

ACCELERATE AUTOMOTIVE ADAS VALIDATION WITH HARDWARE IN THE LOOP RADAR TESTING

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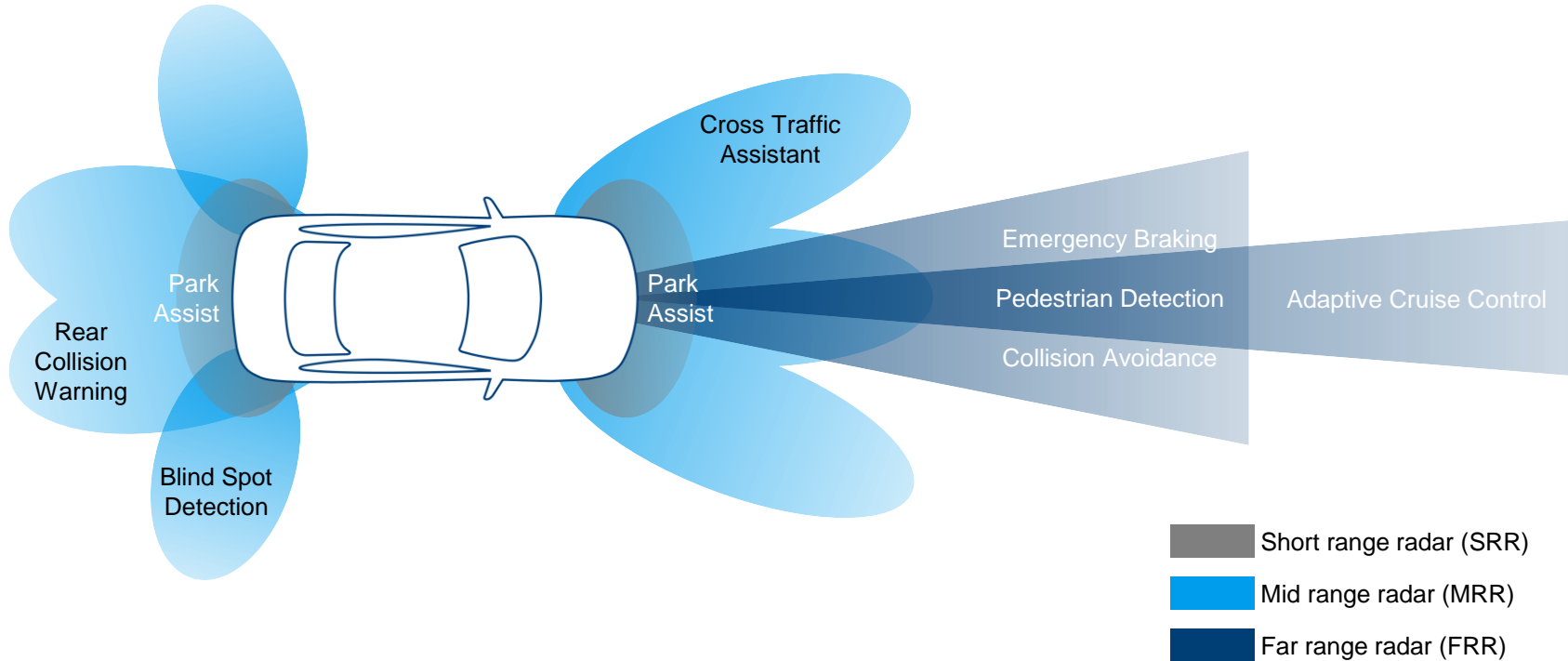
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RADAR BASED AUTONOMOUS DRIVING

THE SITUATION



TEST CHALLENGES

THE SITUATION

Capabilities of closed loop testing

- real-time simulation allows the testing of embedded software running on the ADAS ECU
- Very good, standardized test coverage
- High test cases variability thanks to parametrizable scenarios
- Tests cases include validation of ECU firmware and operating system

Limitation of current laboratory test options

- Limited scenario testing capabilities
- Azimuthal moving targets challenging to simulate
- Scenario based open and closed loop capabilities missing
- Open interfaces for HiL applications often missing



EXEMPLARY DRIVING SCENARIOS

BASIC INSTRUMENT CONFIGURATIONS



Enables selected NCAP, AEB and ACC scenarios

- Simulation of targets moving in azimuth, range, radial velocity and target size.
- Stimulation of a single radar sensor.



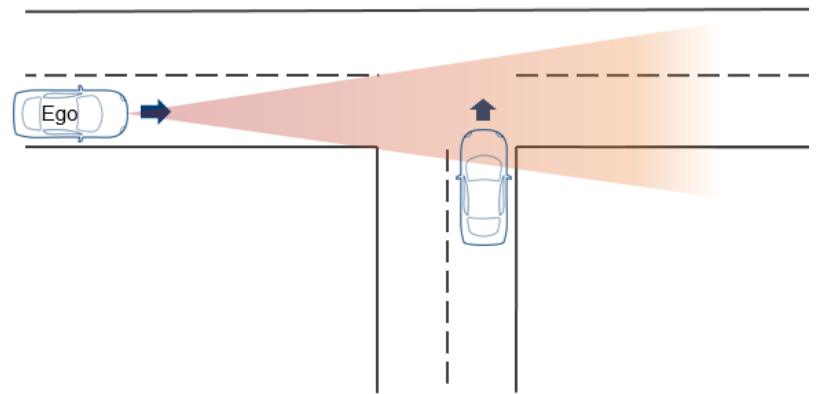
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EXEMPLARY DRIVING SCENARIOS

ADVANCED INSTRUMENT CONFIGURATIONS



Enables advanced NCAP, AEB, ACC and other scenarios

- Simulation of targets moving in azimuth, range, radial velocity and target size.
- Simultaneous stimulation of multiple radar sensors.



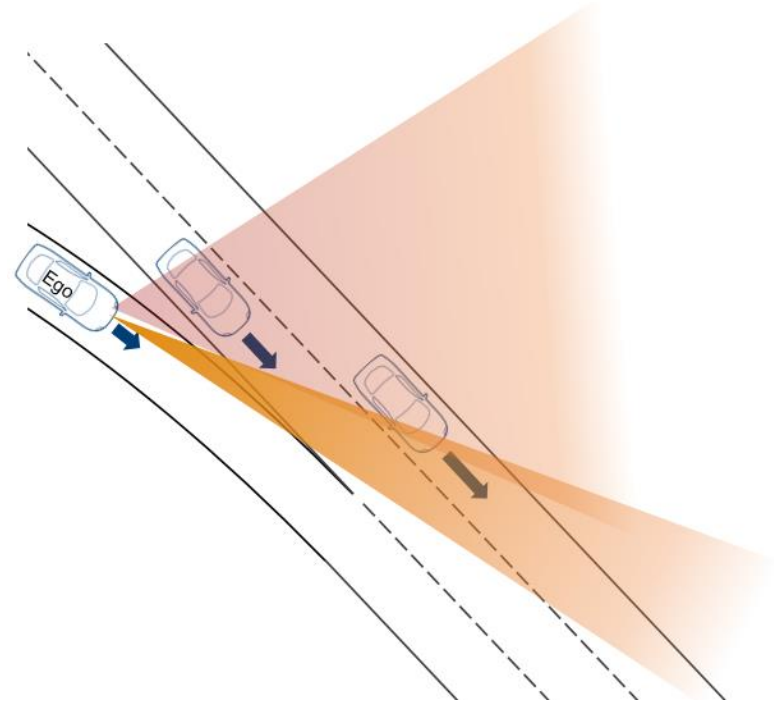
EXEMPLARY DRIVING SCENARIOS

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PART I

CLOSED-LOOP VALIDATION

TESTING AUTOMOTIVE RADAR SENSORS IN ADAS/AD FUNCTIONS

R&S®QAT100 AND R&S®AREG800A

MOVING OBJECT STIMULATION SYSTEM FOR VERIFICATION OF SAFETY-CRITICAL ADAS FUNCTIONS



R&S®AREG800A
Automotive Radar Echo Generator
Backend

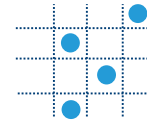


R&S®QAT100
Advanced Antenna Array
Frontend

UNIQUE FEATURES – AREG800A TOGETHER WITH QAT100



Performance
optimized system



Multiple independent
objects



Scalable solution



Synchronization of multiple
QATs and AREG800As



One stop solution
from R&S



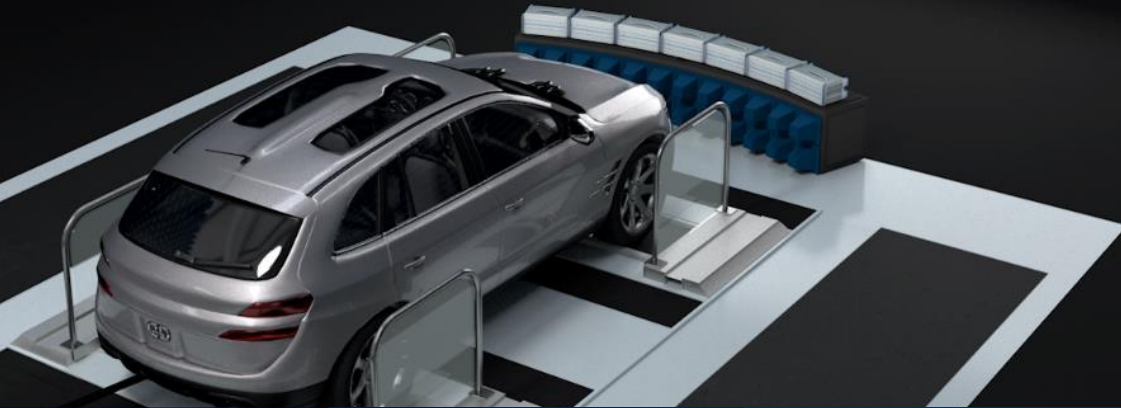
Seamless integration via
Open Simulation Interface



Built-in real time
interface

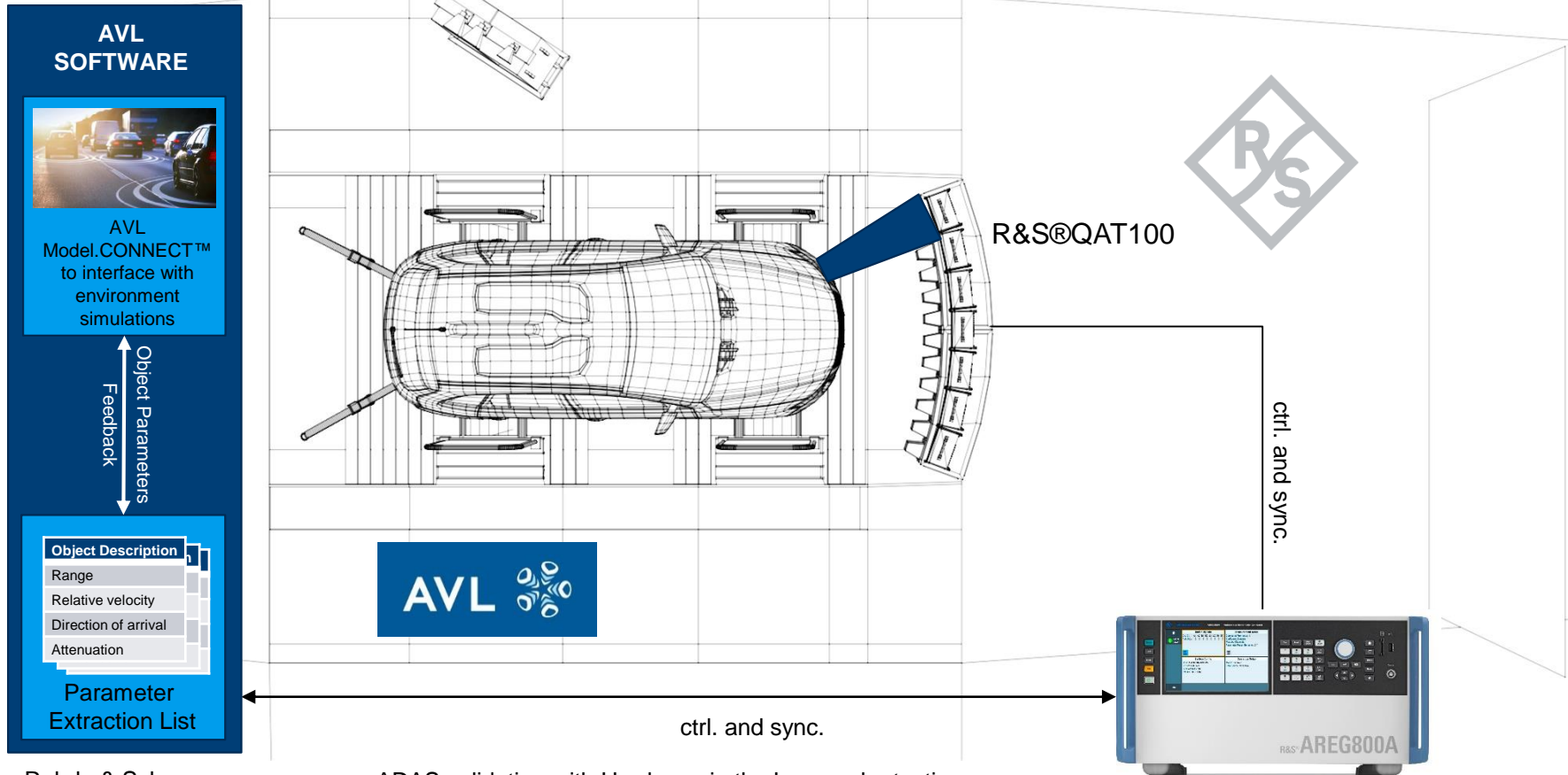
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TEST LIKE IT IS REAL
FROM ROAD TO RIG FOR VEHICLE-IN-THE-LOOP TESTING

VEHICLE-IN-THE-LOOP TESTING



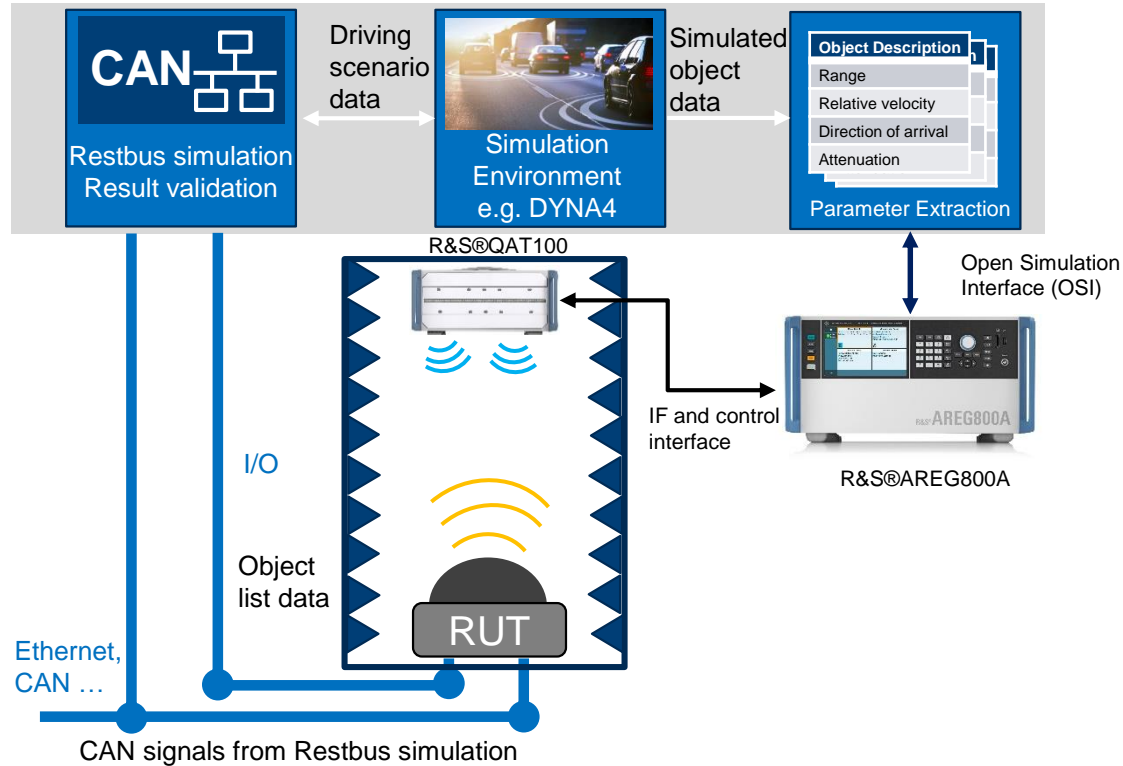
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BRING ROAD REALITY TO YOUR LAB
A REALISTIC HARDWARE-IN-THE-LOOP TESTING SOLUTION

HARDWARE-IN-THE-LOOP TESTING

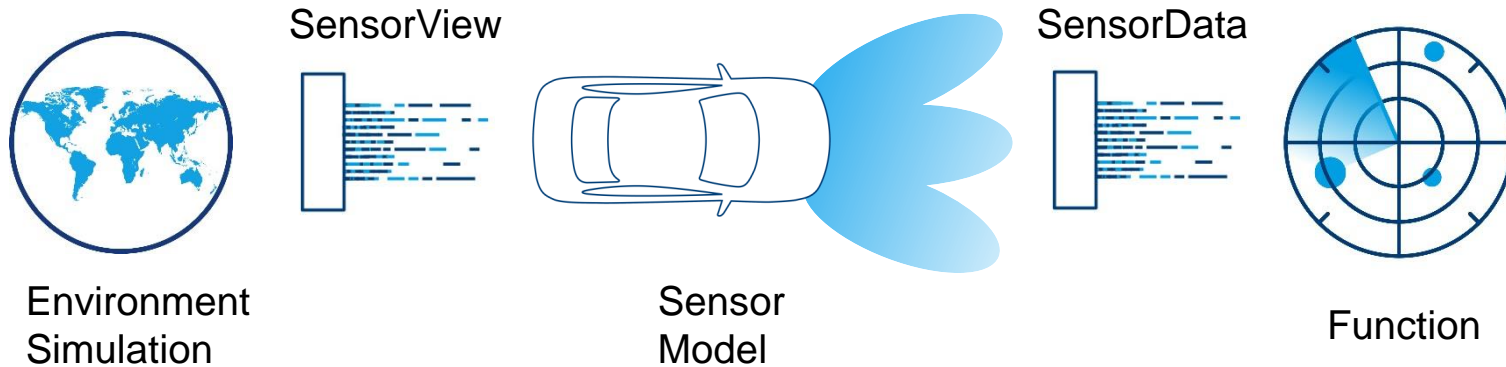




PART II
OPEN SIMULATION INTERFACE

WHAT IS THE OPEN SIMULATION INTERFACE?

- ▶ Specification for interfaces between models and components of a distributed simulation
- ▶ Strongly focused on environmental perception of automated driving functions
- ▶ Object-based environment description using Google's Protocol Buffer library



R&S®AREG800A: OSI INTEGRATION

Parameter Interface

Object Description

Range
Relative velocity
Direction of arrival
Radar Cross Section

Serializer



Scenario Mode Hardware-in-the-loop



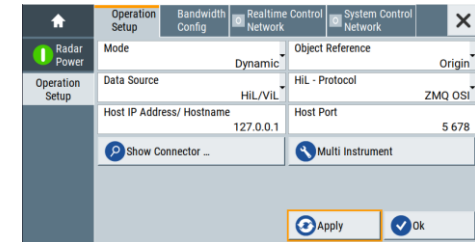
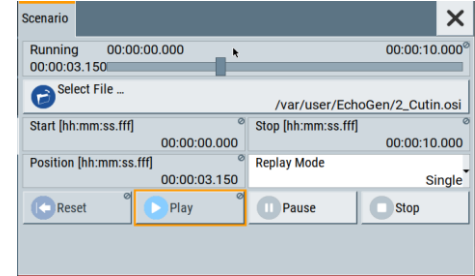
UDP



TCP

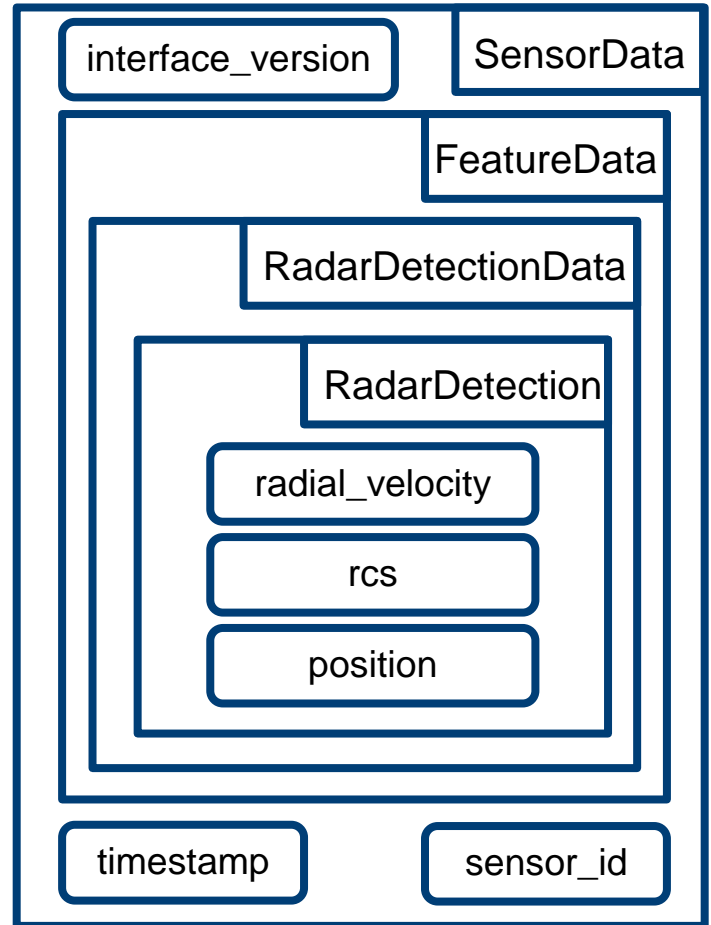


Open Simulation Interface



R&S®AREG800A - OSI MESSAGE

- ▶ Top Level OSI Message: SensorData
- ▶ Nested Structure



◆ rcs

optional double osi3::RadarDetection::rcs = 7

The radar cross section (RCS) of the radar detection.

Unit: dB m²

◆ position

optional **Spherical3d** osi3::RadarDetection::position = 3

Measured position of the detection given in spherical coordinates in the sensor coordinate system.

Source: https://opensimulationinterface.github.io/open-simulation-interface/structosi3_1_1RadarDetection.html

WORKFLOW HARDWARE-IN-THE-LOOP / SCENARIO MODE

Section	Parameter	Value	Action/Label
Measurement Setup	Air Gap	50 cm	Cable Correction ...
	Angle Frontend to Sensor	0.0 deg	Rotation Frontend to Sensor
Info	QAT Hostname	QAT100SIM-900001	TRX ID =
	Disconnect	Connected - SN: QAT100SIM-900001	TRX ID =
	QAT Channel Mode	Single	QAT Channels
	Frontend Bandwidth	1.00 GHz	Frontend Center Frequency
			76.5 GHz

Step 1:
Configure Frontends

Section	Parameter	Value	Section
Measurement Setup	Center Frequency	76.500 0 GHz	Bandwidth
			1.000 000 000 0 GHz
Measurement Setup	Sensor to Origin		Radar Sensor ID = S1
	Relative Distance	0 cm	
Measurement Setup			0.0 deg
	Dynamic Mode ID	1	

Step 2:
Configure Radar Sensors

WORKFLOW HARDWARE-IN-THE-LOOP / SCENARIO MODE

ID	Channel	Show	Frontend	Sensor	Adjust Level
A1	Channel 1	🔍 ...	Q1: QAT Σ1	S1: Radar Sensor	➡
A2	Channel 2	🔍 ...	Q2: QAT Σ1	S1: Radar Sensor	➡

Adjust All Levels Adjust Level Settings

Step 3:
Mapping of AREG800A IF
Channels, Frontends & Sensors

Valid Objects: 0 Invalid Objects: 0

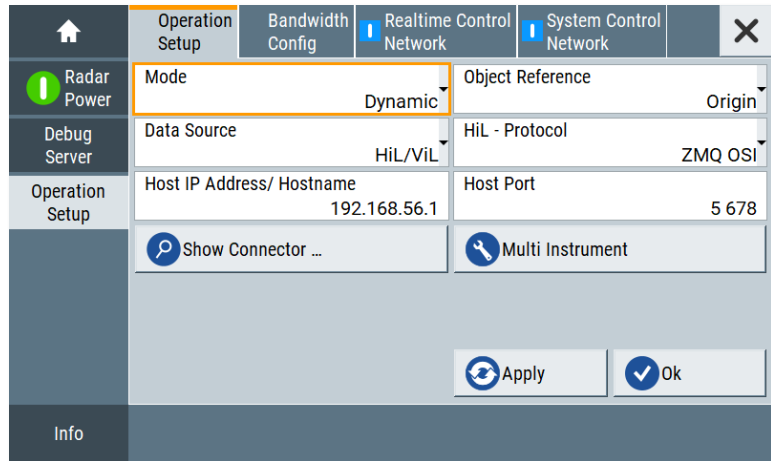
Autoscale

Max. Distance: 3.400 km

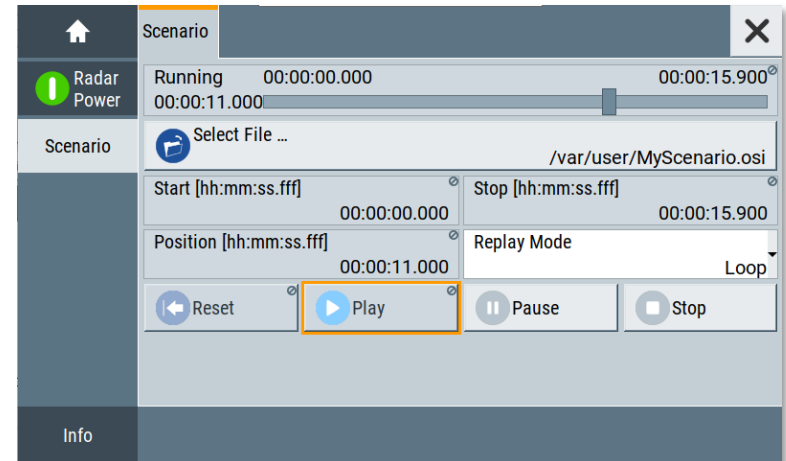
Legend:
◆ Object (Valid)
◆ Object (Invalid)
■ Frontend
✗ Sensor

Step 4:
Visual verification

WORKFLOW HARDWARE-IN-THE-LOOP / SCENARIO MODE

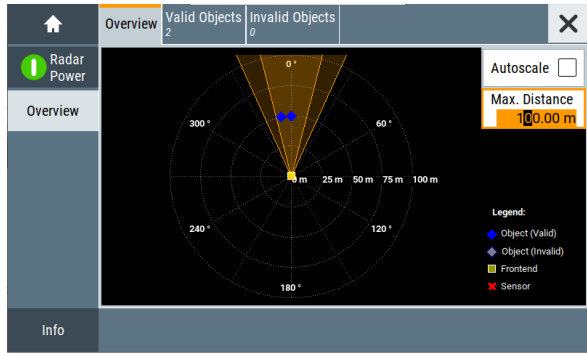


Hardware-in-the-loop setup



Scenario mode setup

WORKFLOW HARDWARE-IN-THE-LOOP / SCENARIO MODE



Visual Overview

Table Overview of radar data. The table displays the following data:

	Range /m	Attenuation /dB	Doppler Speed /(km/h)	Horizontal Angle /deg	RCS /dBm ²
0	78.5	0.0	-18.0	0.0	20.0
0	84.2	0.0	-21.6	0.0	20.0

Table Overview

Event List showing a table with columns: Level, Time Stamp, and Text.

	Level	Time Stamp	Text
1	Info	2022-05-24 07:47:17	Scenario restart.
2	Info	2022-05-24 07:47:01	Scenario restart.

0 | 0 | 2

Clear Save

Event List

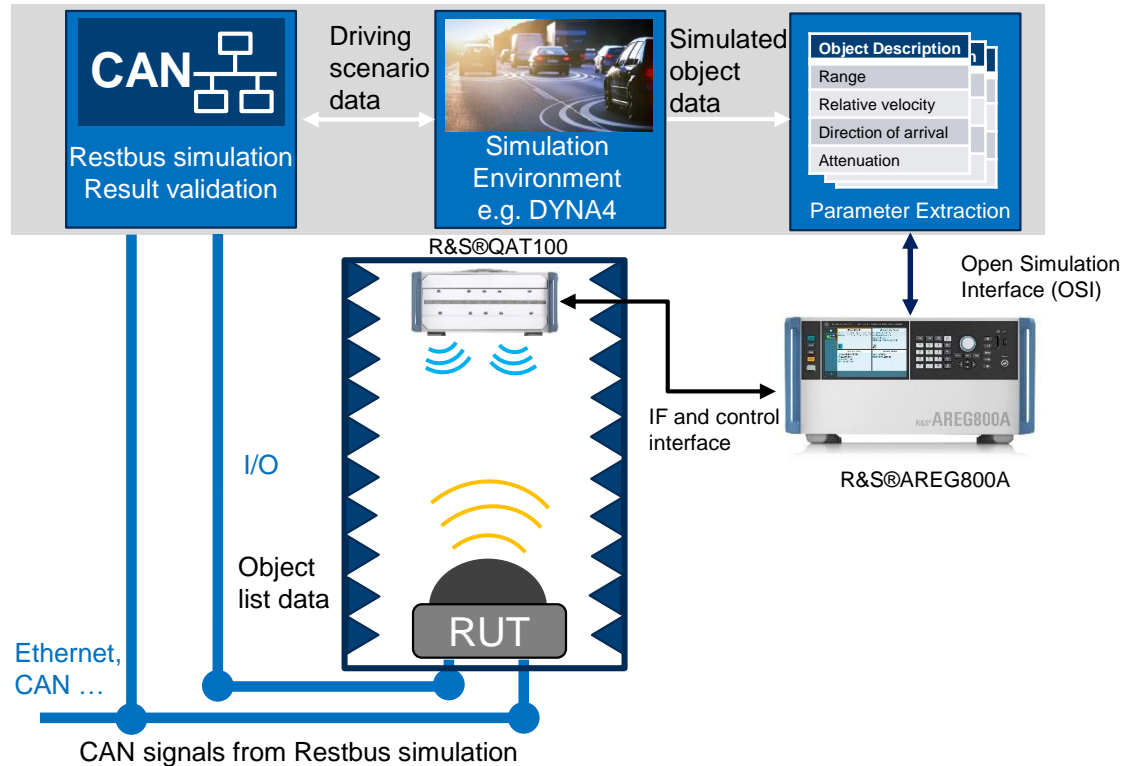


PART III

HARDWARE-IN-THE-LOOP SETUP

EXEMPLARY DRIVING SCENARIO

HARDWARE-IN-THE-LOOP TESTING



VIDEO



PART IV SUMMARY

SUMMARY

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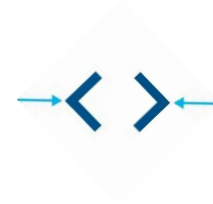
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Easy and convenient
to integrate



Flexibility and scalability



Precise and repeatable
measurement



THANK YOU!