



TATA ELXSI

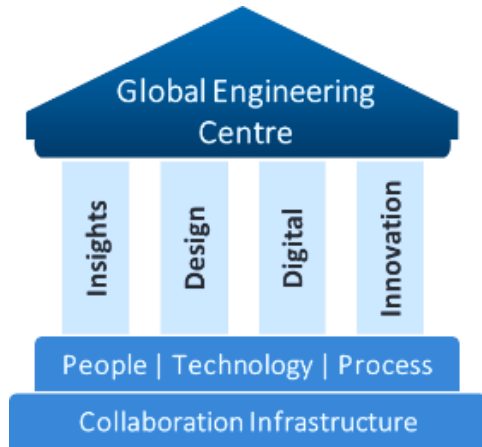
Closed-loop testing of ADAS systems using dSPACE RTPC with MATLAB and Simulink

MathWorks Automotive Conference 2023

10 October 2023



Tata Elxsi Business Overview



30+
Years in Business

12,286
Strong Designers + Engineers

33
Cities Worldwide

17.1%
YoY Growth Q1FY'24



Media & Communication

BROADCAST & MEDIA

- OTT Streaming
- RDK, Android TV, CPE
- QoE, QoS, Customer Experience



COMMUNICATIONS

- 5G, SDWAN
- Network Transformation
- Digital Transformation



Transportation

AUTOMOTIVE

- Passenger Experience
- Connected & Autonomous
- Shared & Electric



RAIL

- Industrial
- Service design
- Rolling Stock



Healthcare

MEDICAL DEVICES

- Product Design
- Systems Engineering
- Regulatory Compliance



PHARMACEUTICALS

- Safety
- Packaging & Labelling
- Pharmacovigilance





Agenda

- Introduction
- Technical overview
- Typical automotive camera system overview
- Real time testing of camera systems
- Methods of simulating CAN messages
- RCP testing of ACC-AEB algorithm in real time platform
- Advantages of MathWorks solutions, Future works

Introduction

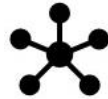
- Advanced driver assistance systems (ADAS) is the foundation of next generation automobiles, aimed at improving safety and comfort of the driver
- Diverse development and validation methods are adopted to make sure that the ADAS systems behave as intended
- Real time embedded systems housing the ADAS applications need to be tested in a real time environment to bring in the aspect of timing and safety criticality
- Virtual simulation solutions from MathWorks are used to enable ADAS validation
- Presentation will cover how rapid control prototyping (RCP) testing can be implemented on a real time platform like dSPACE SCALEXIO
- Presentation will also cover simulation of camera for ADAS testing
- Vehicle network simulation using controller area network (CAN) is also covered in the presentation

Technical overview



The scope of the presentation is the simulation-emulation of camera for the validation of AD/ADAS features:

- Camera injection using frame generator
- Camera over the air emulation

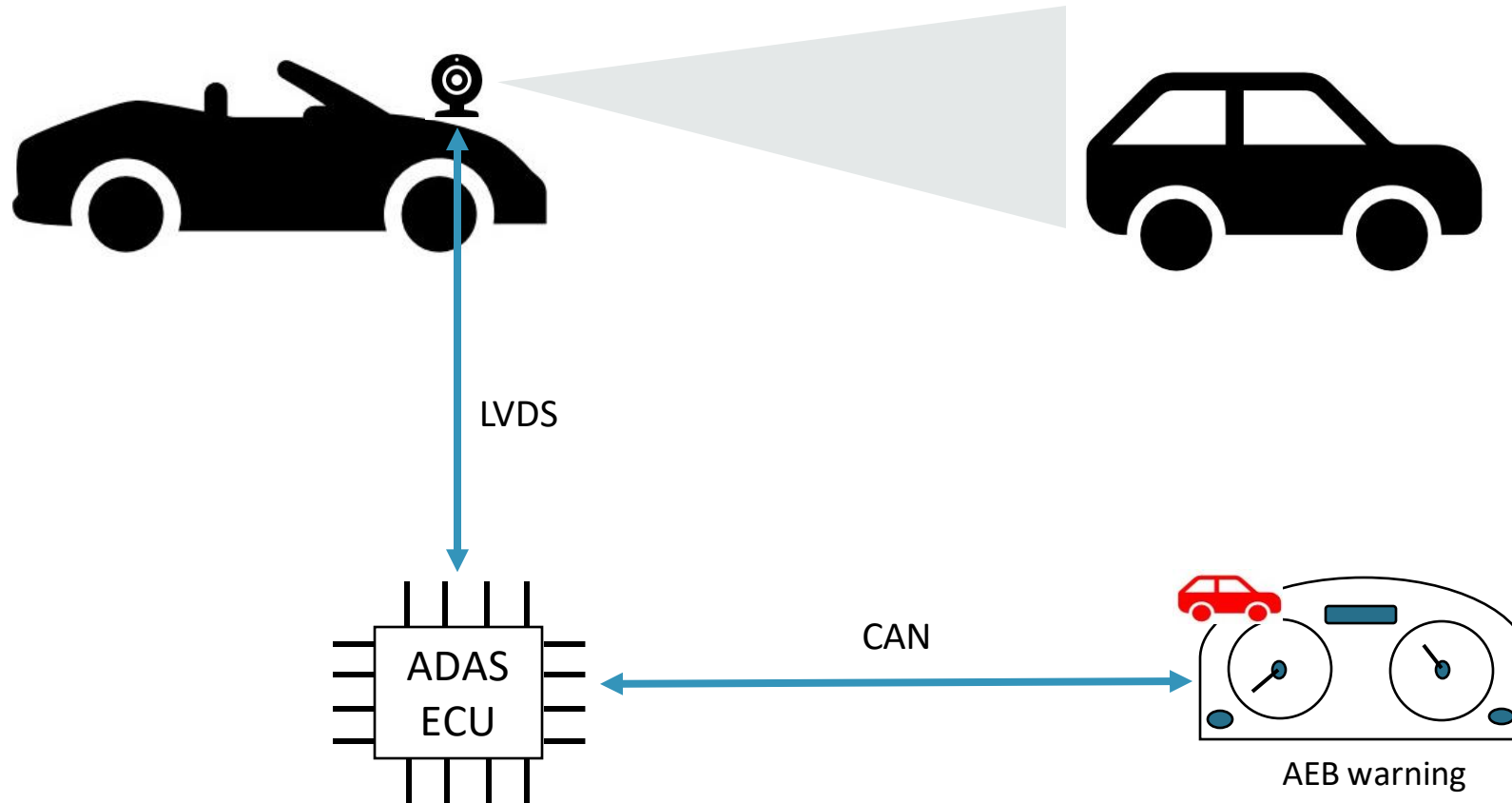


Vehicle network simulation like CAN using hardware

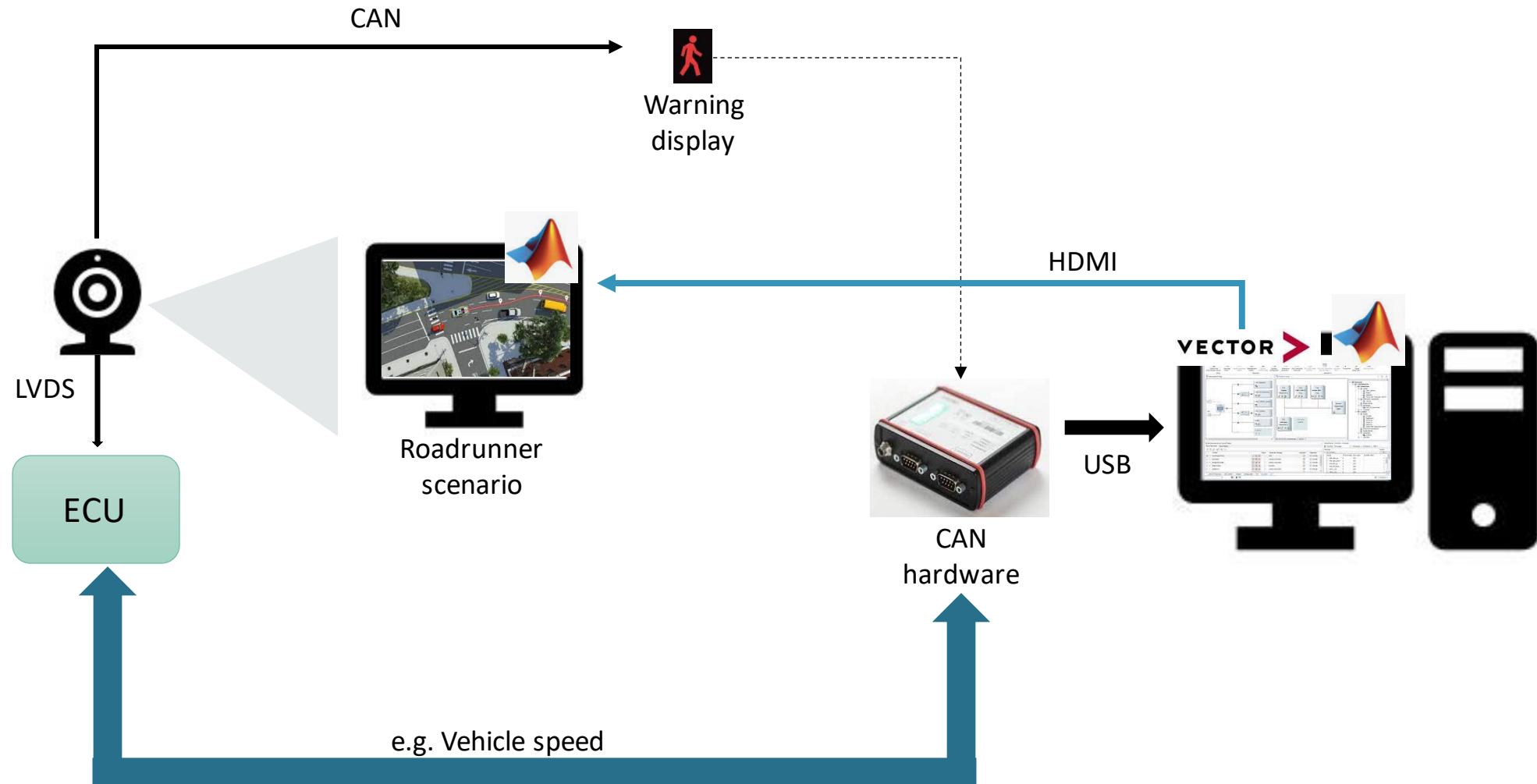


RCP testing of adaptive cruise control-Autonomous emergency braking (ACC-AEB) control algorithm in a real time platform - dSPACE SCALEXIO. Scenario creation, sensor simulation, vehicle dynamics are created using MathWorks solutions.

How camera based ADAS works in vehicle?



Over the air camera simulation: Lab based setup

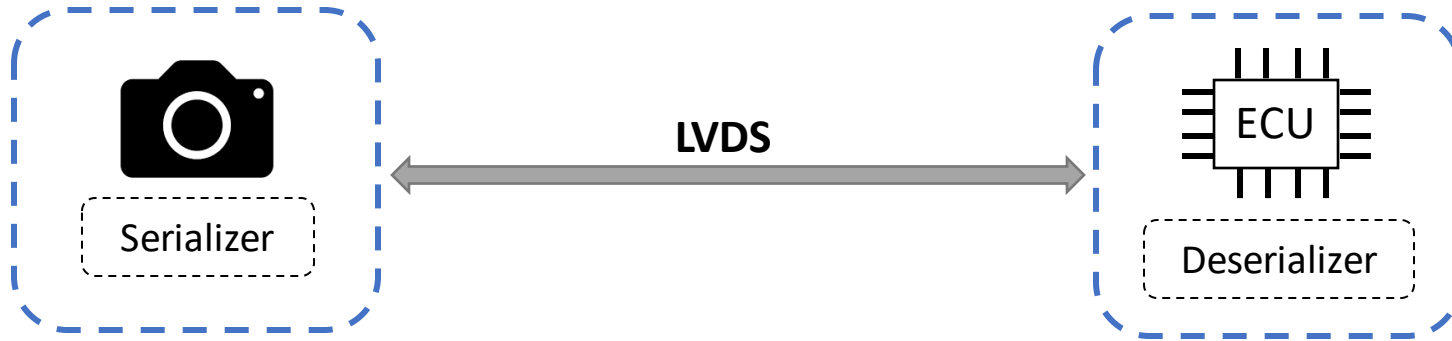


Demo: Over the air camera simulation setup

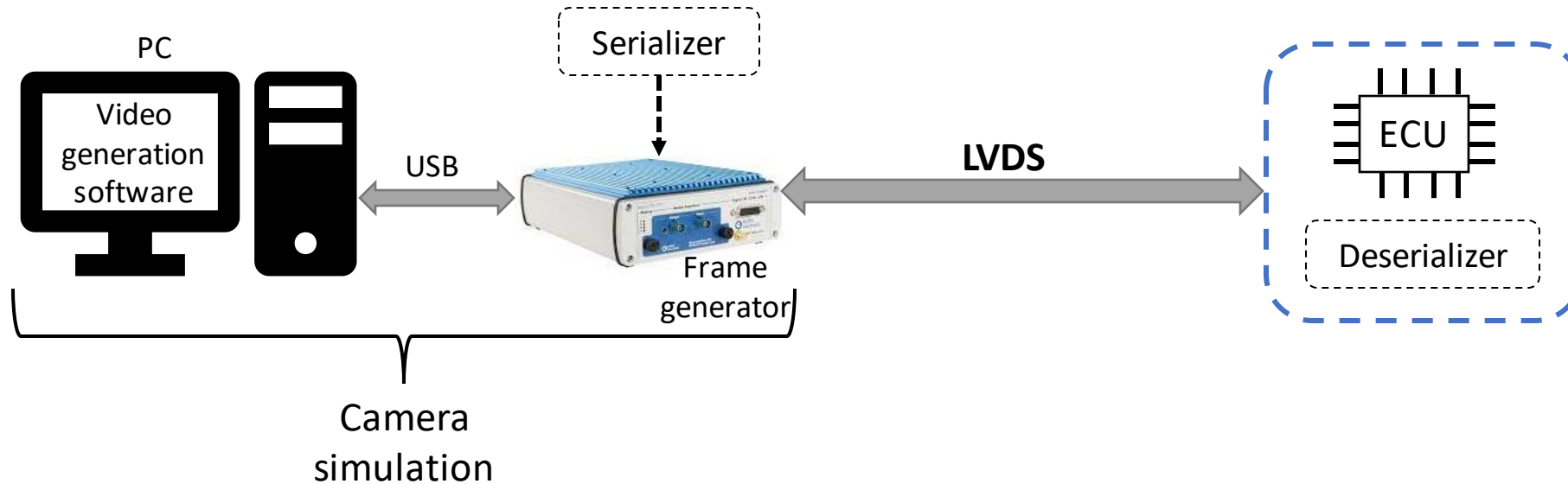


Vehicle to lab – Camera injection

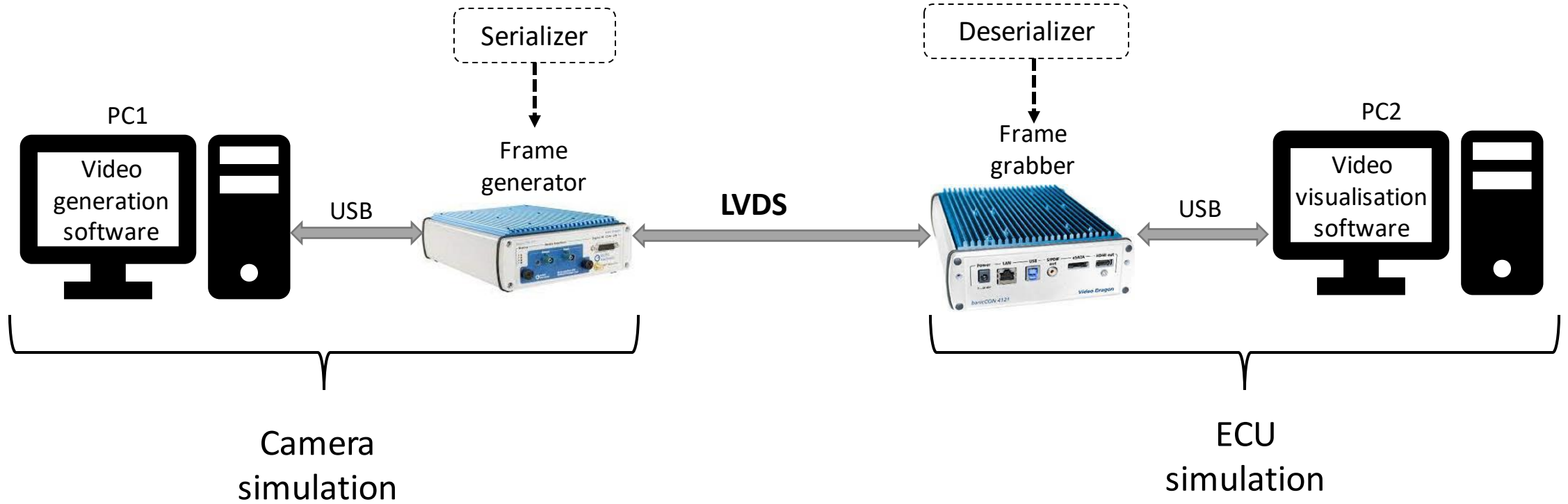
A typical camera system architecture in vehicle



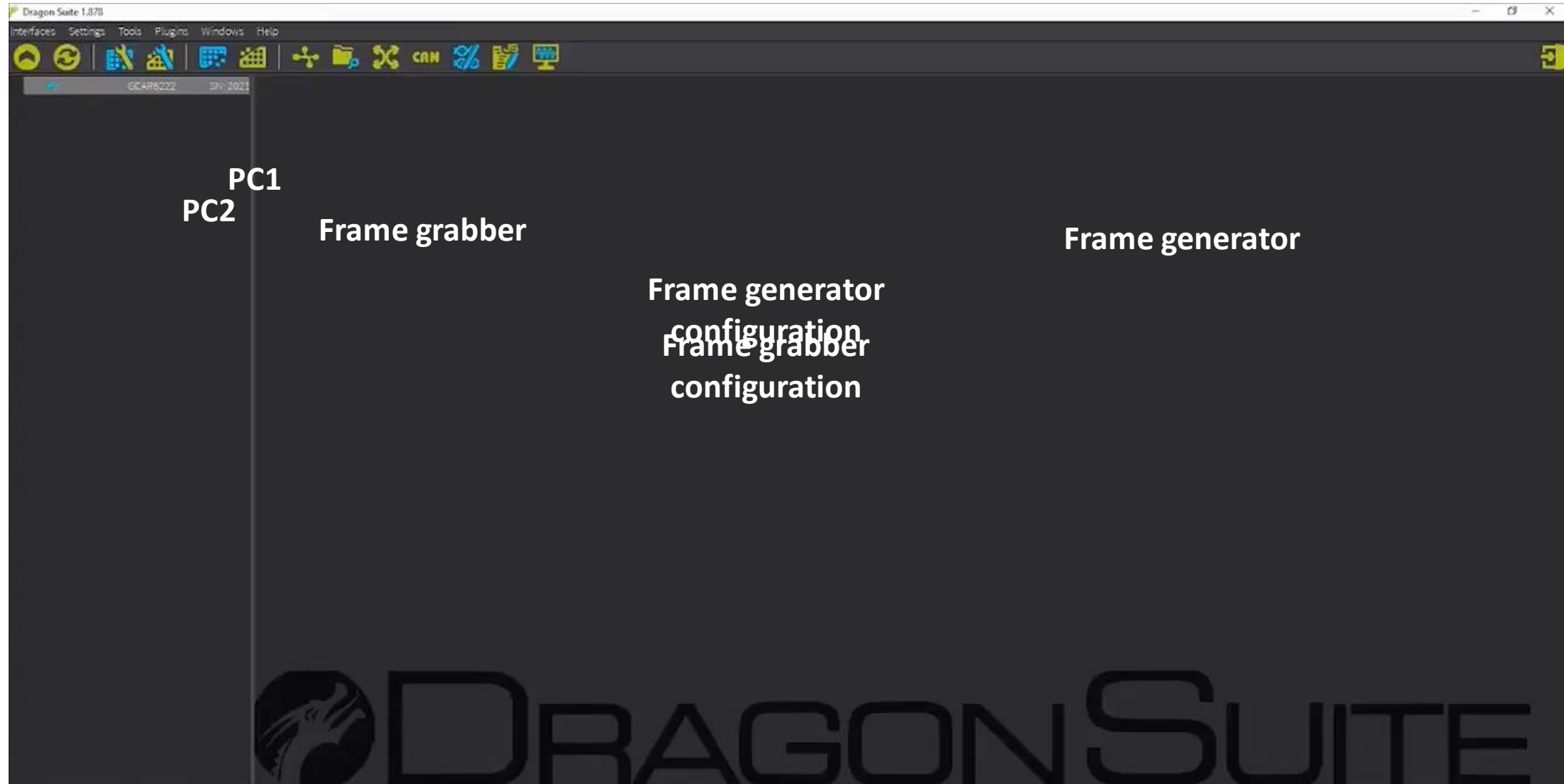
A typical camera system architecture in lab



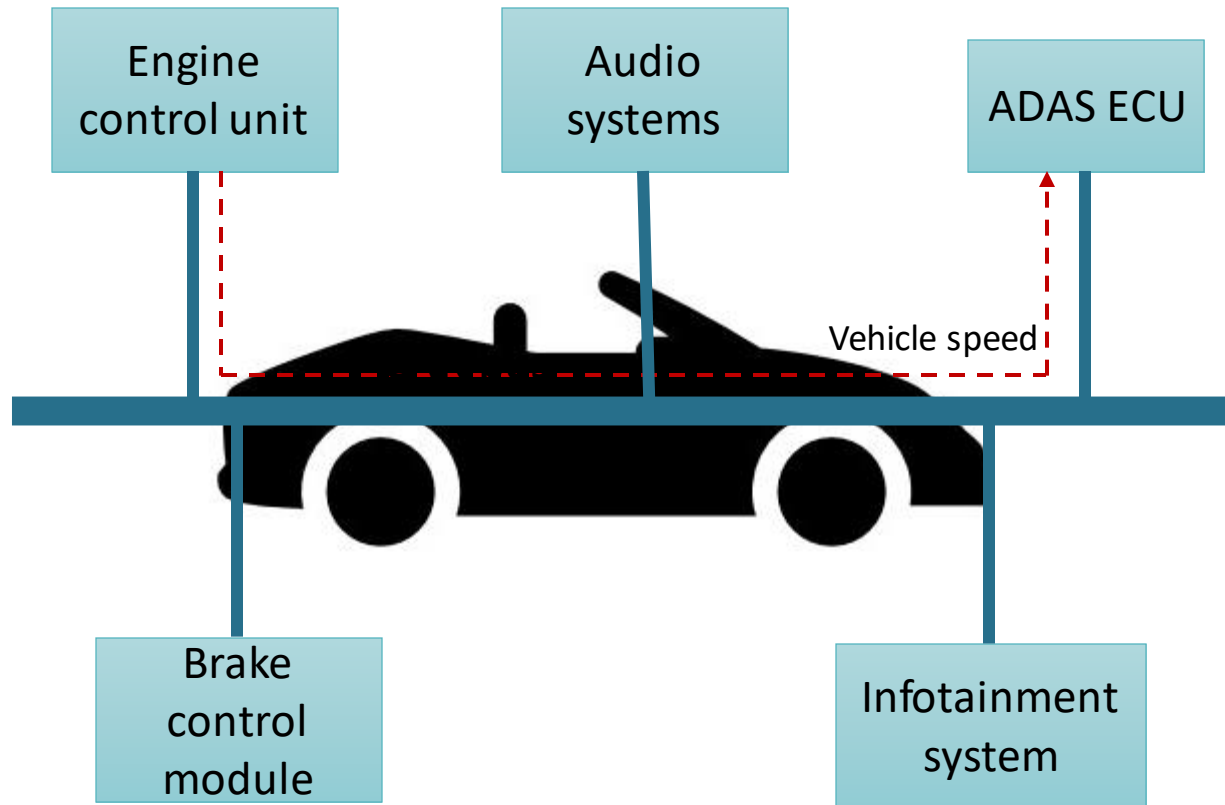
Proposed demo: Camera injection in lab for ADAS validation



Frame generator and frame grabber



Relevance of CAN communication in vehicle



ECUs are interconnected via controller area network or CAN bus

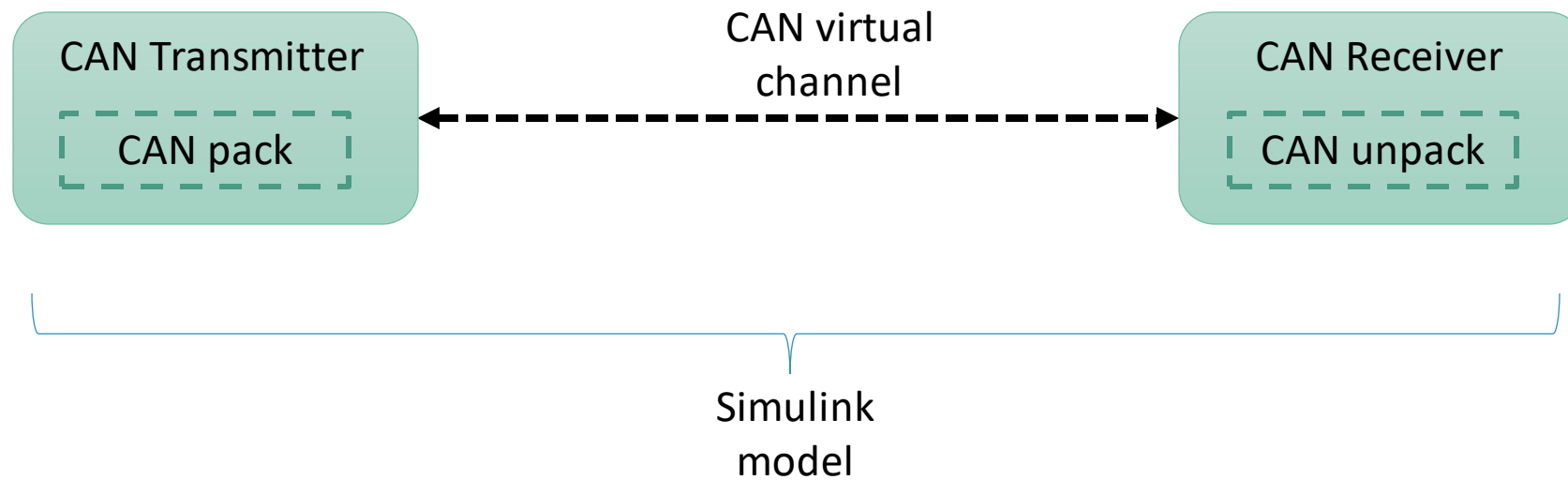
No complex dedicated wiring

Robust towards electrical disturbances and interferences

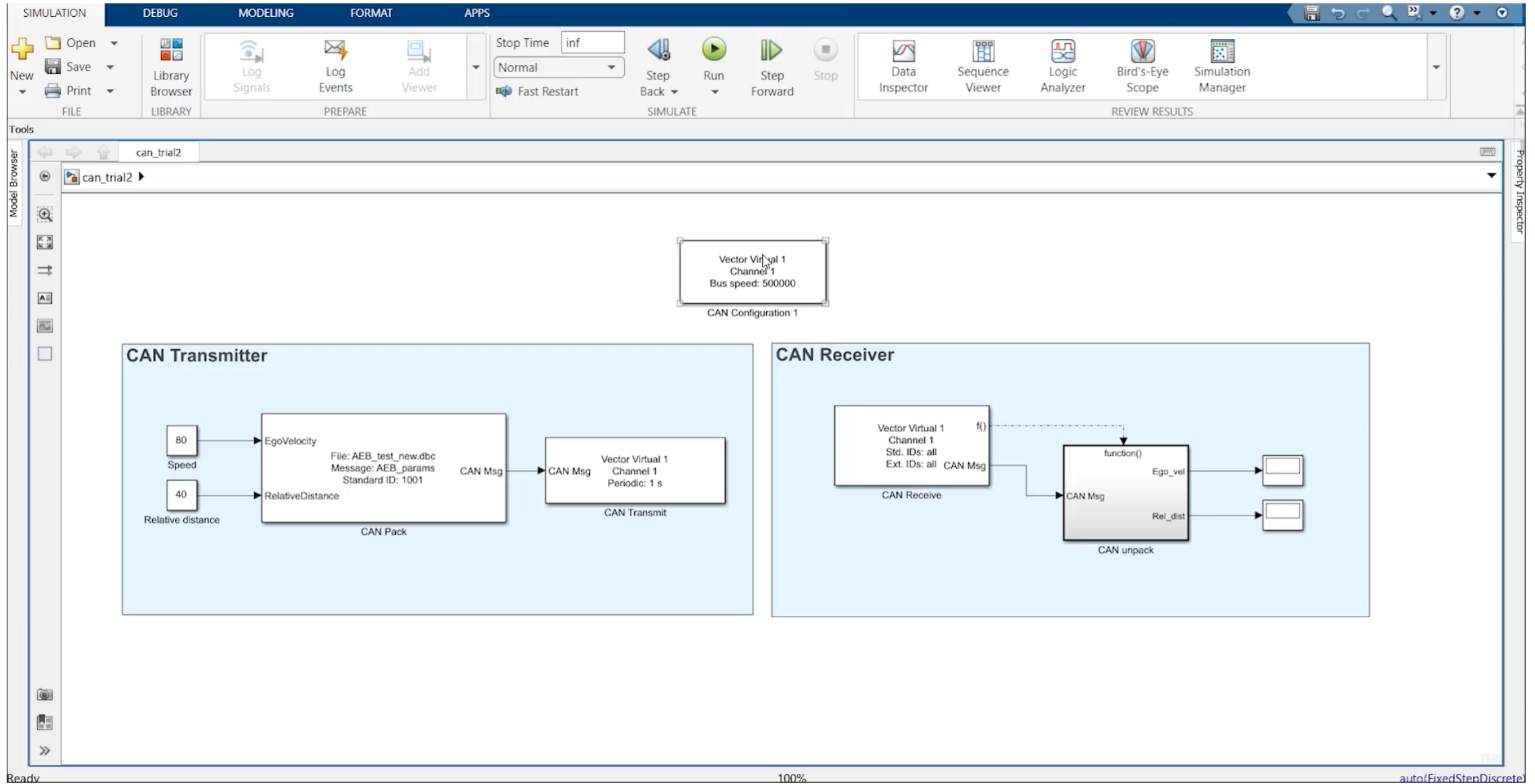
Three ways of simulating CAN message using MathWorks provided solutions:

1. CAN simulation within Simulink:

Where is it used? - Scenario where CAN signals need to be exchanged between subsystems developed in Simulink at software level

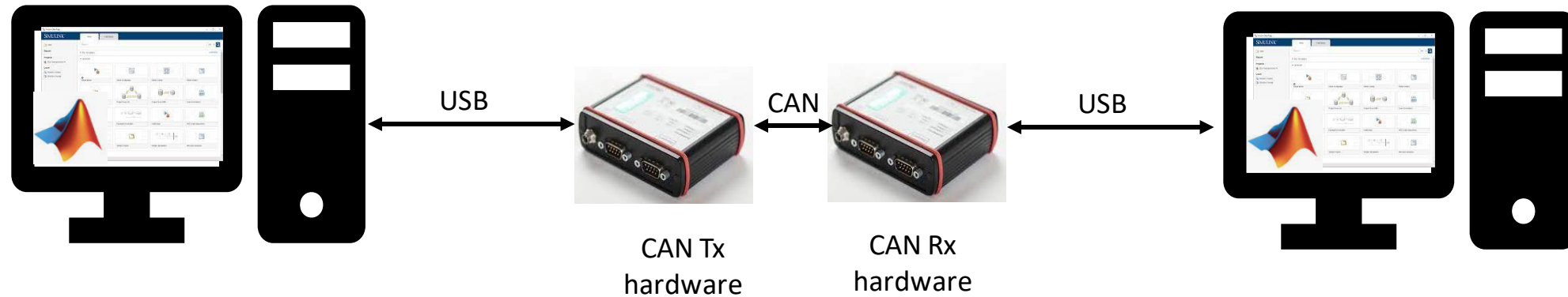


1. CAN simulation within Simulink:

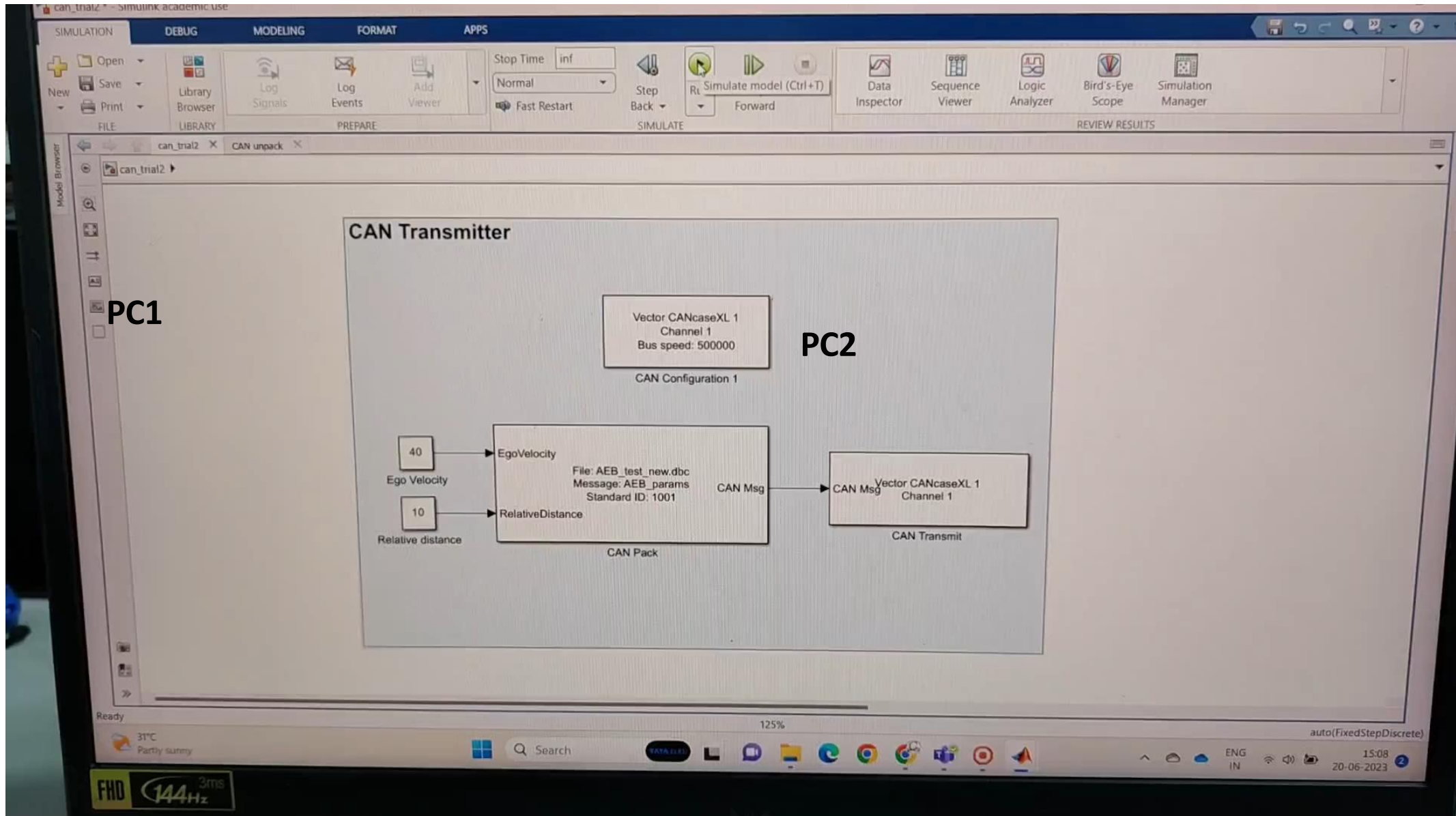


2. Physical CAN simulation between PCs:

Where is it used ? – Different teams are developing different control algorithms in different machines which need to communicate with each other over CAN.



2. Physical CAN simulation between PCs:

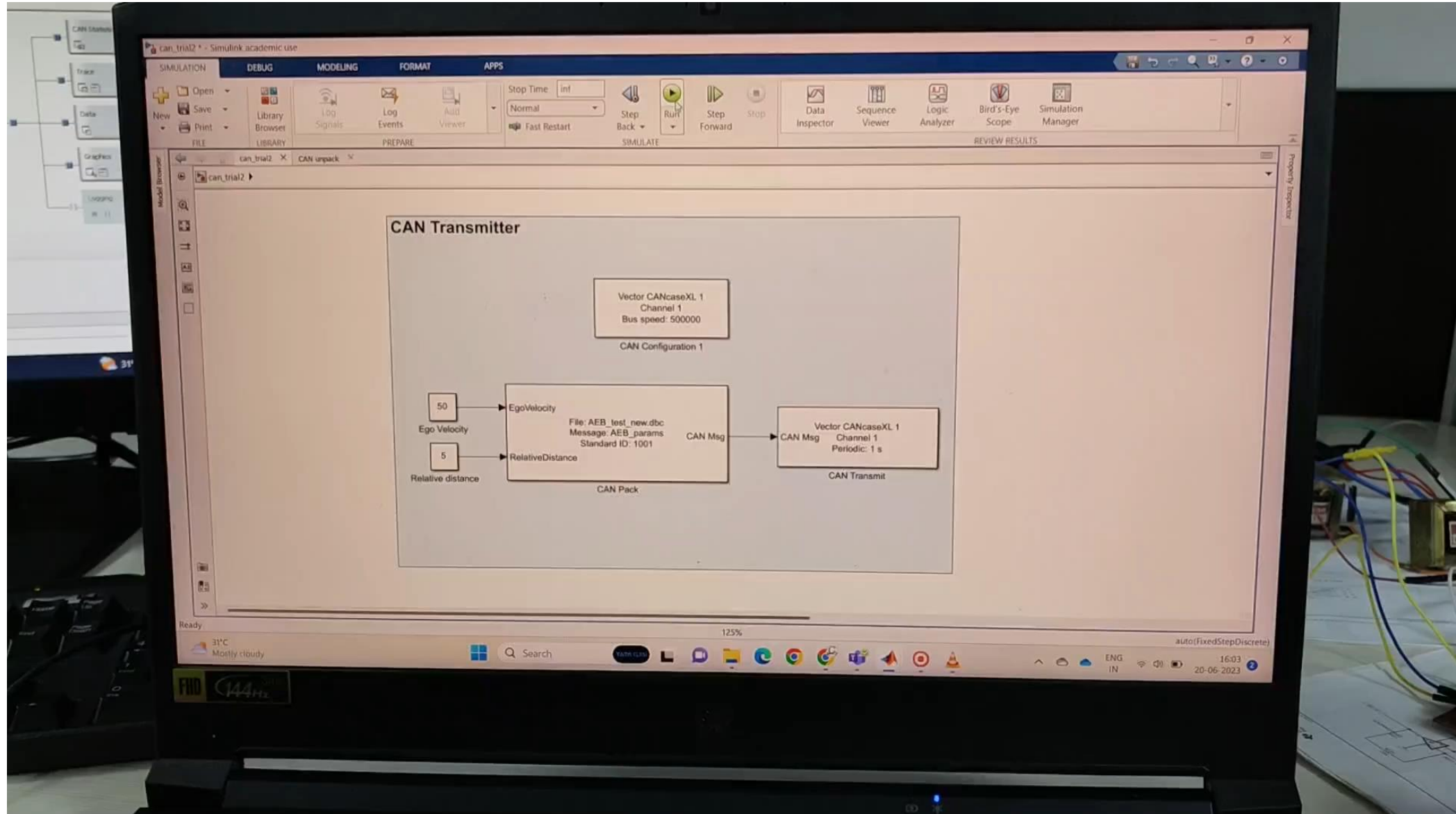


3. Verifying CAN communication using external tool:

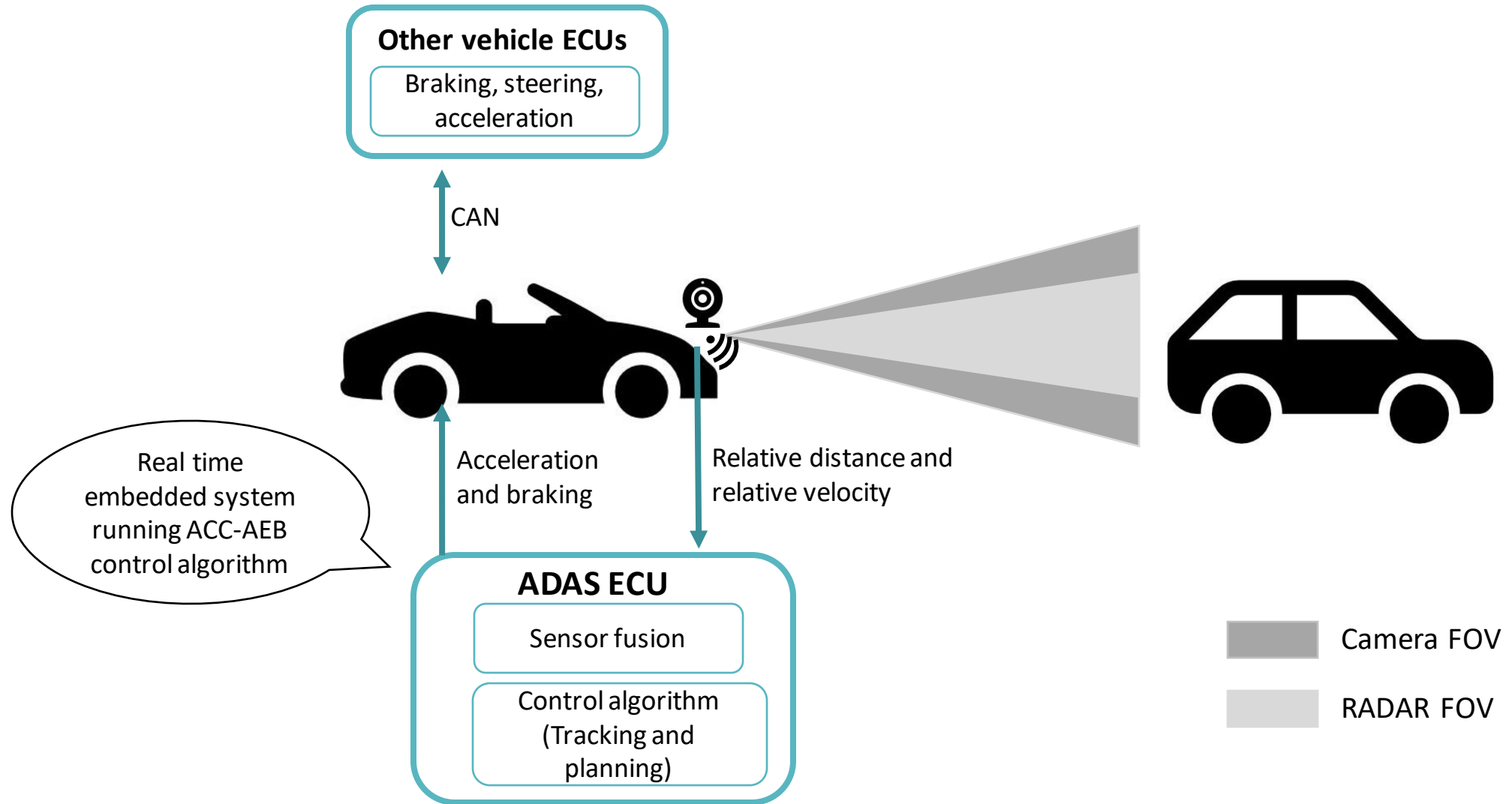
Where is it used ? – Verifying the CAN message communication using an external CAN hardware



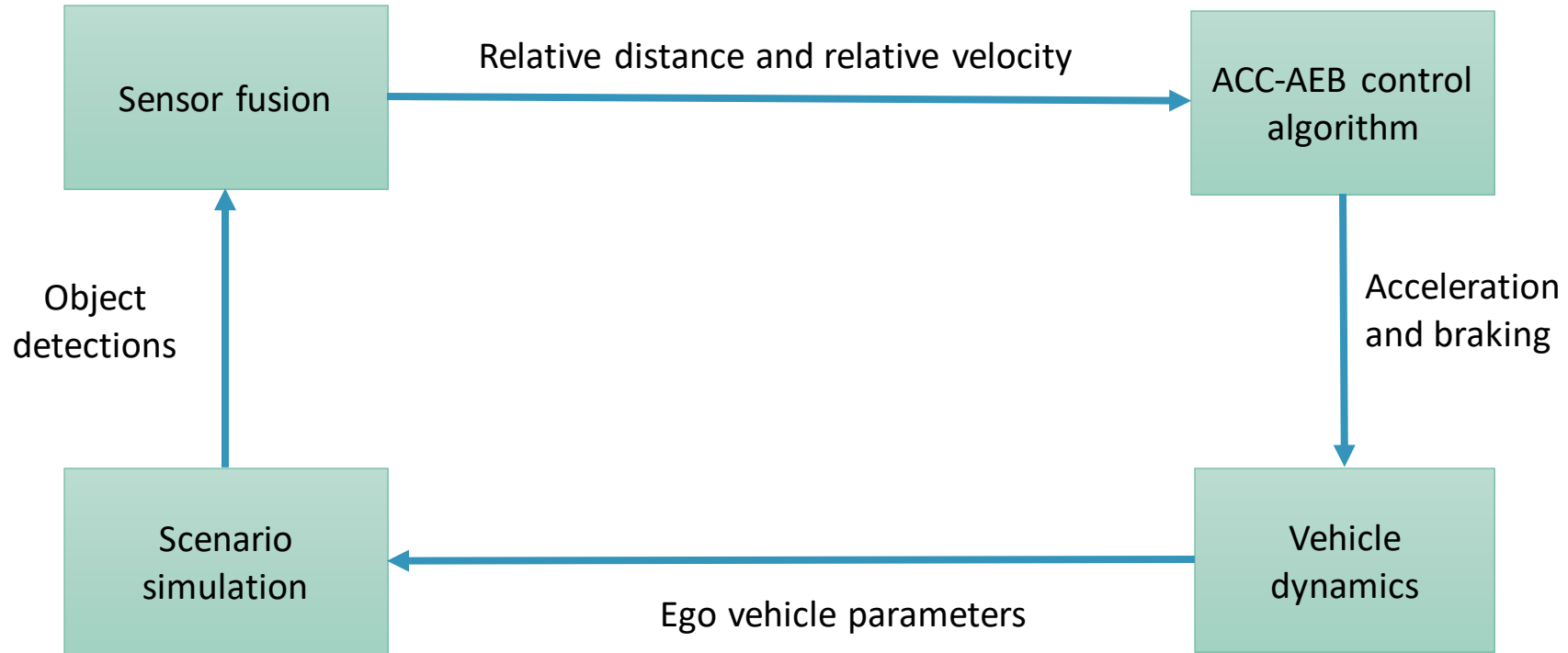
3. Verifying CAN communication using external tool:



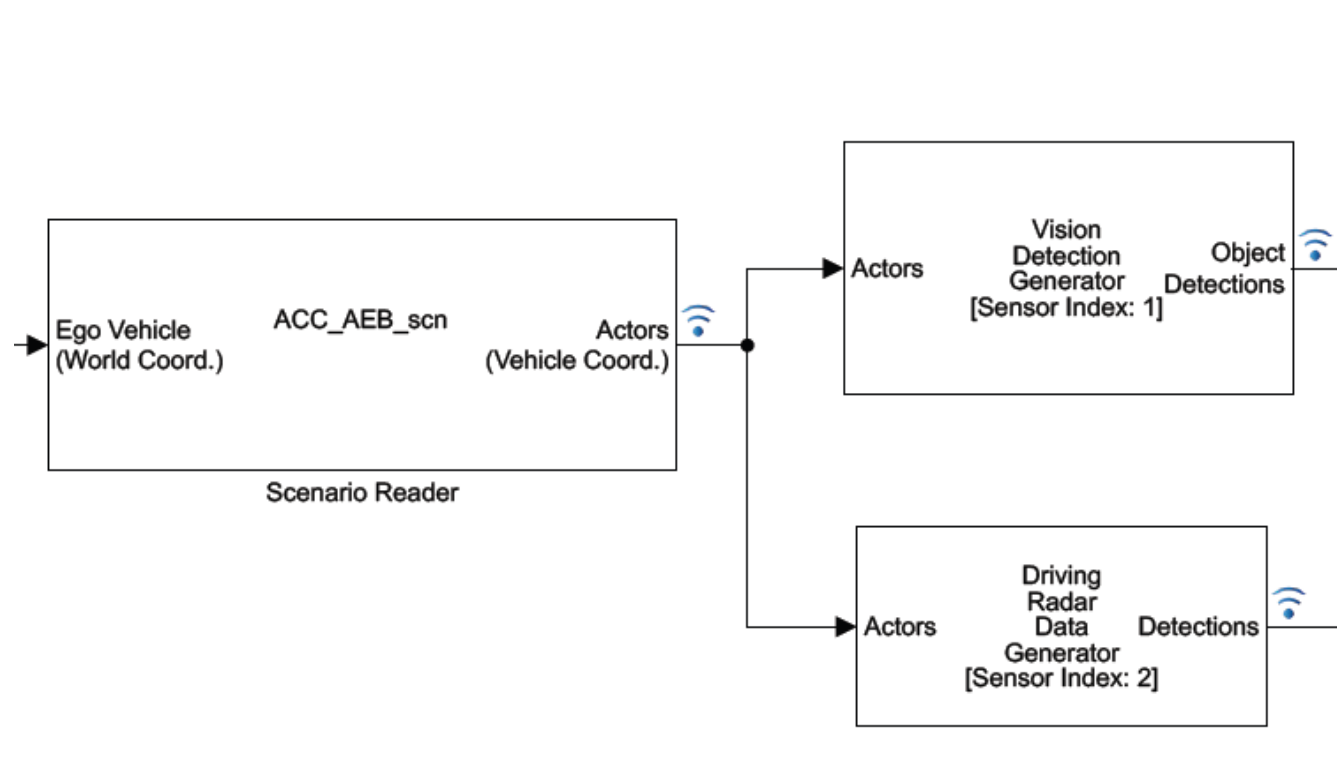
ACC-AEB in vehicle



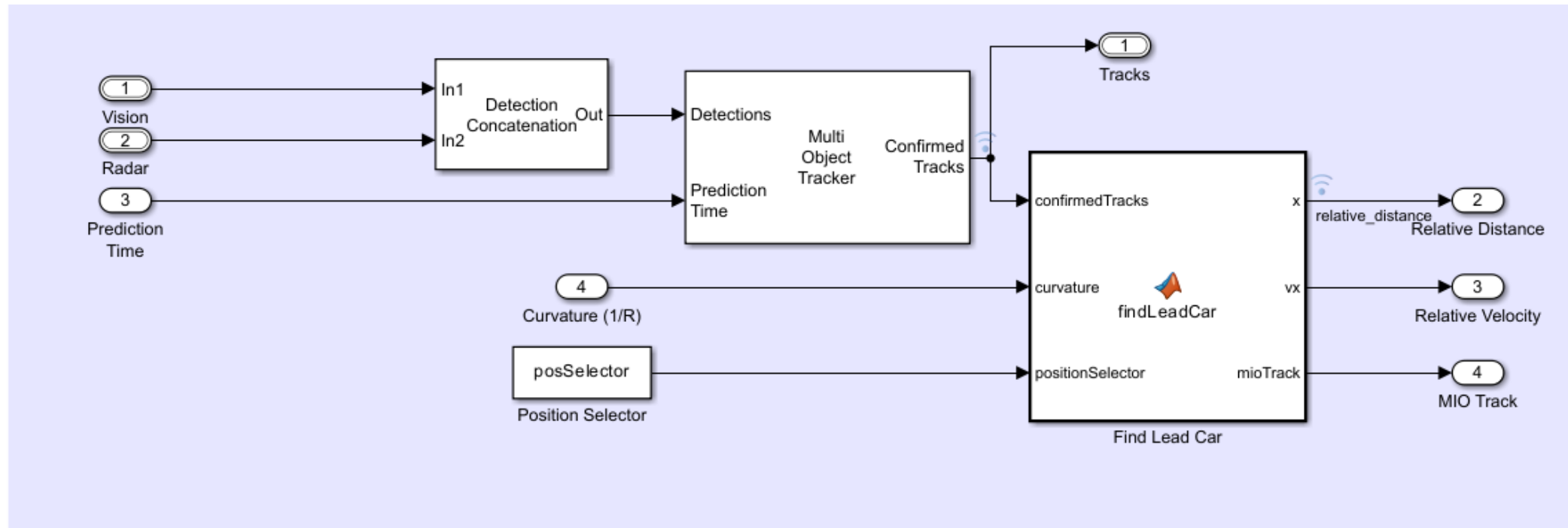
Simulink model architecture of ACC-AEB system



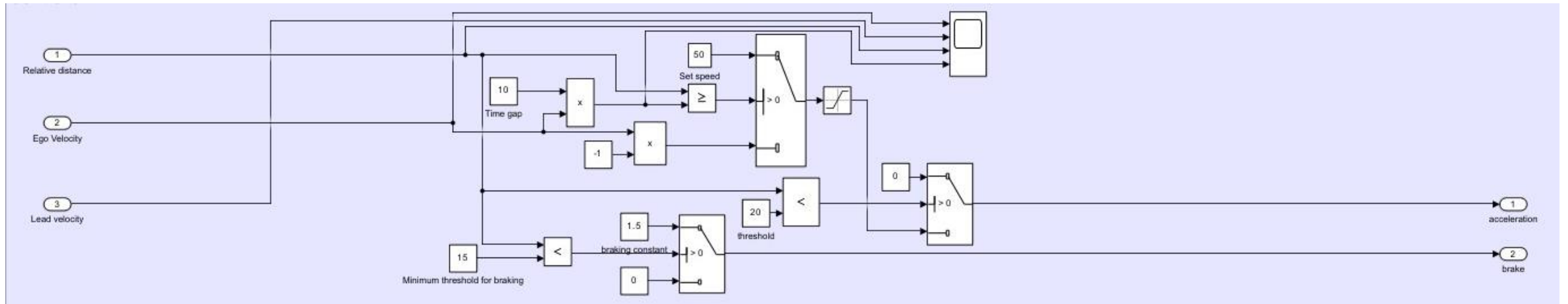
Simulink model for ACC-AEB scenario simulation



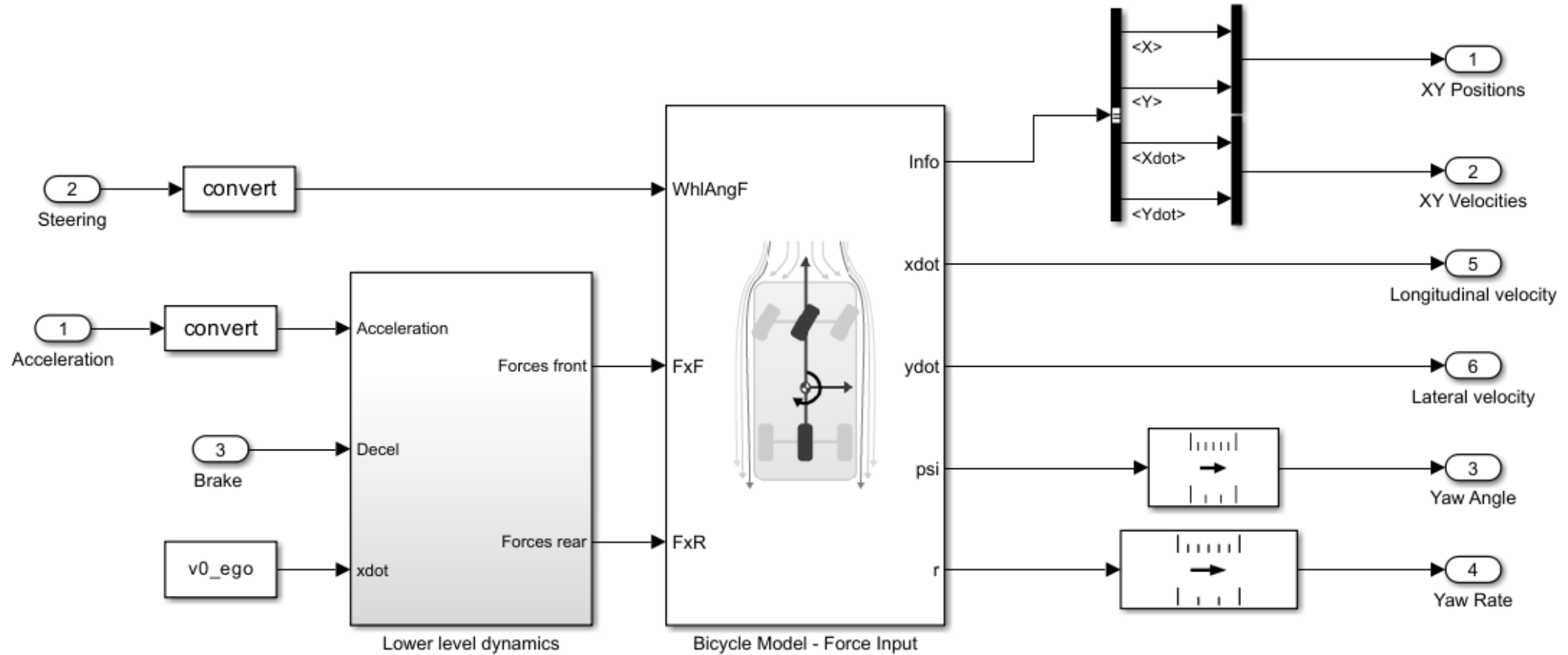
Simulink model for ACC-AEB sensor fusion



Simulink model for ACC-AEB control algorithm

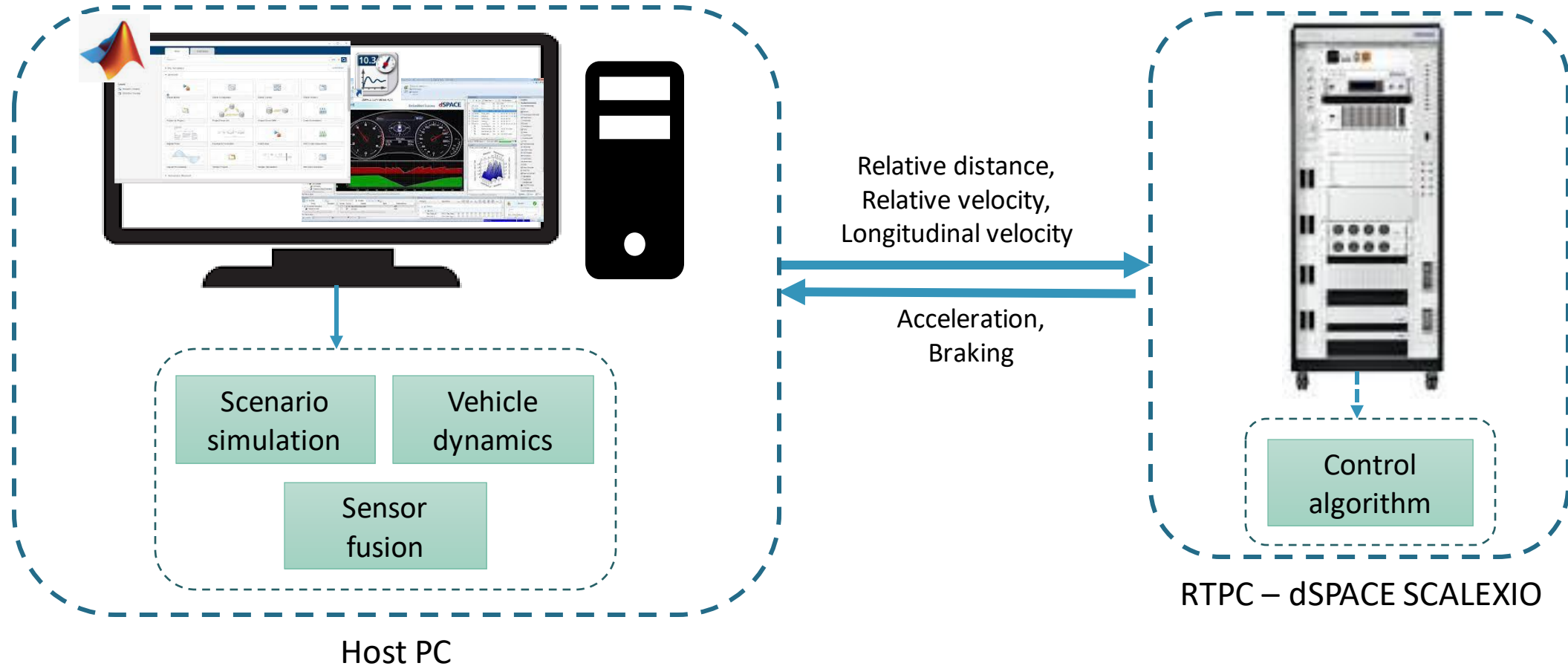


Simulink model for ACC-AEB vehicle dynamics



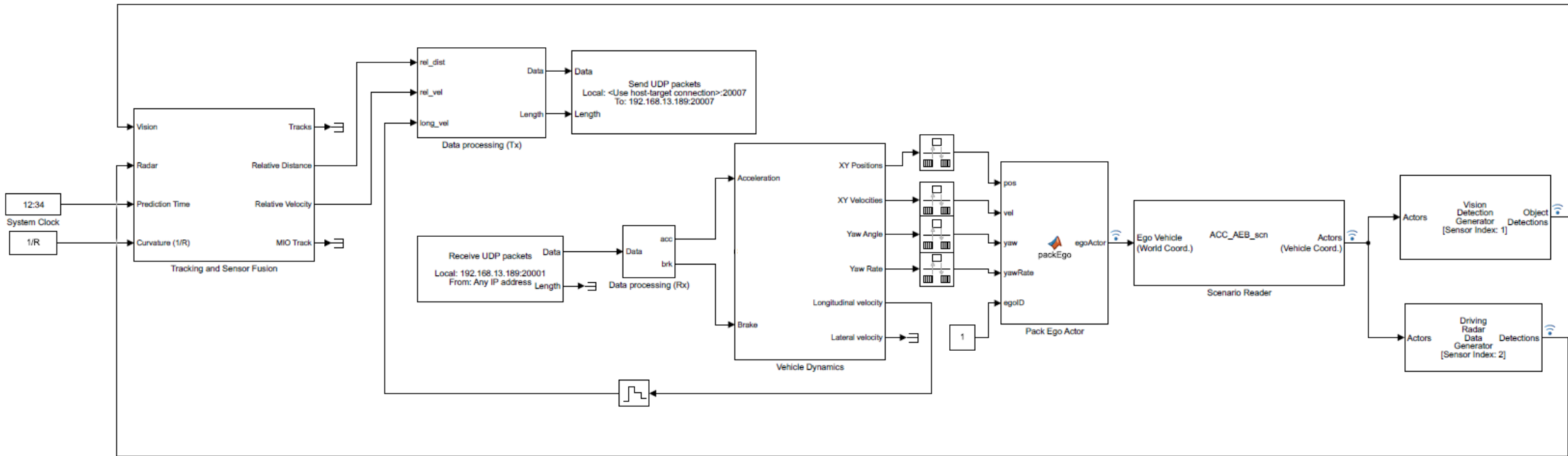
RCP testing of ACC-AEB algorithm in real time platform

Lab setup for testing



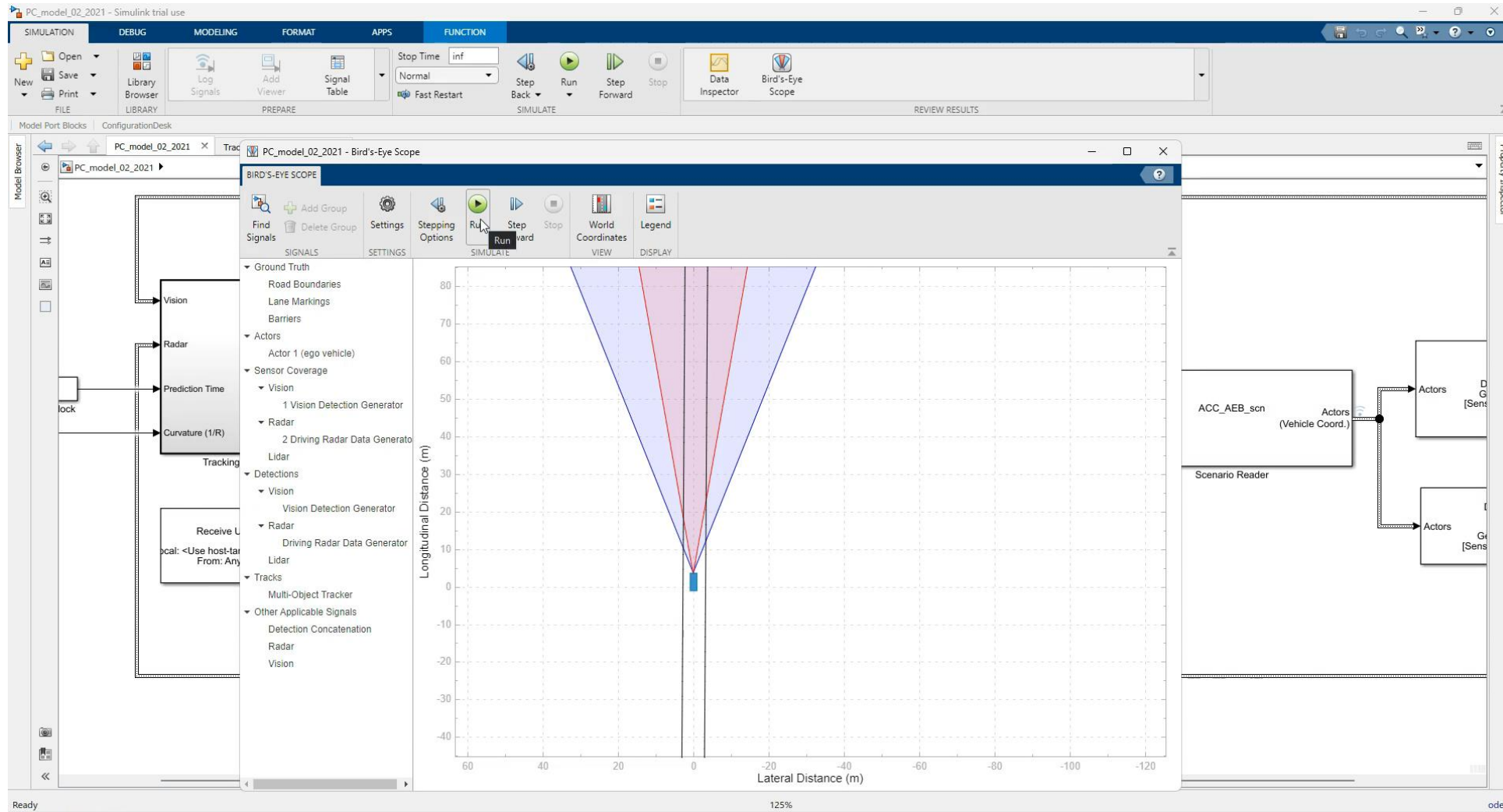
RCP testing of ACC-AEB algorithm in real time platform

Host machine Simulink model



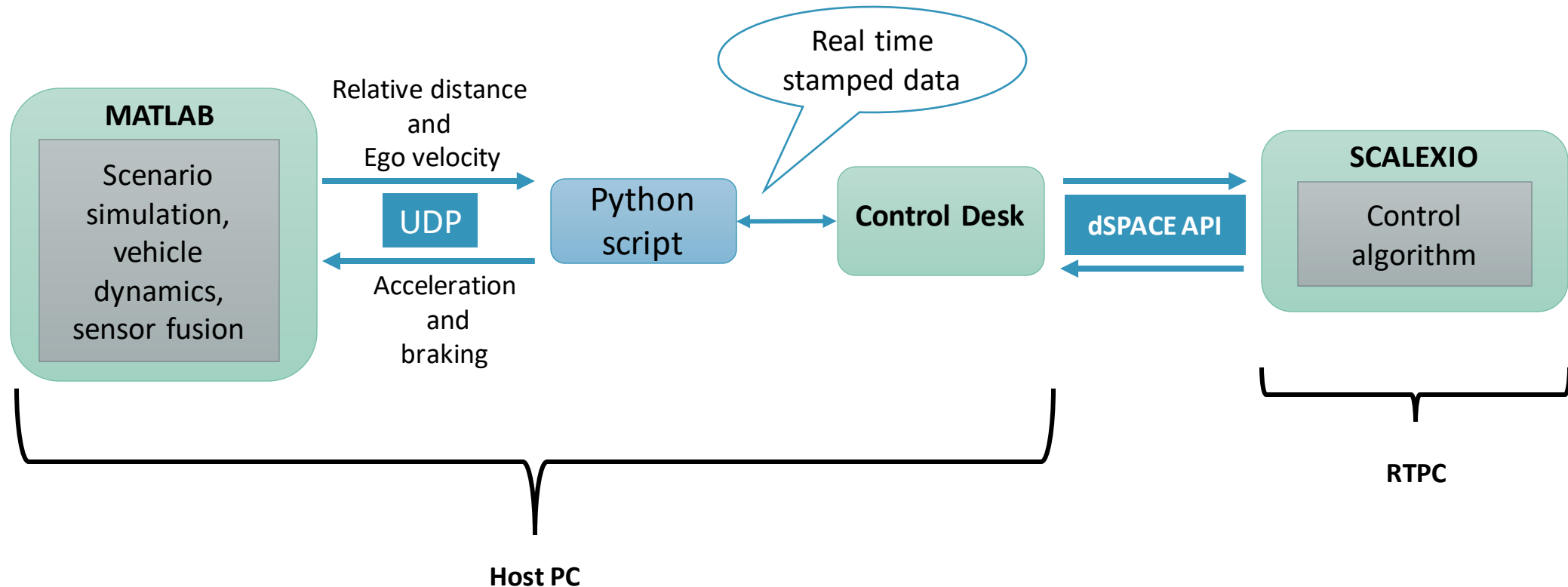
RCP testing of ACC-AEB algorithm in real time platform

Bird's-eye scope view



RCP testing of ACC-AEB algorithm in real time platform

Data exchange methodology



RCP testing of ACC-AEB algorithm in real time platform

dSPACE Control Desk environment

The screenshot displays the dSPACE Control Desk software interface. The main workspace shows a variable array table for 'Rel_vel/Value' and two input fields for 'Acceleration/In1' and 'Braking/In1'. The message log at the bottom indicates that online calibration has started.

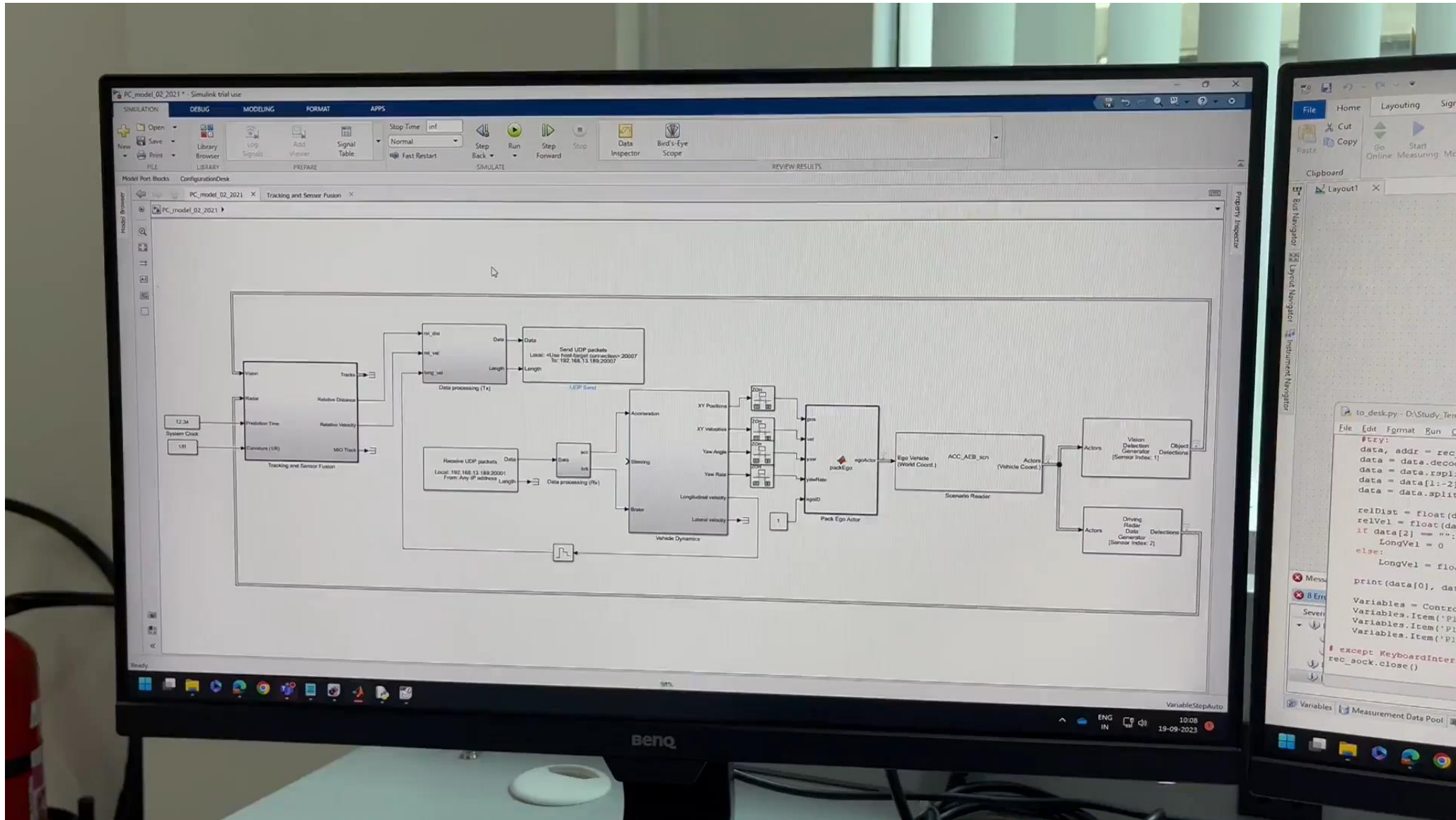
Variable Array 1: Rel_vel/Value			
-1.79769313486232E+308 .1.79769313486232E+308 Converted Incr. +1 / 10			
	Variable	Value	Unit
P	Rel_dist/Value	99999999	
P	Rel_vel/Value	99999999	
P	Long_vel/Value	5	

Acceleration/In1: 0
Braking/In1: 0

Messages: 8 Errors, 0 Warnings, 97 Messages

Severity	Module	Time	Message
Info	Platform...	17:43:10.573	Starting online calibration.
Info	Platform	17:43:10.694	Memory adjustment with the follow...
Info	Platform	17:43:10.696	Online calibration started for the foll...
Info	Platform...	17:43:10.873	Online calibration was started on th...
Info	Platform...	17:43:10.892	Online calibration started.

RCP testing of ACC-AEB algorithm in real time platform



RCP testing of ACC-AEB algorithm in real time platform - Logging

The screenshot displays the ControlDesk software interface for real-time testing. The main workspace shows a grid with two data points: 'AccIn1' with a value of -2 and 'BrakingIn1' with a value of 1.5. A 'Variable Array 3: long_vel/Value' table is also visible, containing three rows of data.

Variable Array 3: long_vel/Value			
-1.79769313486232E+308 1.79769313486232E+308 Converted Incr. ~1 / 10			
Variable	Value	Unit	
re_dist/Value	0		
re_vel/Value	0		
long_vel/Value	5		

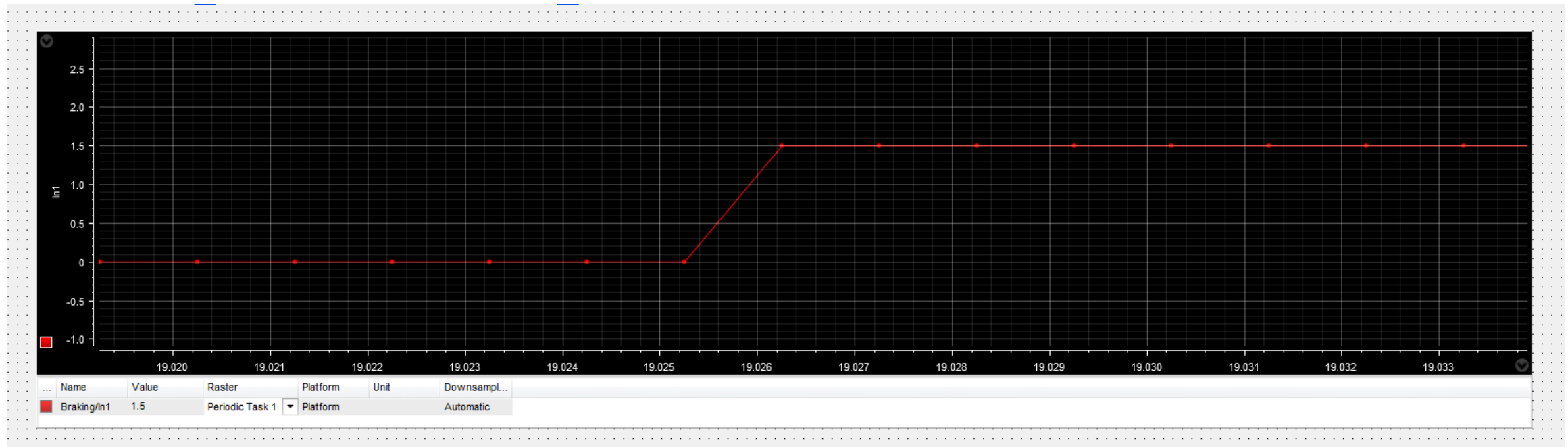
The interface includes a menu bar (File, Home, Layouting, Signal Editor, XIL API EESPort, Automation, Platforms, View, AppTools XILMapper), a toolbar with various control buttons (Start, Stop, Go, etc.), and a status bar at the bottom showing 'Measuring' and a time of 61.4 s.

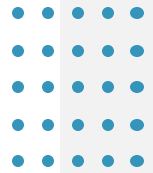
RCP testing of ACC-AEB algorithm in real time platform – Logging @ sample time of .1 s

	A	B	C	D
22	displayidentifier			
23	path		Model Root/Acc	Model Root/Braking
24	flags		2	2
25	min		-1.797693135e+308	-1.797693135e+308
26	max		1.797693135e+308	1.797693135e+308
27	minWeak		-1.797693135e+308	-1.797693135e+308
28	maxWeak		1.797693135e+308	1.797693135e+308
29	trace_valu	0	-2	1.5
30		0.100001	-2	1.5
31		0.200003	-2	1.5
32		0.300004	-2	1.5
33		0.400005	-2	1.5
34		0.500007	-2	1.5
35		0.600008	-2	1.5
36		0.700009	-2	1.5
37		0.80001	-2	1.5
38		0.900012	-2	1.5
39		1.000013	-2	1.5
40		1.100014	-2	1.5
41		1.200016	-2	1.5
42		1.300017	-2	1.5

RCP testing of ACC-AEB algorithm in real time platform@ sample time of .001 s

Braking parameter time-plot





Advantages of MathWorks solutions

- Convenient and user friendly interface makes MATLAB solutions easy to work with
- Control algorithms developed in Simulink can be extended to RCP/HIL setup using the same Simulink framework and tools
- MATLAB solutions such as Simulink is supported by most HIL vendor platforms such as dSPACE, NI, OPAL-RT, etc.
- RoadRunner visuals offer high fidelity scenarios leading to efficient testing for camera based systems
- The entire testing process can be automated using Test manager
- With FMI support, integration with 3rd party tools, like Canoe, is much easier

Future works:

- 2D Simulink app designer created scenarios can be replaced with RoadRunner, UnrealEngine based 3D scenarios for more realistic view
- Vehicle dynamics section can also be run in the RTPC

THANK YOU

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