
# MathWorks Toolchain for Low-Velocity Maneuvering Development at General Motors

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The last hundred meters of an autonomous drive entail unique challenges: there is variability in direction (reverse, three-point turns, etc.) there are often no road markings, no GPS signal, and no map.

This is where a Self-Driving Car is at its most autonomous.


The goal of the Low Velocity Maneuvering (LVM) team at General Motors is to drive the vehicle in GPS-denied environments with high accuracy, to enable a variety of autonomous features.

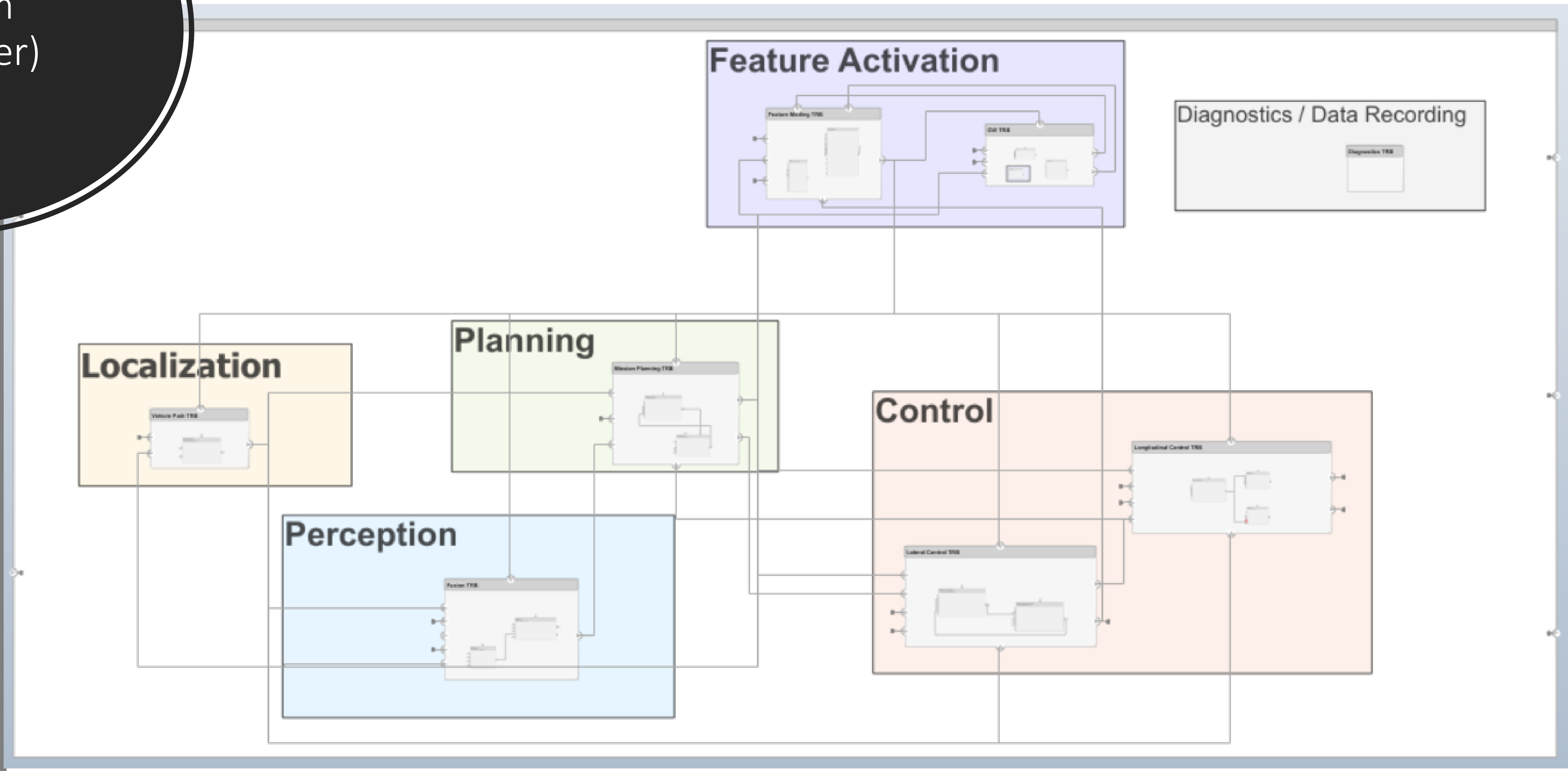
In this talk we review our LVM development cycle, emphasizing MathWorks tools utilization, starting from the architecture management, models base design development, requirements & testing coverage, MIL, SIL, HIL simulations and code generation for multiple platforms.


# Development Process Motivation

- Fast development cycle: fast transition from proof of concept to production-mature software
- Utilize the best of all worlds for simulation, development, validation and deployment:
  - **CarSim** for precise vehicle dynamics
  - **Unreal**-based fisheye photo-realistic image rendering
  - **ROS2** for visualization and debugging
  - **dSpace** for real-time validation
  - **Simulink** for Model-based design

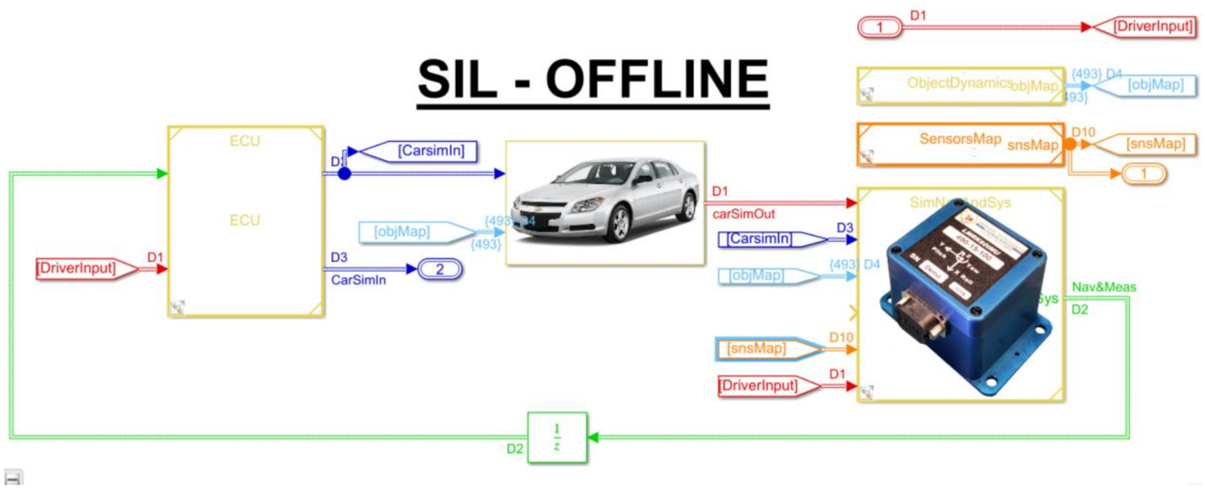
# Architecture management (System Composer)

Easy System and Architecture management – Model-based design approach

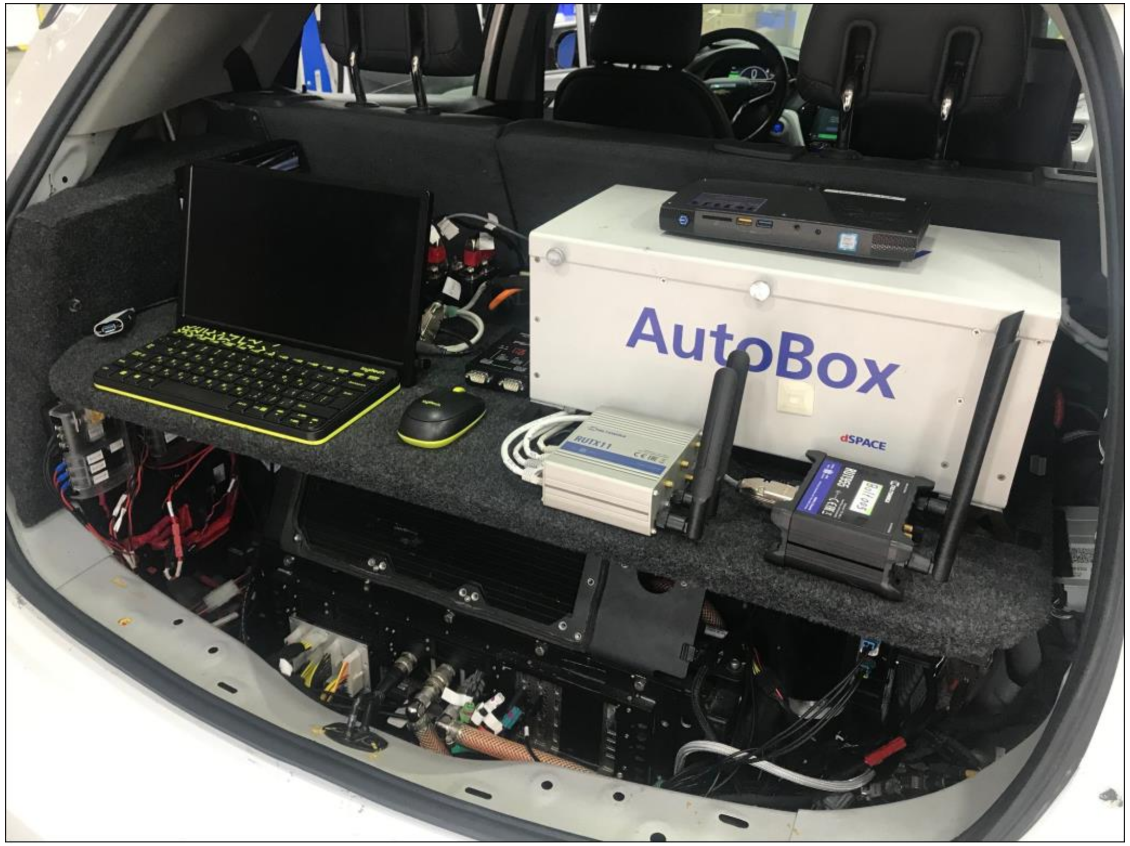


# Simulink/CarSim co-simulation (SIL)

In-house full vehicle system simulation

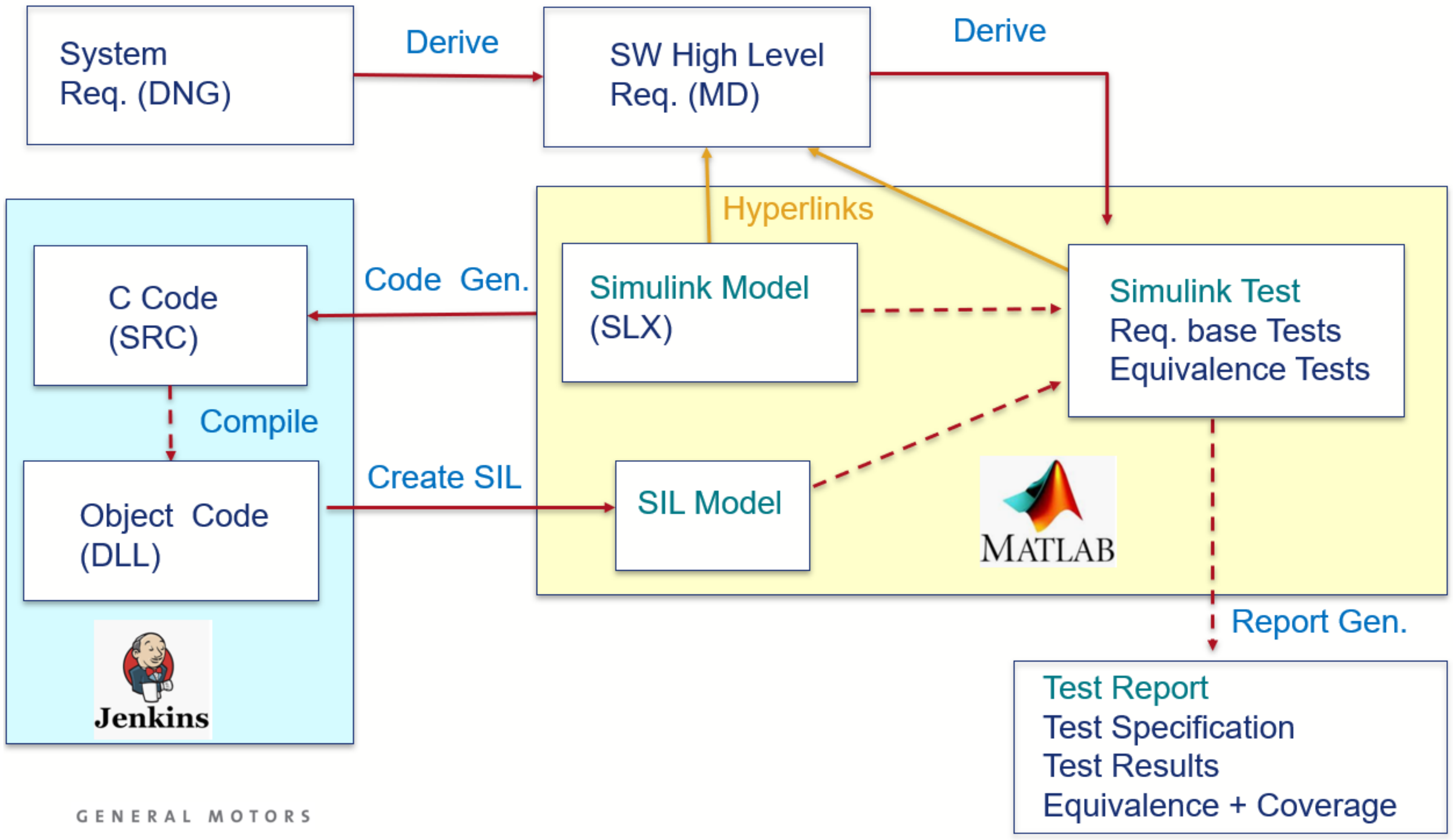


# RT HIL/Vehicle Validation –
# co-simulation (Simulink, Dspace & CarSim / Vehicle)

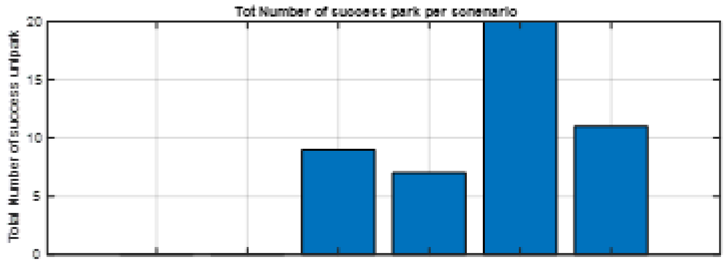
Model and Code validation – “white box”

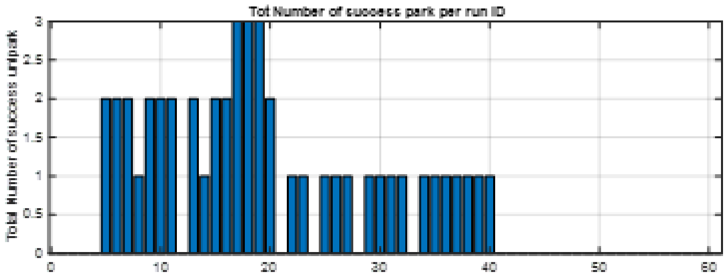
Unit-test process flowchart using Test Manager for requirements coverage analysis

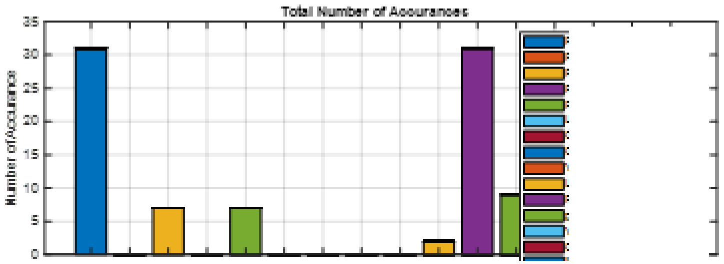


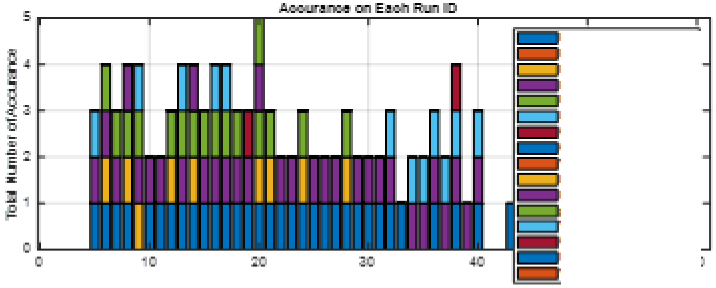
# Model Validation “Black box” (Monte-Carlo)

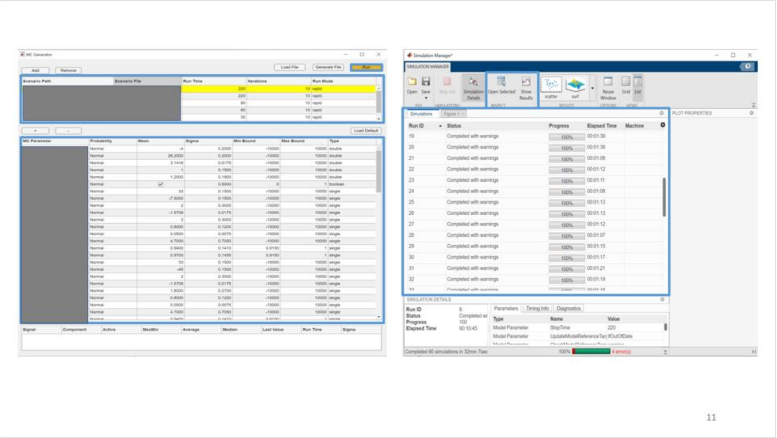
System-level module in the loop verification using Simulation Manager

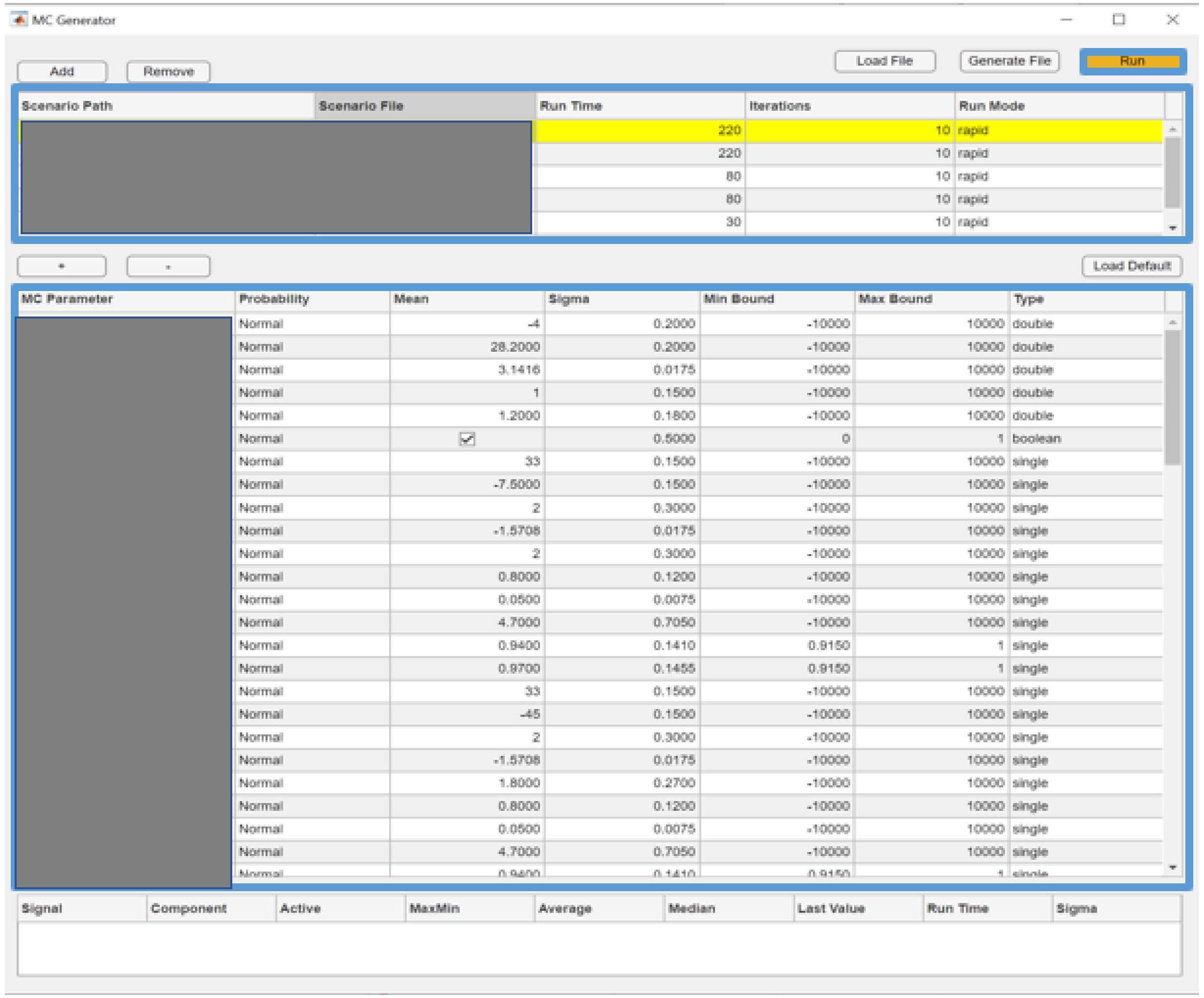
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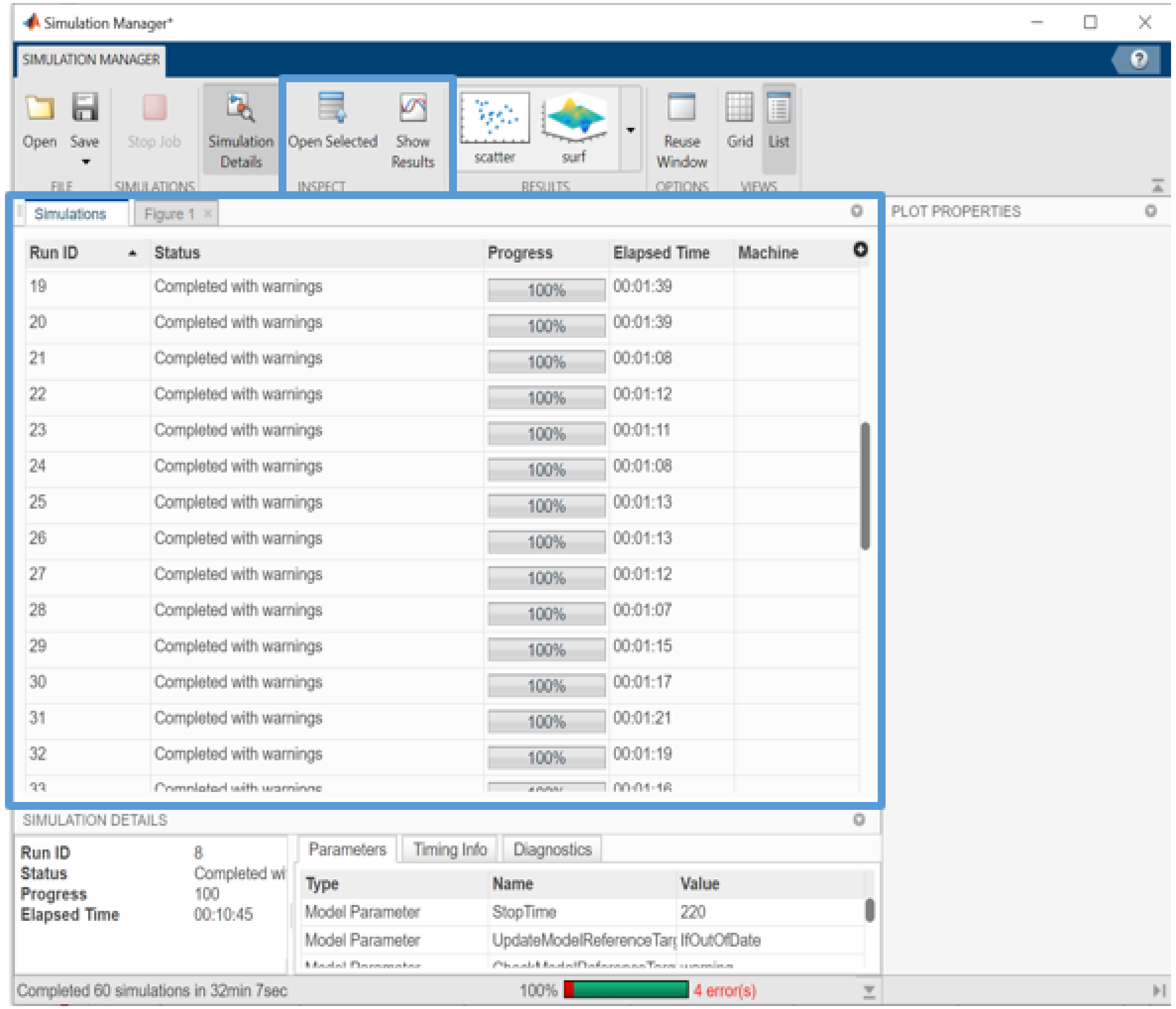
Simulation Manager*
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32 Completed with warnings 100% 00:01:19
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Status Completed wi
Progress 100
Elapsed Time 00:10:45
Parameters
Timing Info
Diagnostics
Type
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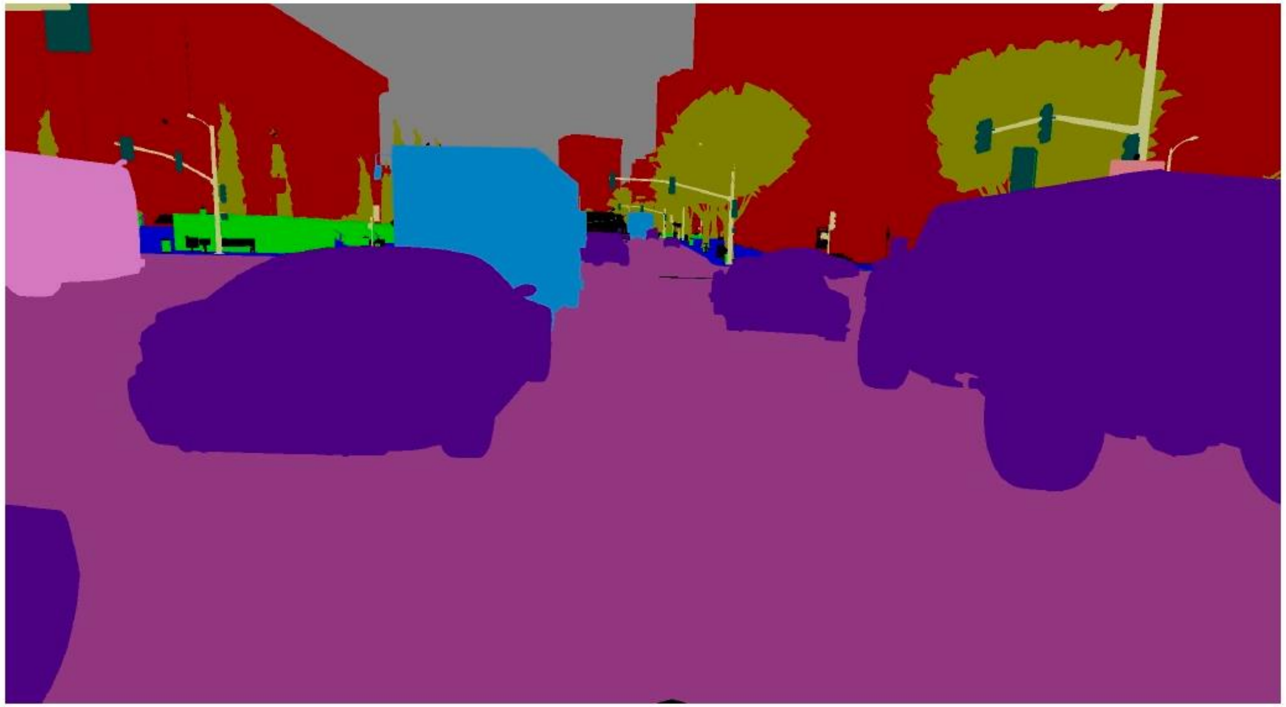
Value
Model Parameter StopTime 220
Model Parameter UpdateModelReferenceTarg IfOutOfDate
Completed 60 simulations in 32min 7sec
100%
4 error(s)

# Adding vision perception to system simulation

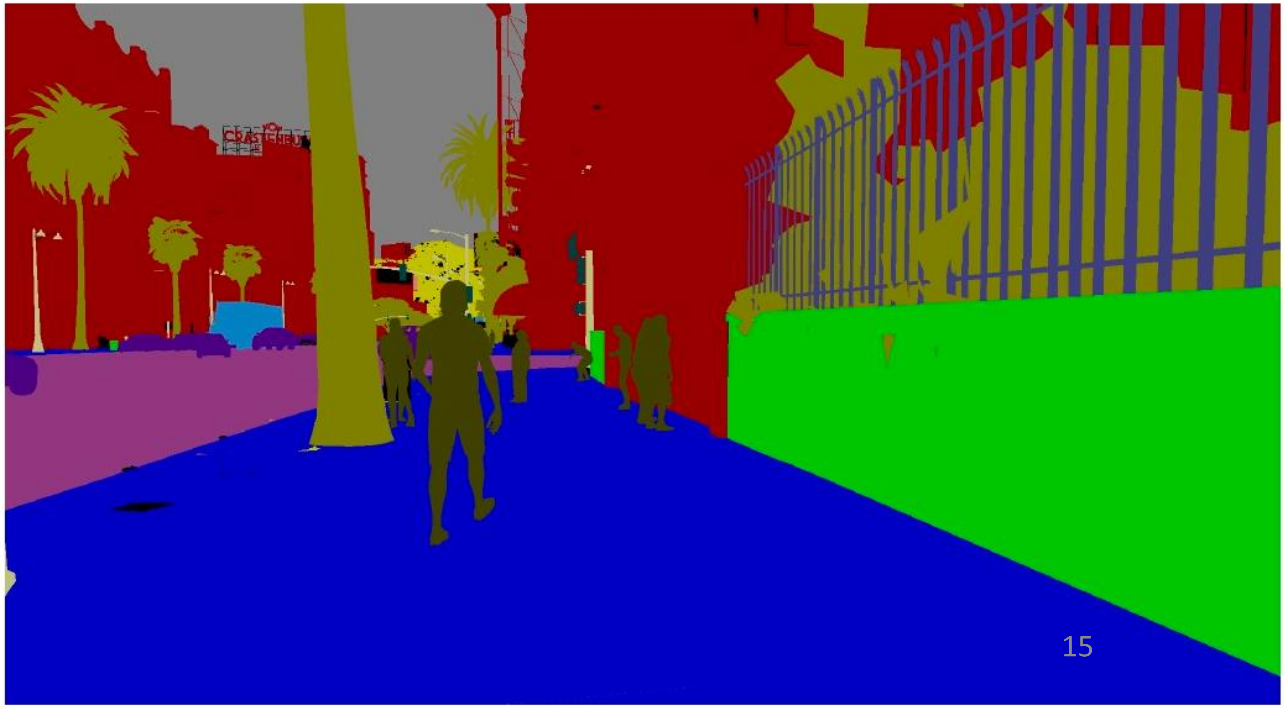
Photorealism

# Requirements: Fisheye Image Generation


# Requirements: Simulated Weather Effects

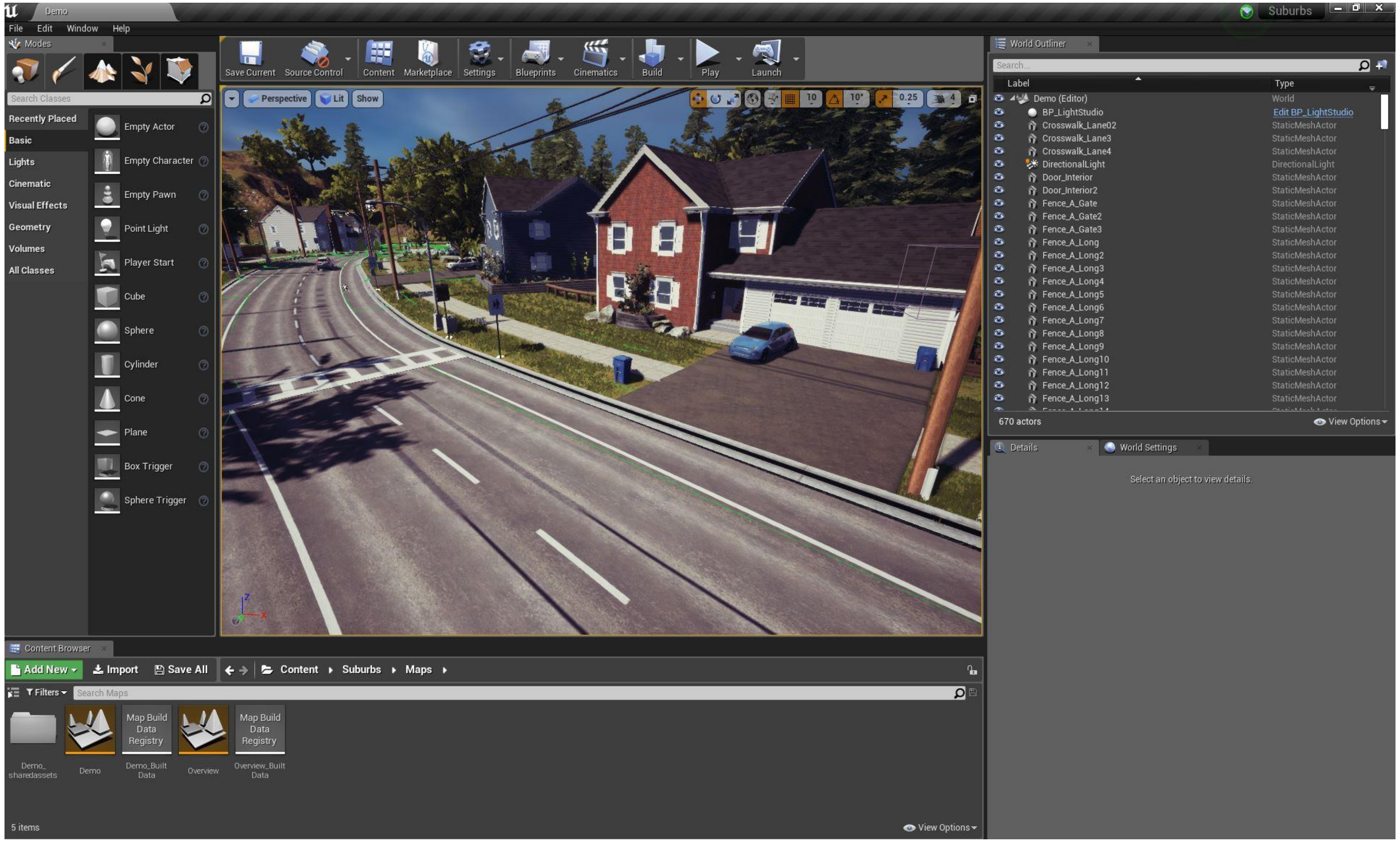


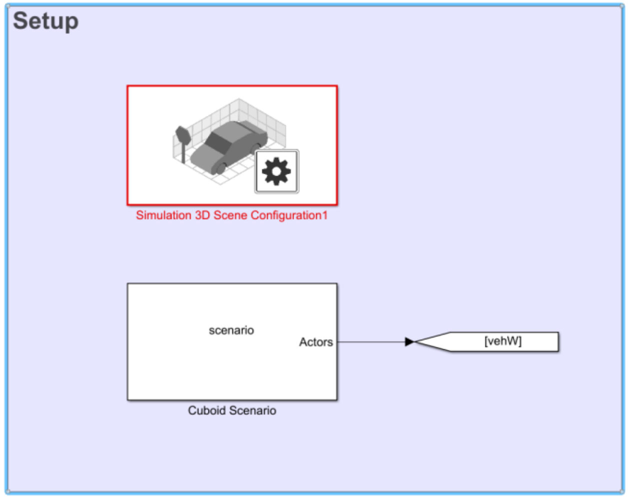
# Requirements: Ground Truth

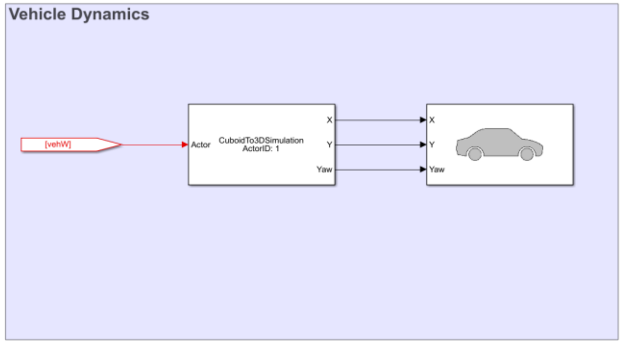


# Requirements: Recording and Visualization

# Photorealism (Unreal Engine Interface)

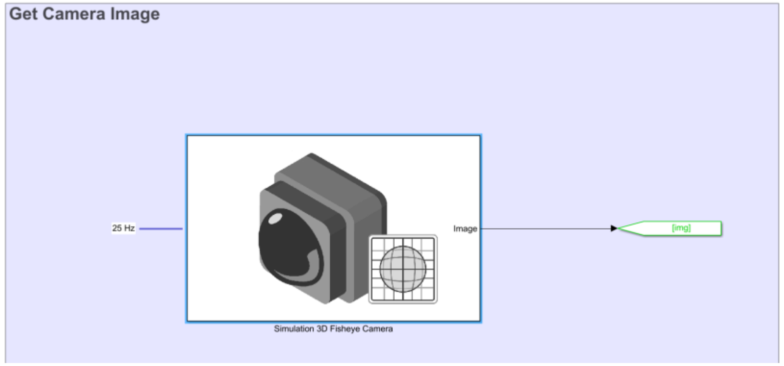


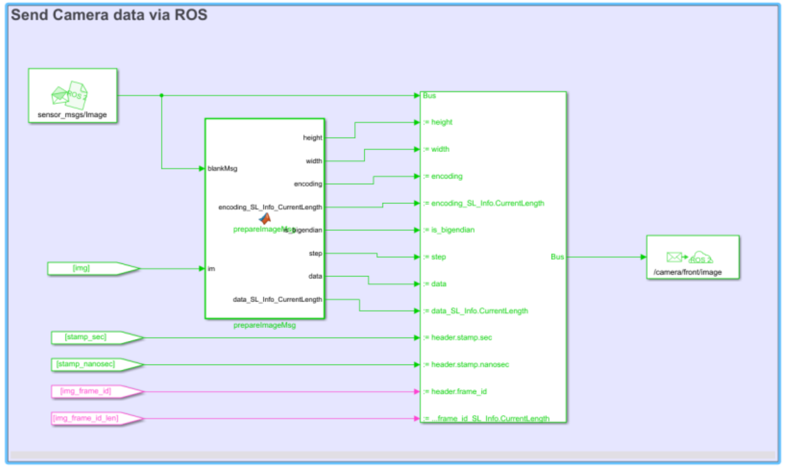




Interface with Unreal Engine enables state of the art photorealistic images in a variety of scenarios

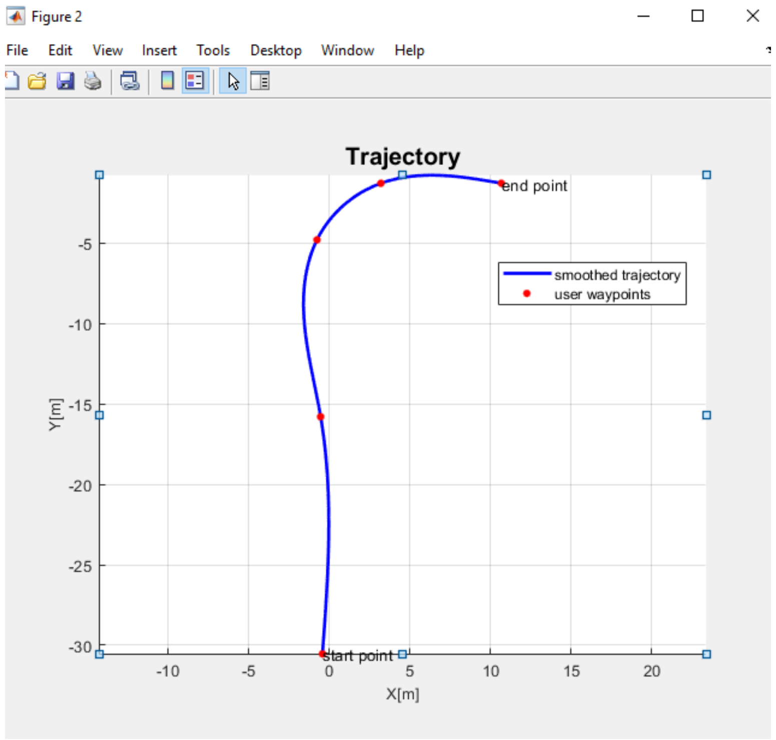
# Fisheye Image Generation



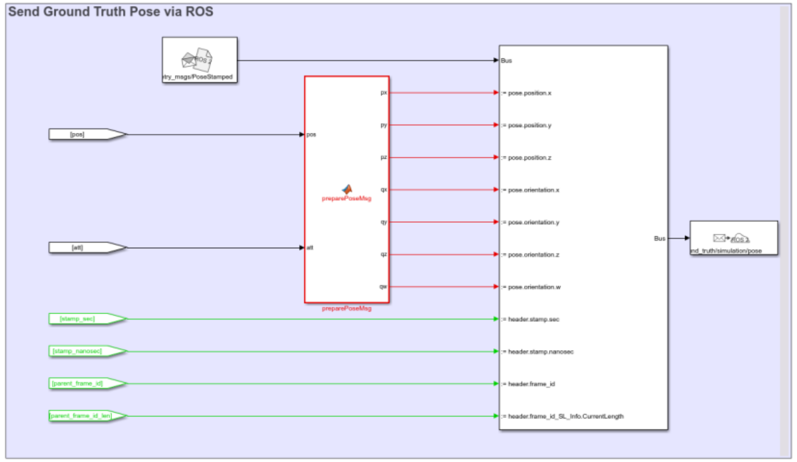




Unique ability to generate fisheye images from Unreal
(configurable intrinsics and extrinsics)

# Ground Truth

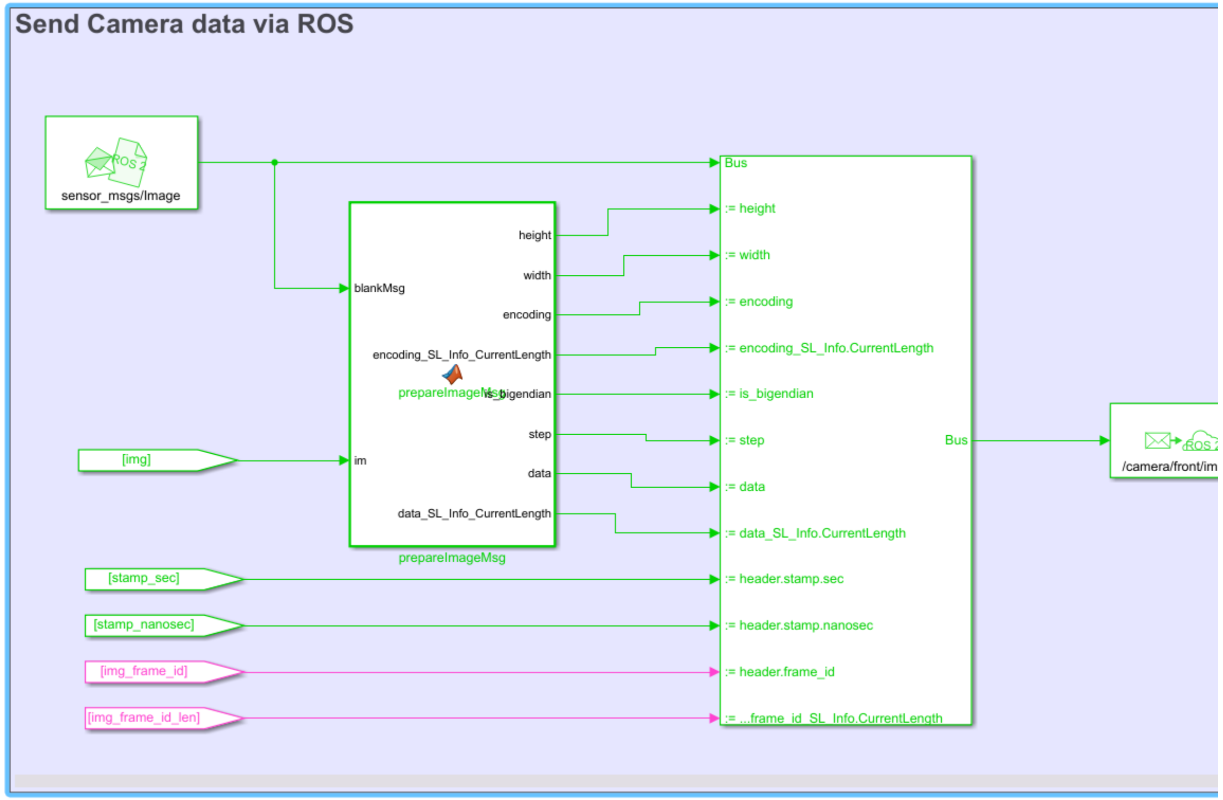


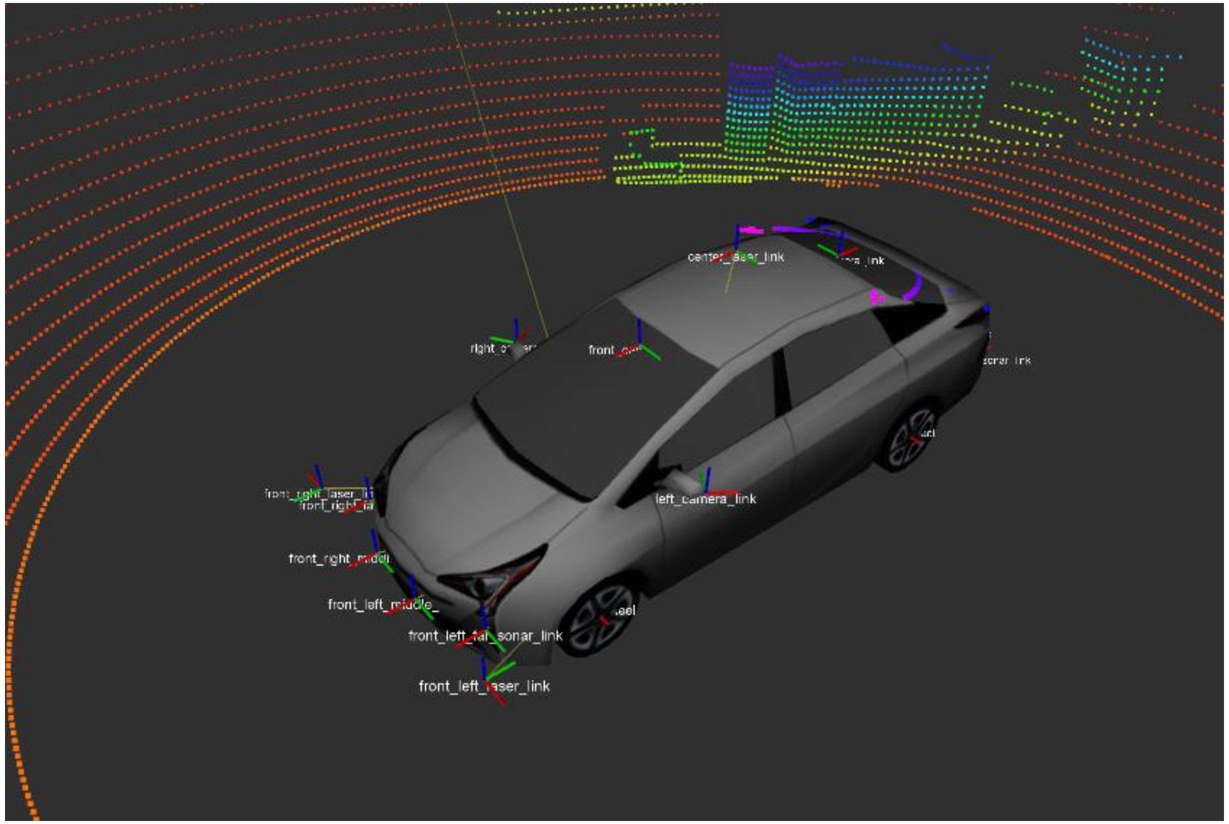




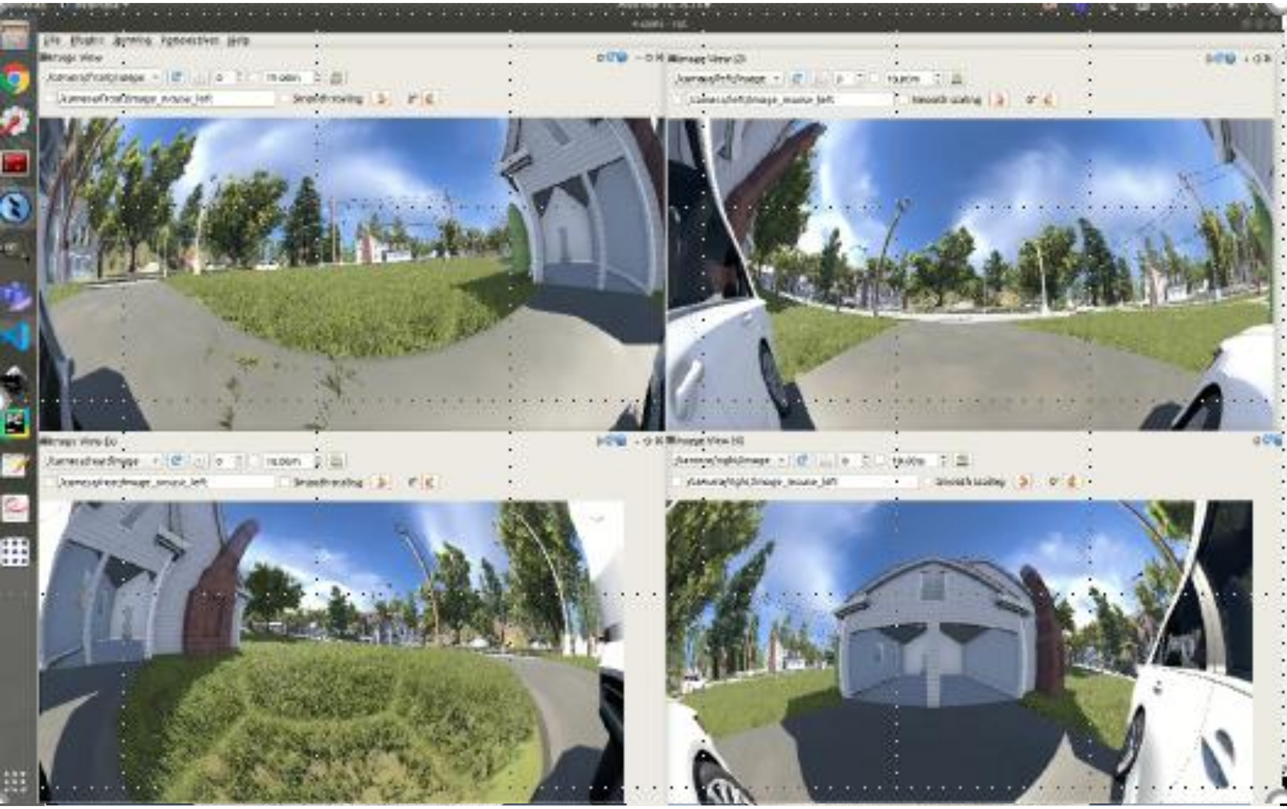

Generate route in MATLAB / Simulink and execute in Unreal

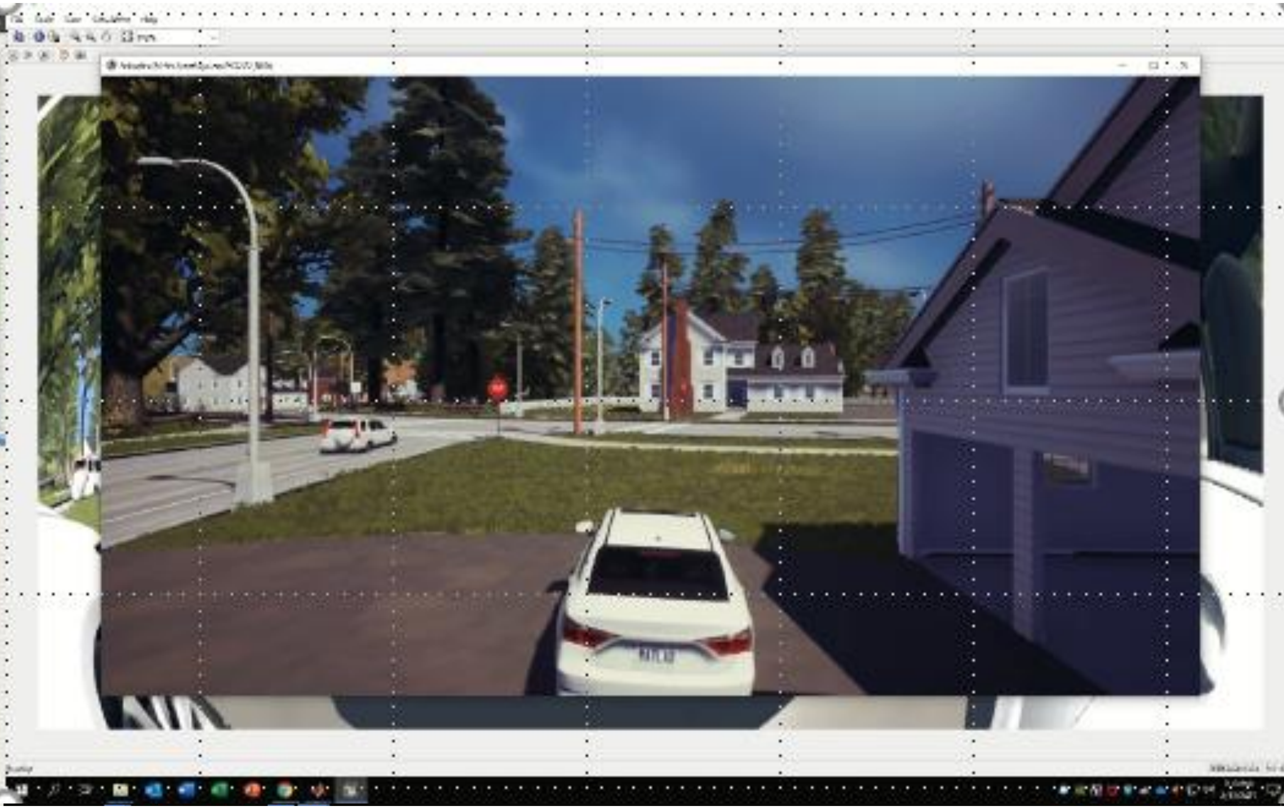
# Recording & Visualization

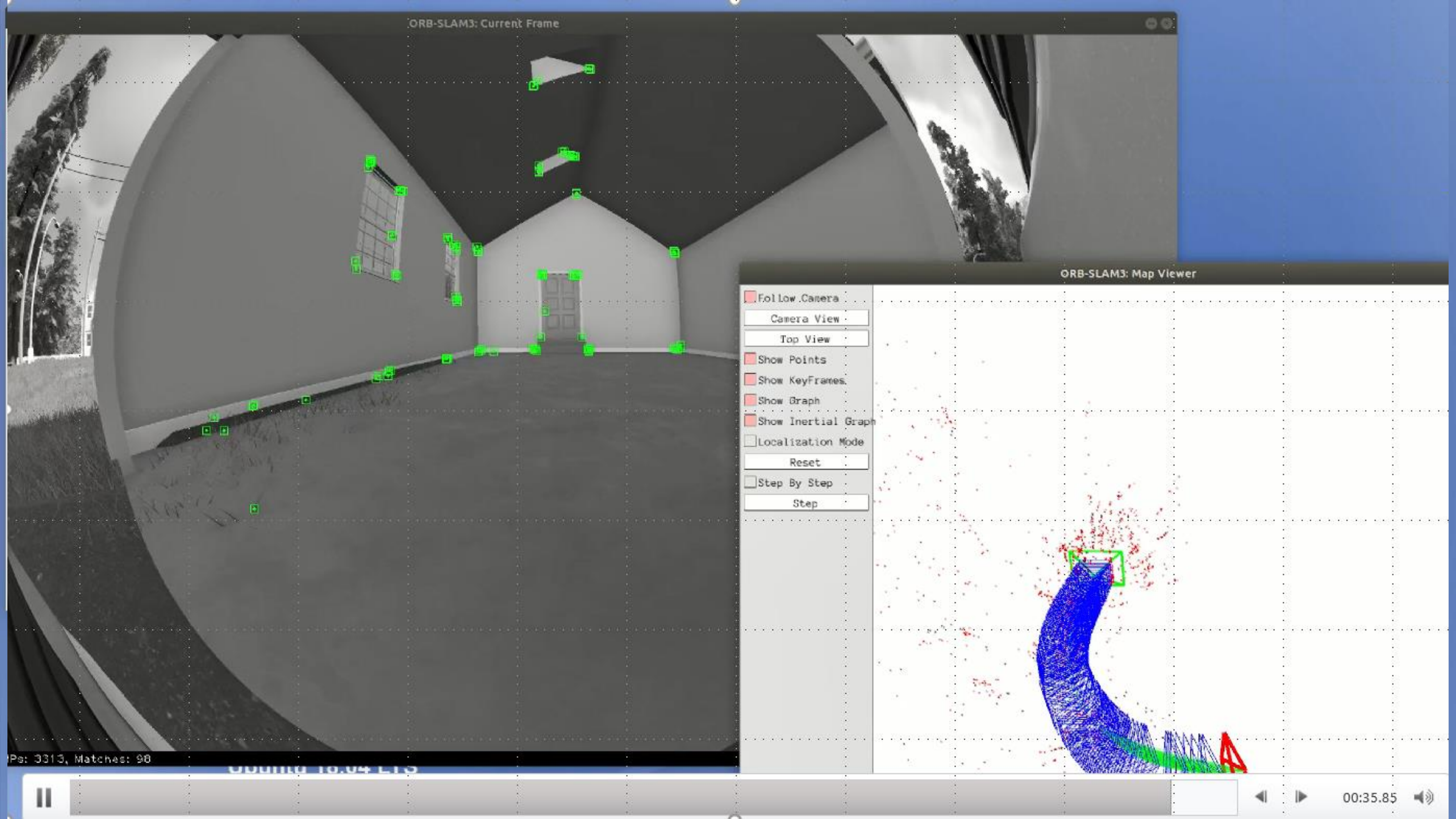



Broadcast sensor data and ground truth in standard ROS2 messages; utilize debugging and visualization tools



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ORB-SLAM3: Map Viewer
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# Wrap up

Using MATLAB/Simulink we were able to quickly:

- Manage
    - Architecture management using System Composer
- Develop
    - Control System
    - Vision Perception System
- Validate
    - Requirement-based and back-to-back testing using Simulink Test
- Deploy
    - Code generation

**Next Steps:**

- Unify control and vision development platforms
- Move to Adaptive AutoSAR architecture

# MathWorks and GM Collaborative Effort

Thank you!