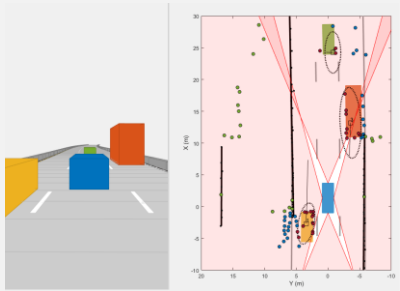
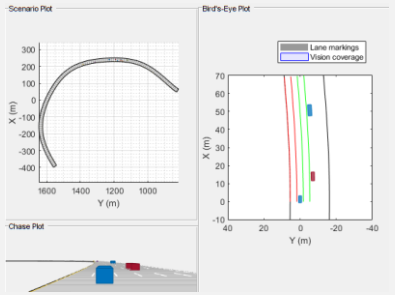


[Autonomous Emergency Braking with Vehicle Variants]

Automated Driving Toolbox, Vehicle Dynamics Blockset

R2022a

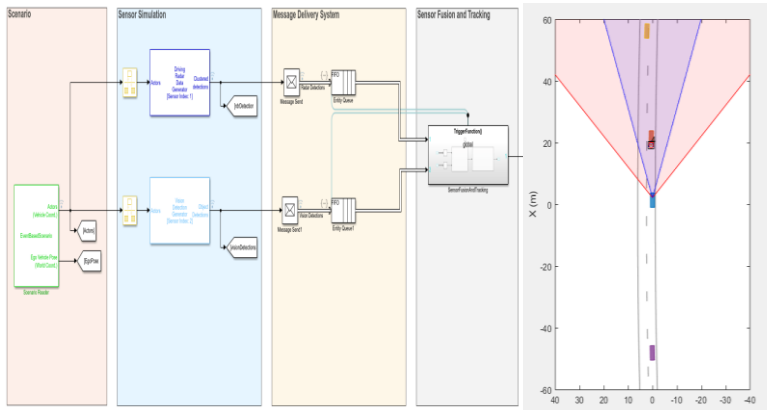
Design tracking and fusion algorithms for automated driving

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

Learn about new features for sensor fusion and tracking

Event Based Sensor Fusion and Tracking with Retrodiction

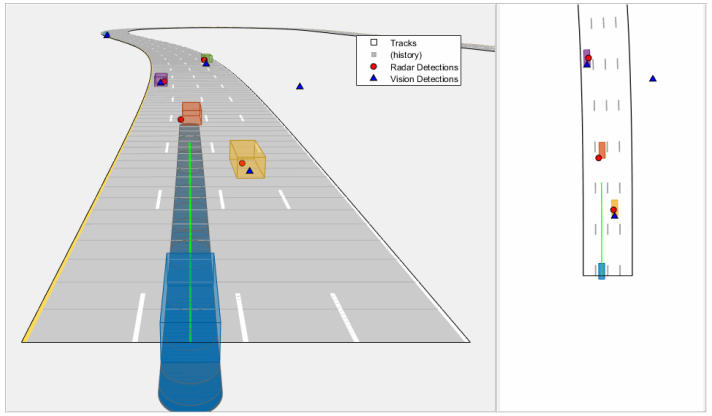


[Event-Based Sensor Fusion and Tracking with Retrodiction]

Sensor Fusion and Tracking Toolbox, Automated Driving Toolbox

R2021b

Object Tracking and Motion Planning

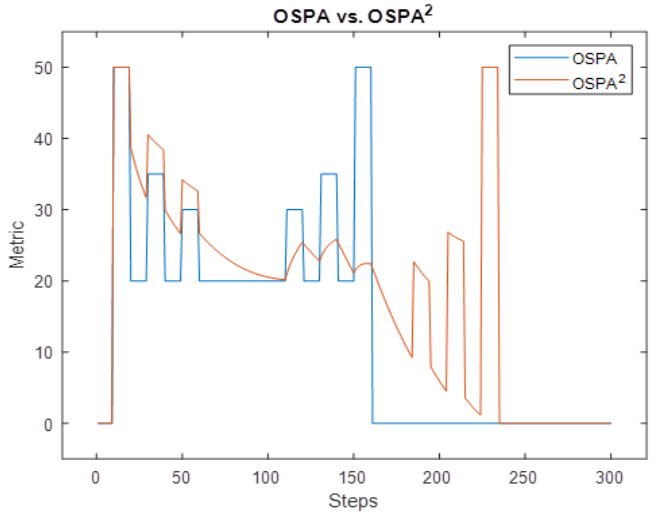


[Object Tracking and Motion Planning Using Frenet Reference Path]

Navigation Toolbox, Automated Driving Toolbox

R2021b

OSPA^2 Metric

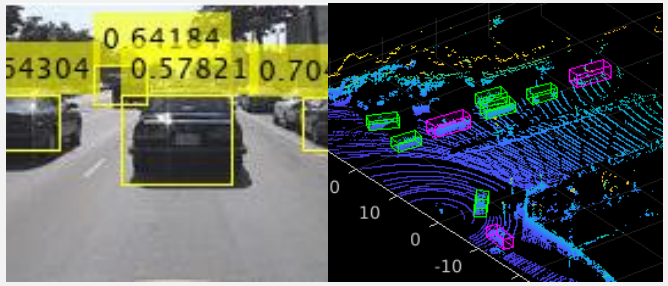
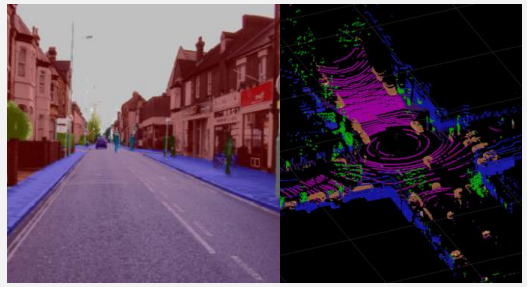
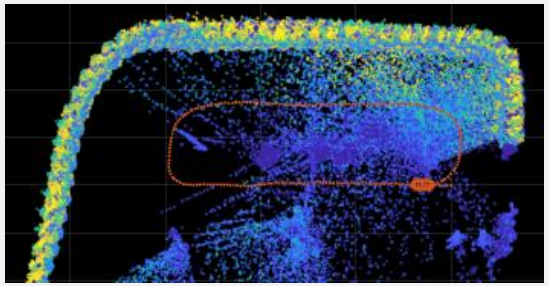
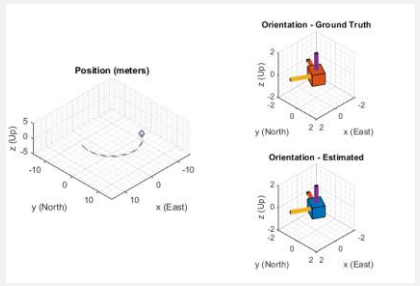


[*Optimal Subpattern Assignment Metric*]

Sensor Fusion and Tracking Toolbox

R2022a

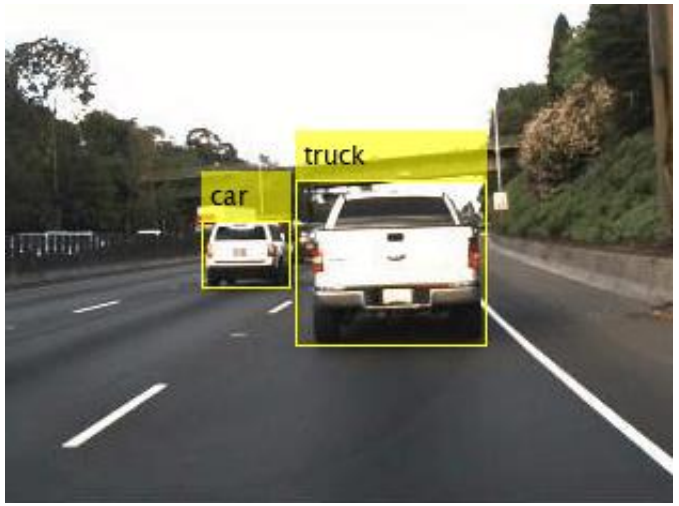
Design detection and localization algorithms for automated driving

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 detection and localization

YOLO V4 Object Detector



[Object Detection Using YOLO V4]
Computer Vision Toolbox, Image Processing Toolbox

R2022a

Lidar Odometry and Mapping (LOAM)

[Build a Map with LOAM using Unreal Engine]
Automated Driving Toolbox, Lidar Toolbox

R2022a

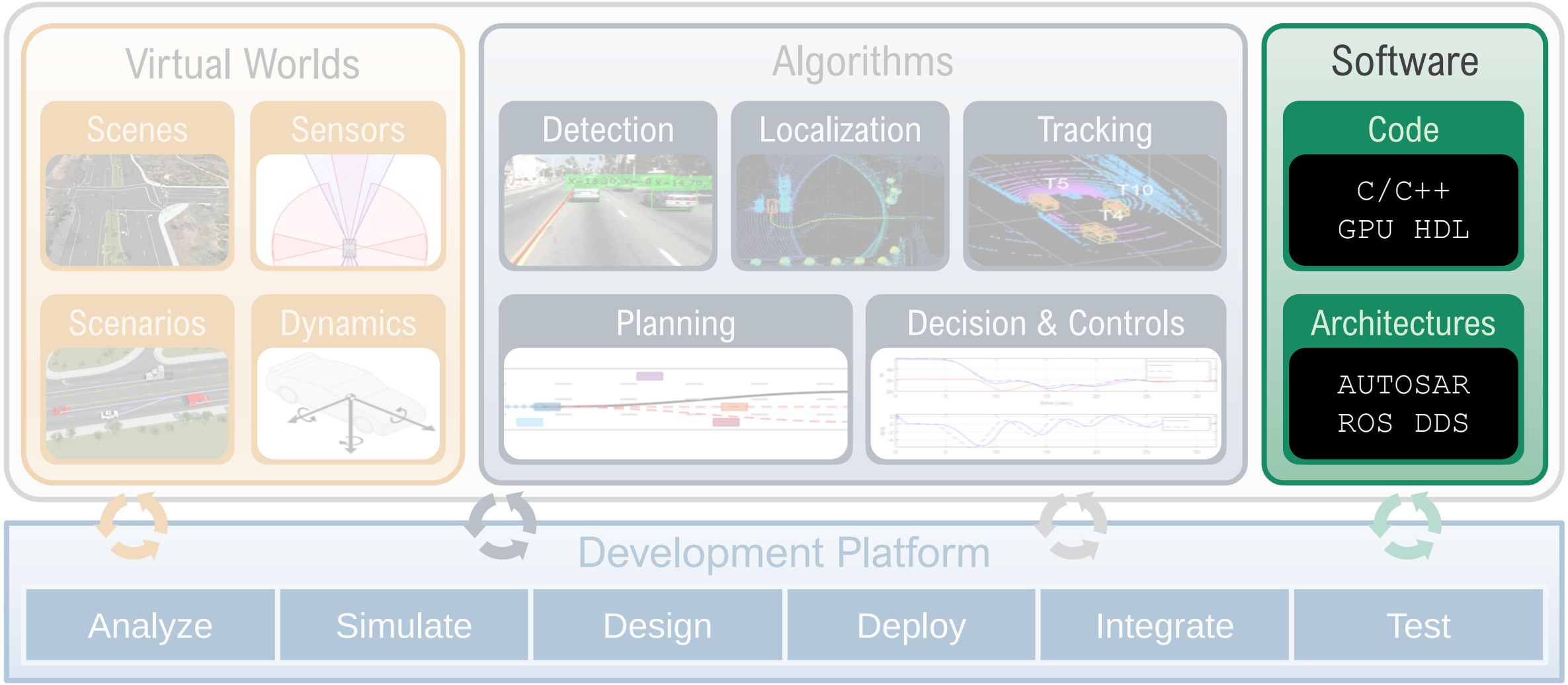
Visual SLAM

[Build a Map with an RGB-D Camera]
Computer Vision Toolbox

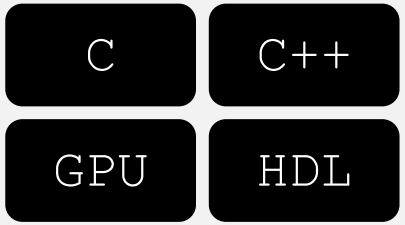
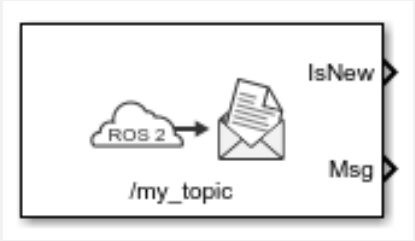
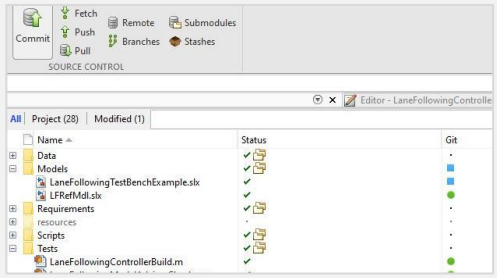
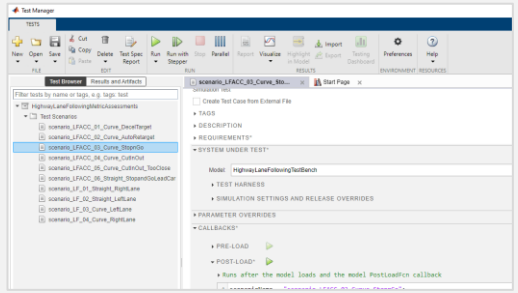
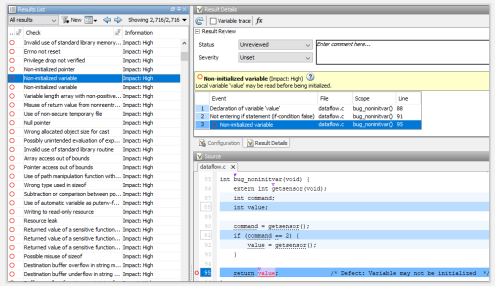
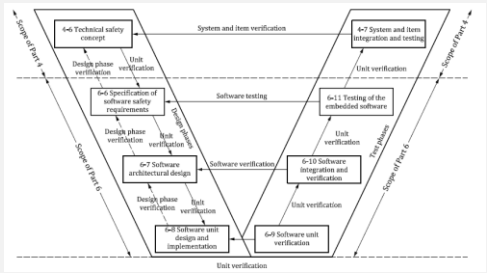
R2022a

Develop Automated Driving Applications

with MATLAB, Simulink, & RoadRunner



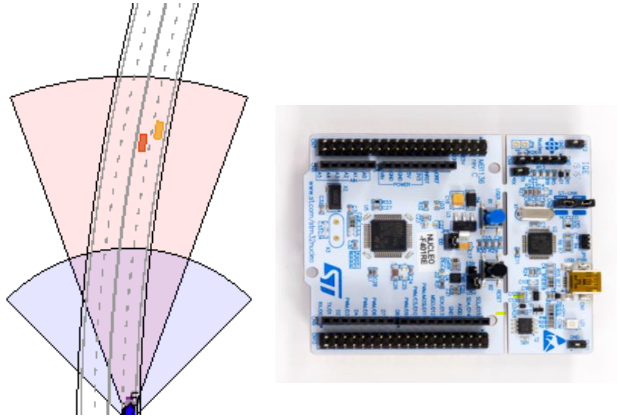
Develop software applications for automated driving

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

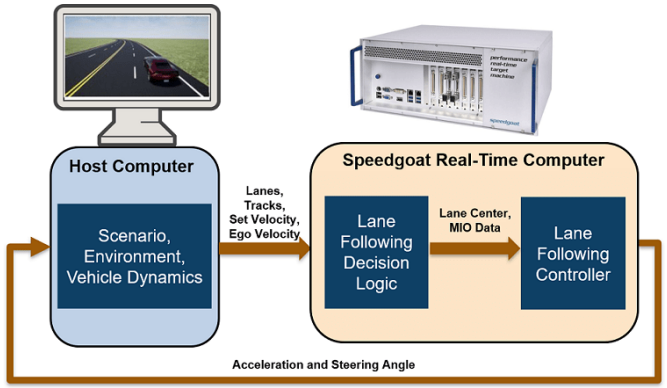
Sensor Fusion PIL Example



[*PIL Verification of JPDA Tracker*]
Sensor Fusion and Tracking Toolbox

R2022a

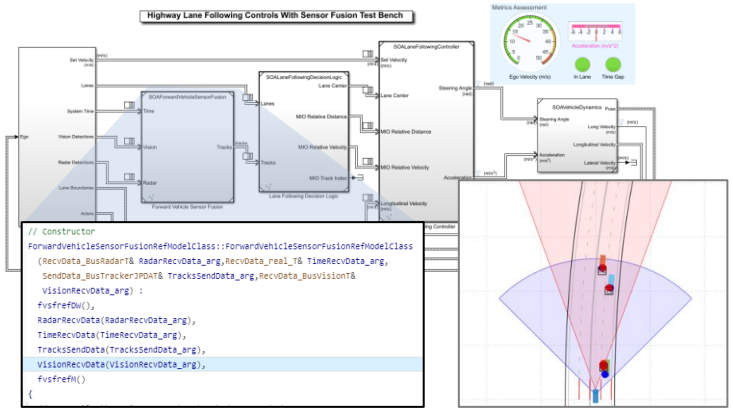
Real-Time Hardware Examples



Automate Real-Time Testing for Highway Lane Following Controller
Automated Driving Toolbox, Simulink Real-TIme

R2022a

SOA C++ Code Generation Example



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

R2021b

Develop Automated Driving Applications

with MATLAB, Simulink, & RoadRunner

Virtual Worlds

- Scenes
- Sensors
- Scenarios
- Dynamics

Algorithms

- Detection
- Localization
- Tracking
- Planning
- Decision & Controls

Software

- Code: C/C++, GPU, HDL
- Architectures: AUTOSAR, ROS, DDS

Development Platform

Analyze | Simulate | Design | Deploy | Integrate | Test

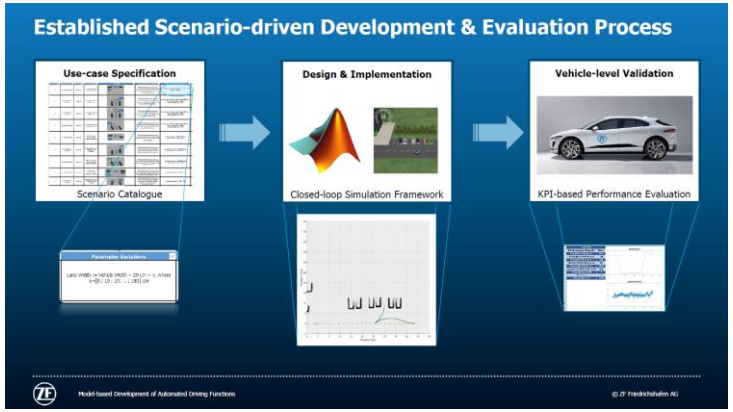
Partner with MathWorks to adopt algorithm development workflows

Porsche develops scenes

[Porsche Engineering builds ADAS/AD software testing and validation environment](#)

MathWorks Automotive Conference 2021

ZF develops automated parking



[ZF accelerates automated parking development through early concept tradeoff in simulation](#)

MathWorks Automotive Conference 2021

TuSimple develops autonomous controls

[TuSimple develops brake-by-wire system for autonomous truck with Model-Based-Design](#)

MathWorks Automotive Conference 2021

MathWorks
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North America

Thank you