

MathWorks
**AUTOMOTIVE
CONFERENCE 2024**
North America

Developing Simulink co-simulation with SUMO and CARLA

Fangjun Jiang, Ford Motor Company



Developing Simulink co-simulation with SUMO and CARLA

Fangjun Jiang, Fadi Tela, Top Chea
Ford Motor Company
Chad Van Fleet, Kim McGarrity
The MathWorks, Inc.

SUMO: Simulation of Urban Mobility
CARLA: Car Learning to Act
Both are open-source simulation software

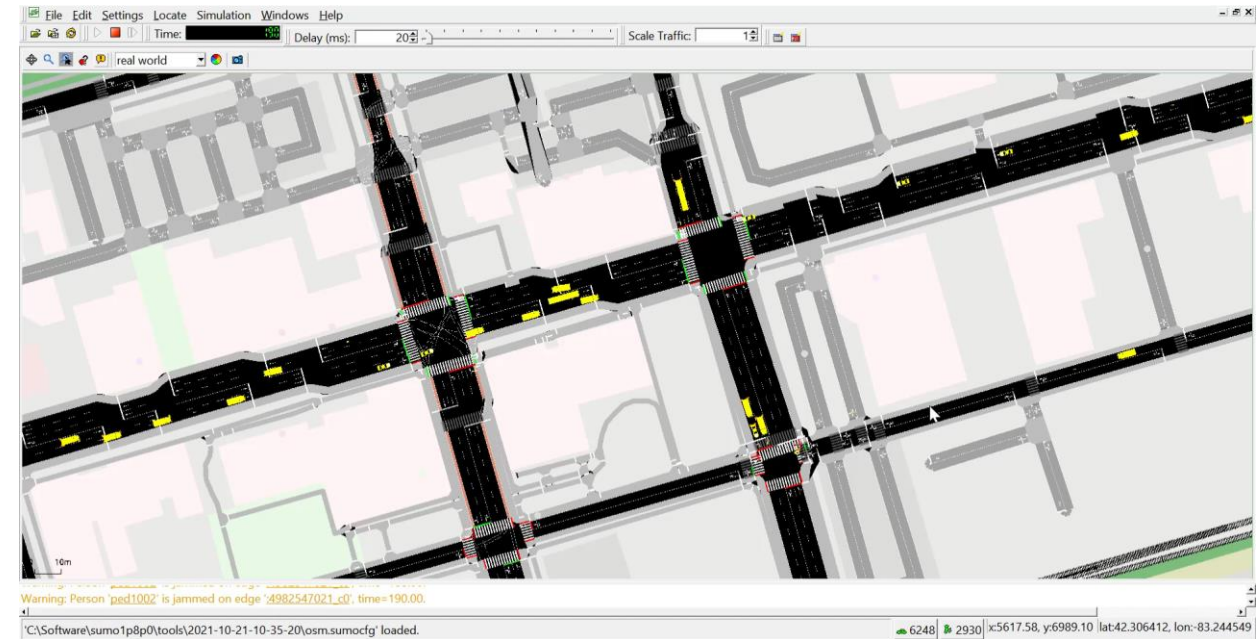
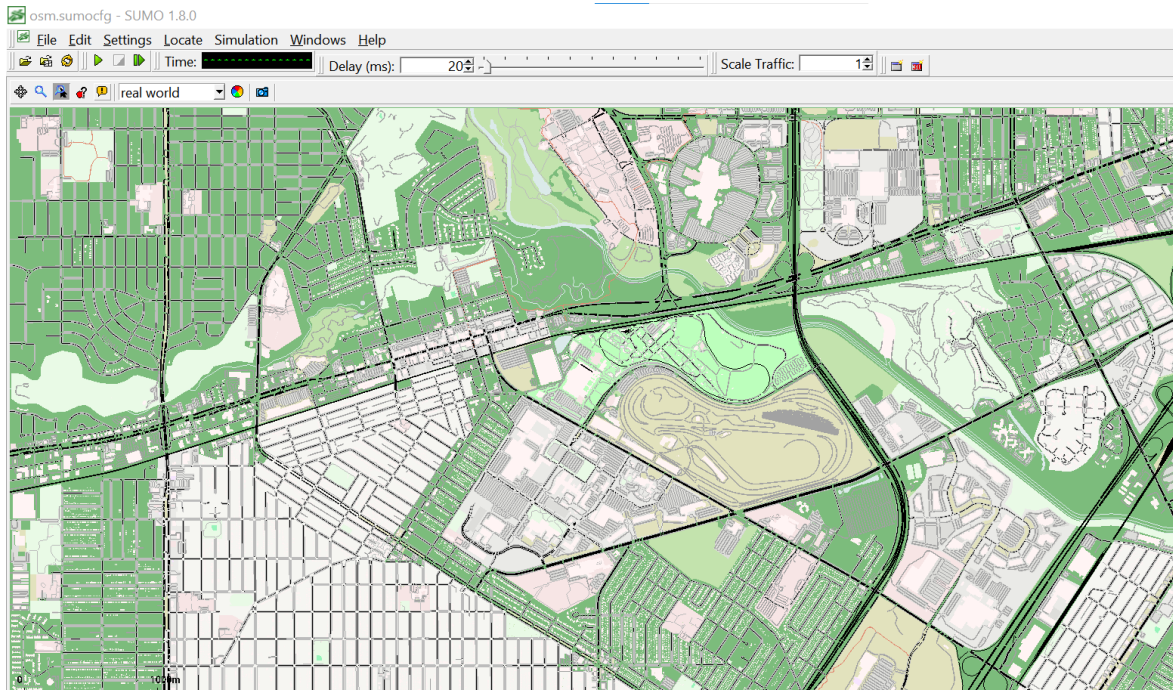
Developing Simulink co-simulation with SUMO and CARLA

- Introduction of SUMO and CARLA
- The motivation to develop this plug-in tool
- Capabilities and performance
- Benefits and use cases
- Summary

SUMO



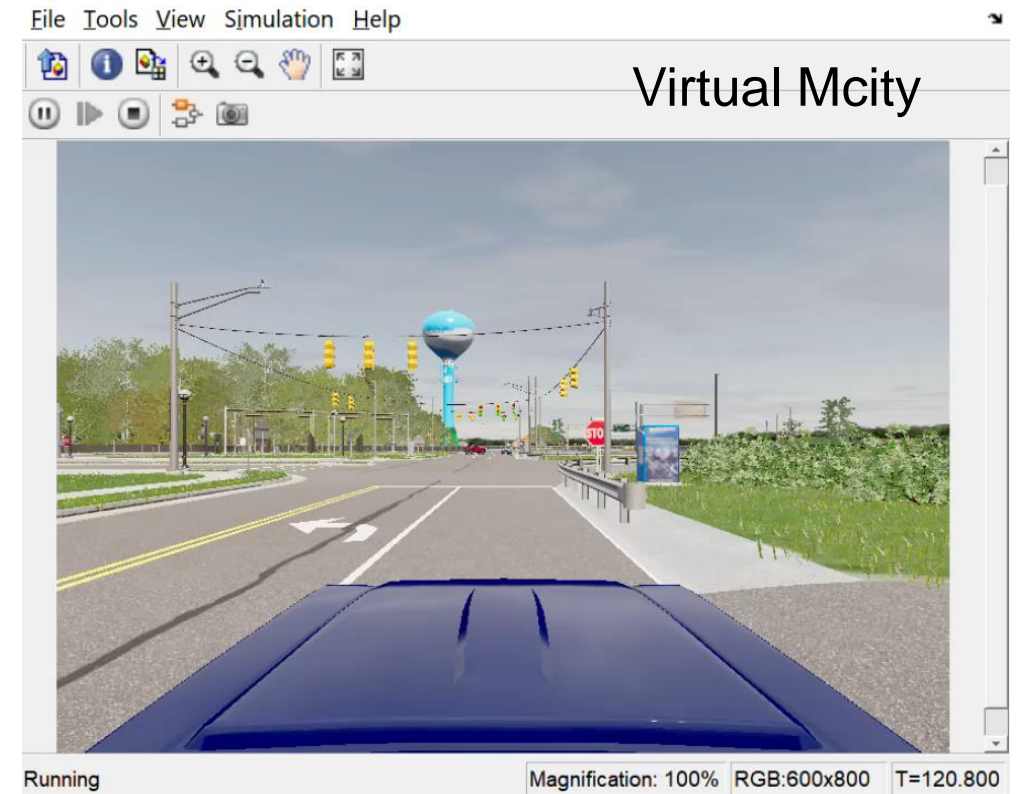
- **Simulation of Urban MObility**
- <https://eclipse.dev/sumo/>
- An open-source traffic simulation package
- 2D, fast simulation, convert/import real world map data



CARLA



- **Car Learning to Act**
- <https://carla.org/>
- Open-source simulator for urban driving
- 3D, model ADAS sensors , support custom-built virtual reality



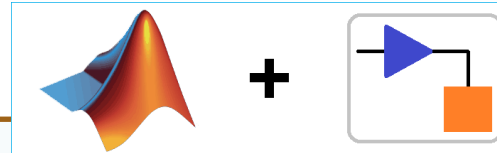
Courtesy of Quantum Signal AI, LLC

Connect and co-simulate



- Run as server/client
- Connect through TCP/IP
- Provide APIs in Python/C++

**S-
Function
in C++**



**MATLAB
SIMULINK®**

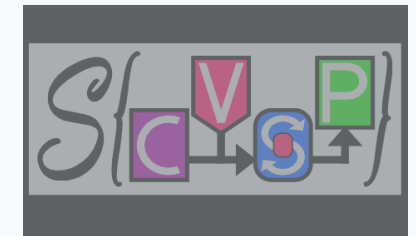


Ford Automated System
Simulation Toolchain

**Collision Avoidance
Driver Support
(CADS) Controller
Model**



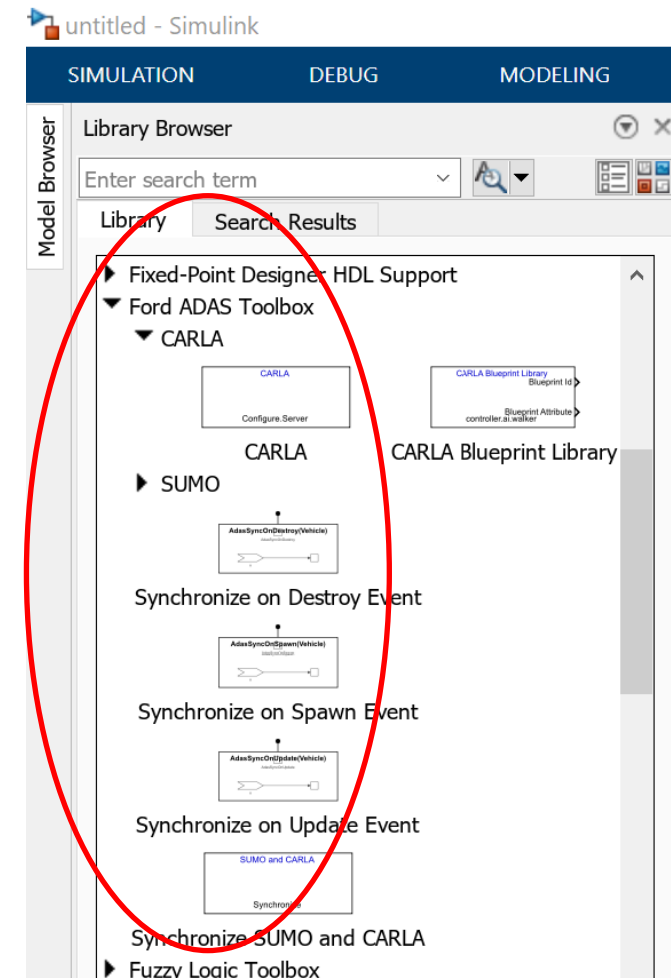
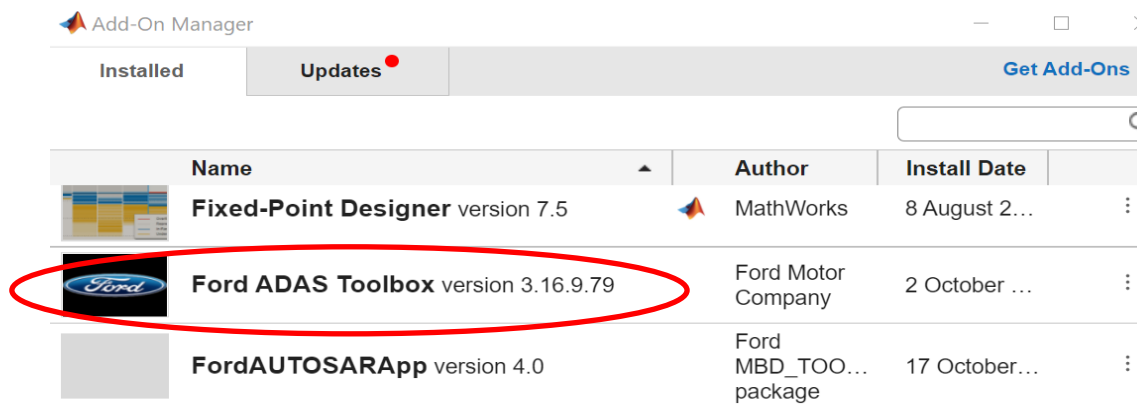
Electrified Virtual Vehicle



Simulink Corporate Vehicle
Simulation Program

Motivation to develop the plug-in tool

- A generic toolbox in Simulink
- Co-simulate SUMO/CARLA with Simulink without coding
- Easy to control simulation and access actors
- Bring traffic scenario and ADAS sensors into Simulink
- Support multi-platforms/cloud platform, CI/CD



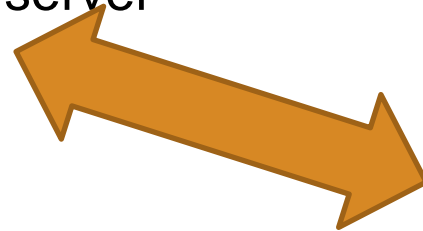
Use the plug-in tool



SUMO server



CARLA server



1. Launch the server
2. Add a Client block in the Simulink model to make it a client
3. Pressing "Run" in Simulink will connect the server and run the co-simulation
4. Use Get/Set blocks to read/write actor properties

The screenshot displays the Simulink interface for a co-simulation with SUMO. A dialog box titled "Block Parameters: SUMO3" is open, showing the following configuration:

- SUMO (mask) (link)
- Co-simulate with SUMO
- Implemented by MathWorks Consulting Services. Learn more at <https://www.mathworks.com/services/consulting>.
- Parameters
- Kind: Configure.Client
- Sample time (-1 for inherited): -1
- Client
- Address: "127.0.0.1"
- Port: 8813
- Order: 1
- Configure SUMO client for co-simulation.

The Simulink model, titled "SumoDemoModel2_R22b", shows a block diagram with the following components:

- ConfigSUMO**: A block that outputs SUMOGetTime to a scope.
- Vehicle Control Blocks**: Three blocks (VehSpd(m/s), VehAccel(m/s^2), DistToLeadVeh(m)) that receive control signals and output vehicle data to scopes.
- Control Logic**: A central block that receives control signals and outputs to a **Simple ACC** block.
- Output Blocks**: **Set_Ego_Veh** and **ChangeLaneFlag** blocks that receive control signals and output to scopes.

The Simulink interface includes standard menus (File, Edit, View, Display, Diagram, Simulation, Analysis, Code, Tools, MBD, Utilities, Help) and a toolbar with simulation controls (Run, Step Back, etc.). The status bar at the bottom indicates "Ready" and "77%".

More functions to access actors

SUMO (mask) (link)
Co-simulate with SUMO
Implemented by MathWorks Consulting Services. Learn more at <https://www.mathworks.com/services/consulting>.

Parameters

Kind: **Configure.Client**

Sample time: -1

Client address: []

Port: []

Order: []

Configuration: []

Kind: **Configure.Client**

Sample time: -1

Client address: []

Port: []

Order: []

Configuration: []

Vehicle.Add
Vehicle.ChangeLane
Vehicle.ChangeSublane
Vehicle.GetAccel
Vehicle.GetAcceleration
Vehicle.GetAccumulate
Vehicle.GetActionStepL
Vehicle.GetAllowedSpe
Vehicle.GetAngle
Vehicle.GetCO2Emissio
Vehicle.GetCOEmission
Vehicle.GetColor
Vehicle.GetDecel
Vehicle.GetDistance
Vehicle.GetElectricityCo
Vehicle.GetPersonNumber
Vehicle.GetPosition
Vehicle.GetPosition3D
Vehicle.GetRightFollowers
Vehicle.GetRightLeaders
Vehicle.GetRoadId
Vehicle.GetRoute
Vehicle.GetRouteId
Vehicle.GetRouteIndex
Vehicle.GetRoutingMode
Vehicle.GetSecureGap
Vehicle.GetShapeClass
Vehicle.GetSignals
Vehicle.GetSlope
Vehicle.GetSpeed

Co-simulate with CARLA
Implemented by MathWorks Consulting Services. Learn more at <https://www.mathworks.com/services/consulting>.

Parameters

Kind: **Client.GetClientVersion**

Sample time: -1

Return receive: []

Referenced: []

Configuration: []

Kind: **Client.GetClientVersion**

Sample time: -1

Return receive: []

Referenced: []

Configuration: []

Actor.GetTransform
Actor.Destroy
Actor.DisableConstant
Actor.EnableConstant
Actor.GetAcceleration
Actor.GetActorAngular
Actor.GetLocation
Actor.GetTransform
Actor.GetVelocity
Actor.SetEnableGrav
Actor.SetLocation
Actor.SetSimulatePhy
Actor.SetTargetAngu
Actor.SetTargetVeloc
Actor.SetTransform
Client.GetClientVersion

Kind: **Client.GetClientVersion**

Sample time: -1

Return receive: []

Referenced: []


Configuration: []

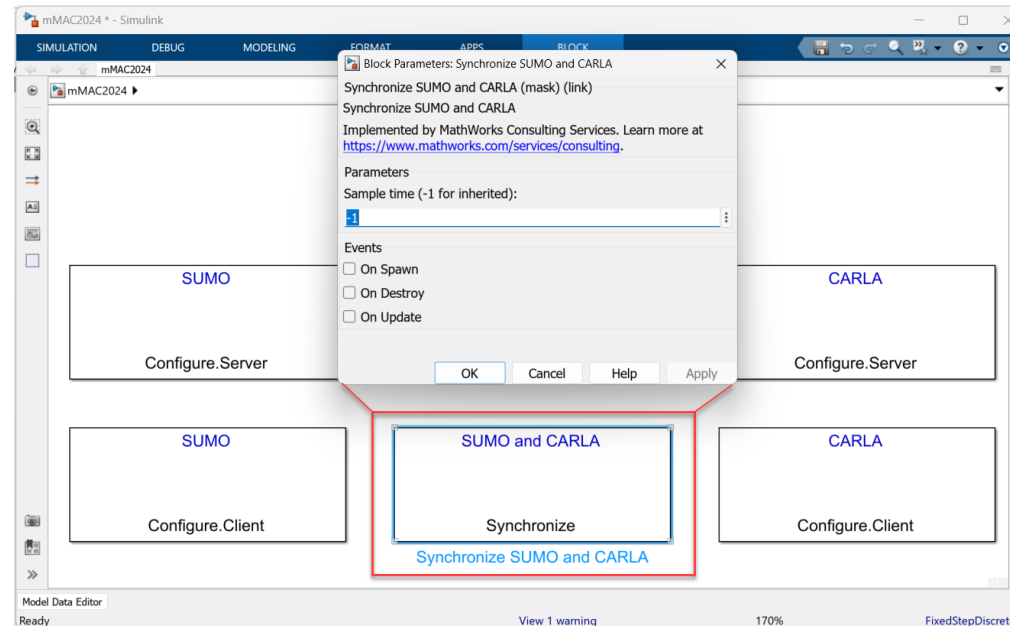
Client.GetClientVersion
Client.GetServerVersion
Sensor.Camera.CustomSegmentation
Sensor.Camera.Depth
Sensor.Camera.InstanceSegmentation
Sensor.Camera.RGB
Sensor.Camera.SemanticSegmentation
Sensor.Lidar
Sensor.Radar
Vehicle.ApplyControl
Vehicle.EnableCarSim
Vehicle.GetBoundingBox
Vehicle.SetAutopilot
World.GetSpectator
World.SpawnActor



- Single Simulink block, dropdown list for functions, link to open-source document

Synchronize SUMO, Simulink and CARLA




**Vehicle
Data**

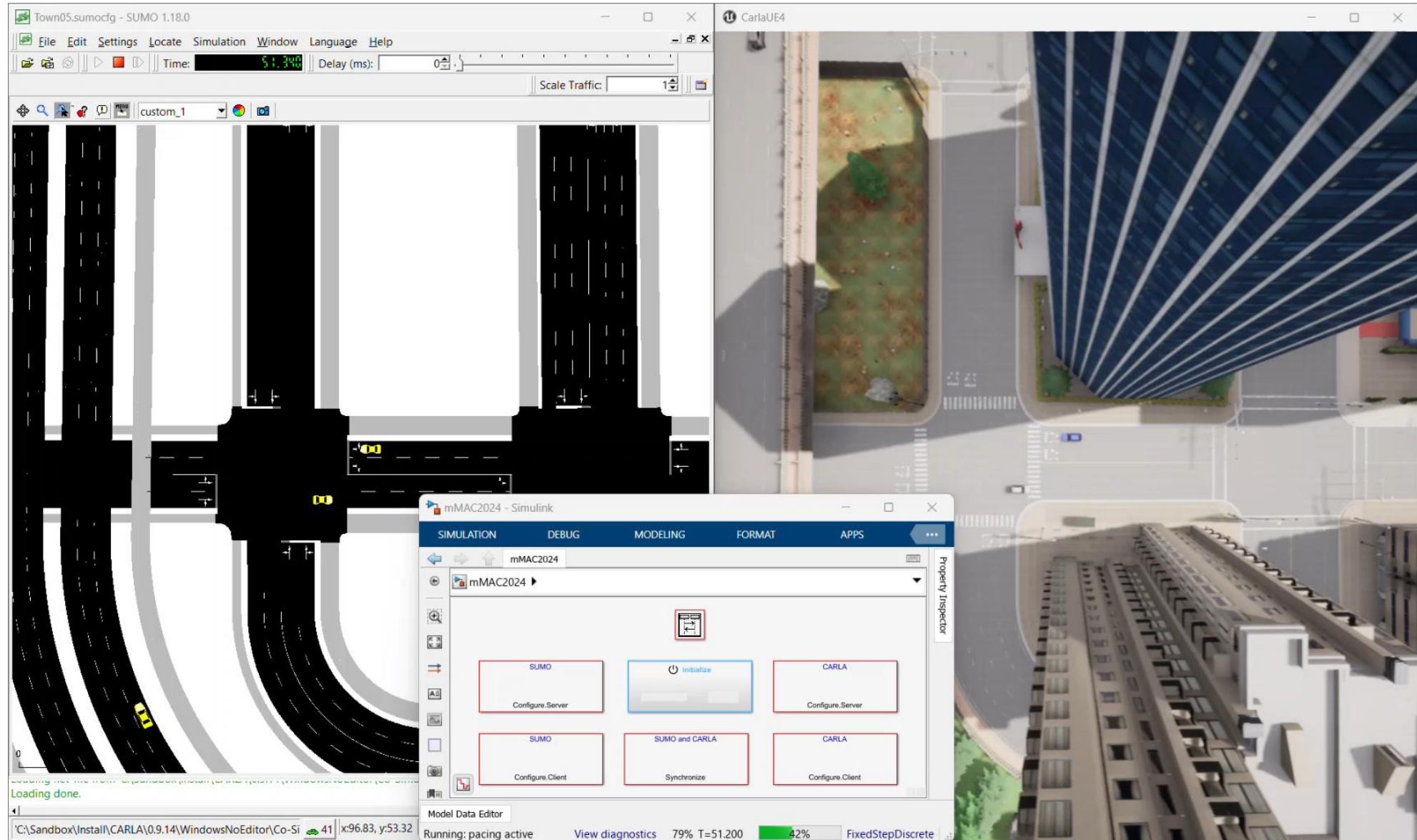



**Vehicle
Data**

Sensor Data



- SUMO handles vehicle traffic
- CARLA handles visualization and sensors
- Simulink pulls vehicle data from SUMO, pushes to CARLA

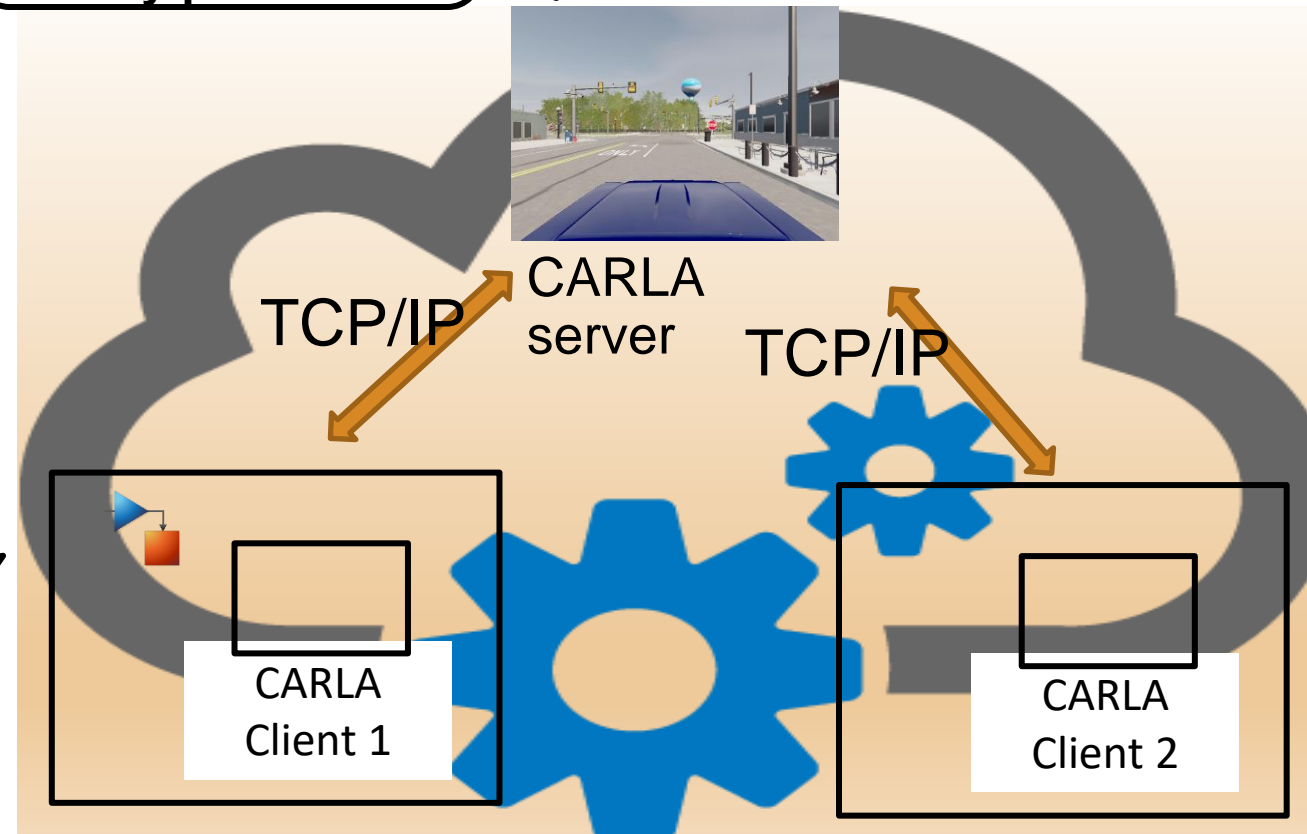
Synchronize SUMO, Simulink and CARLA



Support large scale simulation

- Co-simulation across machines and platforms

CARLA server can be launched on many platforms.

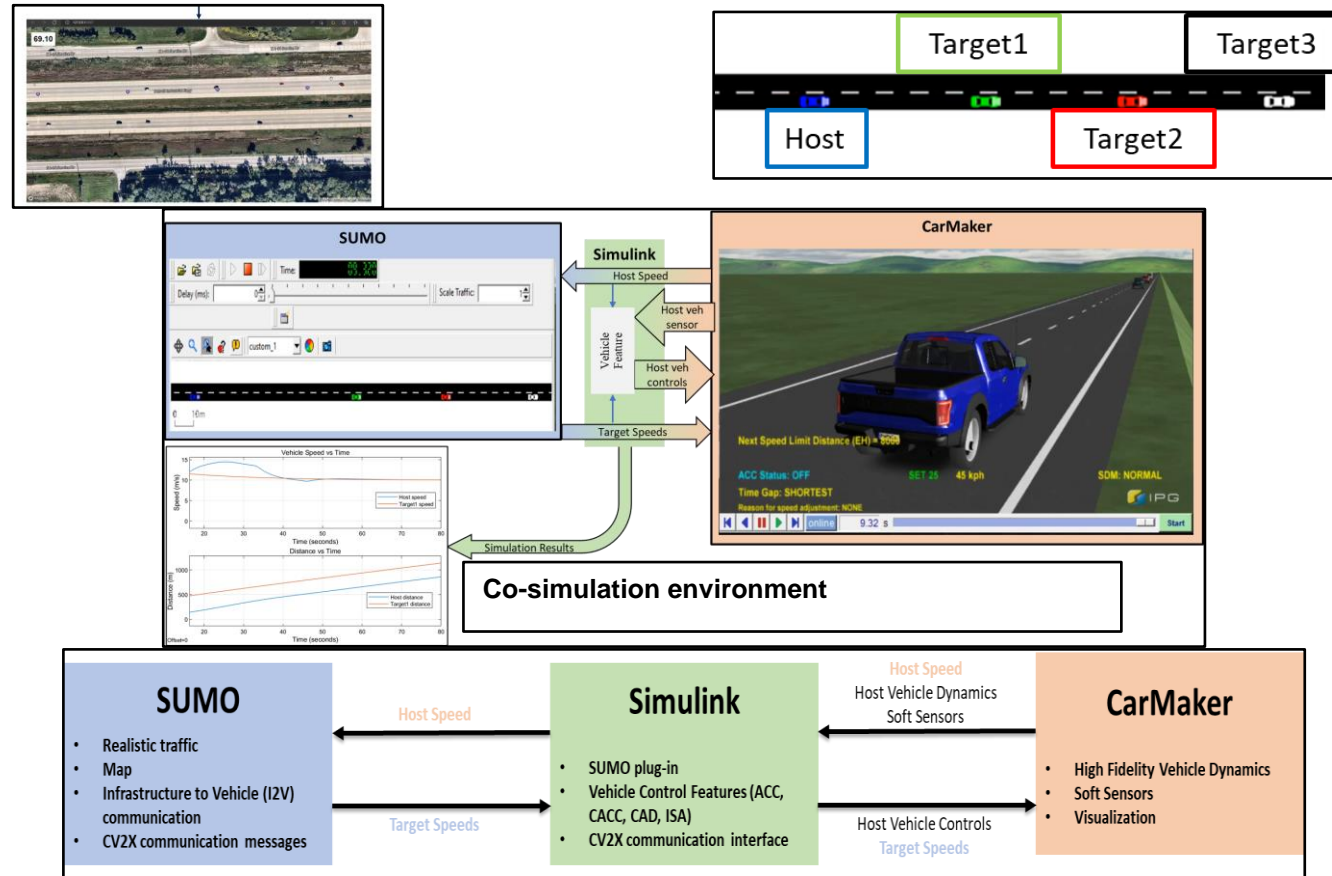


CARLA Client from Simulink is the synchronization orchestrator.

- Support cloud platform

Other CARLA Client, e.g. from Scenario Runner

Use SUMO plug-in for CACC development

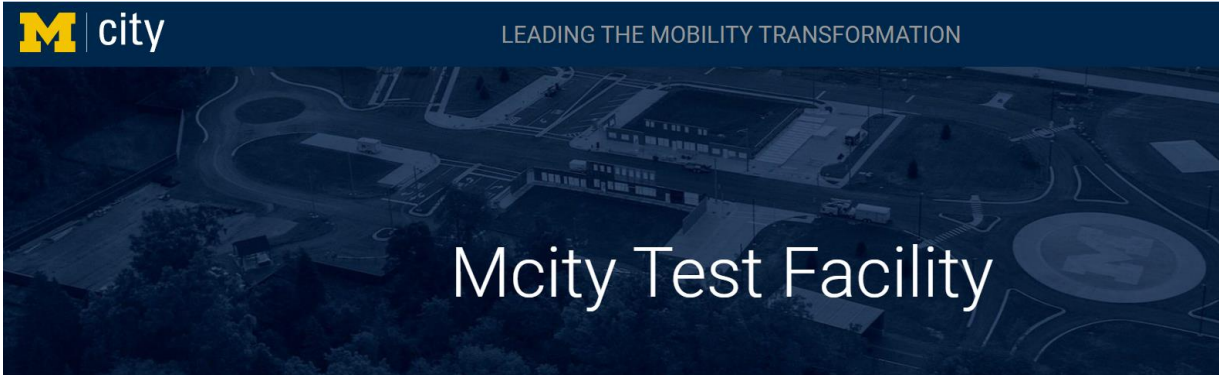


Courtesy of
Ozgenur Kavas Torris
Ford R&AE

- Co-ordinated Adaptive Cruise Control (CACC) is developed in Simulink
- Require Infrastructure-to-vehicle (I2V) and Vehicle-to-Vehicle (V2V) communications
- Enable to use SUMO traffic simulation to develop CACC
- Easy to set up and access multiple target vehicles in SUMO
- Easy to simulate the interactions among multiple vehicles with CACC

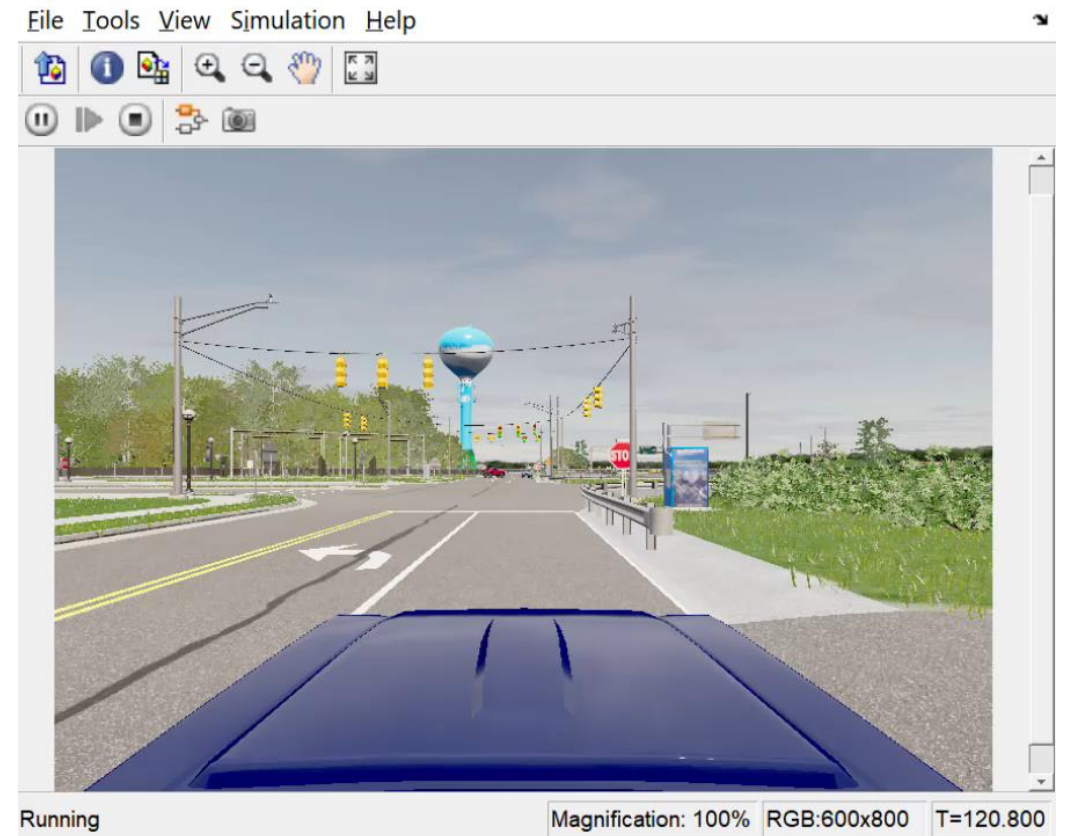
Use CARLA plug-in for simulation at Mcity

Mcity <https://mcity.umich.edu/>



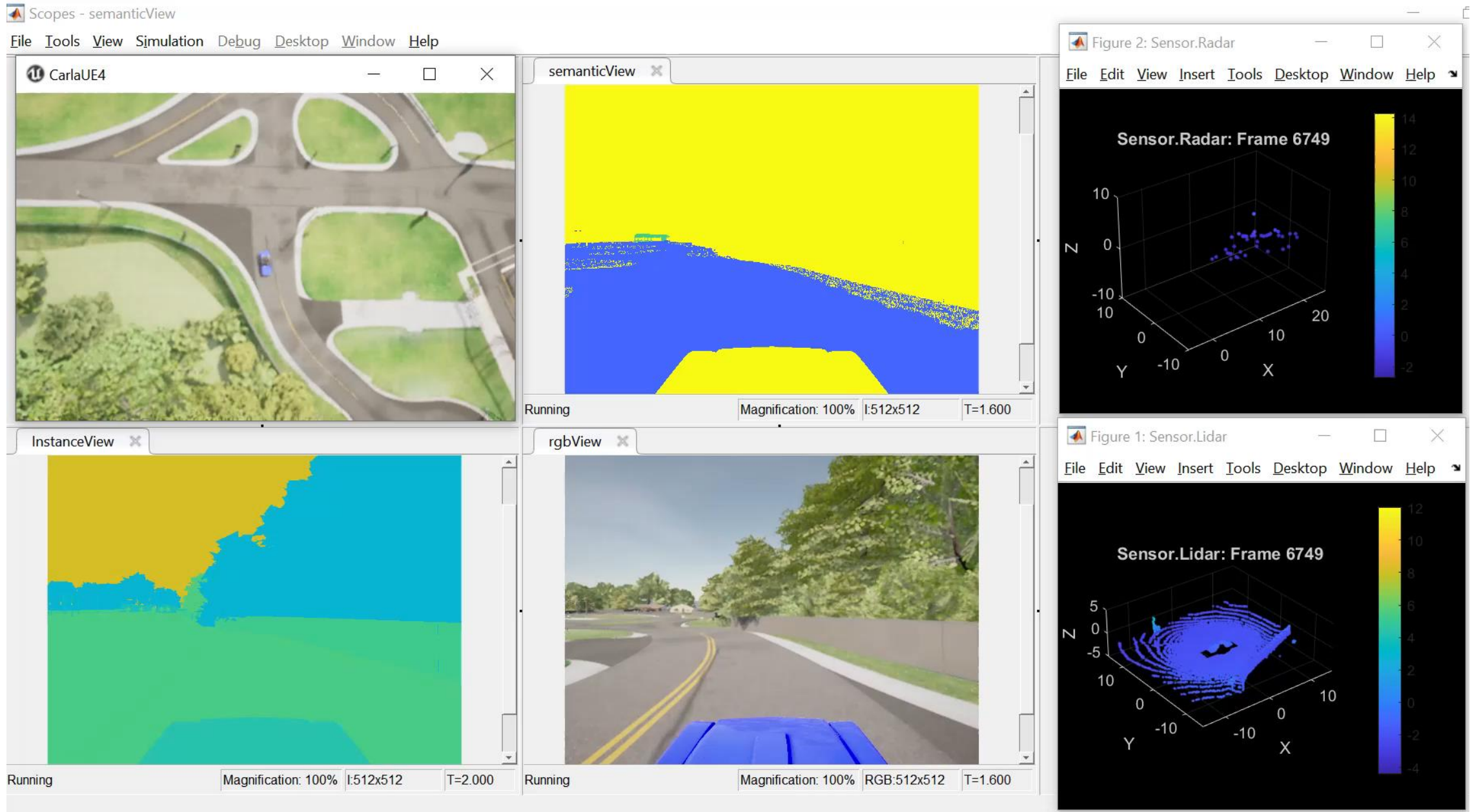
Quantum Signal AI, LLC

<https://quantumsignalai.com/>



Courtesy of Quantum Signal AI, LLC

Bring CARLA Sensor data to Simulink



Summary

- A plug-in tool for Simulink has been developed.
- Enable to co-simulate SUMO/CARLA and Simulink with ease
- Enable easy access and control of the co-simulation
- Support ADAS sensors, multi-platforms/cloud platform



Working with the Mathworks Consulting Services

- Broad experience
- High competency
- Excellent quality
- Excellent service

MathWorks
**AUTOMOTIVE
CONFERENCE 2024**
North America

Thank you

To Contact us

- Fangjun Jiang
fjiang2@ford.com
Ford Motor Company
- Chad Van Fleet
cvanflee@mathworks.com
The Mathworks, Inc.

