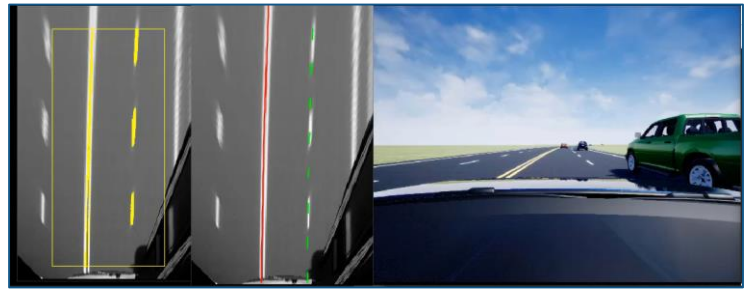
Real-Time Prototyping and Testing for ADAS: Lane Keeping and Following Assist Systems

Abhisek Roy and Rashmi Gopala Rao

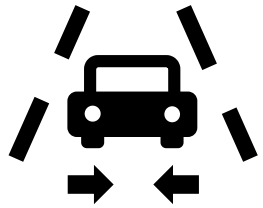
The Things You Will Learn



Virtual Vehicle

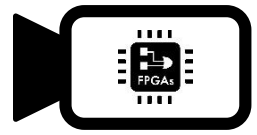
How do I perform real-time virtual vehicle simulation?

Controls



How can I rapidly prototype and test controls?

Camera Perception



How do I test perception and controls?

Fast-Track from Desktop to Real-Time Simulation and Testing

Turnkey Solution from MathWorks and Speedgoat

Create, deploy, monitor and instrument real-time applications

Outline

Part 1

Virtual Vehicle

How do I perform real-time virtual vehicle simulation?

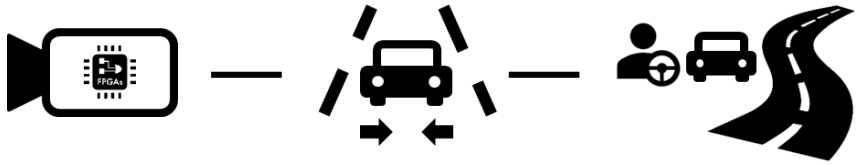
Part 2

Controls + Virtual Vehicle

How can I rapidly prototype and test controls?

Part 3

Perception + Controls + Virtual Vehicle



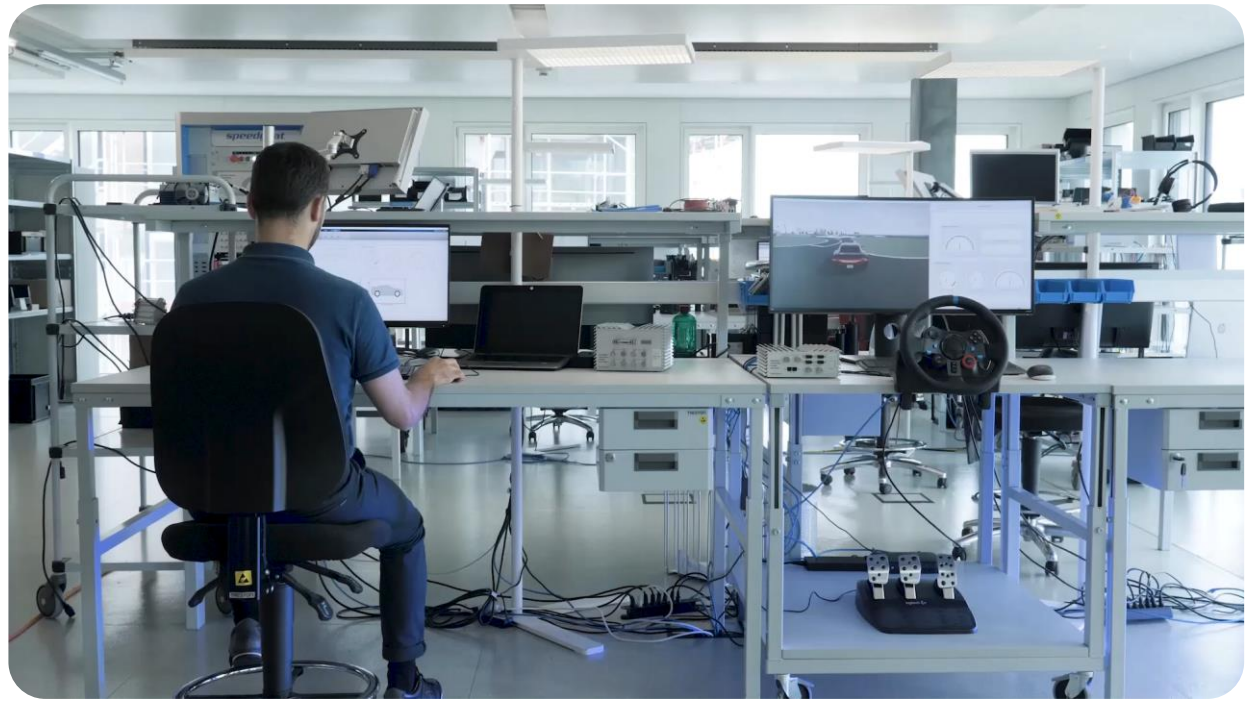
How do I test perception and controls?

Real-Time Virtual Vehicle Simulation

Part 1

Virtual Simulation

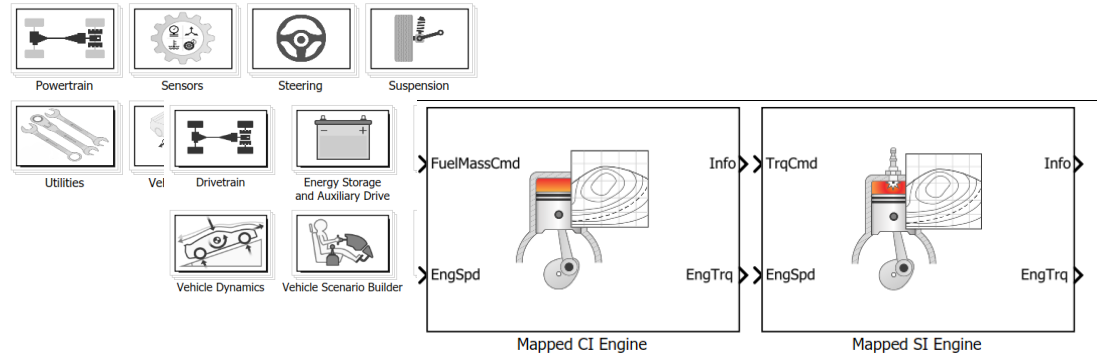
How do I perform real-time virtual vehicle simulation?



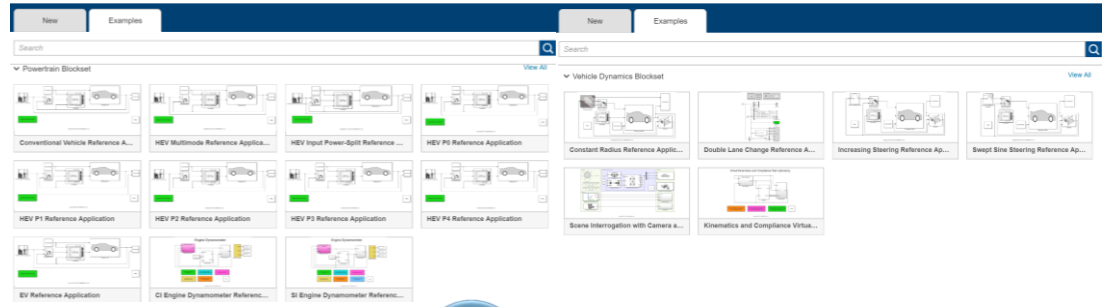
Need for Virtual Vehicle Simulation & Testing

- Prototypes are expensive
- Logistics and safety
- Early validation
- Development accelerator
- Synthetize edge scenarios
- Test handoff, platooning
- Repeatability, reproducibility
- Qualified miles

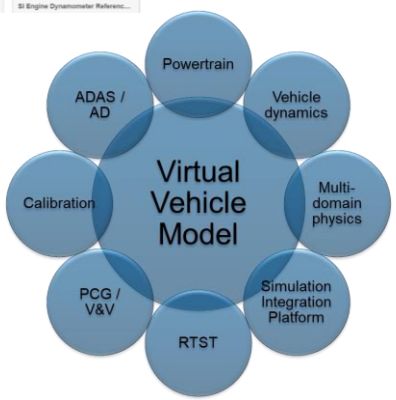
Virtual Vehicle Simulation



- Common challenges:
  - Solutions are expensive and cumbersome
  - Poor Simulink integration
  - Solutions geared towards experts

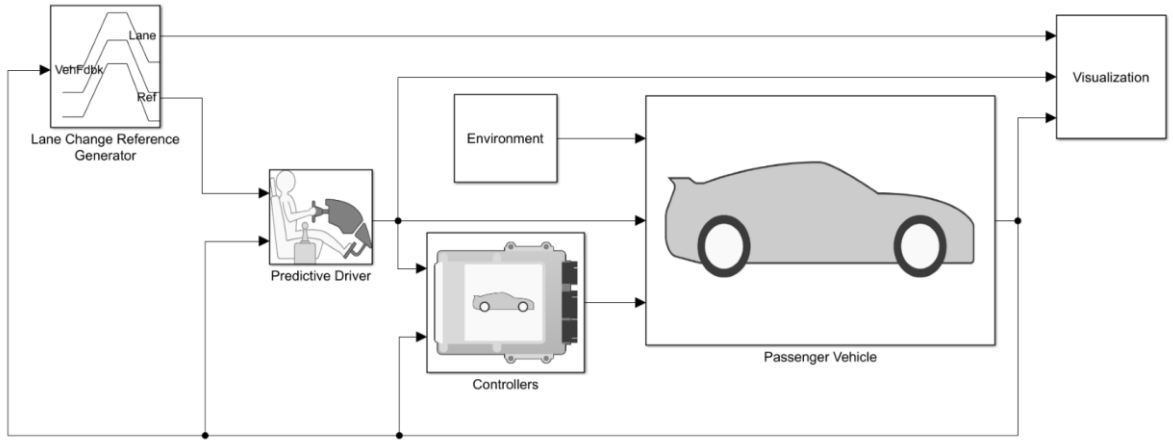


- Strengths of MathWorks solution:
  - Extensively supported
  - Open, customization possible
  - Integrated, flexible and well connected
  - **Fast, ready for Hardware-in-the-Loop deployment**



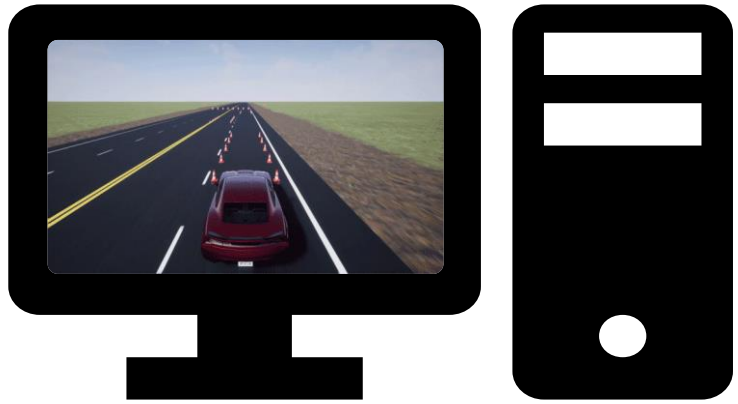
Virtual Vehicle: Desktop Simulation

[Example: Double-Lane Change Maneuver]



- *Vehicle Dynamics Blockset™*

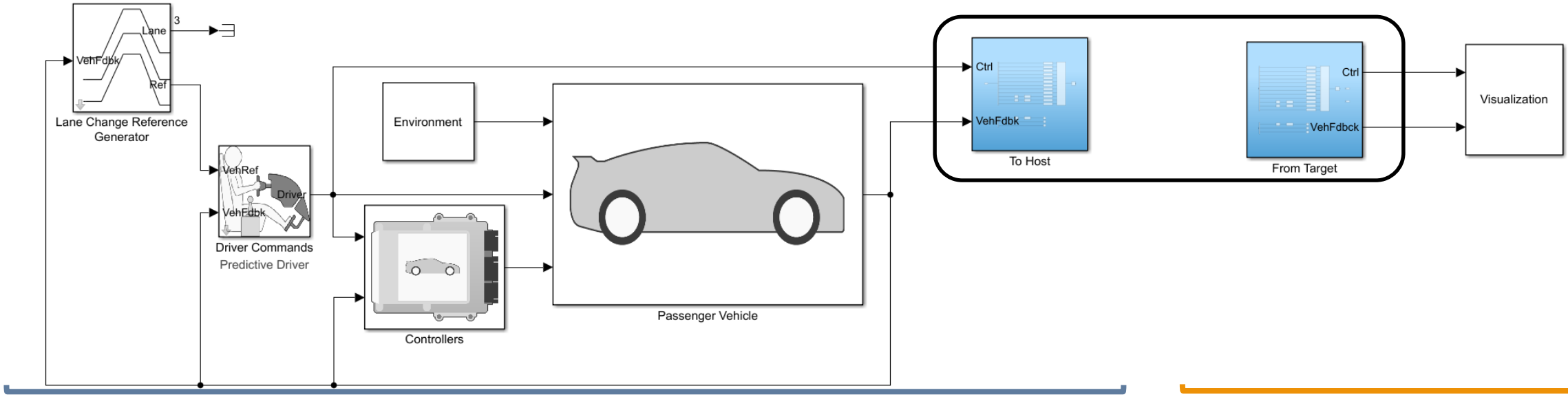
Ride & Handling



Chassis Controls

ADAS / AD

Virtual Vehicle: From Desktop to Real-Time Simulation



Real-Time Application – Virtual Vehicle

Host Application

Speedgoat target computer running Simulink Real-Time

Driver Controllers & Vehicle

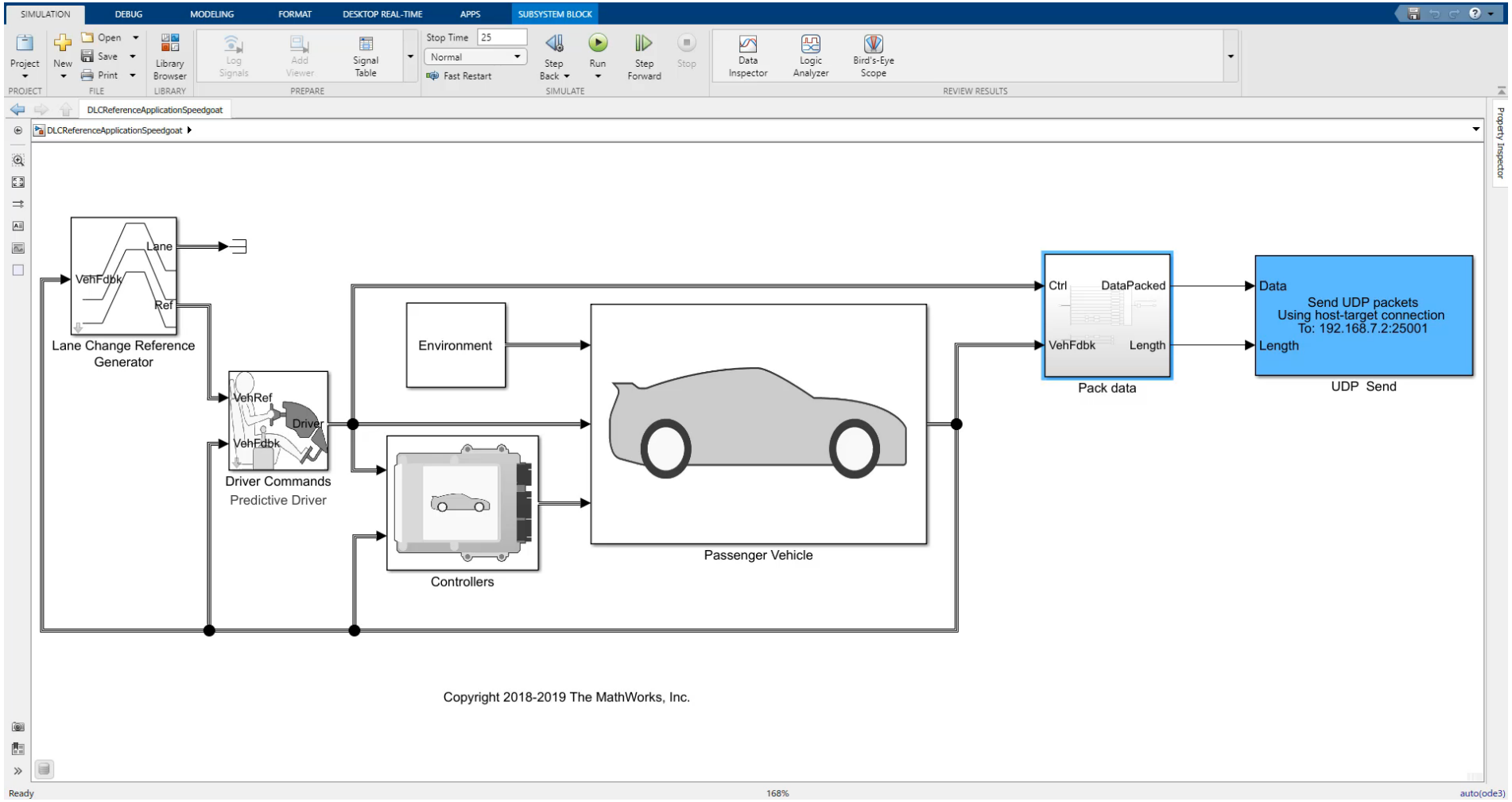
Host-target link

(Vehicle dynamics and driver control data)

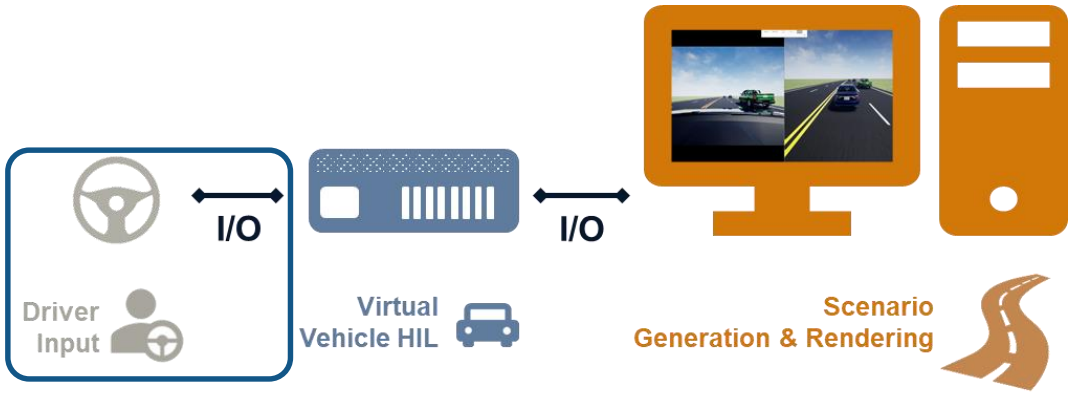
Host PC running game engine

Scenario Generation & Rendering

Virtual Vehicle: From Desktop to Real-Time Simulation

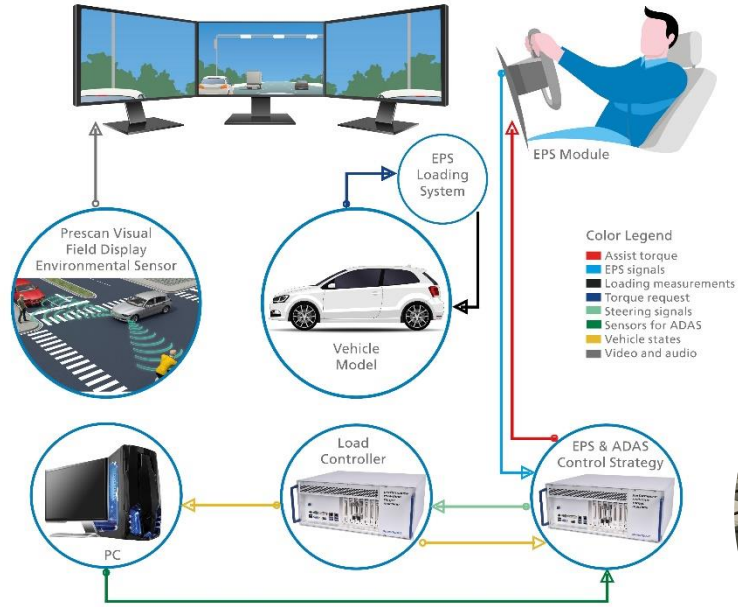


Real-Time Driver-in-the-Loop (DIL) Simulator



[Webinar: Building Real-Time DIL Simulators]

[Success story: Tongji University]



"The Speedgoat system works well with many of the tools in MATLAB. It is a very efficient way to construct the test platform so that we can concentrate on the development of the ADAS algorithm."

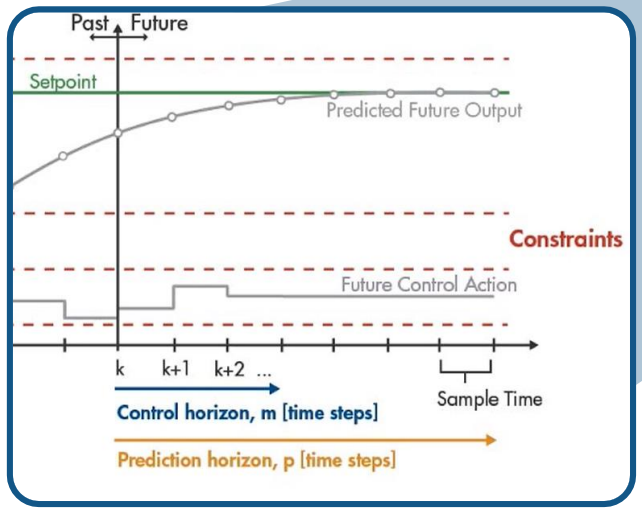
Professor Hui Chen, Tongji University

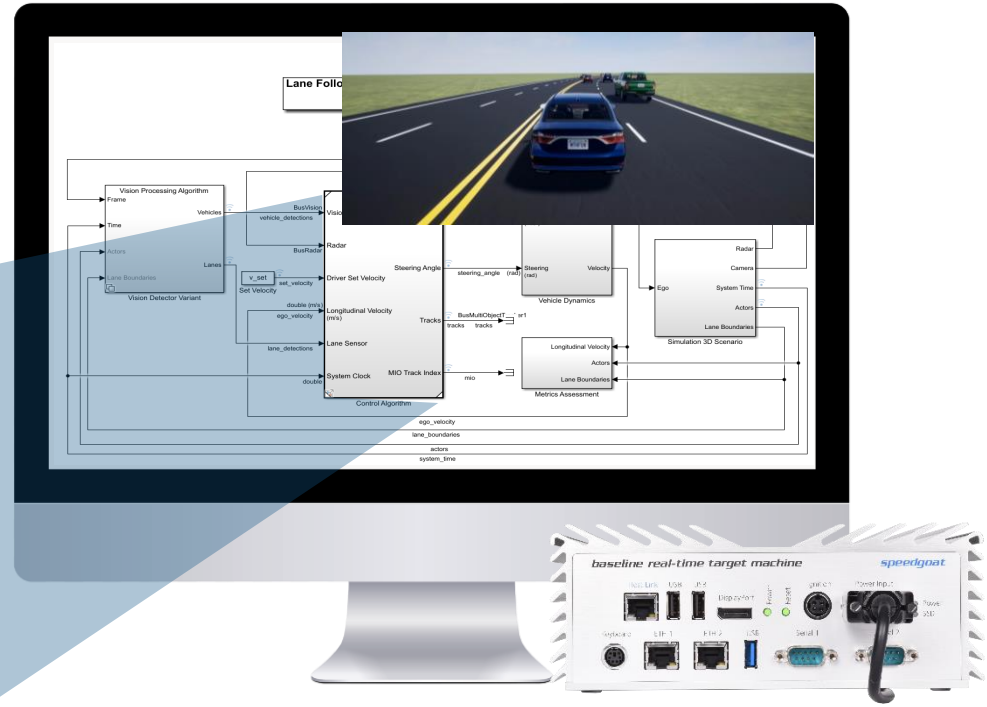
Part 2: Real-Time Prototype and Test Lane Keeping Controller

Part 2

Controls + Virtual Vehicle

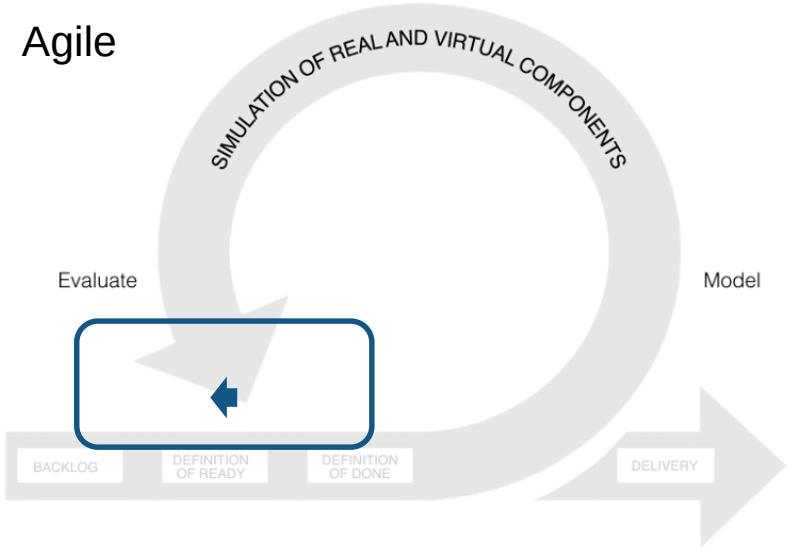
How can I rapidly prototype and test controls?



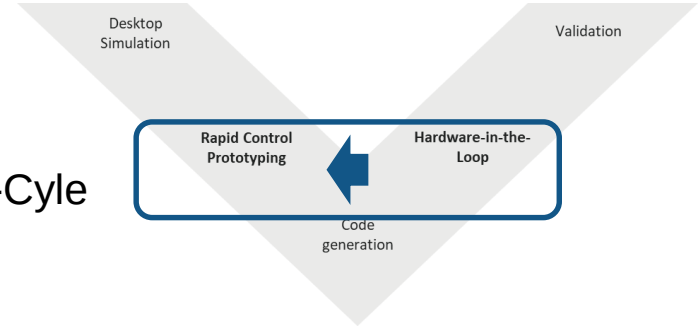


Expediting Development by Frontloading Virtual Vehicle HIL

Agile



V-Cyle

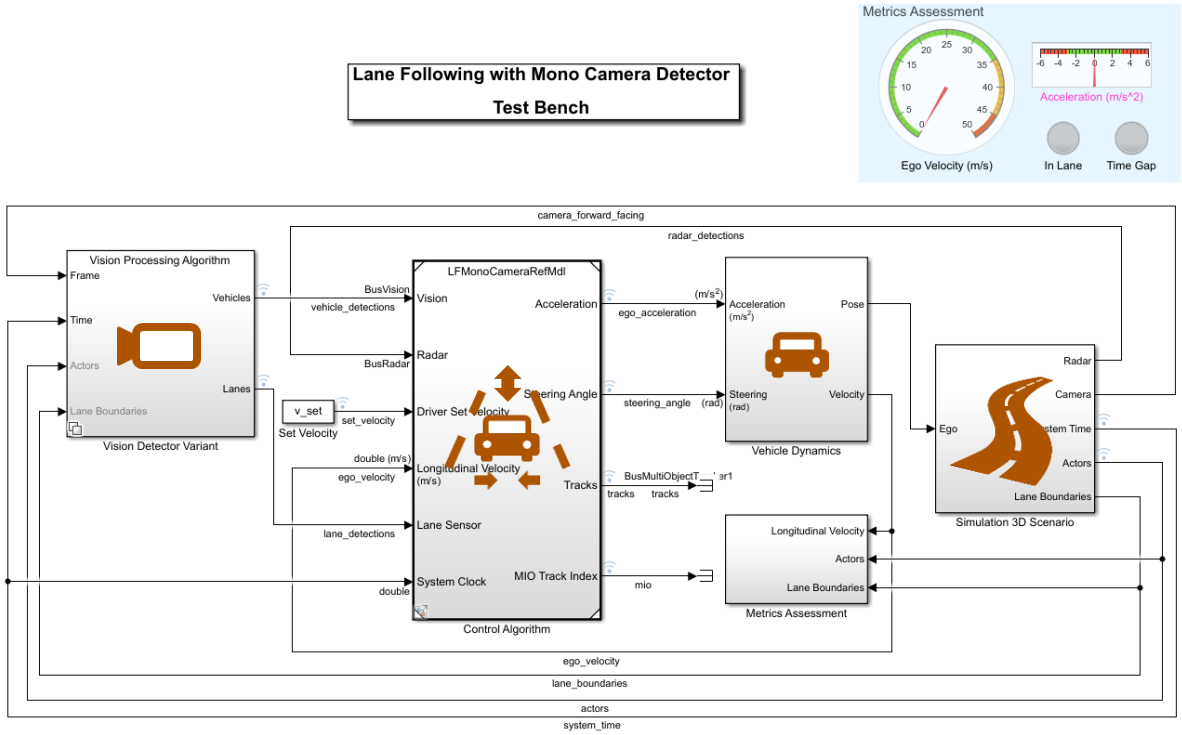


Rapid Control Prototyping

Hardware-in-the-Loop

Lane Keeping Control with Model Predictive Control

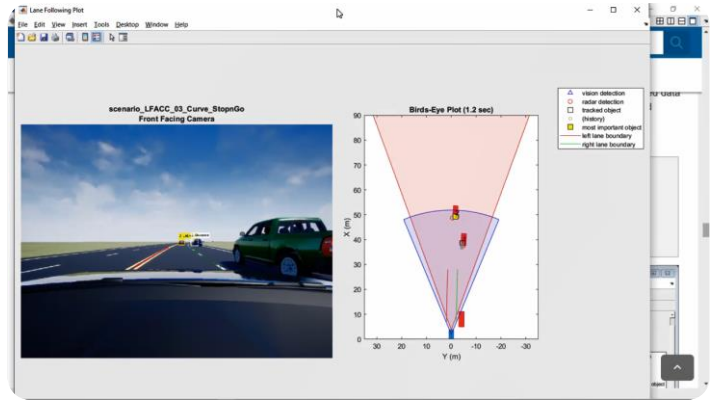
[Example: Lane-Following Control with Monocular Camera Perception]



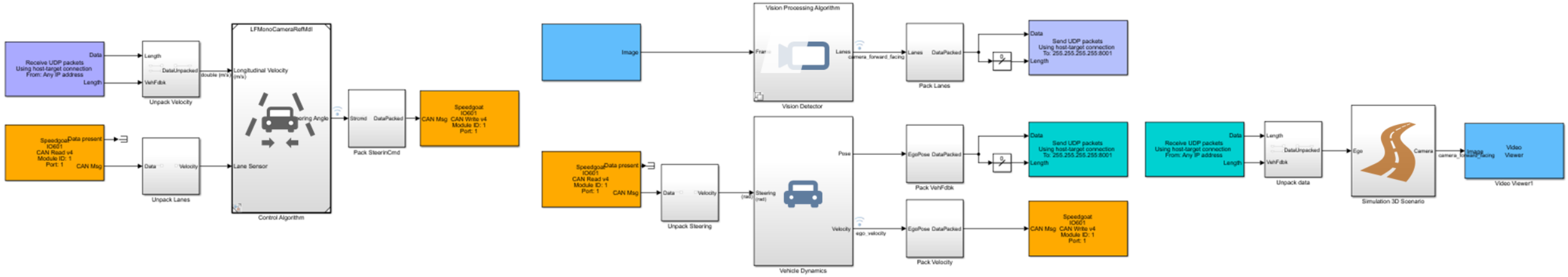
- *Automated Driving Toolbox™*
- *Model Predictive Control Toolbox™*
- *Simulink Control Design™*

Simulate controls with perception

Visualize logged simulations

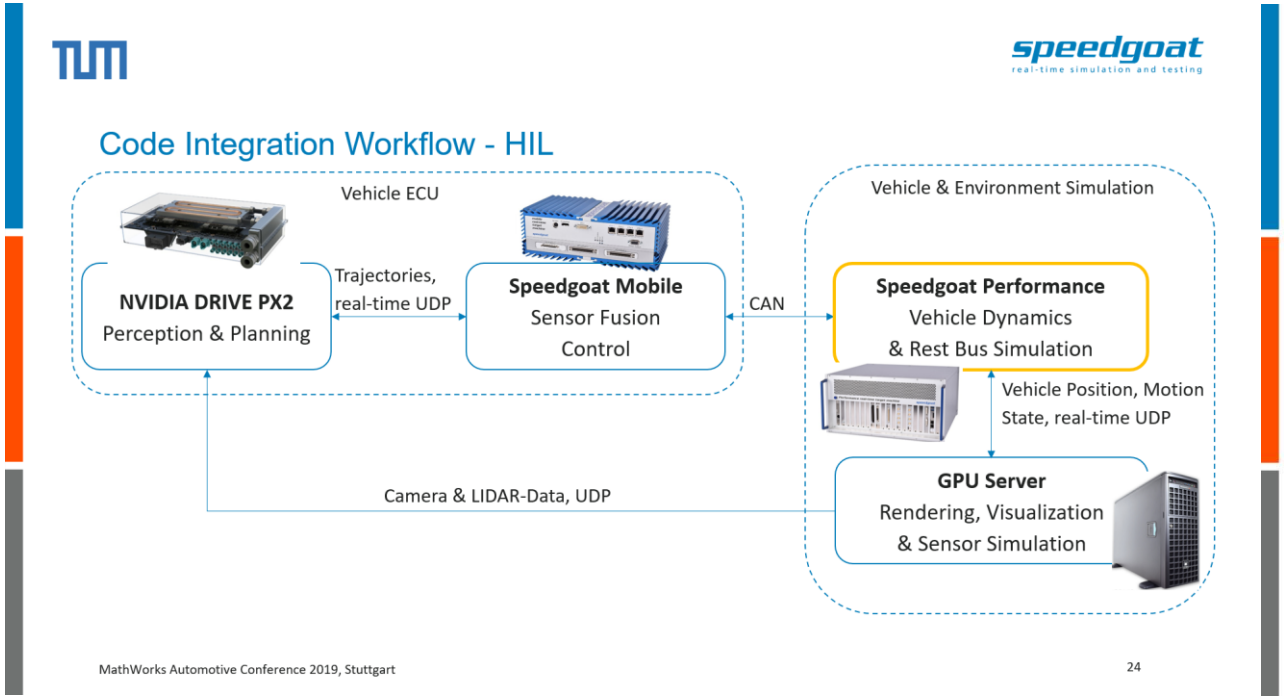


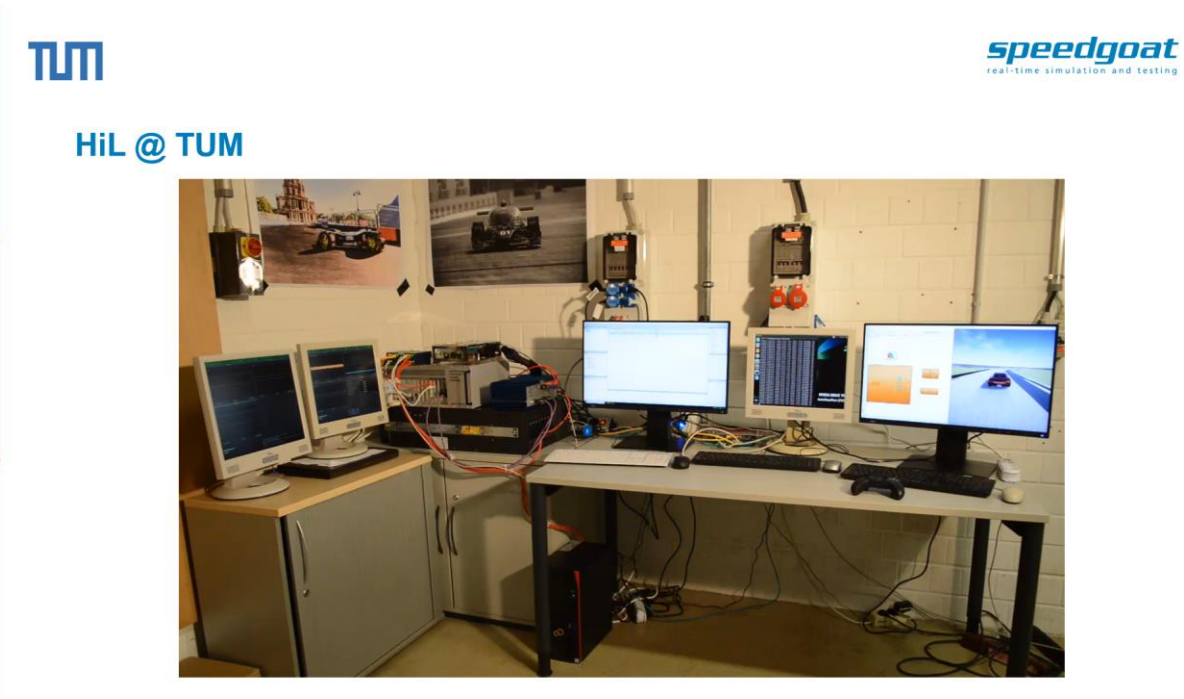
Lane Keeping Control Real-Time Test Bench



Lane Keeping Control Real-Time Testbench

Customer Success Story: TUM / Roborace





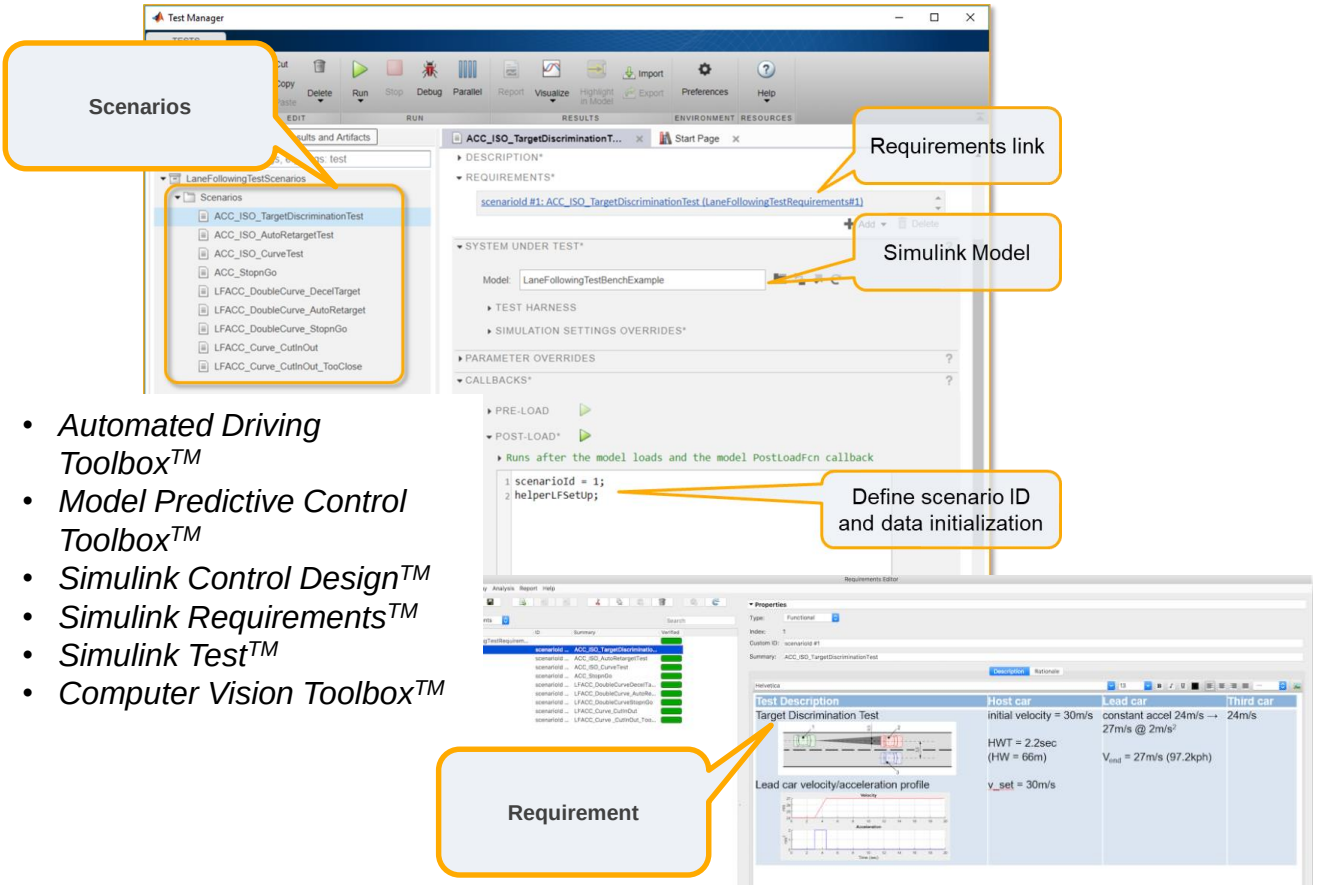
"The seamless integrated workflow provided by Speedgoat and Simulink Real-Time™ really helped us to minimize the time we had to invest building this HIL simulator and maximized the time we could spend developing the functionalities of our algorithms."

Thomas Herrmann, TUM RoboraceTeam

[MathWorks Automotive Conference 2019]

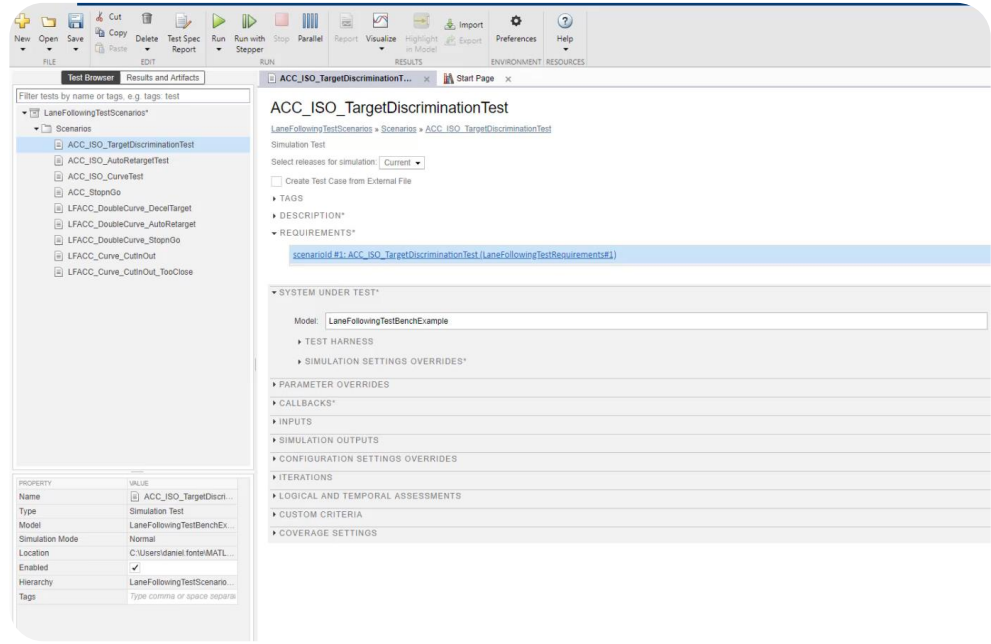
Automate Testing in Real-time

[Example: Testing a Lane Following Controller with Simulink Test]



- *Automated Driving Toolbox™*
- *Model Predictive Control Toolbox™*
- *Simulink Control Design™*
- *Simulink Requirements™*
- *Simulink Test™*
- *Computer Vision Toolbox™*

Reuse Desktop Test Cases for Real-Time Testing

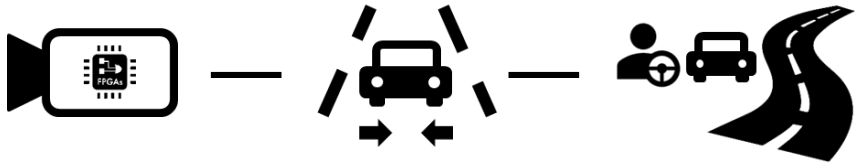


[Webinar: Test Automation - From Desktop Simulation to Real-Time]

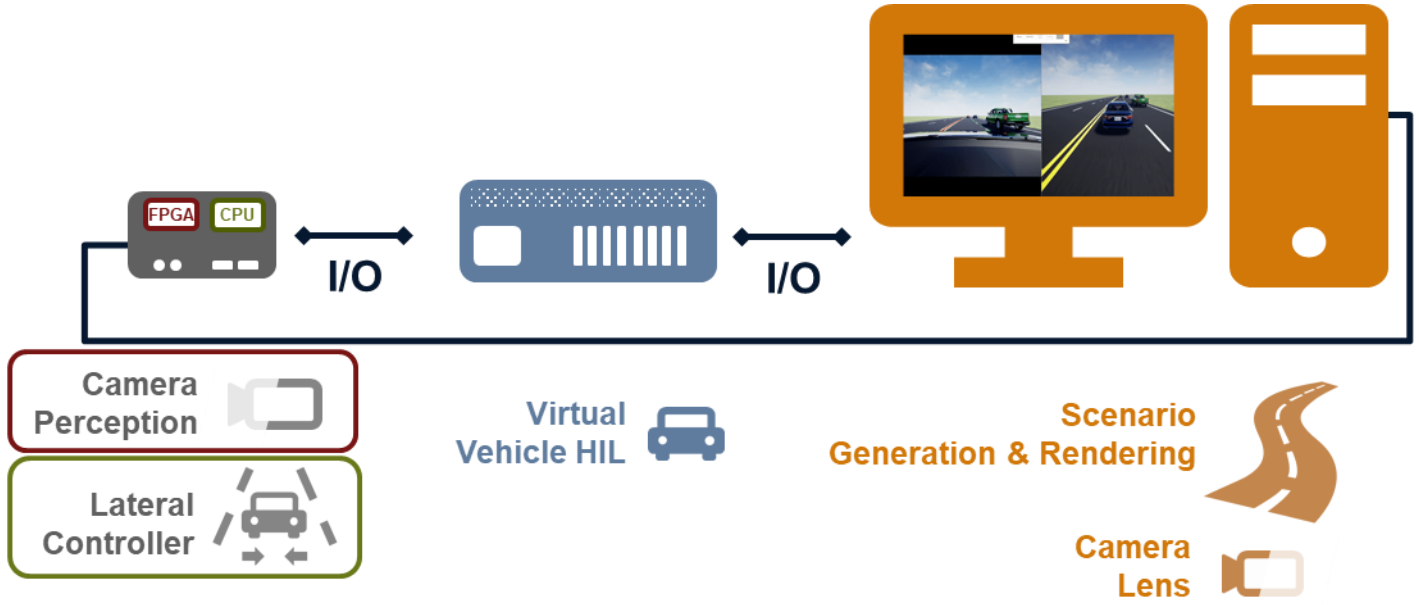
Real-Time Test Bench for a Lane Keeping Assistance System

Part 3

Perception + Controls + Virtual Vehicle

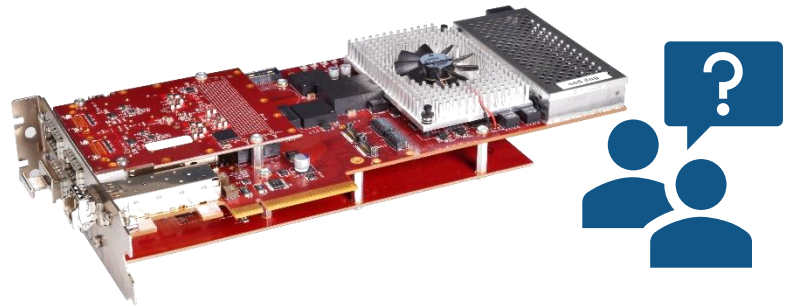


How do I test perception and controls?



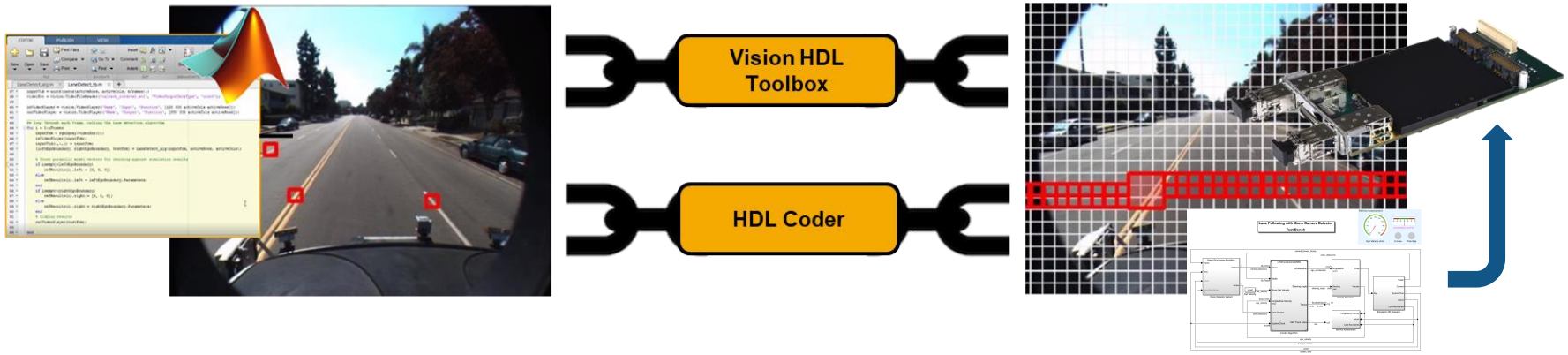
Modern Vision Applications Often Require FPGA Acceleration

- Lane detection is a critical processing stage in ADAS
- Computational expensive
- Acceleration needed,
  e.g., on FPGAs



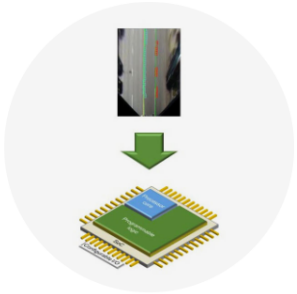
Concept and Algorithm Development

Prototyping, architecture and chip design



Bridging the Gap between Exploration and Deployment

[Video series: Vision Processing for FPGA]

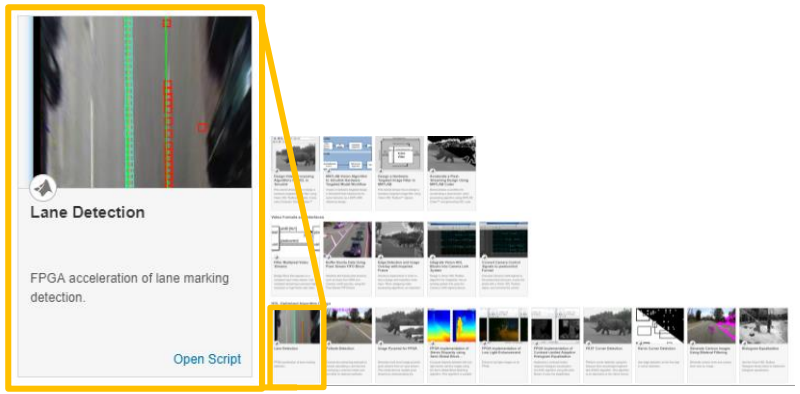


Vision Processing for FPGA

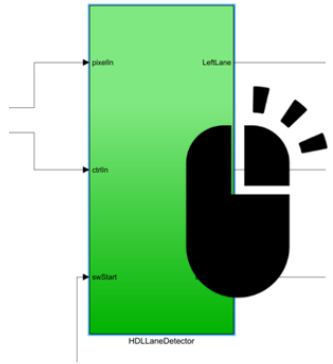
Watch this five-part video series that introduces key concepts and the workflow for targeting vision applications to FPGAs for prototyping and production.

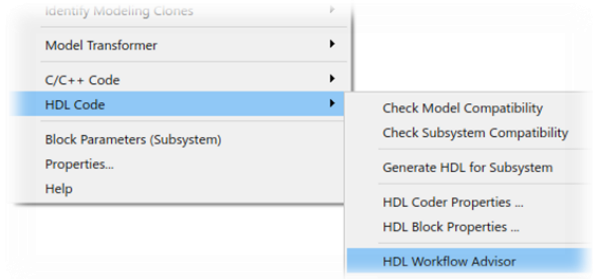
Learn more (5 Videos)

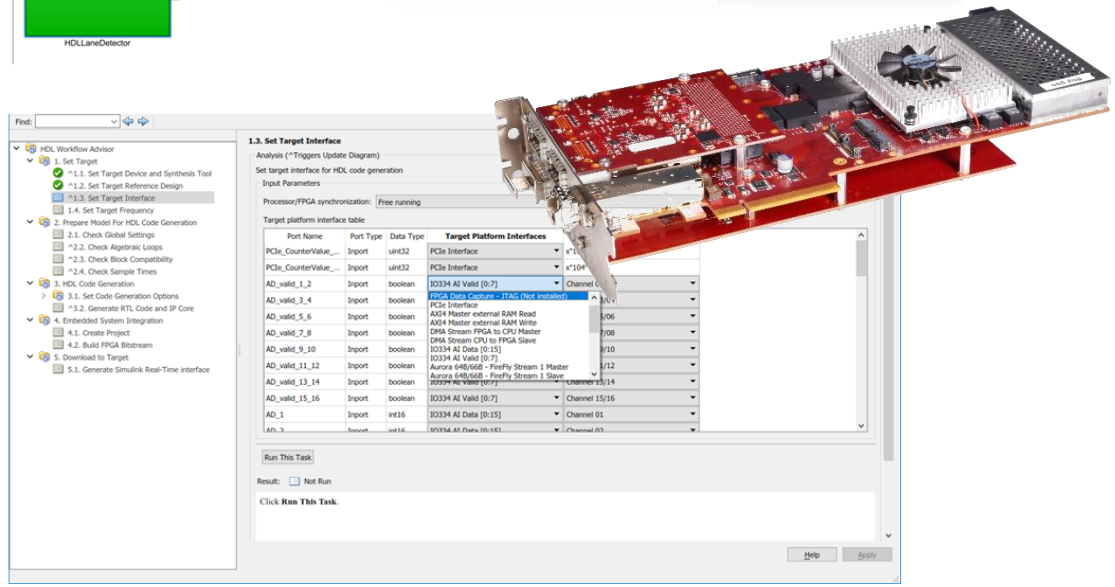
[Example: FPGA acceleration of lane marking detection]



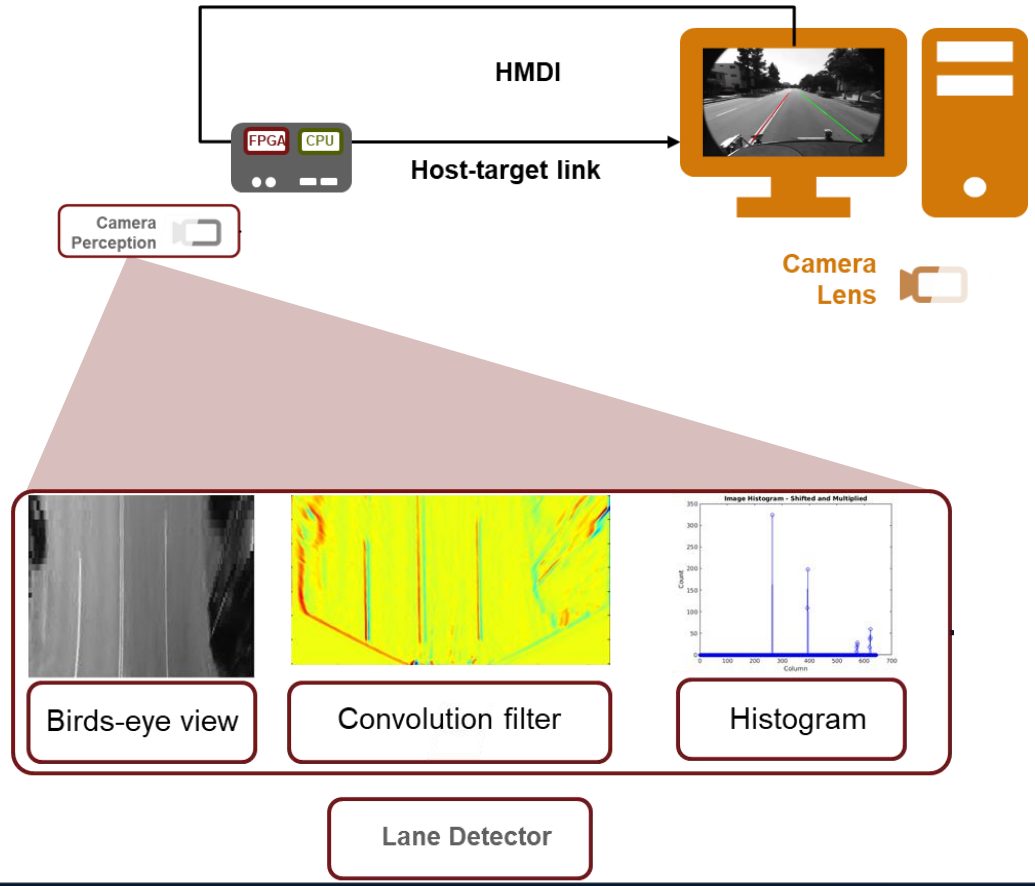
[Example: Prototype Speedgoat FPGA with HDL Workflow Advisor]

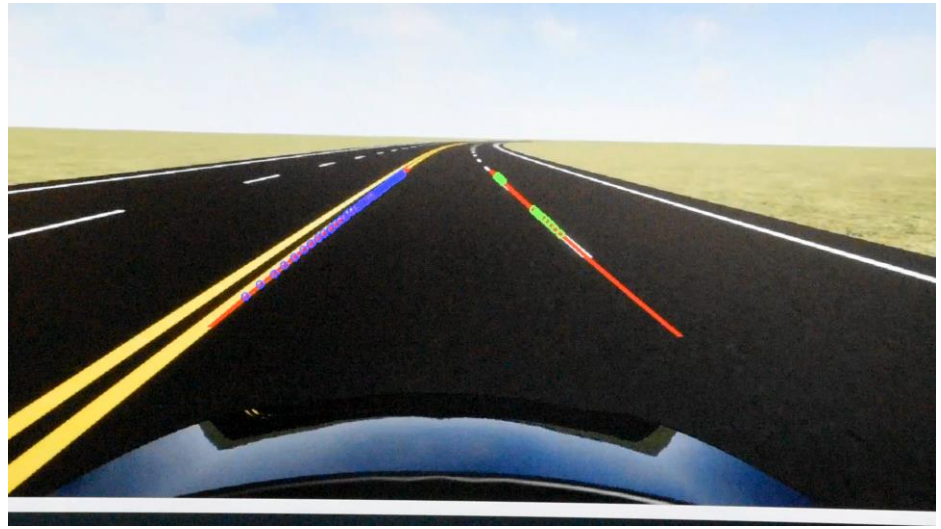




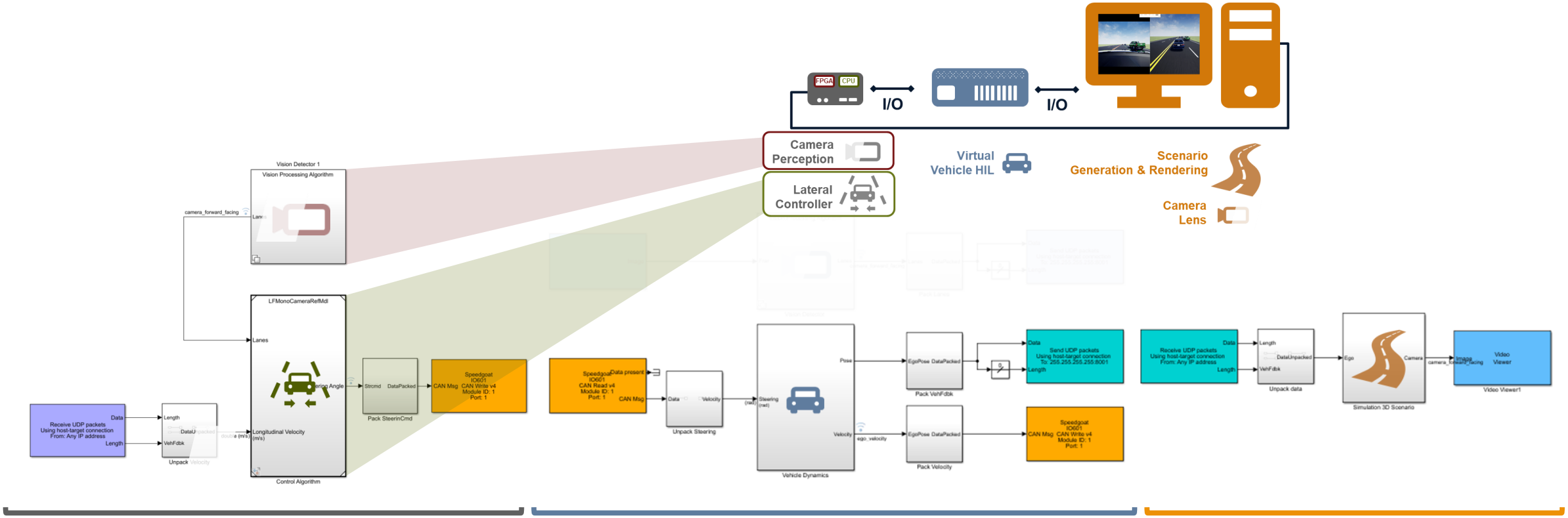


Lane Marking Detector on FPGA





Lane Keeping Control Real-Time Test Bench



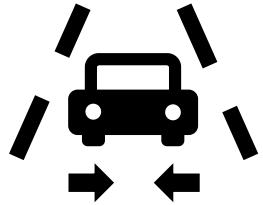
Demo the Real Thing

What You Have Learned

Virtual Vehicle

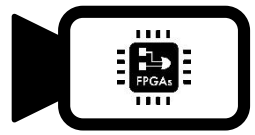
How do I perform real-time virtual vehicle simulation?

Controls

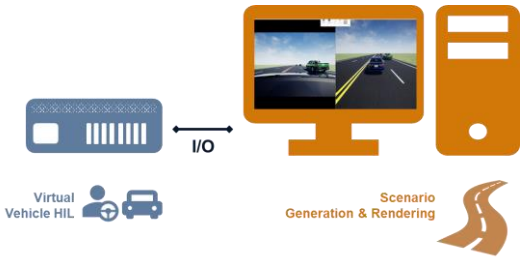


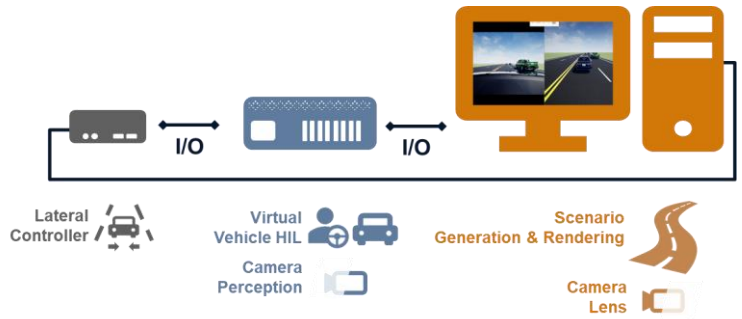
How can I rapidly prototype and test controls?

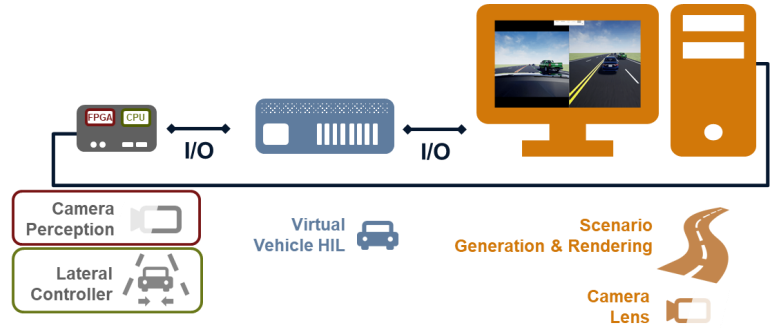
Camera Perception



How do I test perception and controls?







Call to Action

- MATLAB and Simulink for Automated Driving Systems
  - Contact us: aroy@mathworks.com and rgopala@mathworks.com
- Webinar: Building Real-Time DIL Simulators
- Testing a Lane Following Controller with Simulink Test
- www.speedgoat.com – Speedgoat real-time solutions