

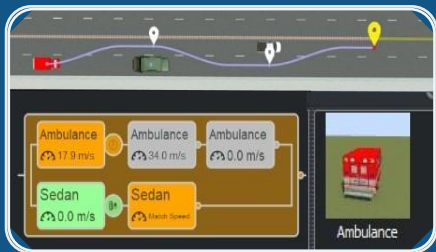
MATLAB EXPO

设计和仿真面向自动驾驶应用的场景

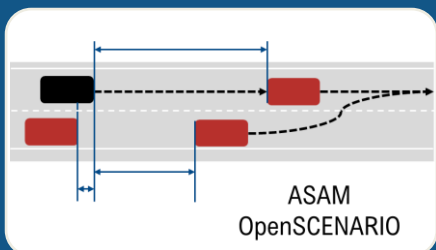
王鸿钧, MathWorks 中国



使用RoadRunner Scenario，设计和仿真面向自动驾驶应用的场景



设计和仿真交通场景

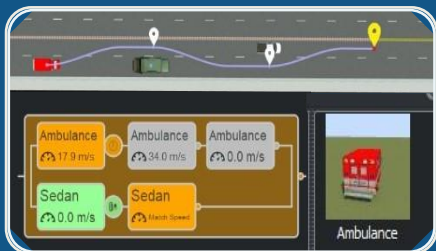


与OpenSCENARIO的接口

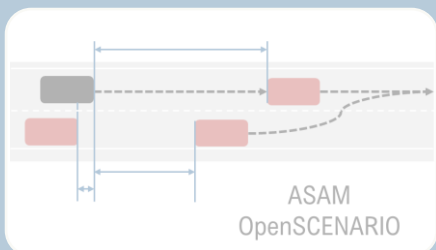


联合MATLAB，Simulink，以及CARLA仿真

使用RoadRunner Scenario，设计和仿真面向自动驾驶应用的场景



设计和仿真交通场景



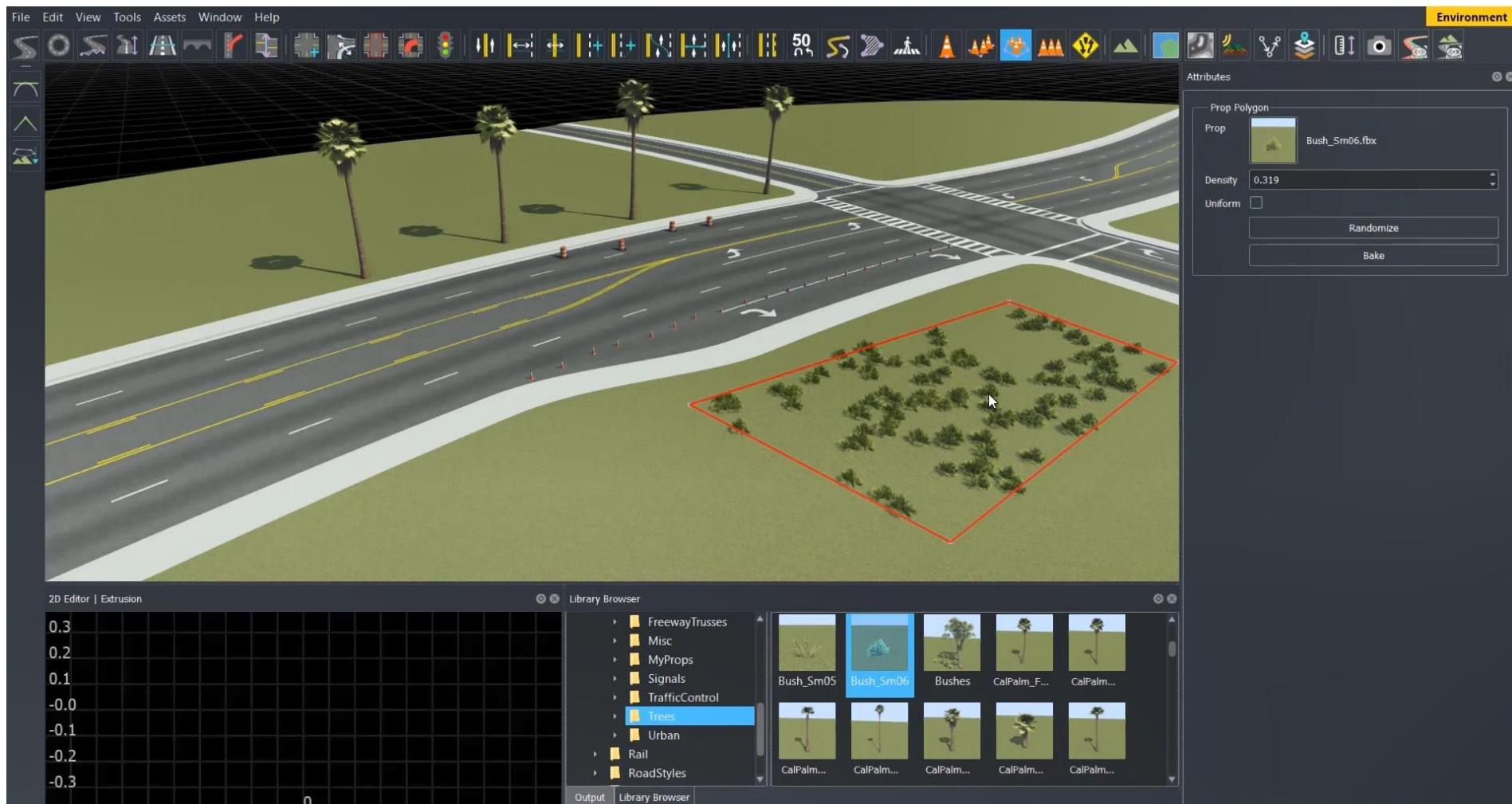
与OpenSCENARIO的接口



联合MATLAB，Simulink，以及CARLA仿真

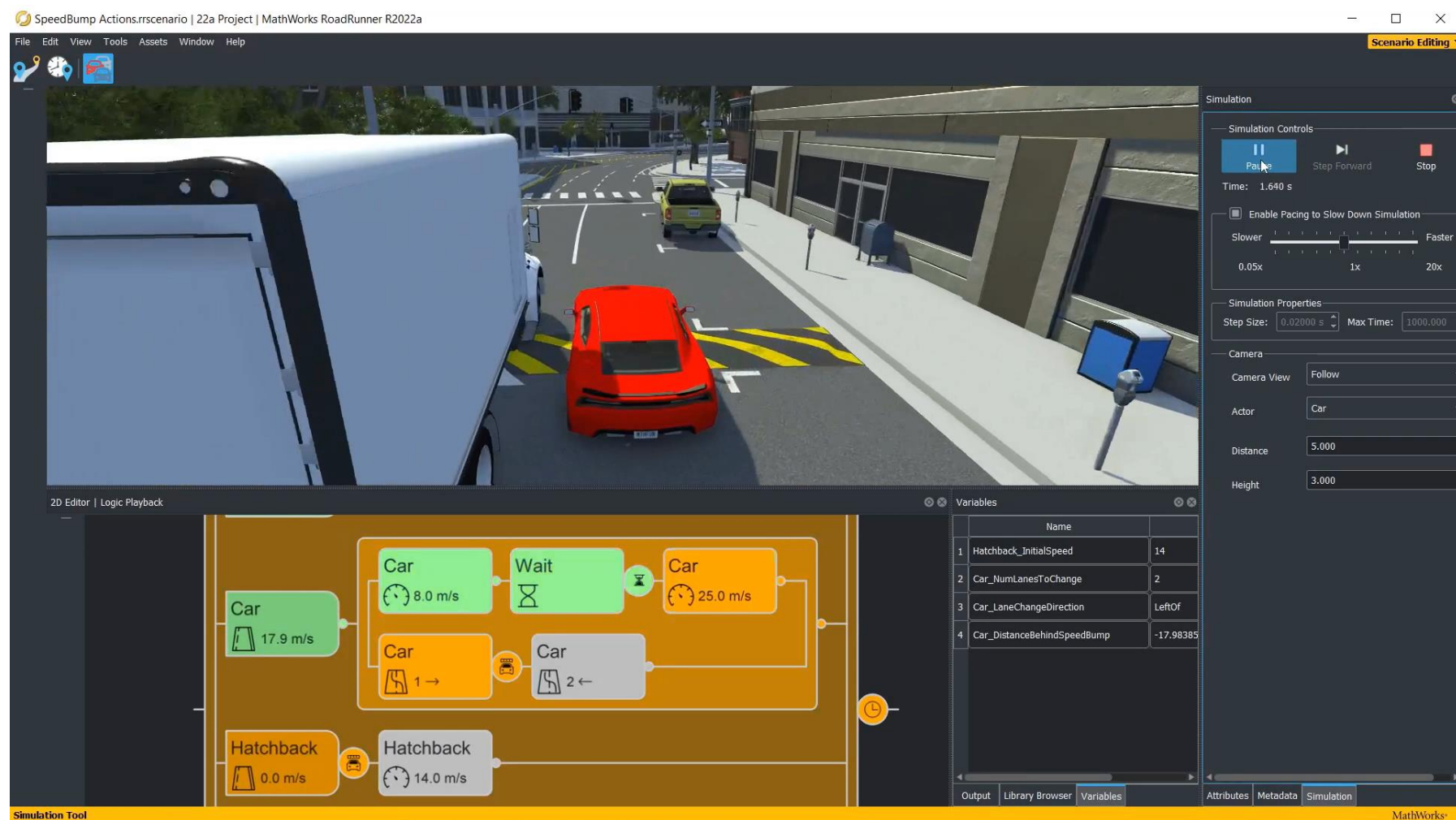
使用RoadRunner交互式设计道路环境

- 创建写实的道路和交叉路口
- 导入/导出 OpenDRIVE
- 导入 HD 地图
- 导入地理信息系统 (GIS) 文件
- 导出到常用的驾驶仿真环境



使用RoadRunner Scenario交互式设计交通场景

- 添加多种车辆
- 创建车辆轨迹
- 定义动作和逻辑
- 参数化调整变量



[Scenario Edit Tool](#)
RoadRunner Scenario

R2022a

仿真地图相关的车辆路径和场景逻辑

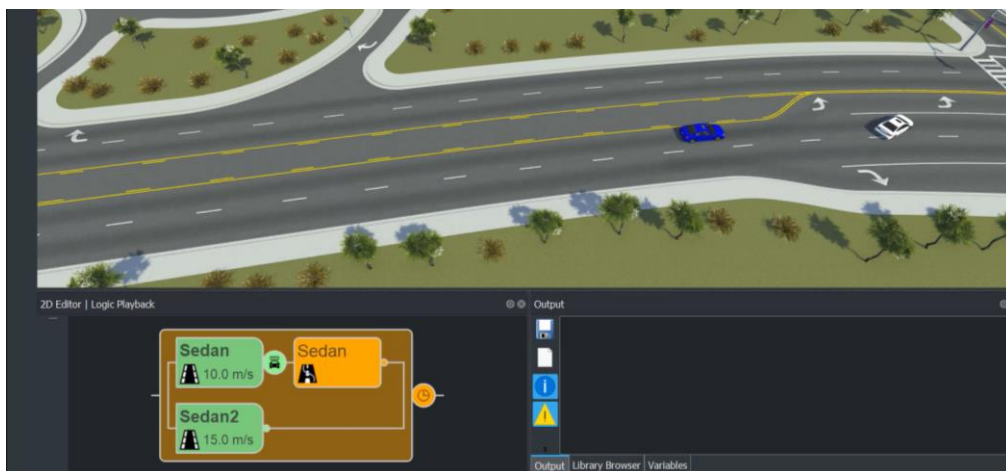
未定义路径时保持车道行驶



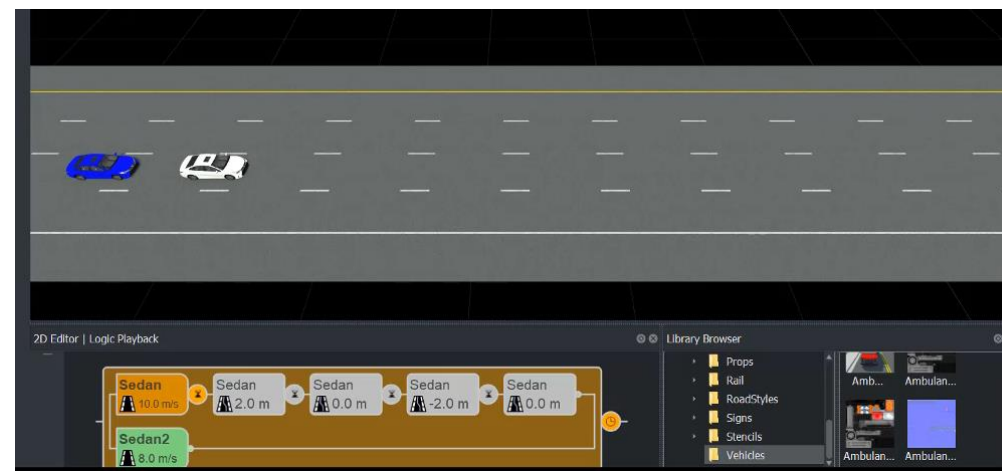
速度变换动作



车道变换动作

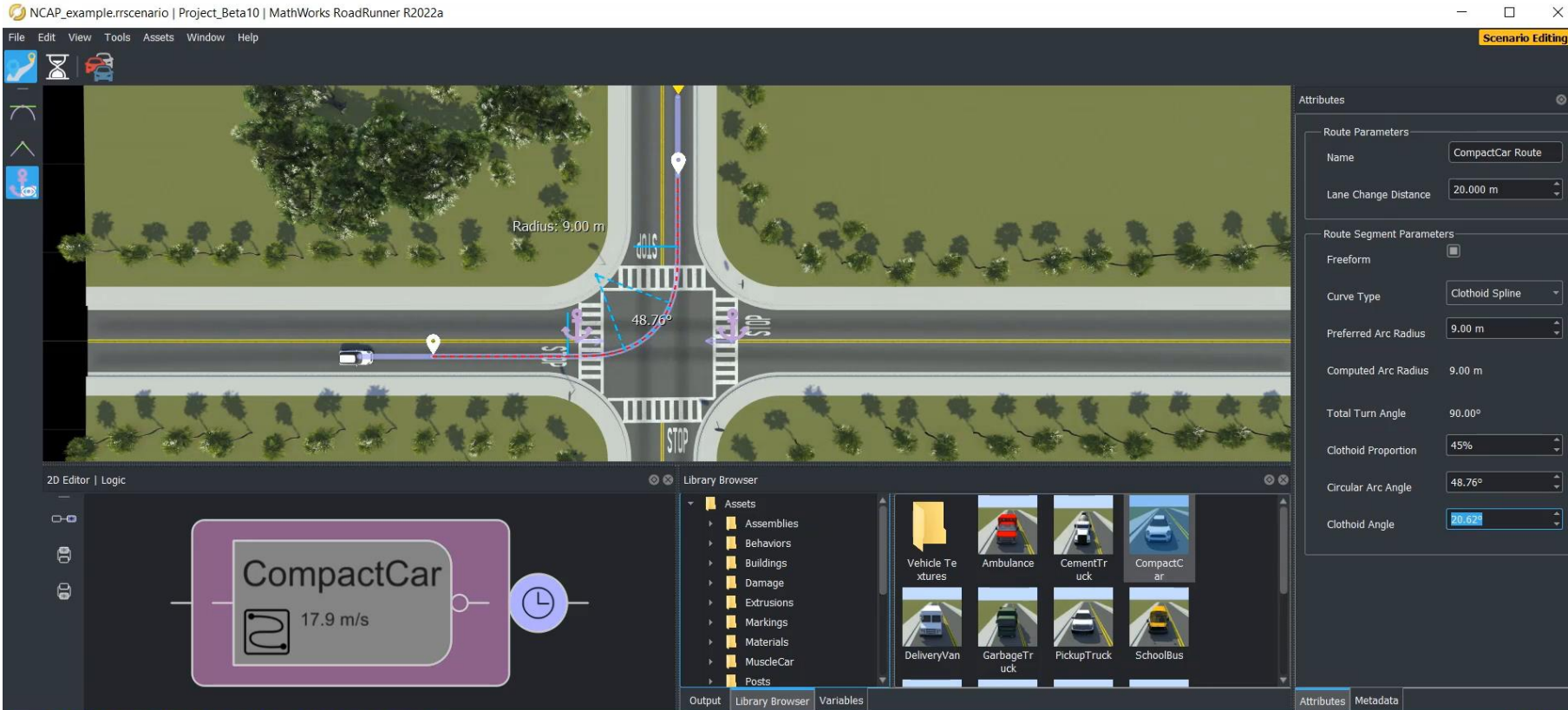


侧向偏移动作



设计交通参与者路径和生成轨迹

- 三次曲线插值
- 回旋曲线插值
- Euro NCAP
(回旋-圆弧-回旋曲线
clothoid-arc-clothoid)



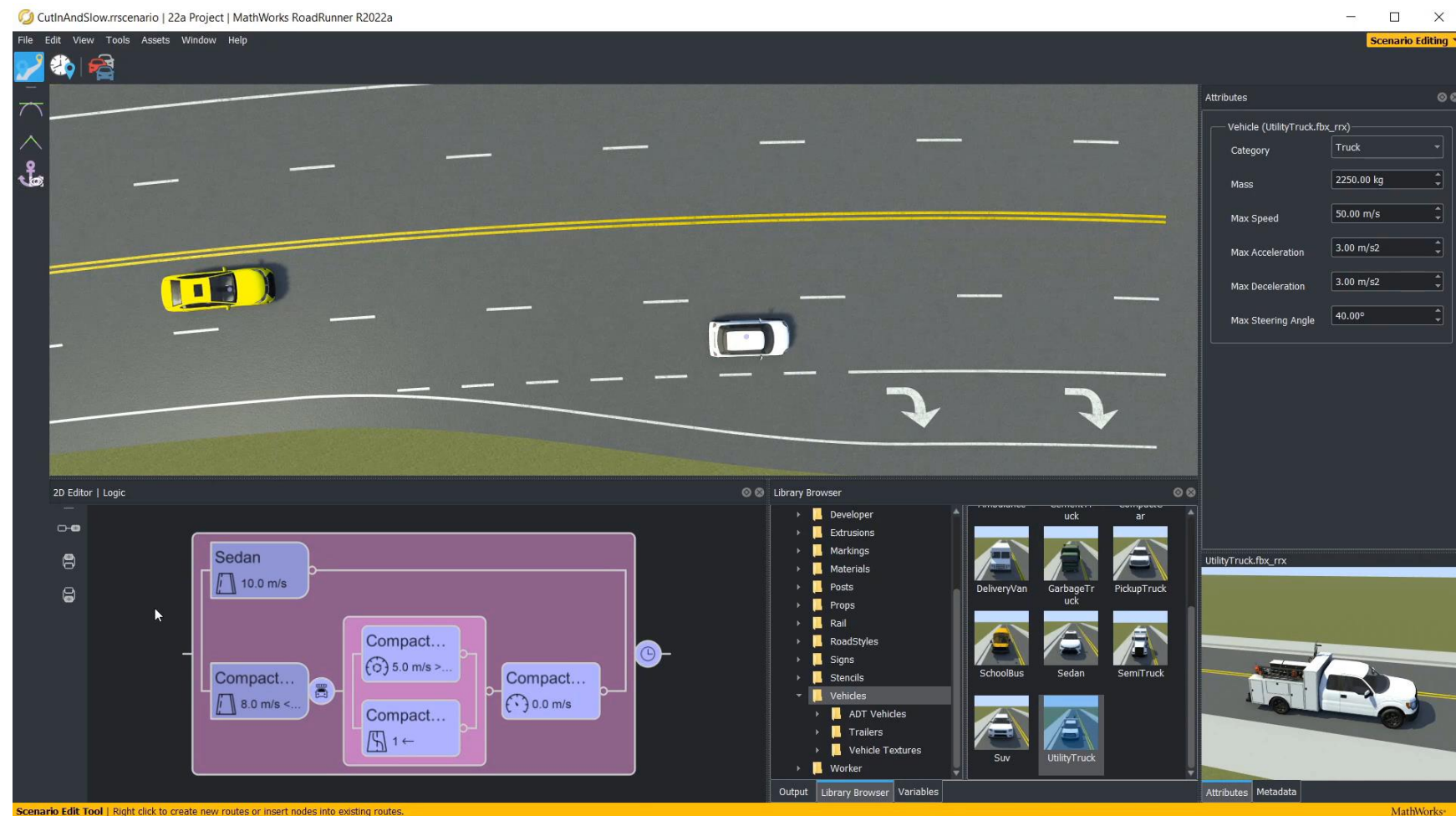
[Route Timing Tool](#)
RoadRunner Scenario

R2022a

通过编程方式泛化场景参数

RoadRunner Scenario提供 MATLAB/gRPC命令行API

- 定义编辑器中的场景变量
- 通过API编程设定变量
- 运行仿真
- 导出到OpenSCENARIO

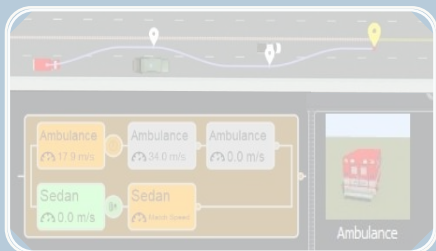


[Programmatic Scenario Interfaces](#)

RoadRunner Scenario

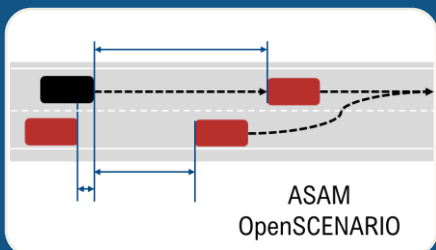
R2022a

使用RoadRunner Scenario，设计和仿真面向自动驾驶应用的场景



设计和仿真交通场景

- 设计车辆路径和场景逻辑
- 在不同的道路中重用场景设计
- 通过编程方式泛化场景参数

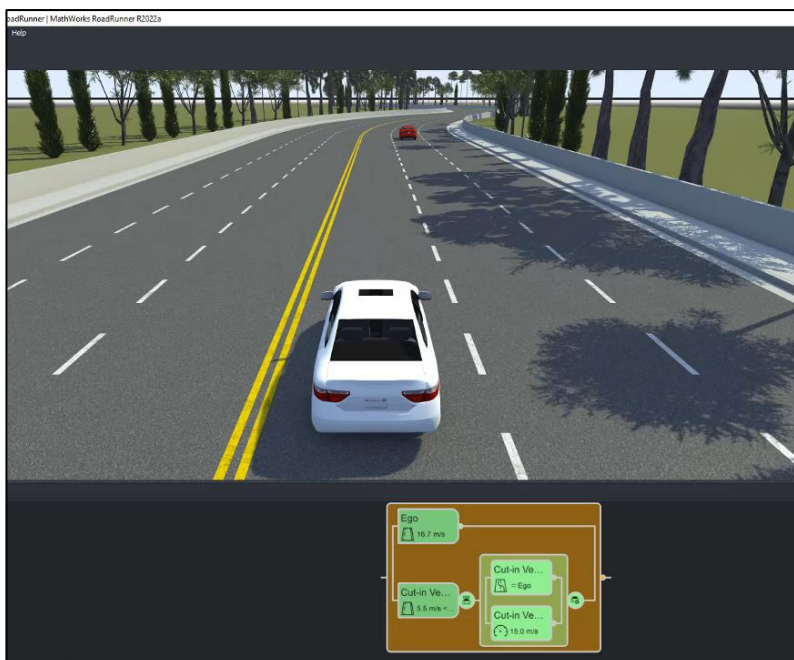


与OpenSCENARIO的接口



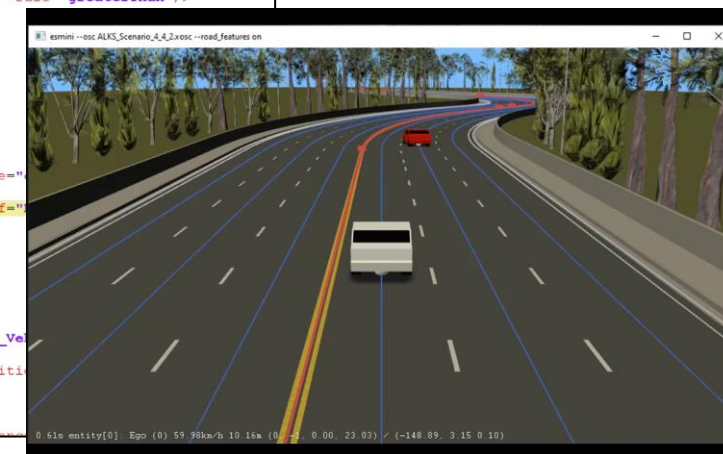
联合MATLAB， Simulink， 以及CARLA仿真

导出场景到 OpenSCENARIO V1.x 和 V2.0



OpenSCENARIO
V1.x

```
<Condition name="Start Condition of Event_Vehicle2" conditionEdge="none">
  <ByValueCondition>
    <SimulationTimeCondition value="0" rule="greaterThan"/>
  </ByValueCondition>
</Condition>
</StartTrigger>
</Event>
<Event name="Event_Vehicle2_2" priority="overwrite">
  <Action name="Speed Action_Vehicle2_2">
    <PrivateAction>
      <LongitudinalAction>
        <SpeedAction>
          <SpeedActionDynamics dynamicsShape="
          <SpeedActionTarget>
            <RelativeTargetSpeed entityRef="
          </SpeedActionTarget>
        </SpeedAction>
      </LongitudinalAction>
    </PrivateAction>
  </Action>
  <StartTrigger>
    <ConditionGroup>
      <Condition name="Start Condition of Event_Ve
      <ByEntityCondition>
        <TriggeringEntities triggeringEntiti
        <EntityRef entityRef="Ego"/>
      </TriggeringEntities>
      <EntityCondition>
        <RelativeTargetSpeed entityRef="Ego"
        </EntityCondition>
      </ConditionGroup>
    </StartTrigger>
  </Event>
```



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

OpenSCENARIO
V2.0

```
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_v
90   parallel:
91     cut-in_vehicle.
92     cut-in_vehicle.
93     speed(15mps,
94   with:
95     until (ego.time
96
```

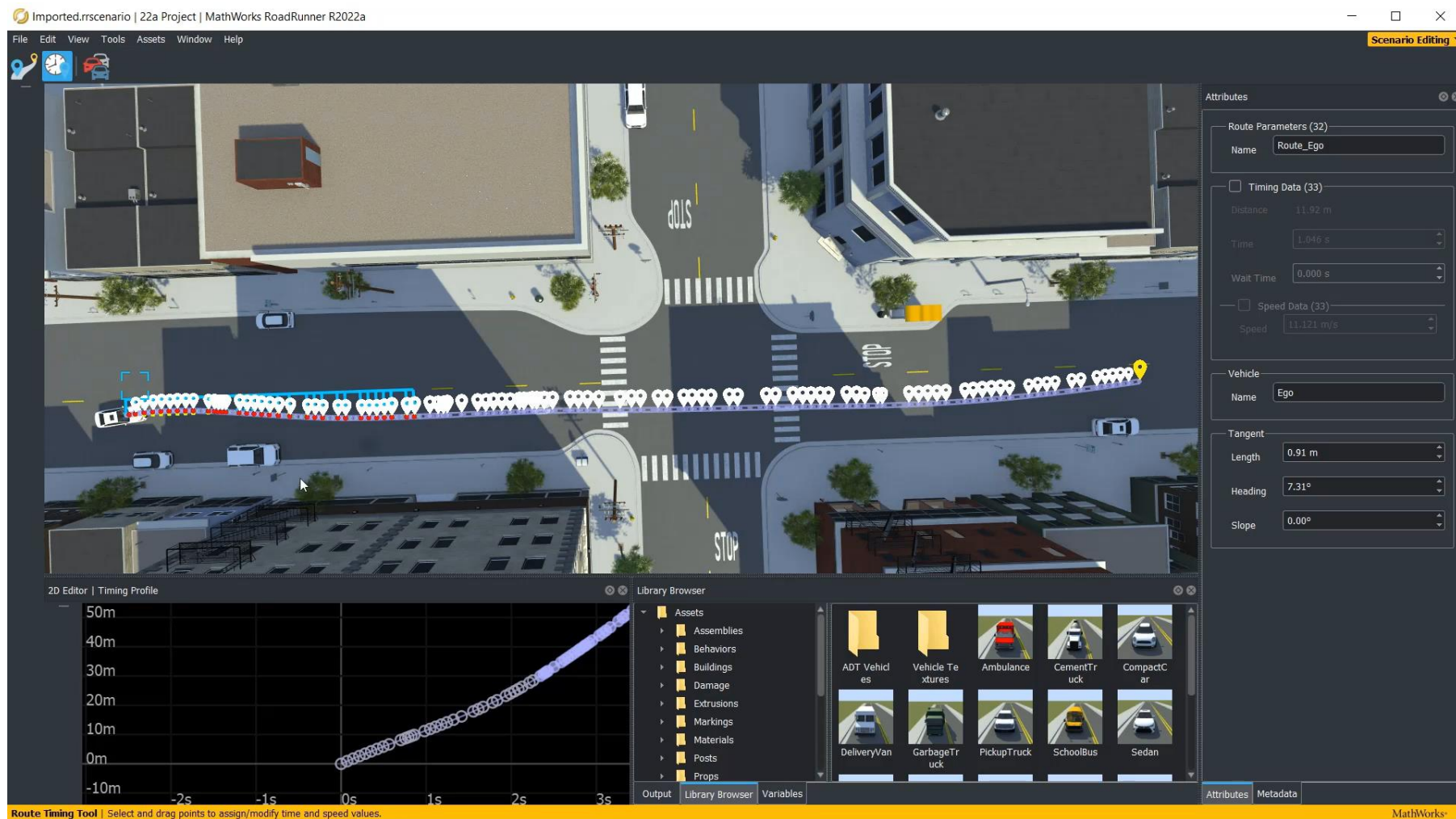
MathWorks是ASAM会员，
正积极参与
OpenSCENARIO 2.0
执行论坛

[Export to ASAM OpenSCENARIO](#)
RoadRunner Scenario

R2022a

导入和编辑来自 OpenSCENARIO V1.x 的轨迹

- 从OpenSCENARIO V1.x 导入轨迹
- 交互式编辑轨迹
- 在不同的道路环境中重新放置导入的轨迹
- 抽取路径片段并添加场景逻辑

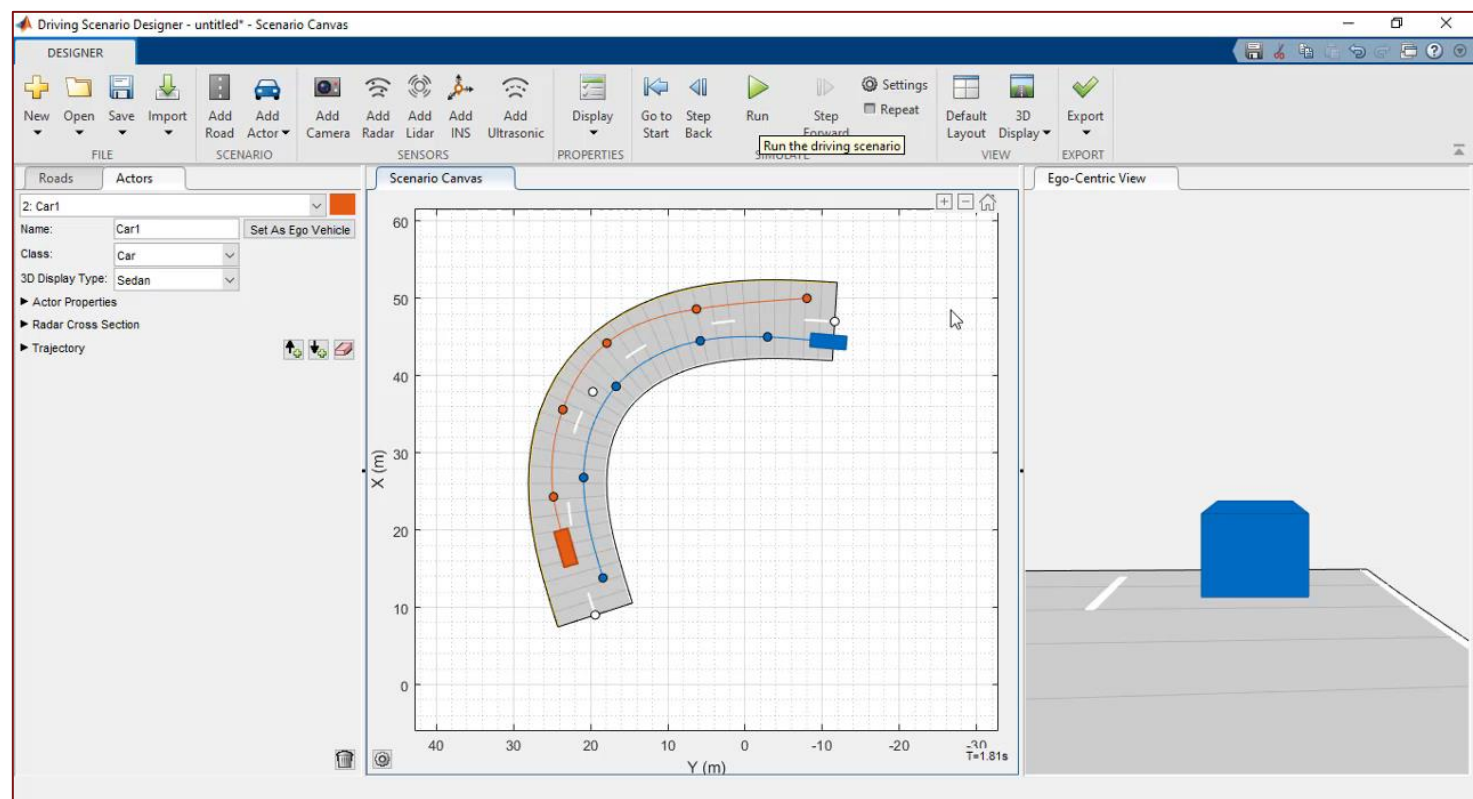
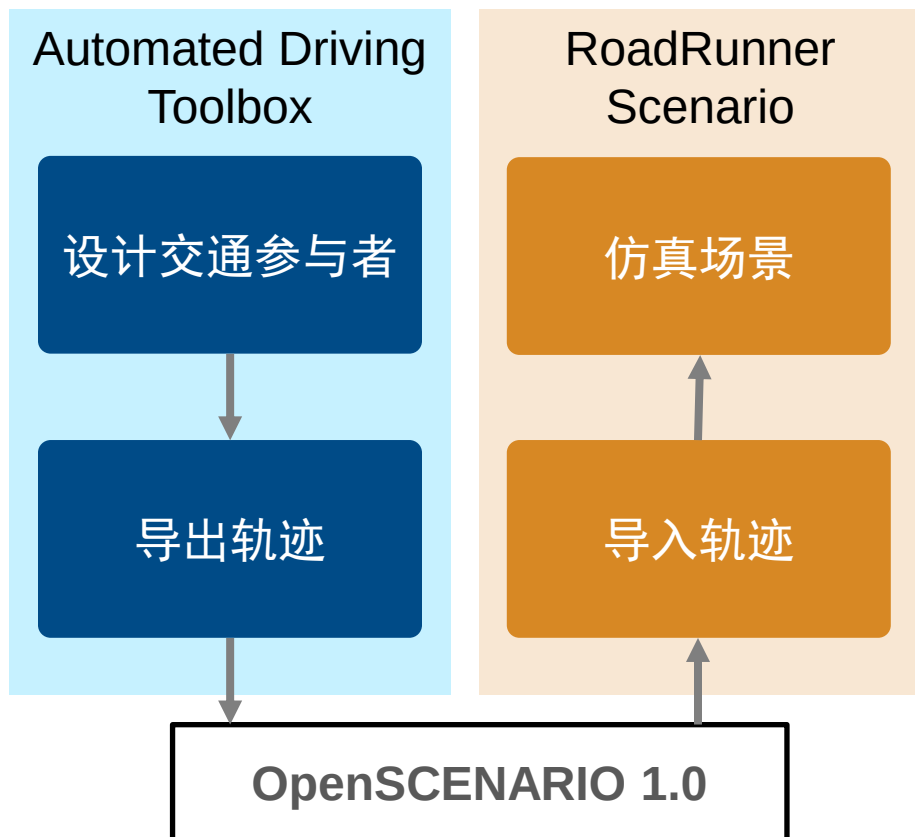


[Import Trajectories from ASAM OpenSCENARIO Files](#)

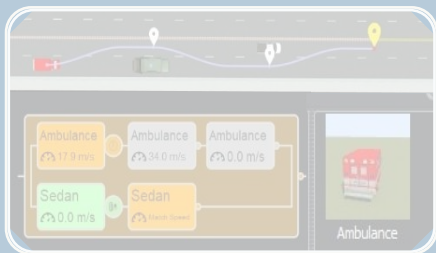
RoadRunner Scenario

R2022a

从Driving Scenario Designer (DSD) 迁移到RoadRunner Scenario

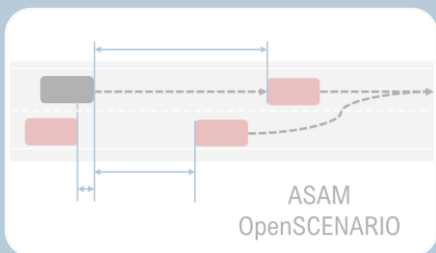


使用RoadRunner Scenario，设计和仿真面向自动驾驶应用的场景



设计和仿真交通场景

- 设计车辆路径和场景逻辑
- 在不同的道路中重用场景设计
- 通过编程方式泛化场景参数



与OpenSCENARIO的接口

- 导出到 OpenSCENARIO v2.0
- 导出到 OpenSCENARIO v1.x
- 导入来自 OpenSCENARIO v1.x 的轨迹



联合MATLAB，Simulink，以及CARLA仿真

仿真含有不同来源的交通参与者行为的交通场景

RoadRunner Scenario可以连接来自MATLAB, Simulink, 以及CARLA的交通参与者

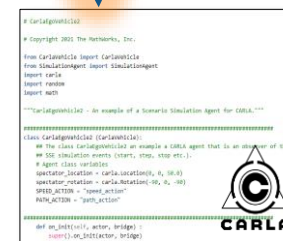
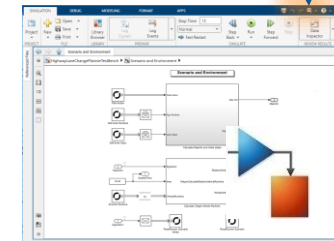
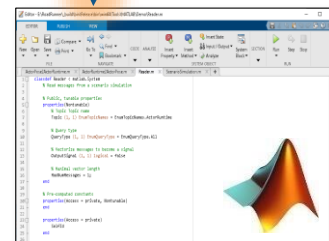
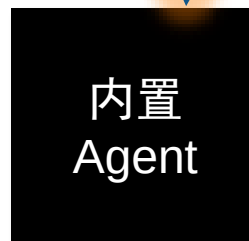
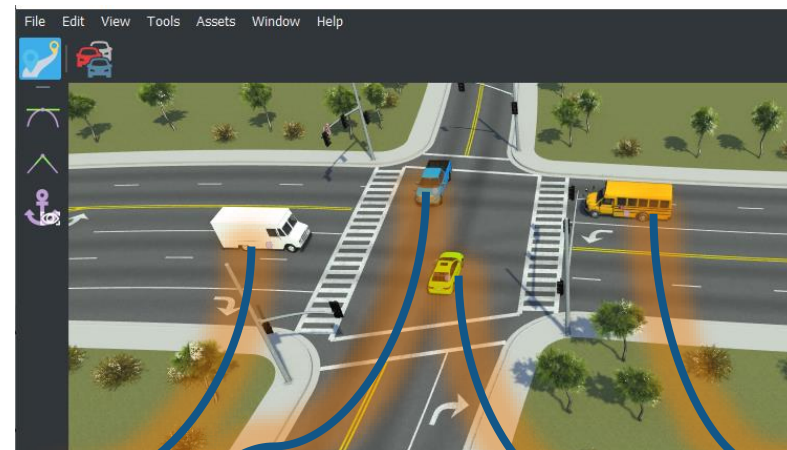
RoadRunner Scenario可以作为一个仿真服务器，交通参与者客户端相当于该智能系统中的智能体（Agent）

交通参与者可在场景中设定自身状态

- 包括当前时刻自身的位姿和速度

交通参与者可以获取场景状态

- 动作命令，包括路径、速度、换道、偏移
- 场景中所有交通参与者的位姿和速度
- 场景中所有交通参与者的尺寸
- 地图中的车道和车道边界



在MATLAB中编写交通参与者行为

在Automated Driving Toolbox中提供了MATLAB API，实现RoadRunner Scenario接口

- 连接到仿真场景
- 从场景读取世界状态
- 从场景读取交通参与者动作命令
- 向场景写入交通参与者状态
- 向场景报告Error或Warning

▼ Scenario Simulation

<code>Simulink.ScenarioSimulation</code>	Create, access, and control scenario simulation
--	---

▼ Actor Modeling

<code>convertToStruct</code>	Convert actor to MATLAB structure
<code>get</code>	Get scenario or static attribute of actor
<code>getAction</code>	Get actions associated with actor
<code>getAttribute</code>	Get runtime attribute of actor
<code>setAttribute</code>	Set runtime attribute of actor
<code>getAttribute</code>	Return static attribute of actor

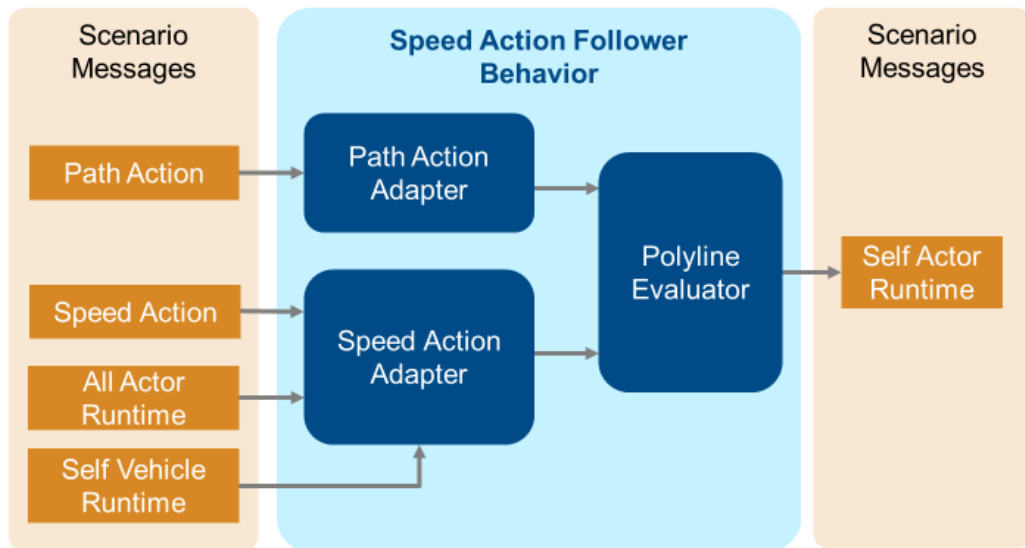
```
obj.mScenarioSimulationHdl = ...  
    Simulink.ScenarioSimulation.find( ...  
        'ScenarioSimulation', 'SystemObject', obj);  
  
obj.mActorSimulationHdl = Simulink.ScenarioSimulation.find( ...  
    'ActorSimulation', 'SystemObject', obj);  
  
obj.mActor.pose = ...  
    obj.mActorSimulationHdl.getAttribute('Pose');  
  
obj.mActor.velocity = ...  
    obj.mActorSimulationHdl.getAttribute('Velocity');
```

[Simulate RoadRunner Scenarios with Actors Modeled in MATLAB](#)

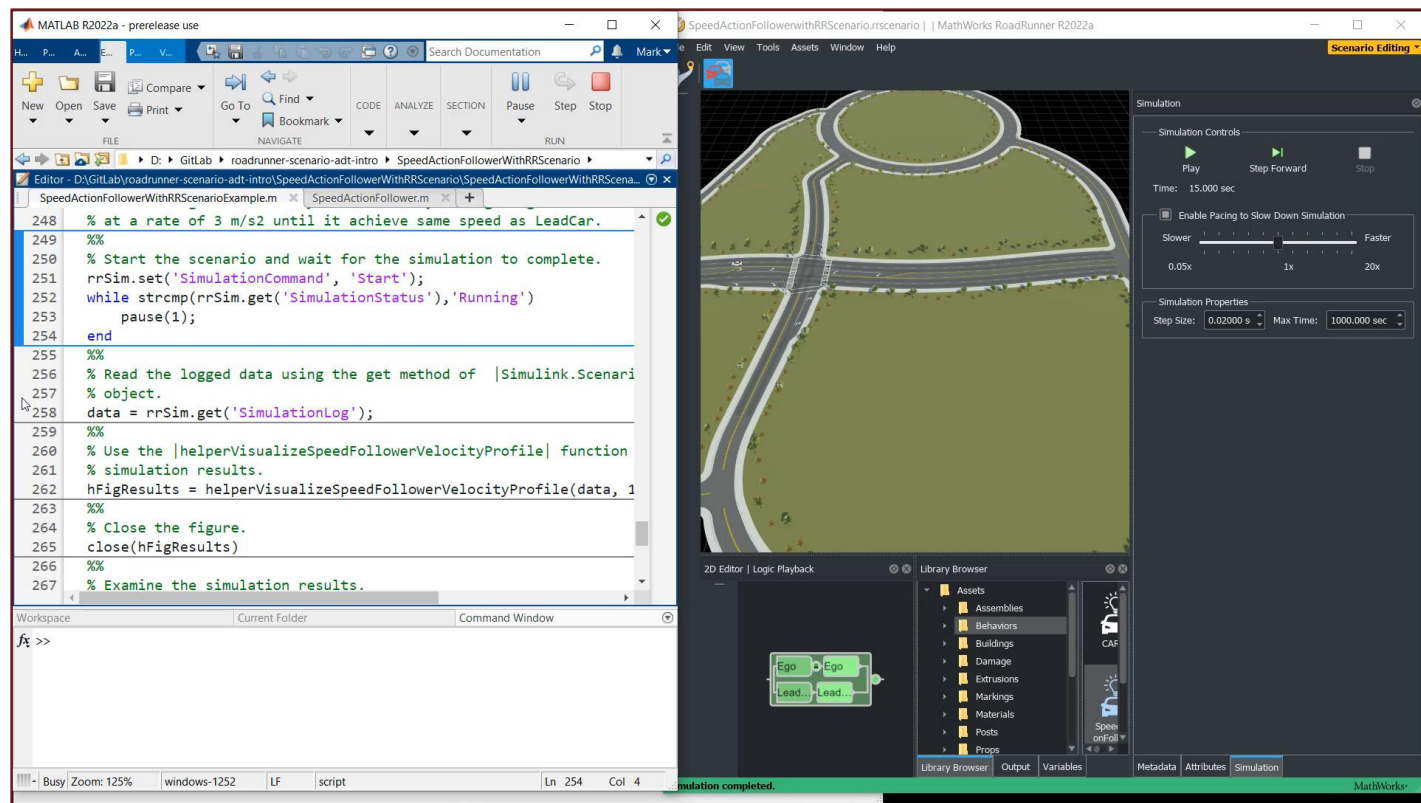
RoadRunner Scenario, Automated Driving Toolbox™

R2022a

在MATLAB中实现速度动作跟随并仿真场景



- 在MATLAB中实现交通参与者的速度动作跟随行为
- 关联MATLAB中的参与者与RoadRunner Scenario中的参与者
- 仿真并可视化结果



[Speed Action Follower with RoadRunner Scenario](#)

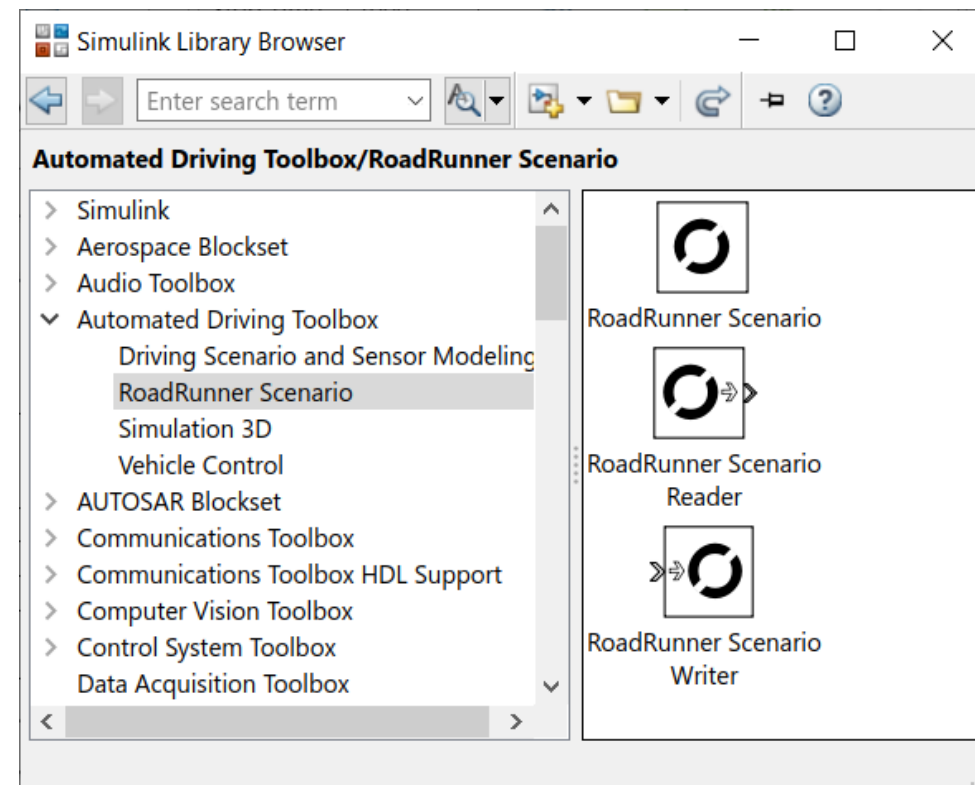
RoadRunner Scenario, Automated Driving Toolbox™

R2022a

在Simulink中编写交通参与者行为

在Automated Driving Toolbox中提供了Simulink相关模块，实现RoadRunner Scenario接口

- *RoadRunner Scenario*
 - 建立一个模型与场景间的接口
- *RoadRunner Scenario Reader*
 - 读取世界状态: 交通参与者位姿、速度、颜色和动作命令
- *RoadRunner Scenario Writer*
 - 向场景写入交通参与者状态
 - 向场景报告Error或Warning

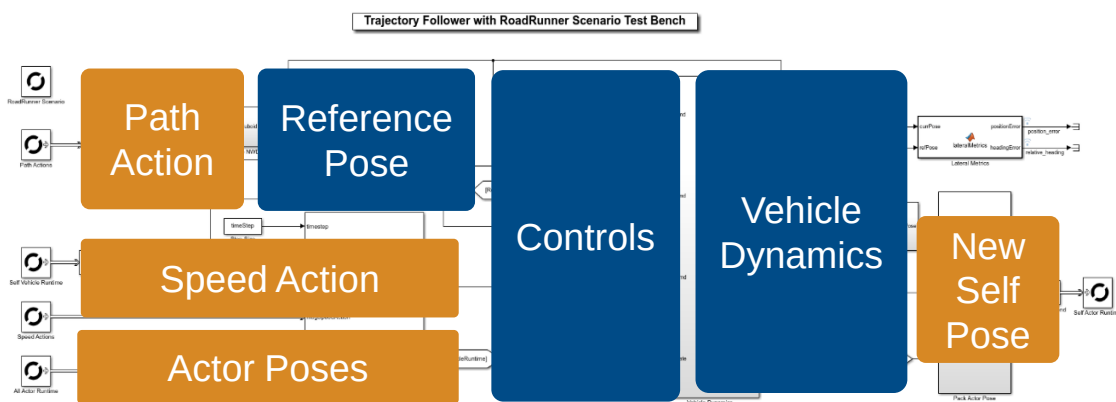


[Simulate RoadRunner Scenarios with Actors Modeled in Simulink](#)

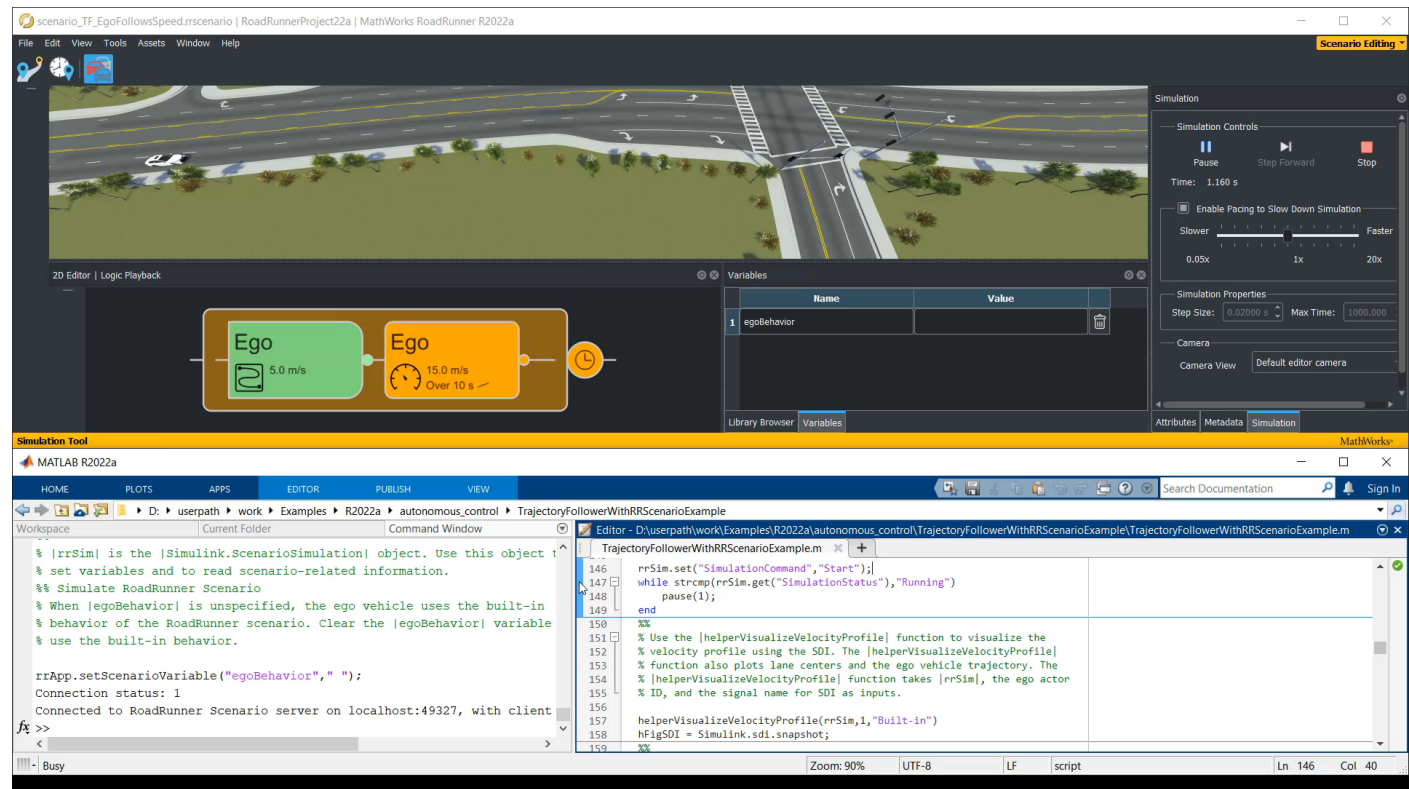
RoadRunner Scenario, Automated Driving Toolbox™

R2022a

在Simulink中实现轨迹跟随并仿真场景



- 观察RoadRunner Scenario内置的对线性加速的轨迹跟随行为（理想控制）
- 在Simulink中设计交通参与者行为，包括真实控制和车辆动力学（实际控制）
- 仿真和对比结果



[Trajectory Follower with RoadRunner Scenario](#)
 RoadRunner Scenario, Automated Driving Toolbox™

R2022a

实现Simulink与RoadRunner Scenario的接口

Path Action

Self Vehicle Pose

New Self Vehicle Pose

Block Parameters: Path Actions

RoadRunner Scenario Reader
Reads the selected topic type from RoadRunner Scenario

Parameters

Topic Category: Action

Action Type: Path Following

Filter: Self

Sample time: 0

Block Parameters: Self Vehicle Runtime

RoadRunner Scenario Reader
Reads the selected topic type from RoadRunner Scenario

Parameters

Topic Category: Actor

Actor Type: Vehicle

Topic: Vehicle Pose

Filter: Self

Block Parameters: New Self Vehicle Runtime

RoadRunner Scenario Writer
Writes selected topic type to RoadRunner Scenario. Before you use this block, load the [load function](#)

Parameters

Category: Actor

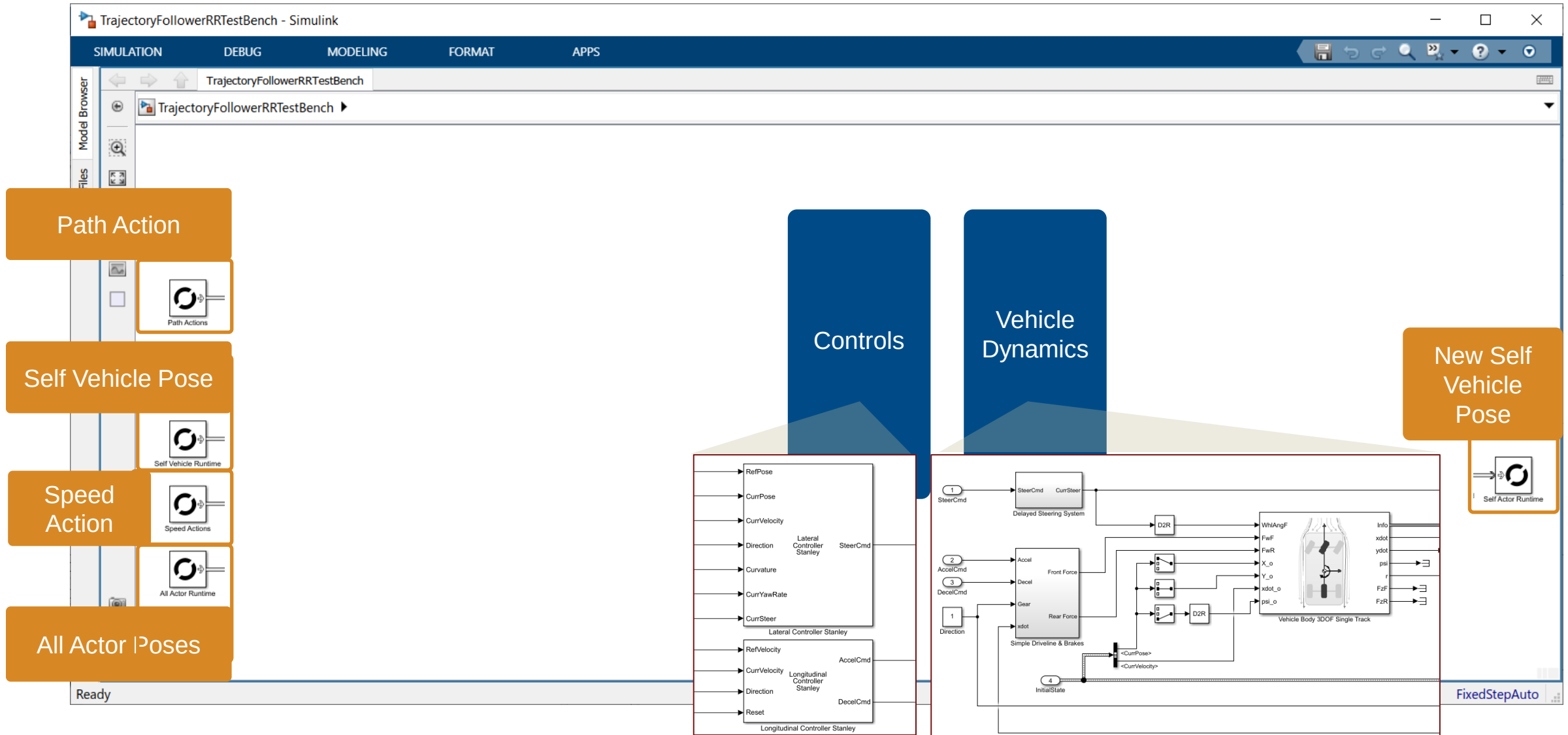
Type: Vehicle

Vehicle Pose

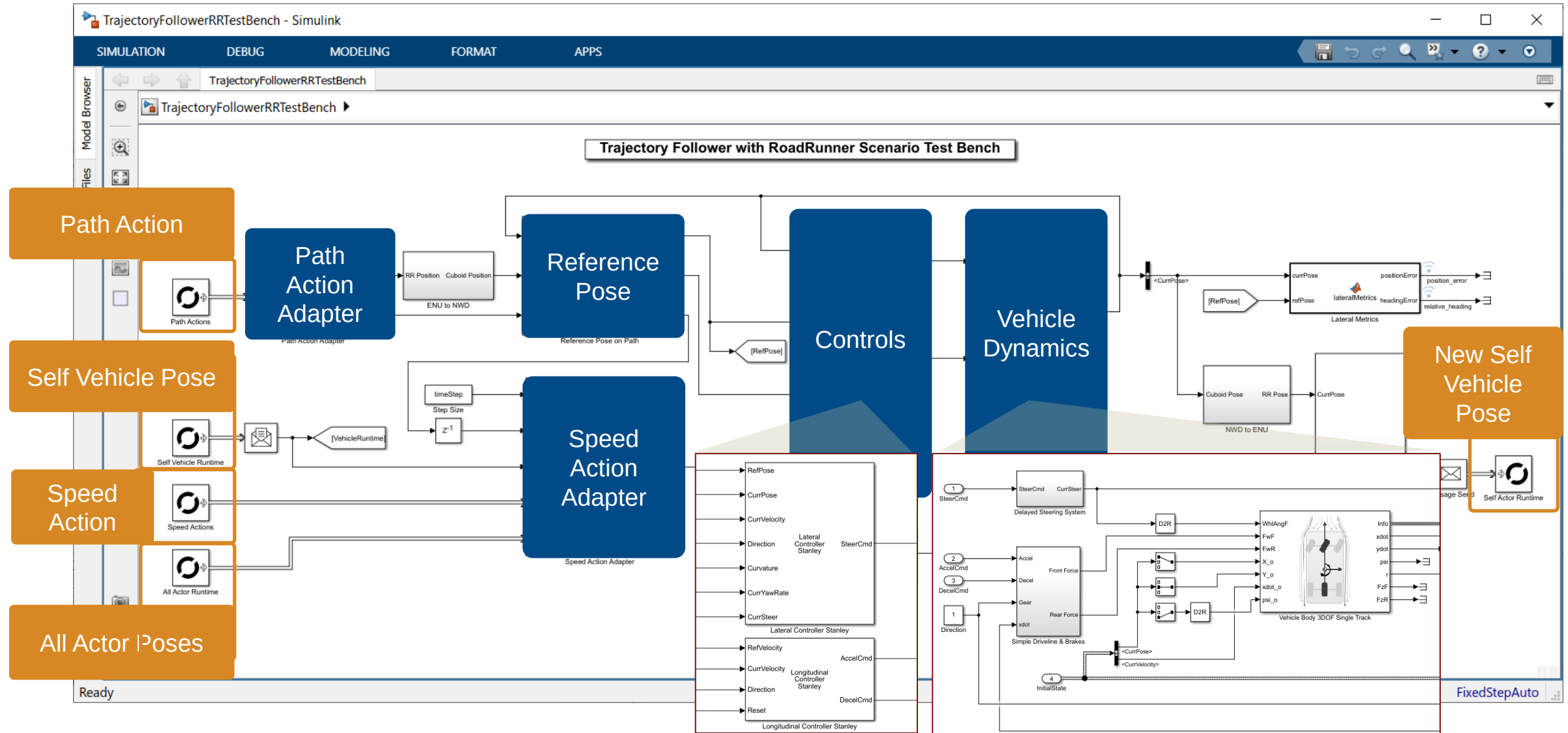
BusVehicleRuntime

- ActorRuntime
 - ActorID
 - Pose
 - Velocity
 - AngularVelocity
 - NumWheels
 - WheelPoses

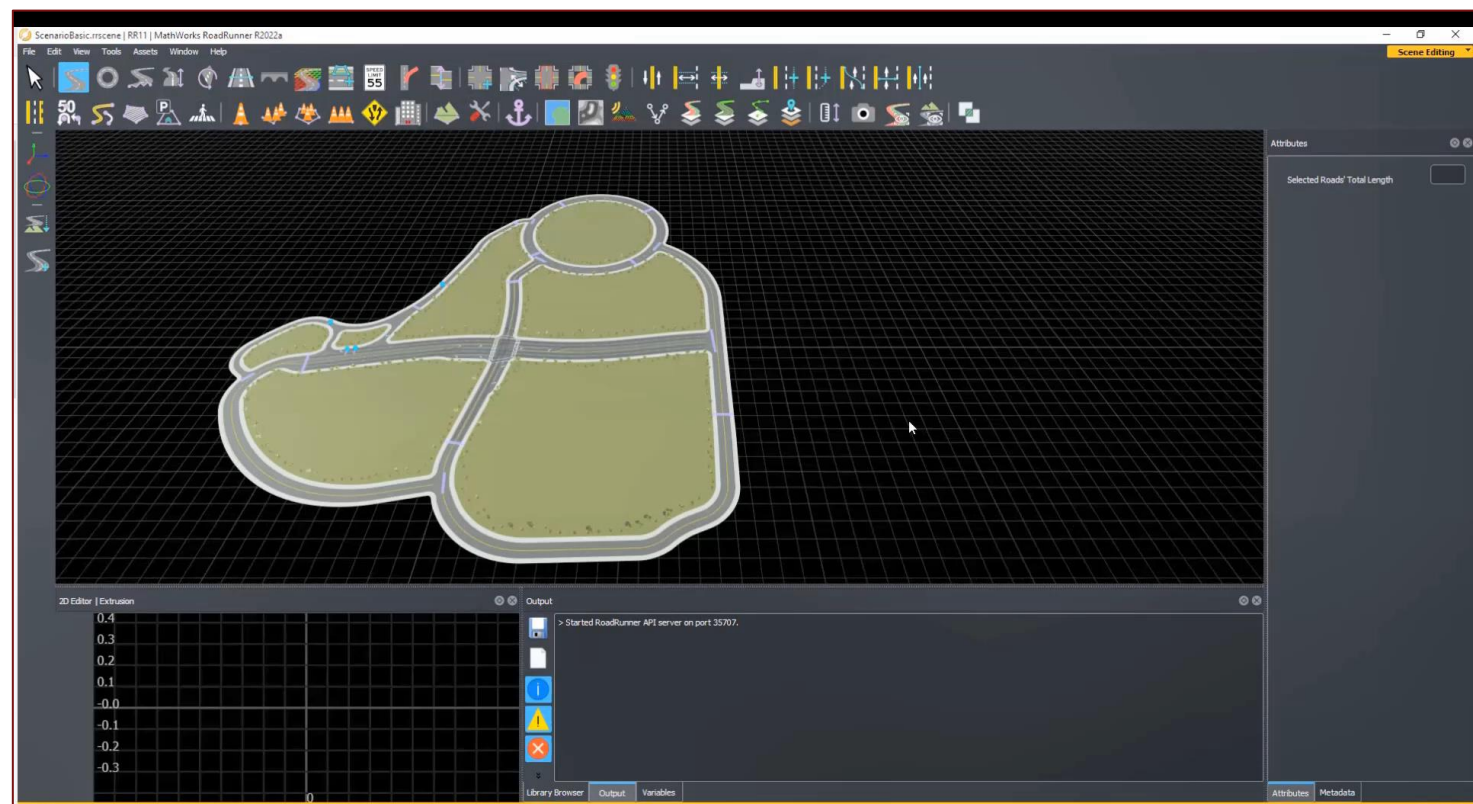
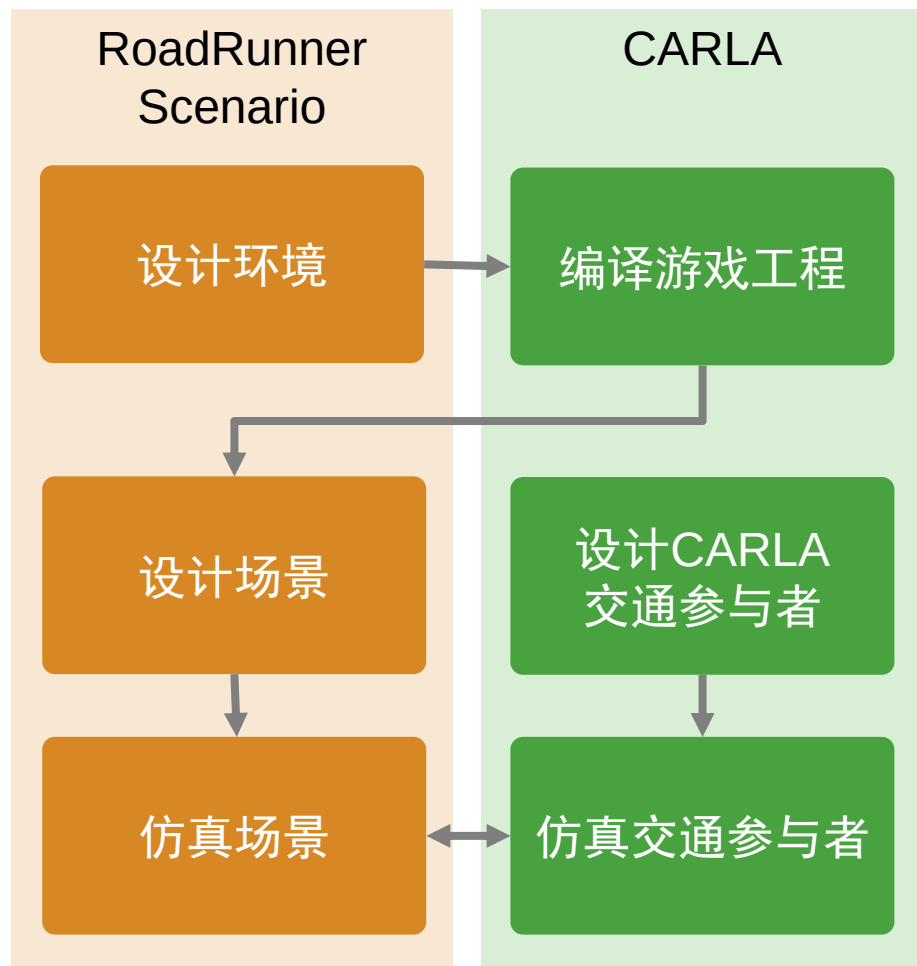
实现Simulink与RoadRunner Scenario的接口



实现Simulink与RoadRunner Scenario的接口



在CARLA中设计交通参与者并仿真场景

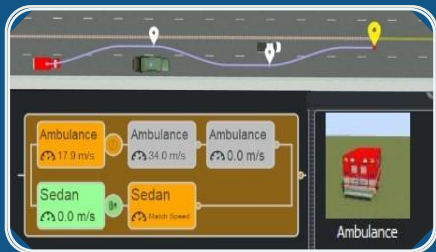


[Cosimulate Actors with CARLA](#)

RoadRunner Scenario

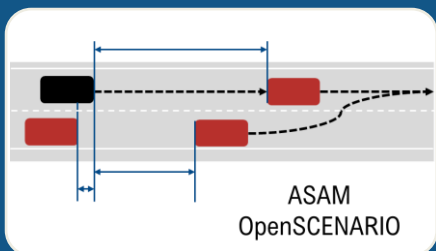
R2022a

使用RoadRunner Scenario，设计和仿真面向自动驾驶应用的场景



设计和仿真交通场景

- 设计车辆路径和场景逻辑
- 在不同的道路中重用场景设计
- 通过编程方式泛化场景参数



与OpenSCENARIO的接口

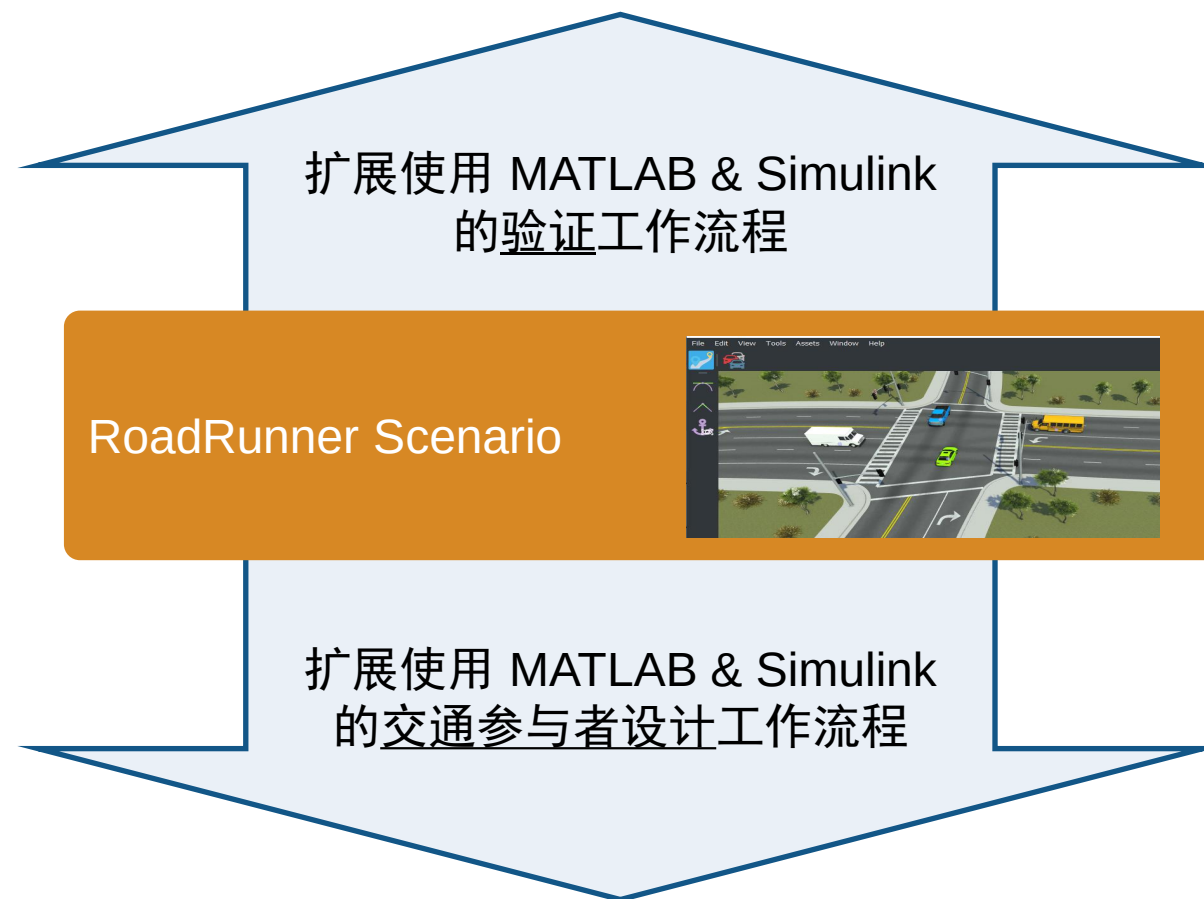
- 导出到 OpenSCENARIO v2.0
- 导出到 OpenSCENARIO v1.x
- 导入来自 OpenSCENARIO v1.x 的轨迹



联合MATLAB，Simulink，以及CARLA仿真

- 在 MATLAB 中设计交通参与者行为
- 在 Simulink 中设计交通参与者行为
- 在 CARLA 中设计交通参与者行为

与MathWorks合作，扩展工作流程

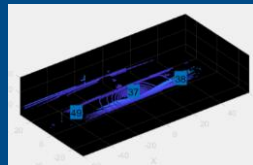


联系MathWorks工程师，获取PoC原型或咨询服务，扩展RoadRunner Scenario工作流程。

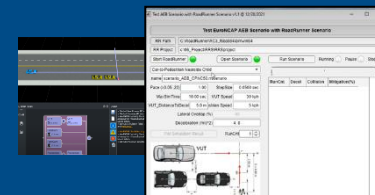
与MathWorks合作，扩展工作流程

验证

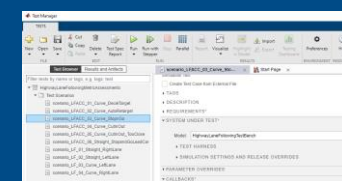
从记录的数据
生成场景



生成场景
的变体



场景的自动
测试

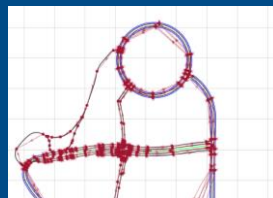


RoadRunner Scenario



交通参与者

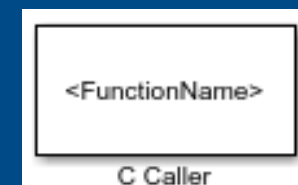
集成
规划和控制



集成
传感器



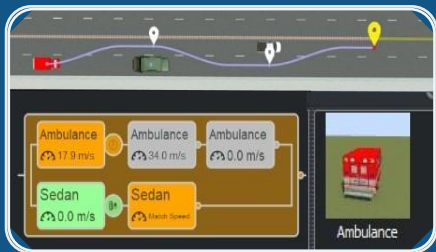
集成
外部代码



联系MathWorks工程师，获取PoC原型或咨询服务，扩展RoadRunner Scenario工作流程。

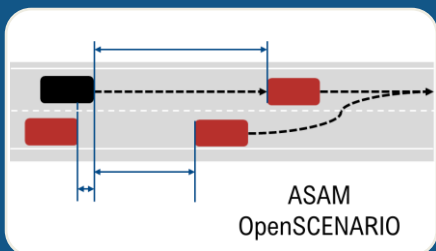
R2022a

使用RoadRunner Scenario，设计和仿真面向自动驾驶应用的场景



设计和仿真交通场景

- 设计车辆路径和场景逻辑
- 在不同的道路中重用场景设计
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与OpenSCENARIO的接口

- 导出到 OpenSCENARIO v2.0
- 导出到 OpenSCENARIO v1.x
- 导入来自 OpenSCENARIO v1.x 的轨迹



联合MATLAB，Simulink，以及CARLA仿真

- 在 MATLAB 中设计交通参与者行为
- 在 Simulink 中设计交通参与者行为
- 在 CARLA 中设计交通参与者行为