

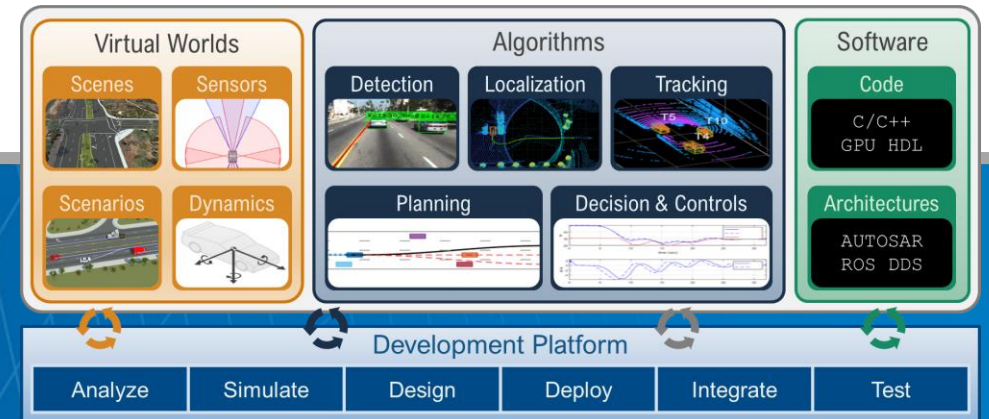
What's New in MATLAB, Simulink, and RoadRunner for Automated Driving Development



Marco Rossi

MathWorks Academia Team

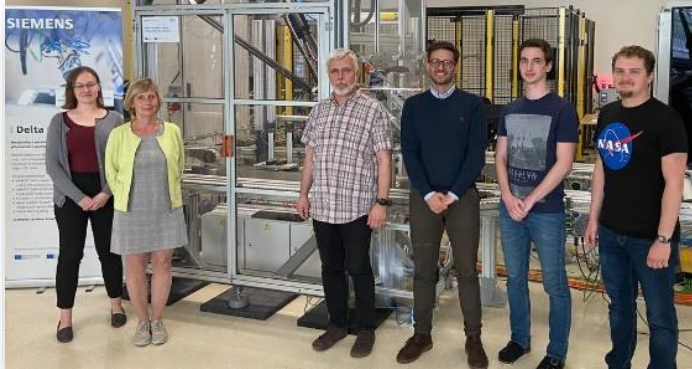
mrossi@mathworks.com



Dr.-Ing. Marco Rossi

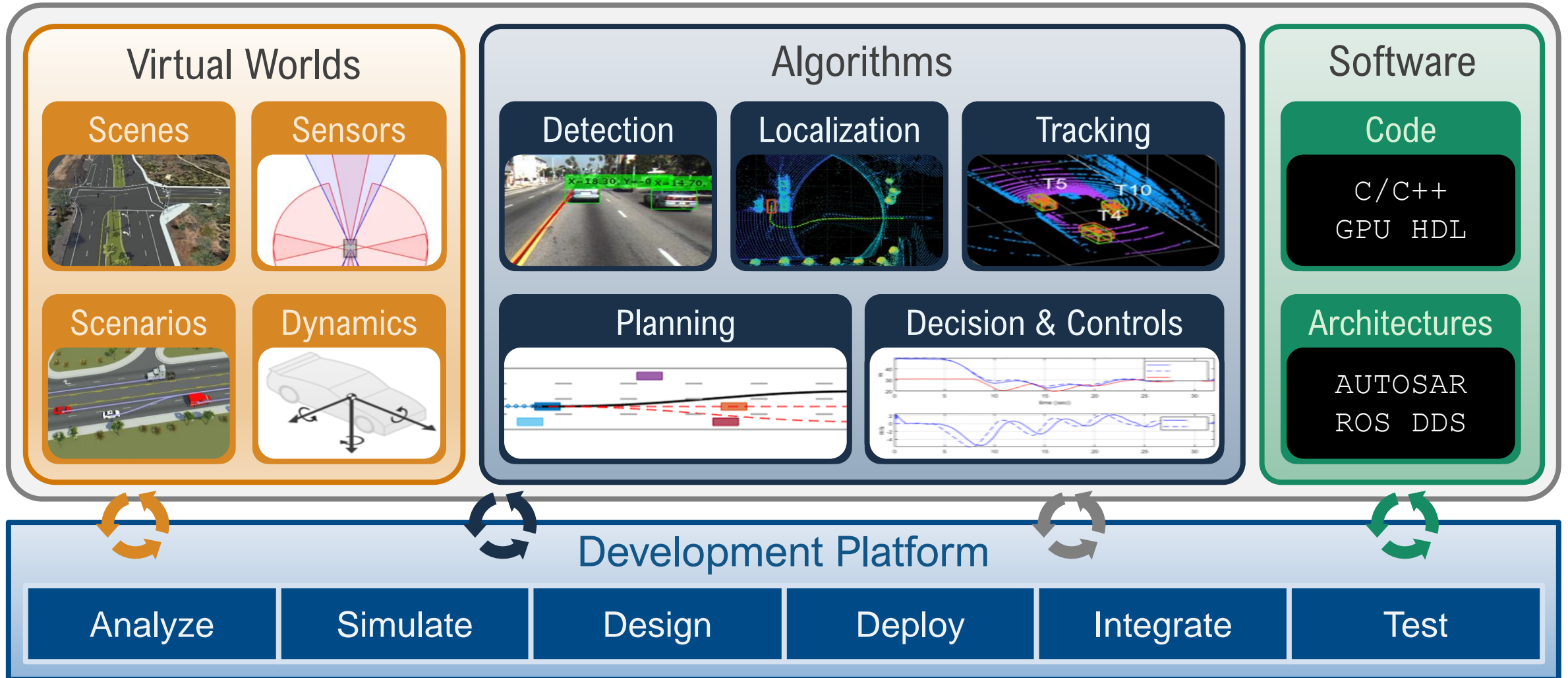
Education Customer Success Engineer EMEA Indirect

- Marco's direct support
- Marco's team support

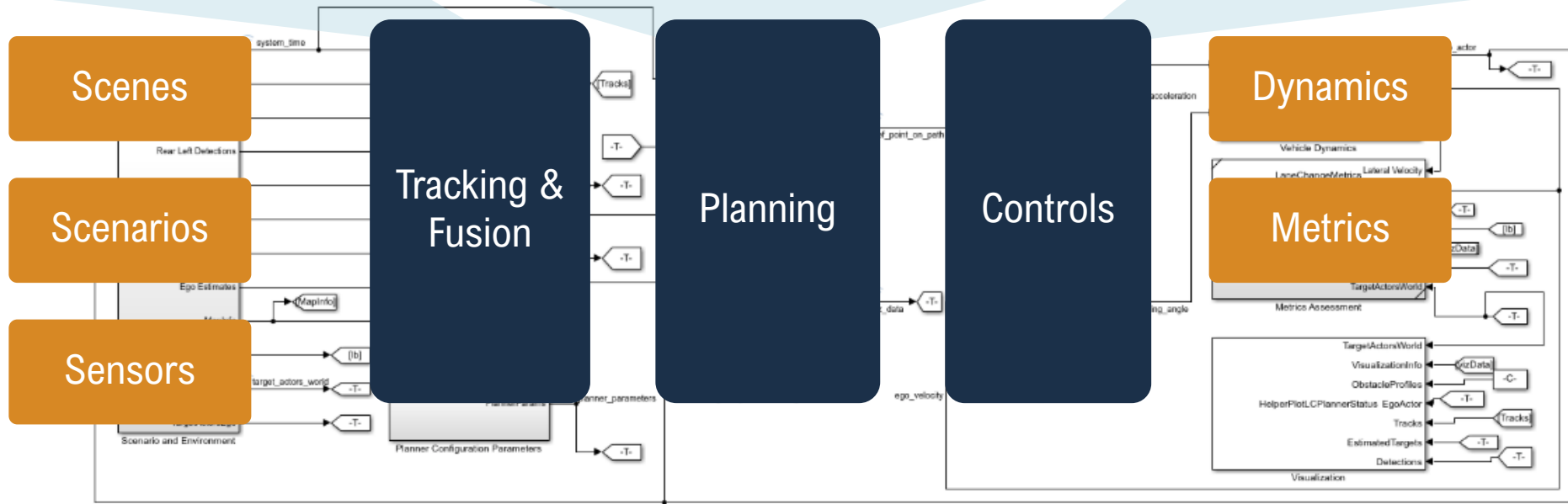
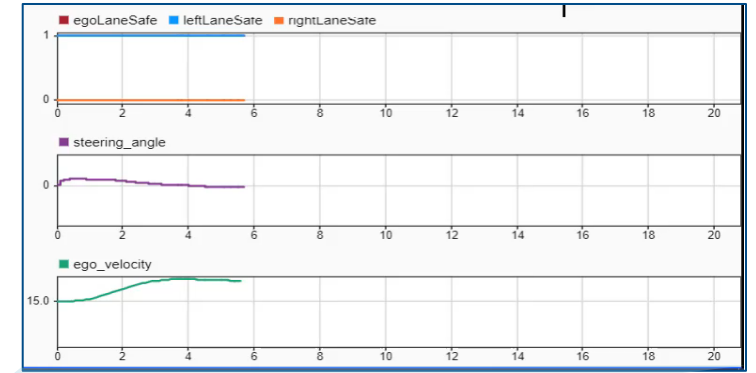
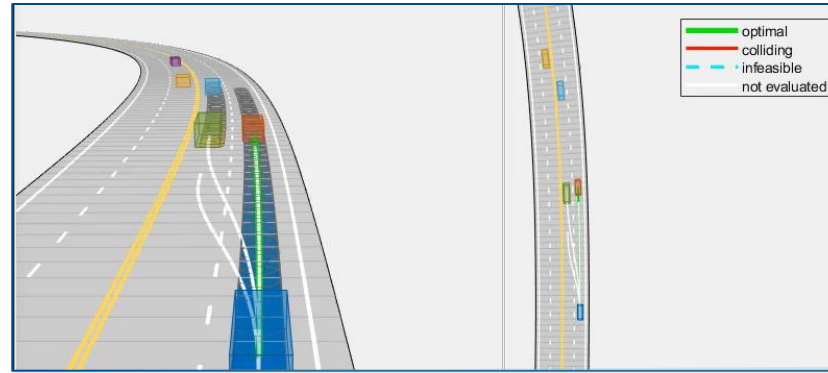
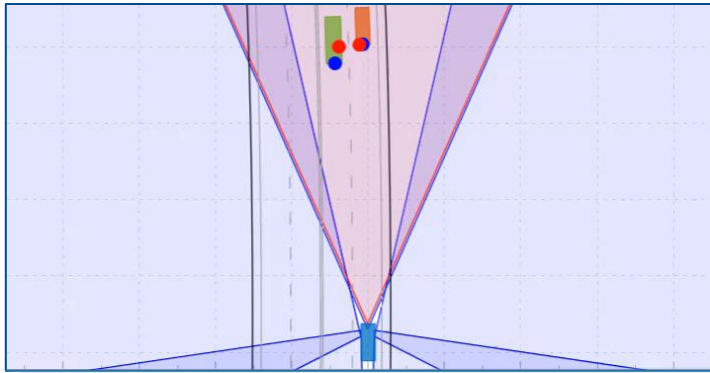


Develop Automated Driving Applications

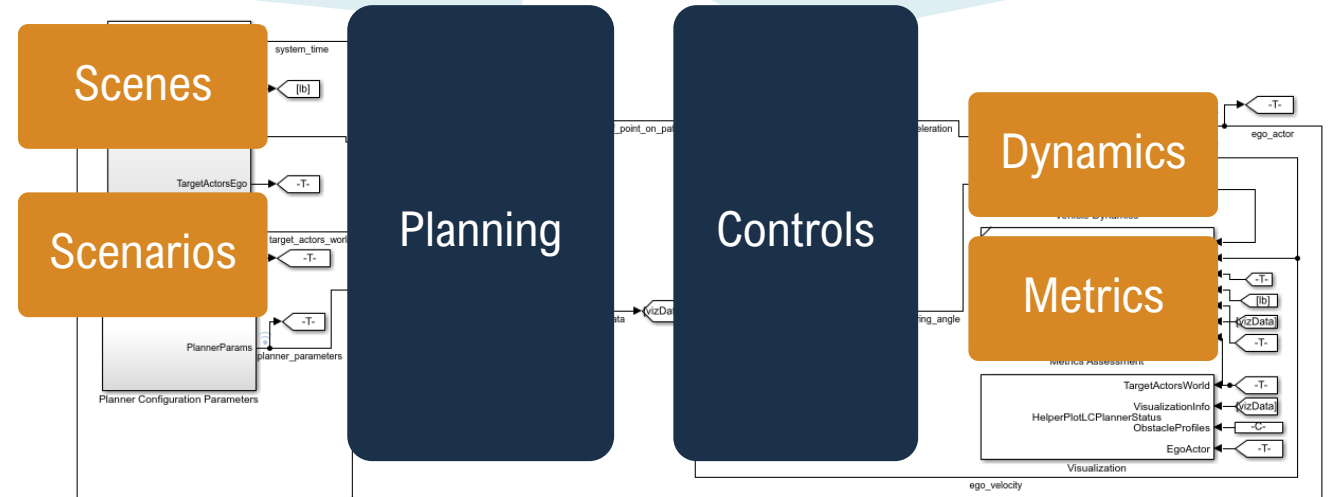
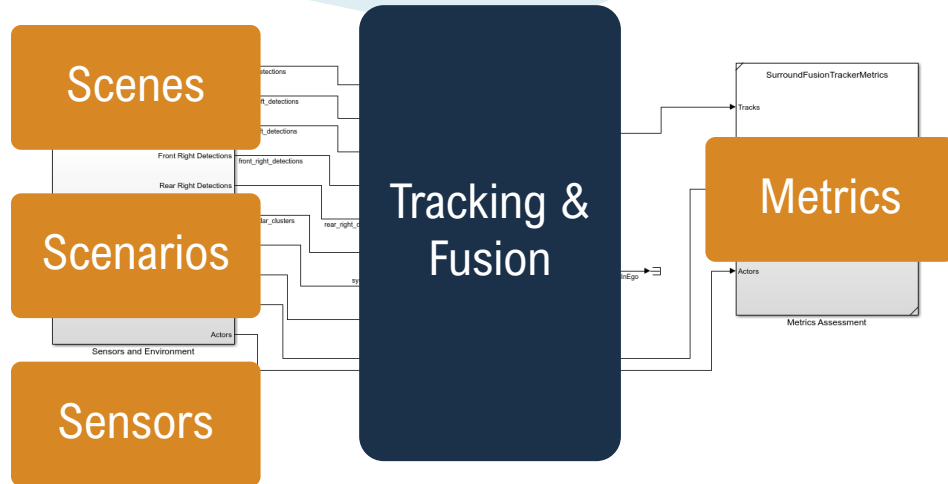
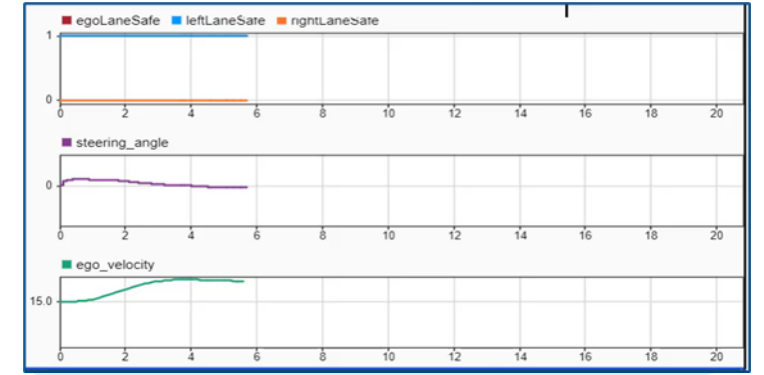
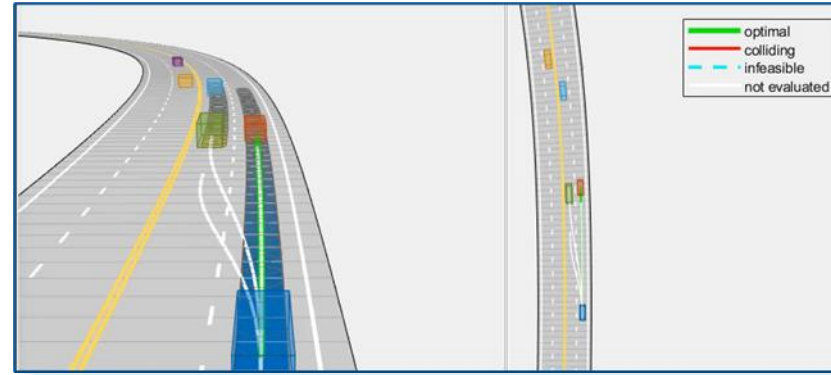
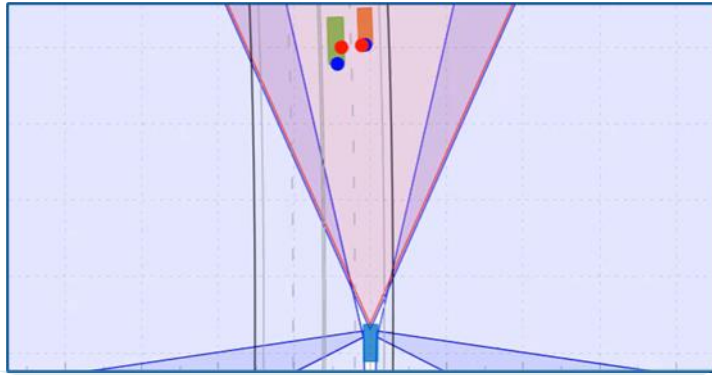
with MATLAB, Simulink, & RoadRunner



Develop virtual worlds for automated driving applications

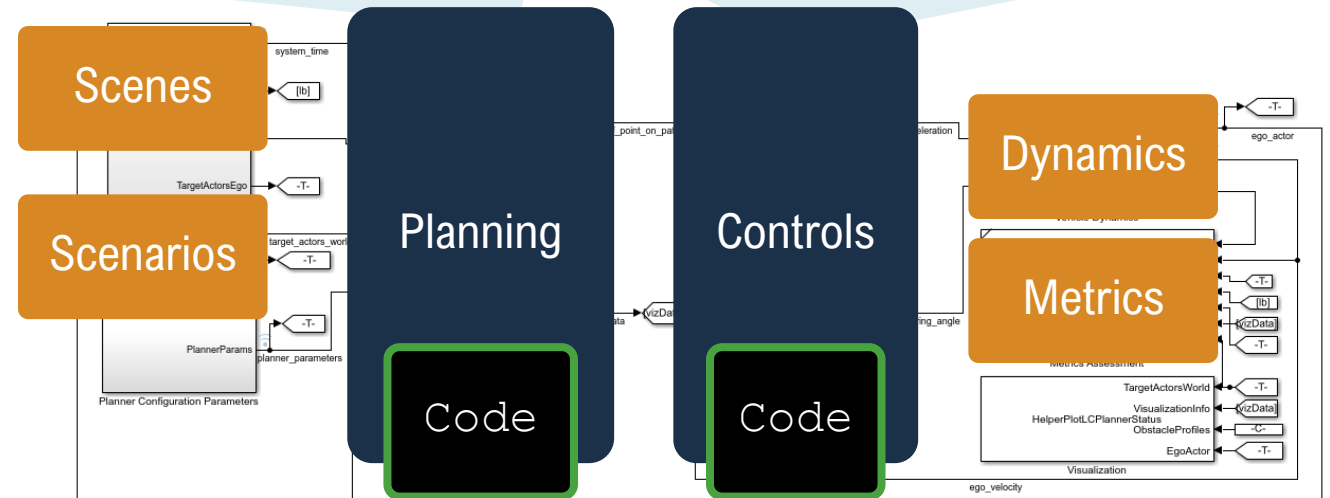
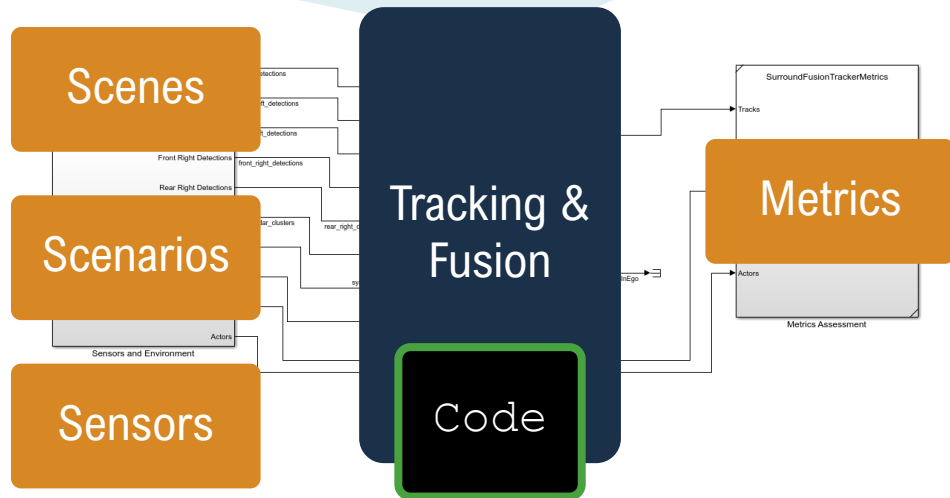
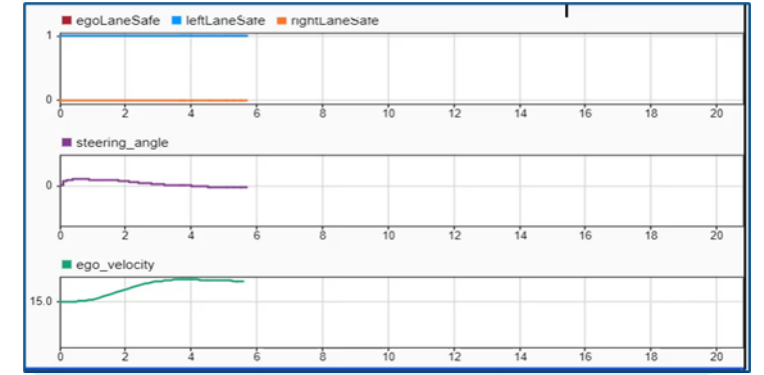
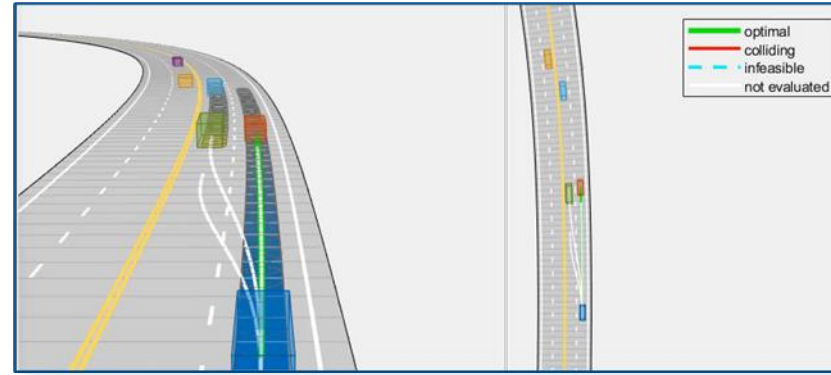
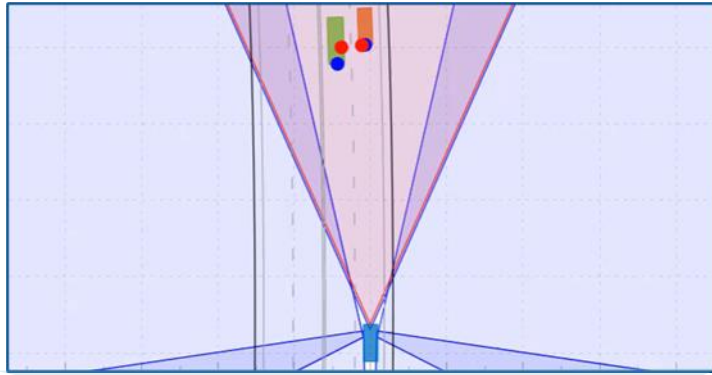


Develop algorithms for automated driving applications



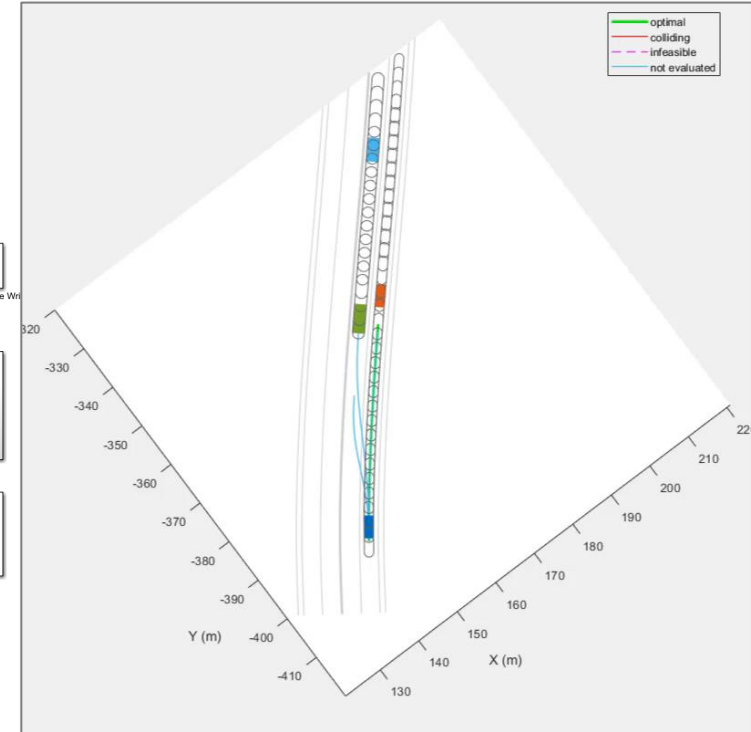
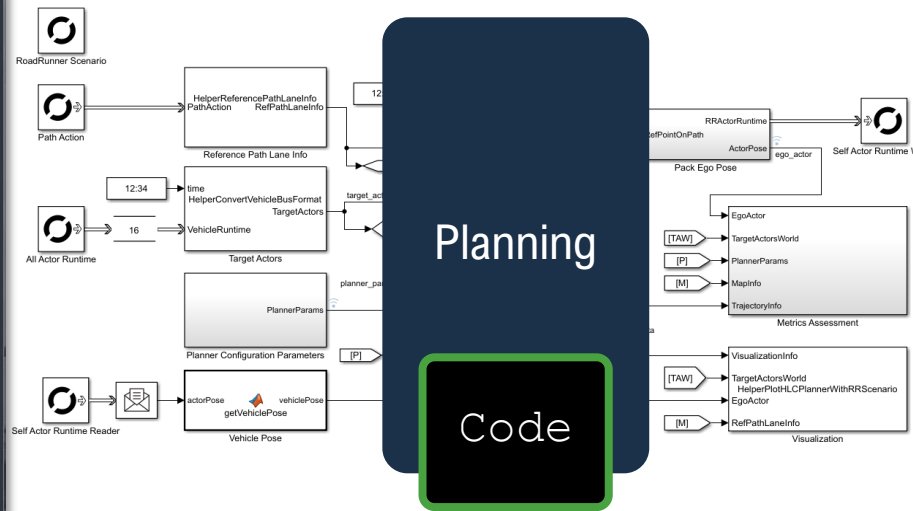
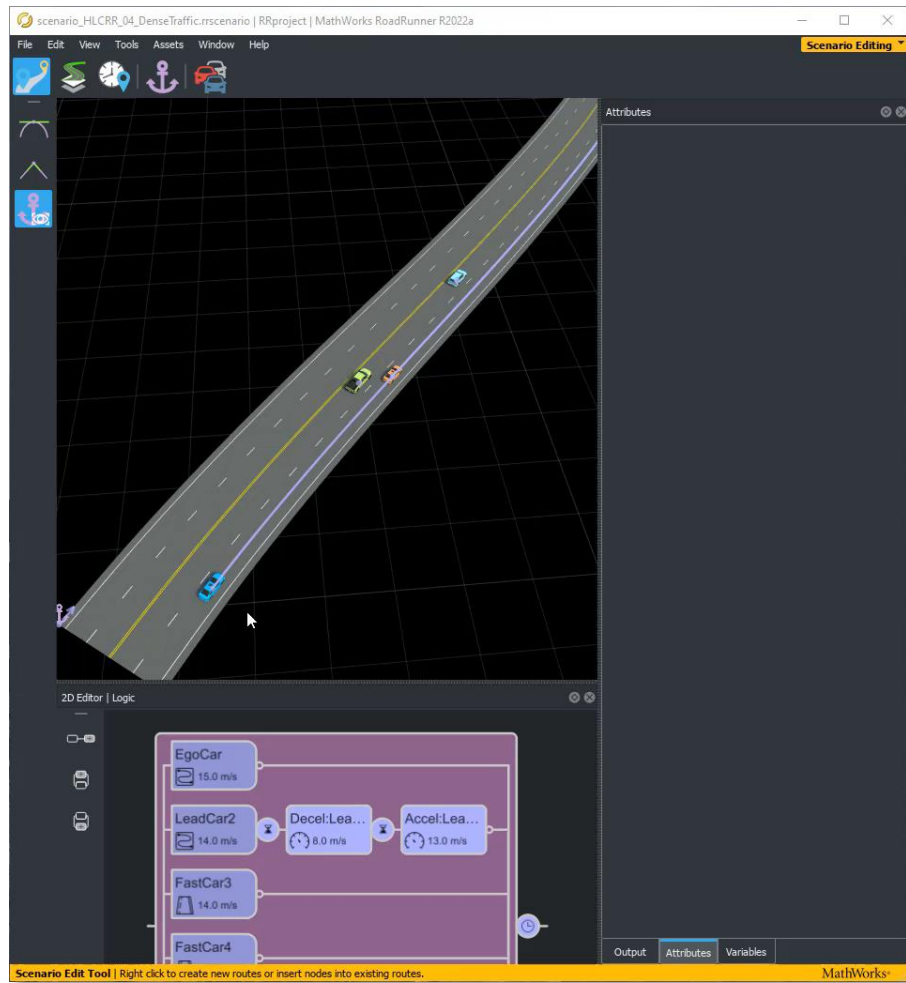
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Develop software for automated driving applications



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Develop scenarios for automated driving applications

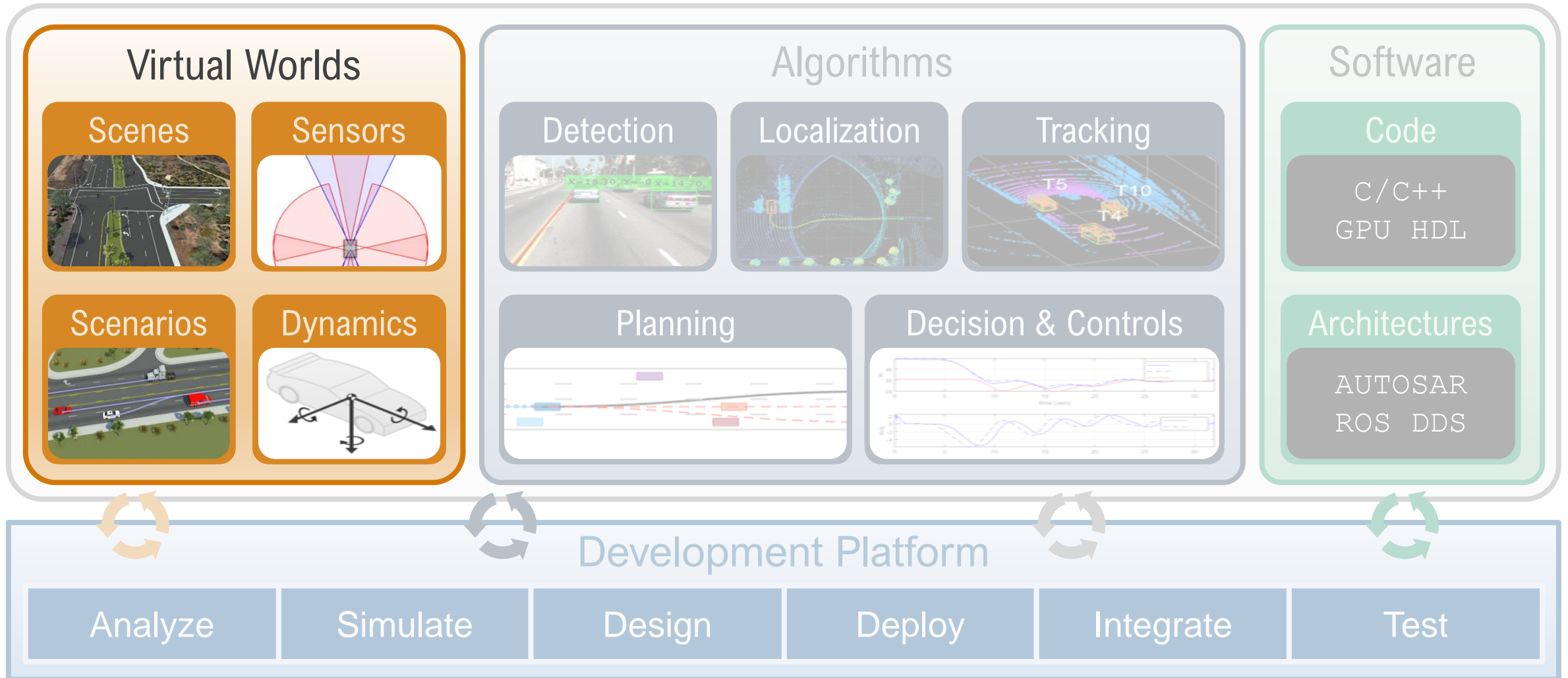


Author map-aware vehicle paths, specify scenario logic conditions and goals

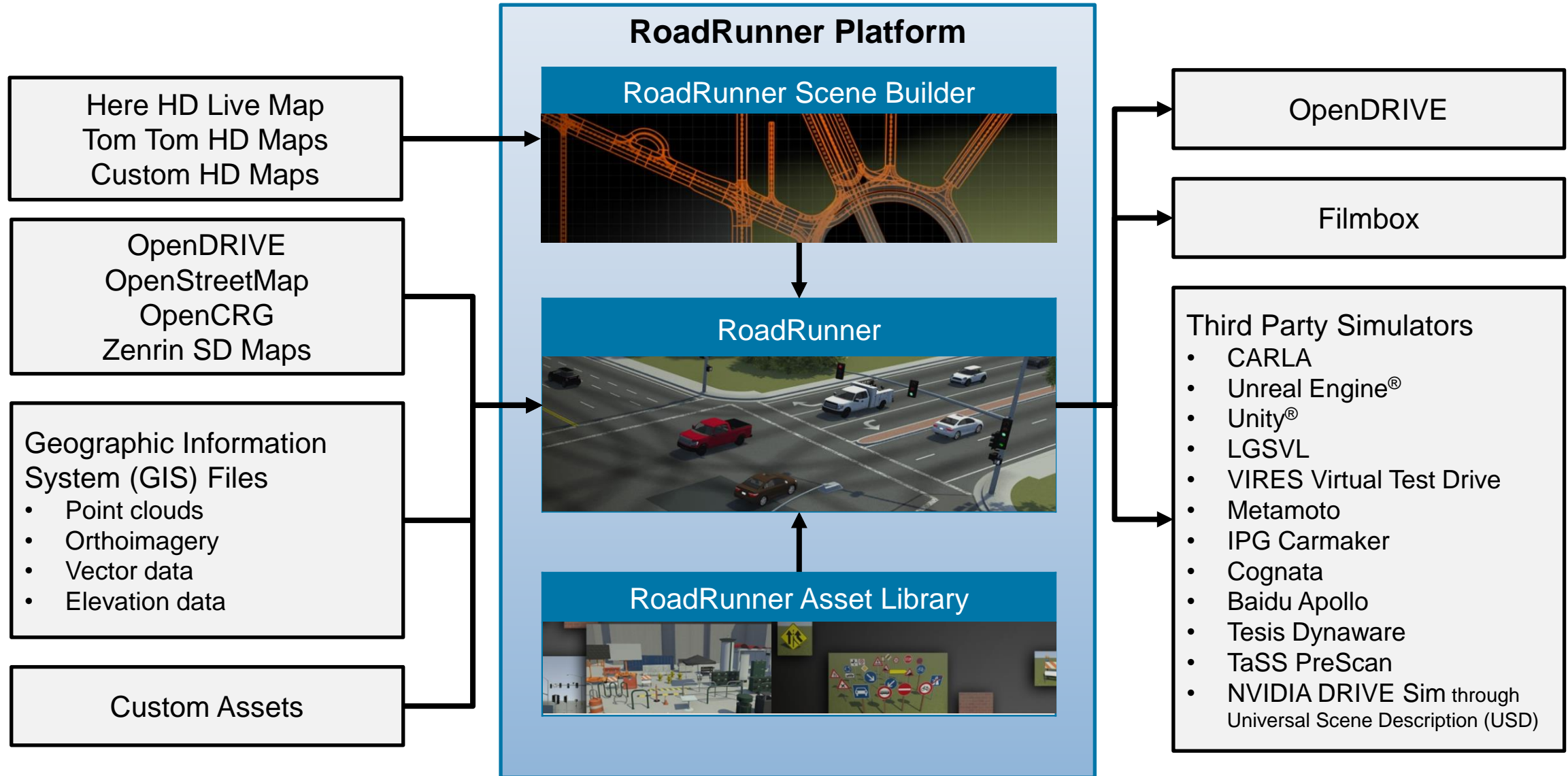
[Highway Lane Change Planner with RoadRunner Scenario](#)

Develop Automated Driving Applications

with MATLAB, Simulink, & RoadRunner



Design 3D scenes for automated driving applications



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");

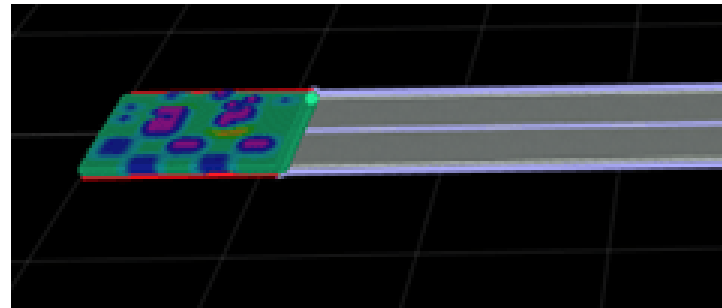
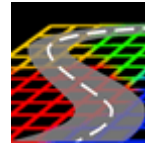
% Options for exporting scene to OpenSCENARIO
options = openScenarioExportOptions(...
    "SceneGraphFormatName", 'OpenSceneGraph');
    
```

[RoadRunner API](#)

RoadRunner

R2021b

Import OpenCRG

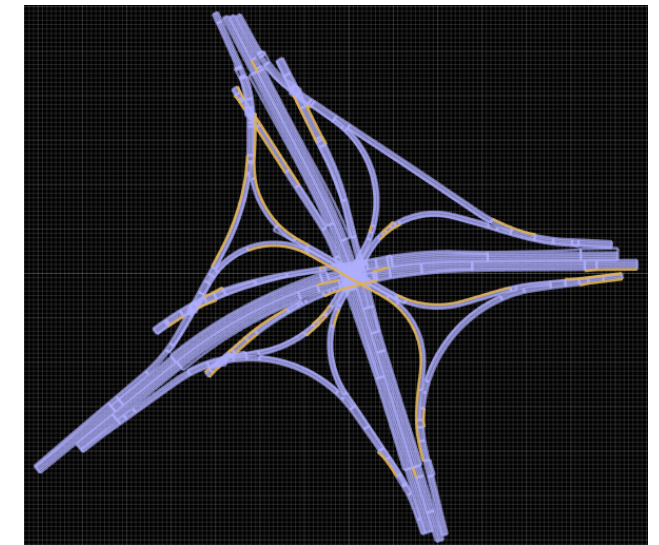


[Road CRG Tool](#)

RoadRunner

R2021b

Import Custom HD Maps



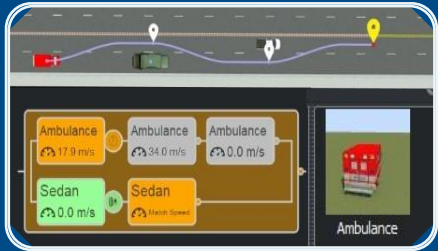
[Build Scenes Using TomTom HD Map](#)

[Data](#)

RoadRunner Scene Builder

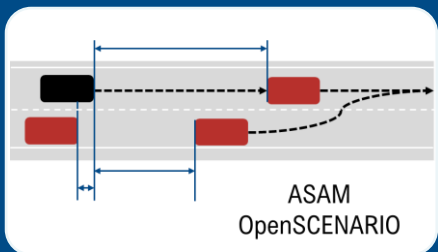
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Develop Scenarios for Automated Driving Applications with RoadRunner Scenario



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



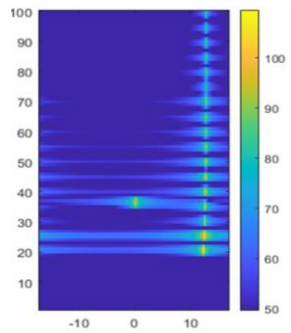
Simulate with MATLAB, Simulink, and CARLA

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

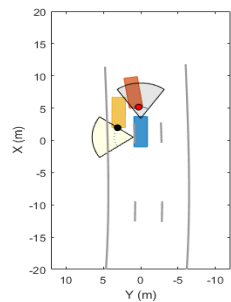
Simulate sensors for automated driving applications

Cuboid Sensors

Radar IQ Signals

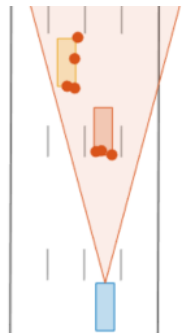


Ultrasonic Detections

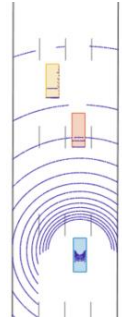


Cuboid & Unreal Engine

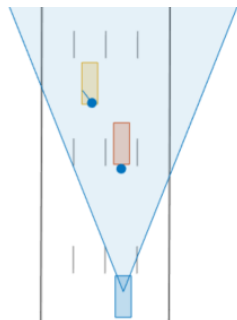
Radar Detections



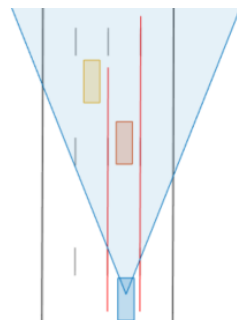
Lidar



Vision Detections



Lane Detections

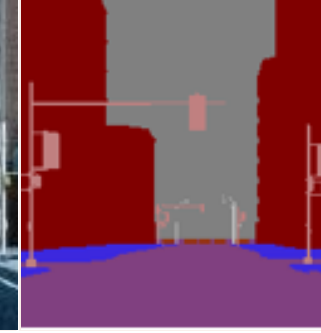


Unreal Engine Sensors

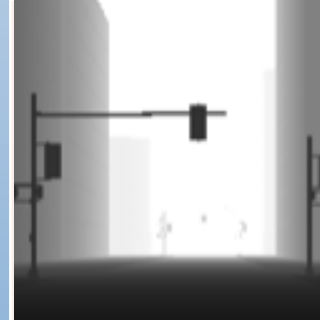
Monocular Camera



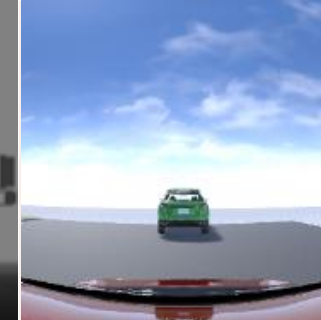
Semantic Segmentation



Depth



Fisheye Camera



Positional Sensors

Wheel Encoder

Global Positioning System (GPS)

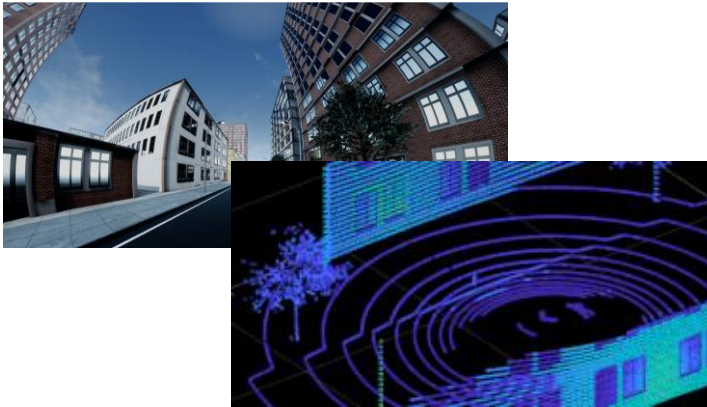
Inertial Measurement Unit (IMU)

Inertial Navigation System (INS)

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

Learn about new features to simulate sensors

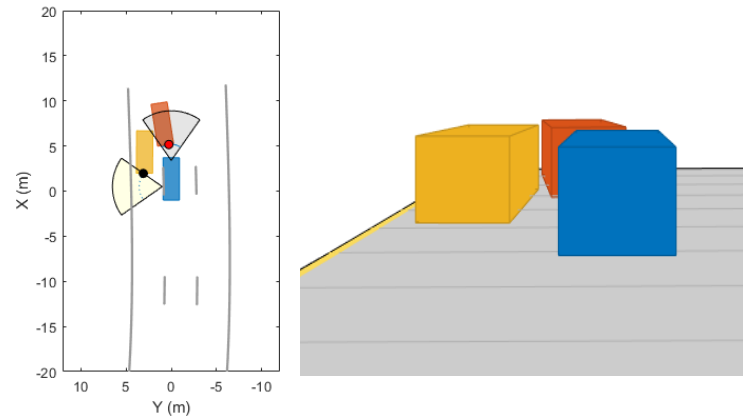
Lidar Reflectivity (Unreal)



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

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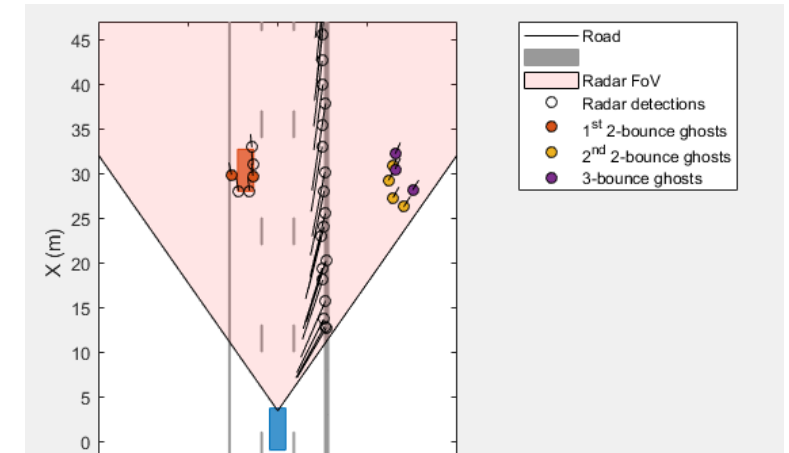
Ultrasonic Sensor (Cuboid)



[Ultrasonic Detection Generator](#)
Automated Driving Toolbox

R2022a

Radar Reflection (Cuboid)

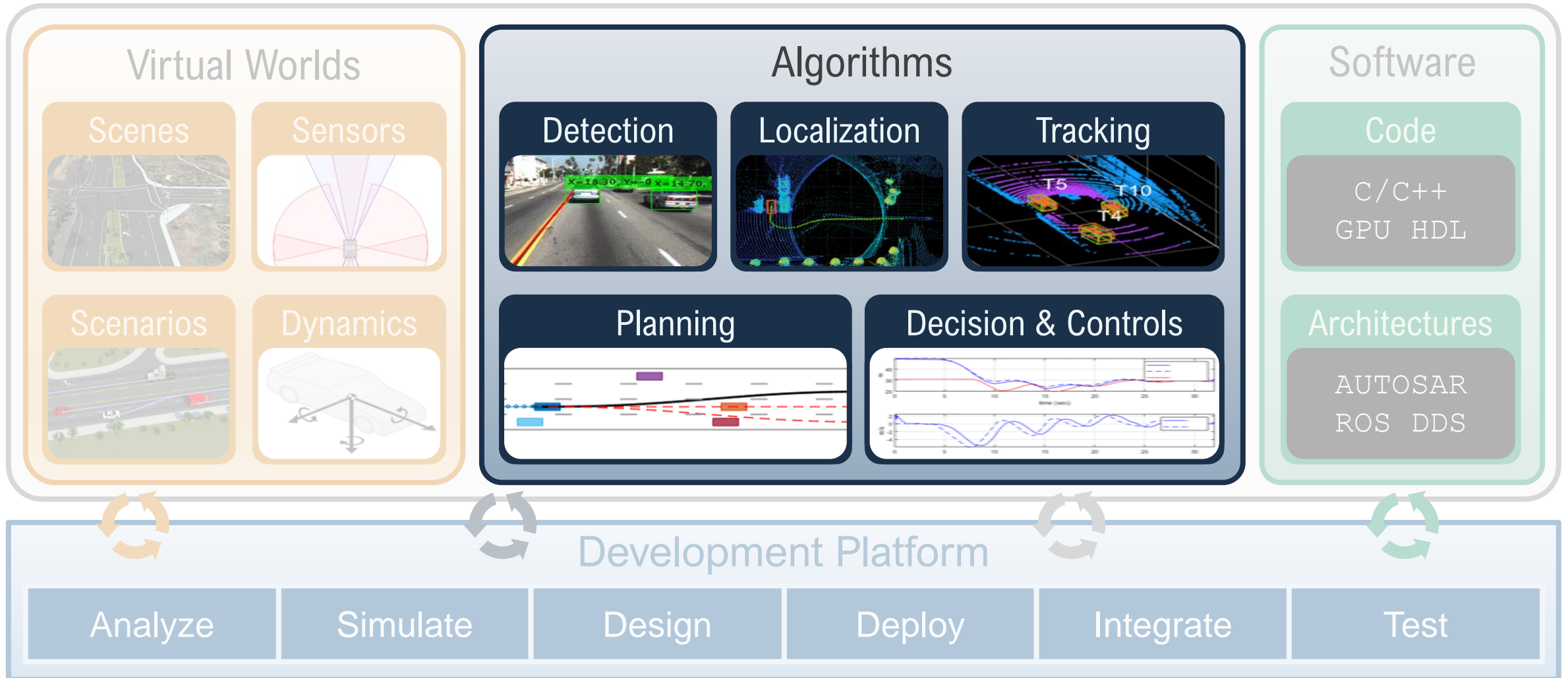


[Simulate Radar Ghosts due to Multipath Return](#)
Radar Toolbox, Automated Driving Toolbox

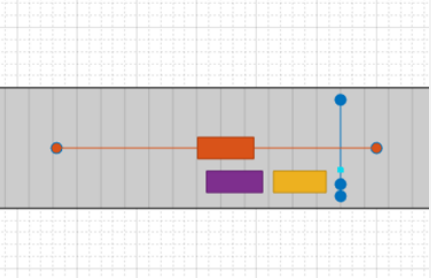
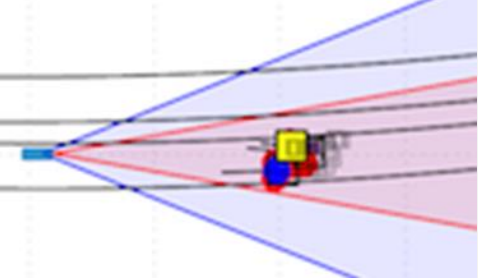
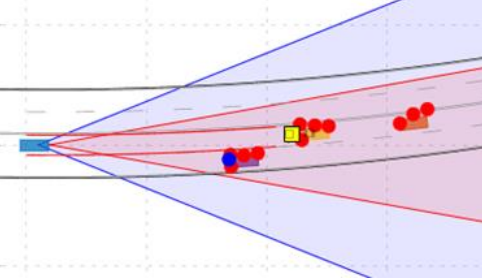
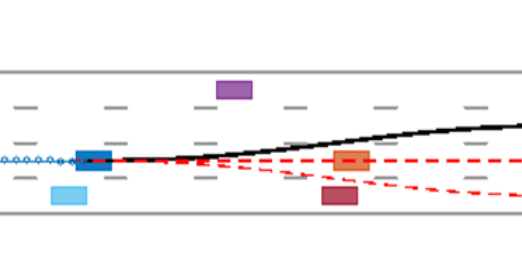
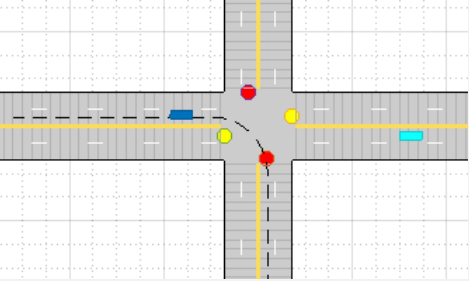
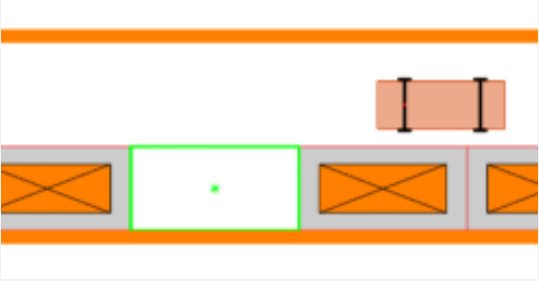
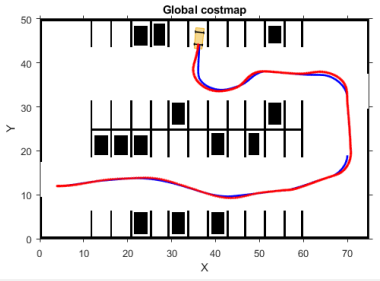
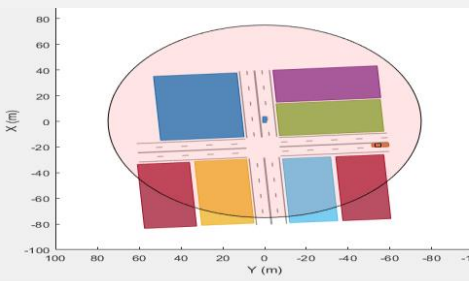
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Develop Automated Driving Applications

with MATLAB, Simulink, & RoadRunner



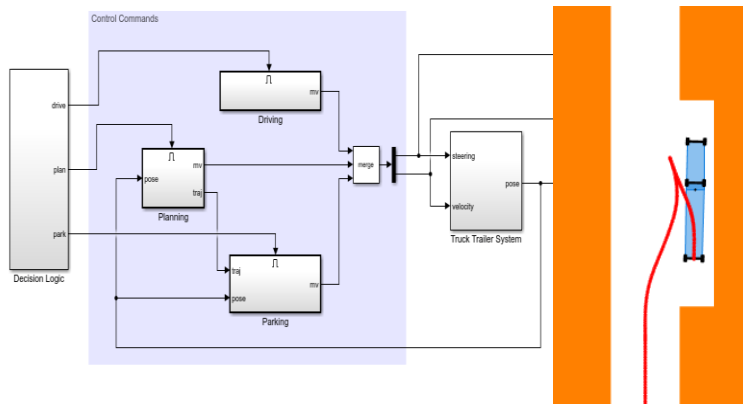
Design planning and control algorithms for automated driving

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

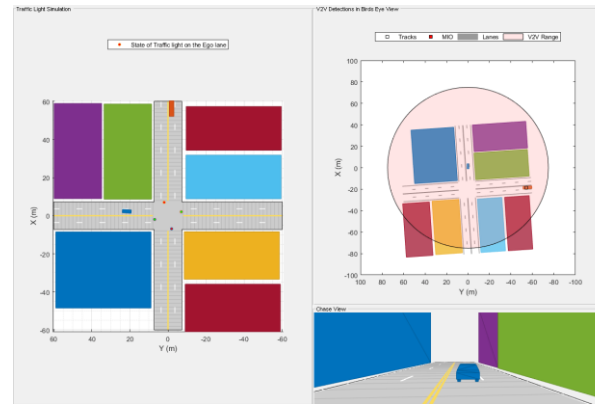
Truck Trailer Parking



[Parallel Parking of Truck Trailer Using Multistage Nonlinear MPC](#)
Model Predictive Control Toolbox, Optimization Toolbox

R2022a

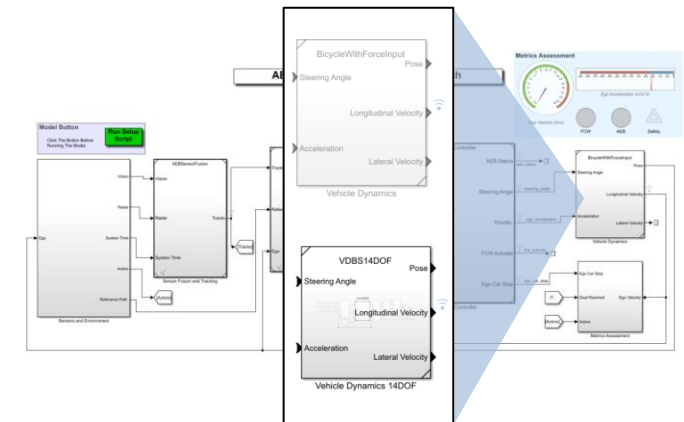
V2X



[Traffic Light Negotiation Using Vehicle-to-Everything Communication](#)
Automated Driving Toolbox, Stateflow, Model Predictive Control Toolbox

R2022a

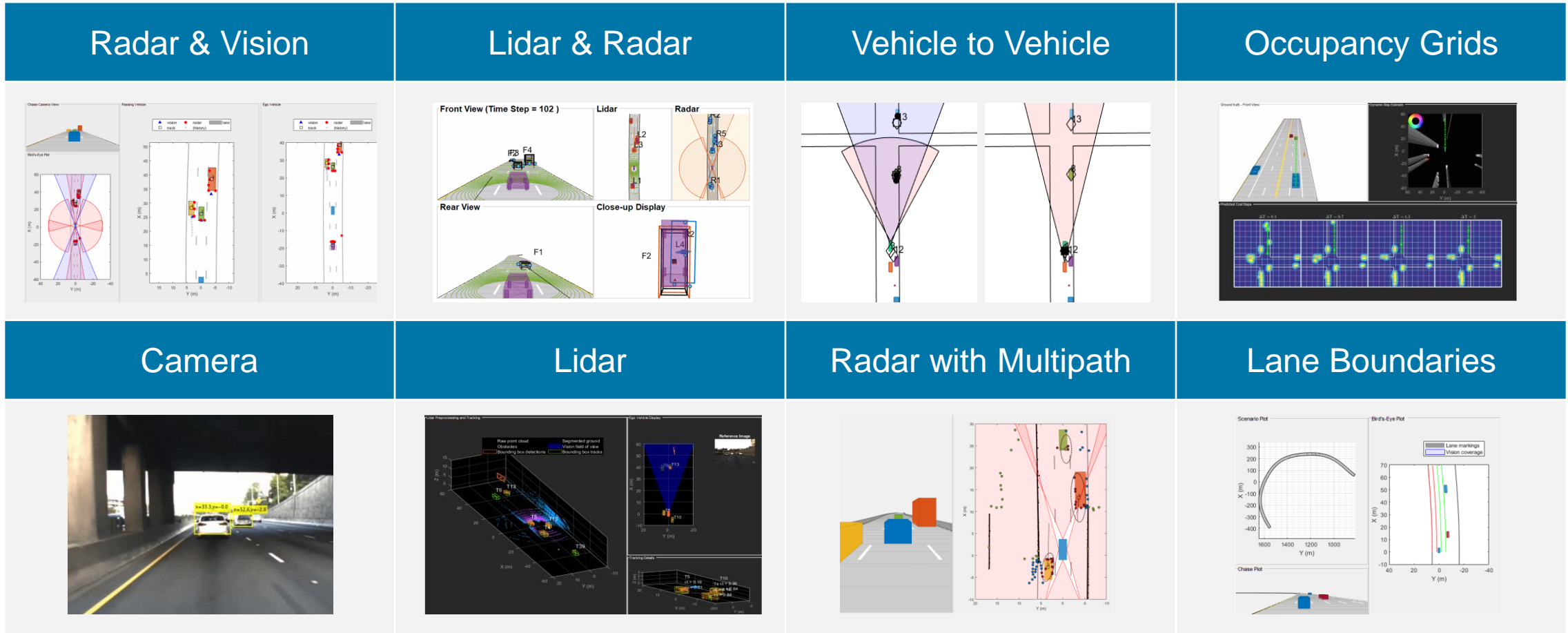
14 DOF Vehicle Dynamics in AEB



[Autonomous Emergency Braking with Vehicle Variants](#)
Automated Driving Toolbox, Vehicle Dynamics Blockset

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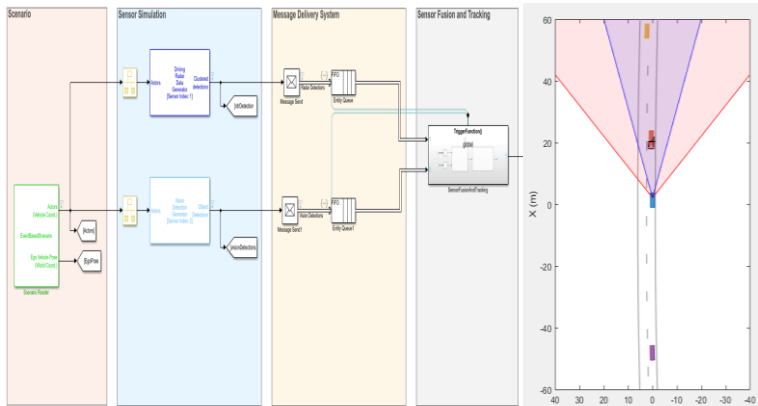
Design tracking and fusion algorithms for automated driving



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

Learn about new features for sensor fusion and tracking

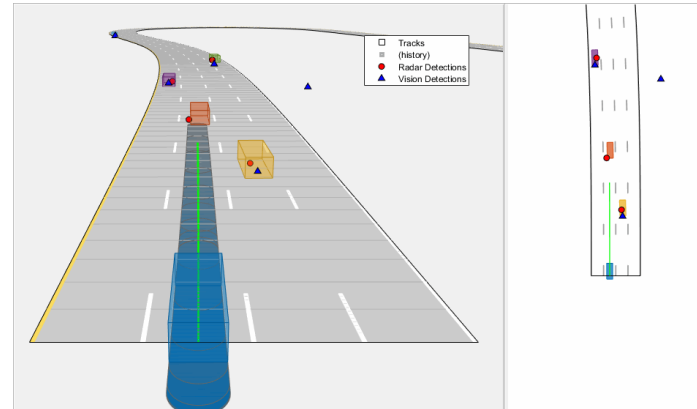
Event Based Sensor Fusion and Tracking with Retrodiction



[Event-Based Sensor Fusion and Tracking with Retrodiction](#)
Sensor Fusion and Tracking Toolbox, Automated Driving Toolbox

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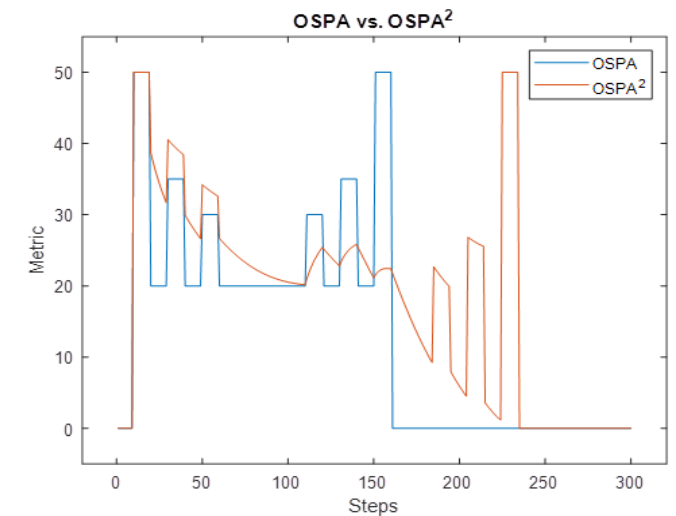
Object Tracking and Motion Planning



[Object Tracking and Motion Planning Using Frenet Reference Path](#)
Navigation Toolbox, Automated Driving Toolbox

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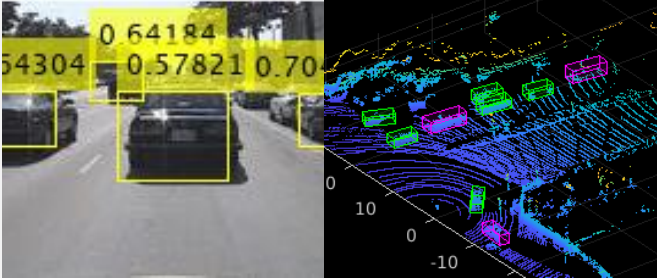

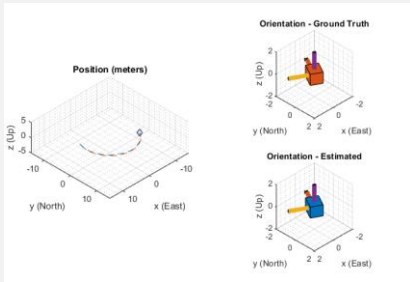
OSPA² Metric



[Optimal Subpattern Assignment Metric](#)
Sensor Fusion and Tracking Toolbox

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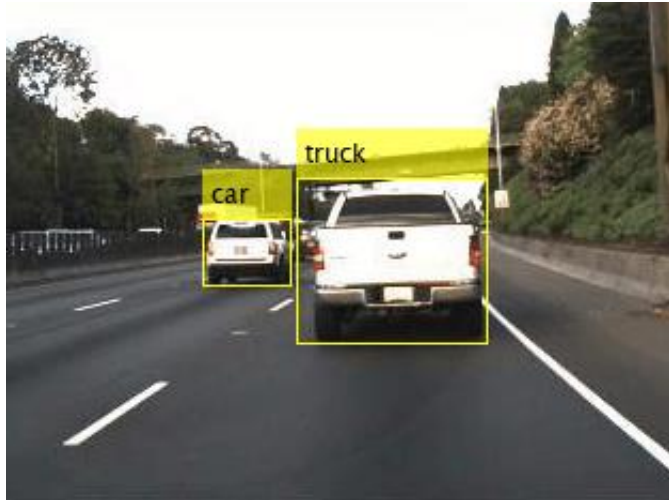
Design detection and localization algorithms for automated driving

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

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Lidar Odometry and Mapping (LOAM)



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

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Visual SLAM

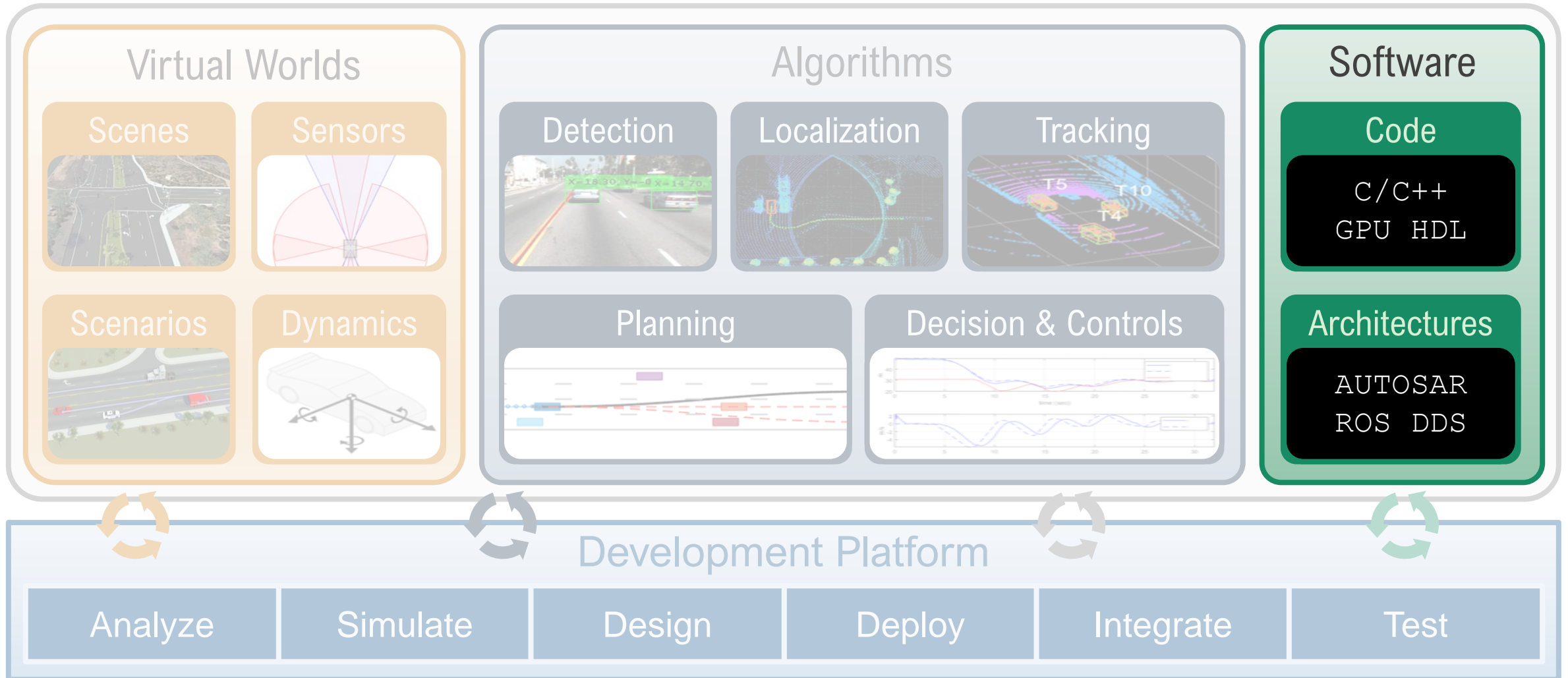


[Build a Map with an RGB-D Camera](#)
Computer Vision Toolbox

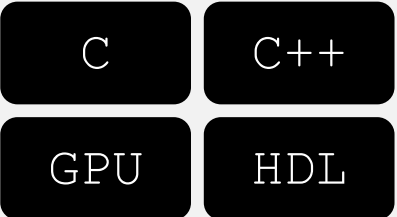



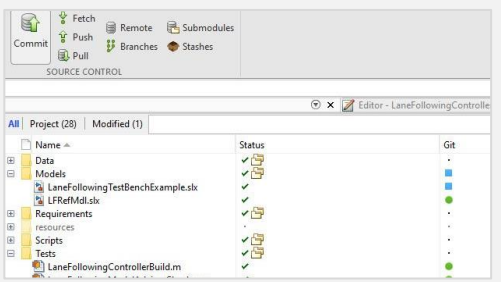
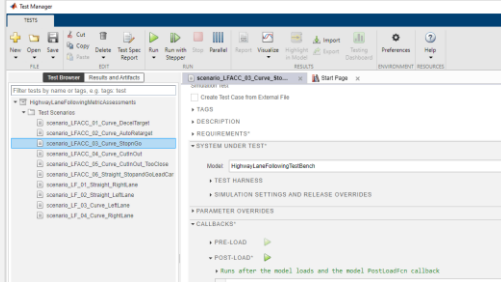
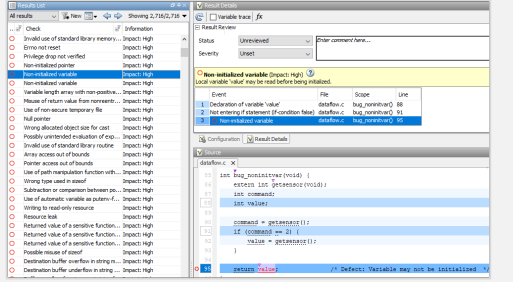
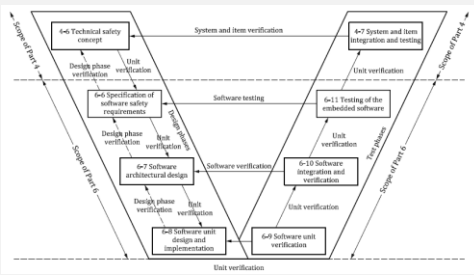
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Develop Automated Driving Applications

with MATLAB, Simulink, & RoadRunner



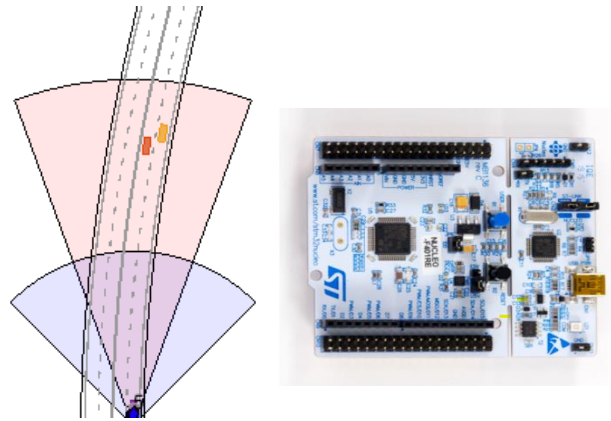
Develop software applications for automated driving

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

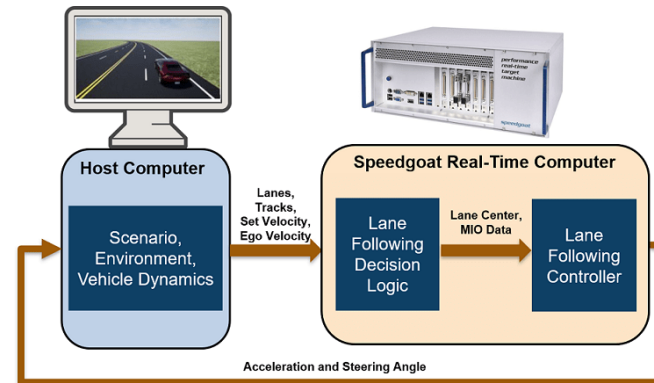
Sensor Fusion PIL Example



[PIL Verification of JPDA Tracker Sensor Fusion and Tracking Toolbox](#)

R2022a

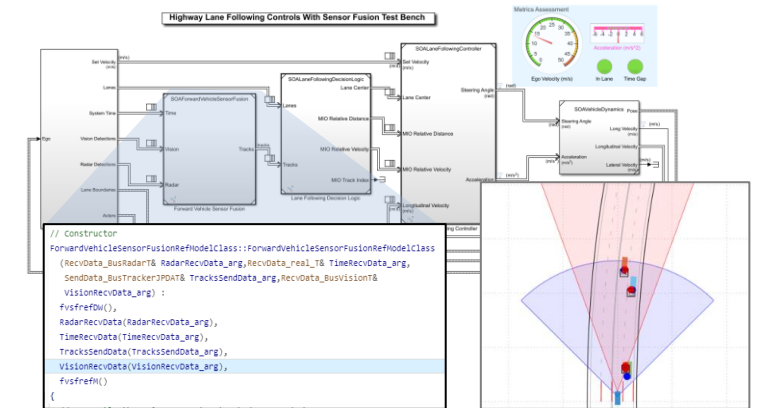
Real-Time Hardware Examples



[Automate Real-Time Testing for Highway Lane Following Controller](#)
Automated Driving Toolbox,
Simulink Real-Time

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SOA C++ Code Generation Example

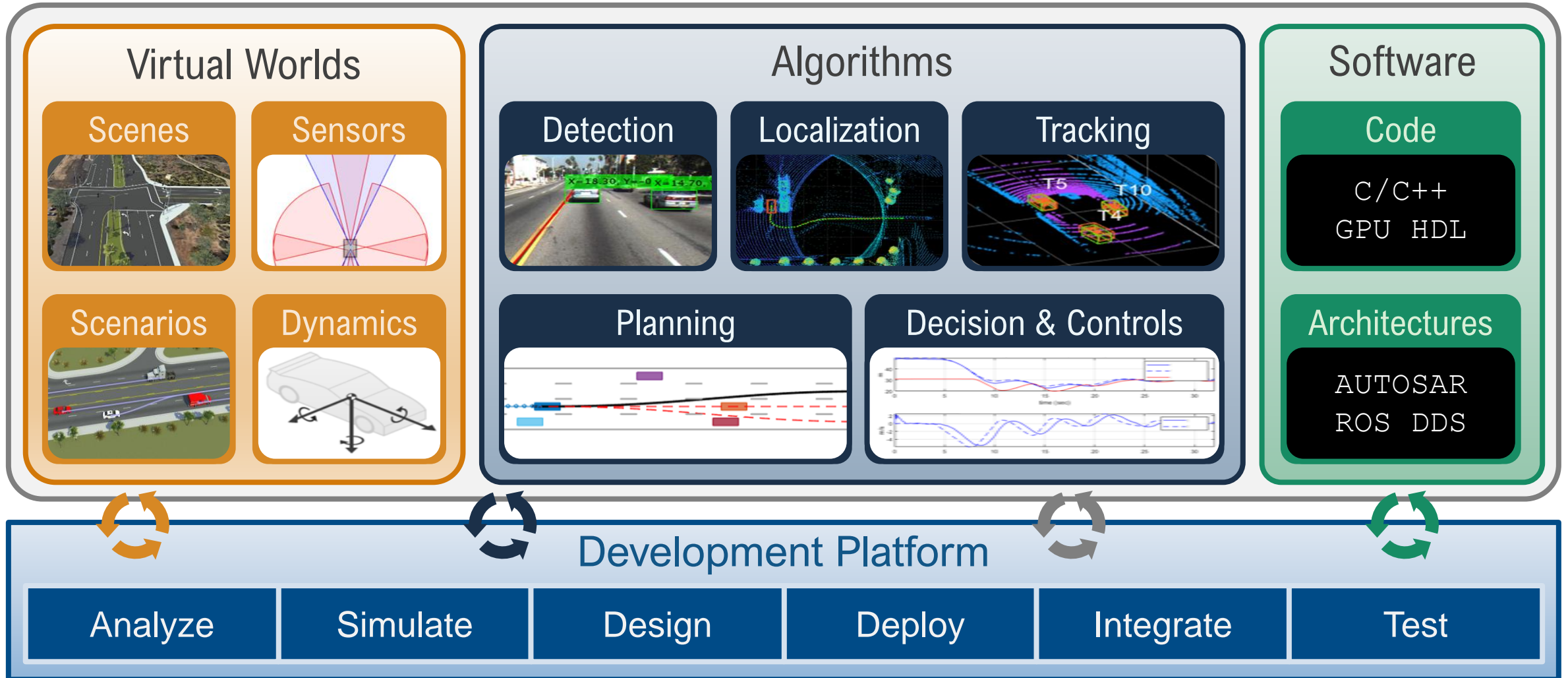


[Generate C++ code for Message Interfaces in Lane Following Controls & Sensor Fusion](#)
ROS Toolbox, AUTOSAR Blockset, DDS
Blockset

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Develop Automated Driving Applications

with MATLAB, Simulink, & RoadRunner



Partner with MathWorks to adopt algorithm development workflows

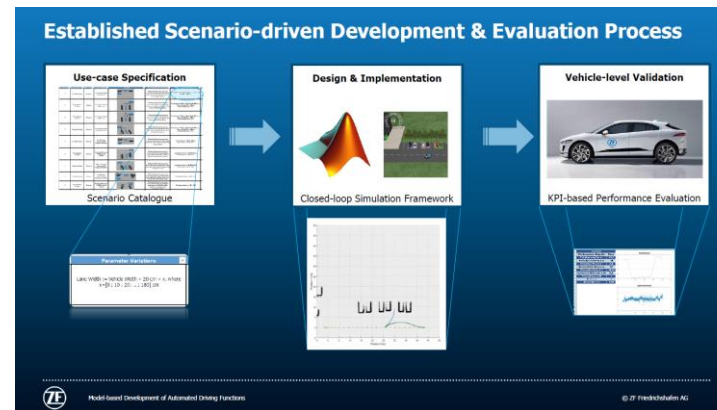
Porsche develops scenes



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

Thanks



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 MathWorks

 Technische Universität Dresden

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[linkedin.com/in/marcorossi90](https://www.linkedin.com/in/marcorossi90)