R&S®RADEST

THE ESSENTIAL IN RADAR TESTING:
YOUR ALL-ROUNDER FROM LAB TO VEHICLE

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Product Management Microwave Imaging

ROHDE&SCHWARZ
Make ideas real

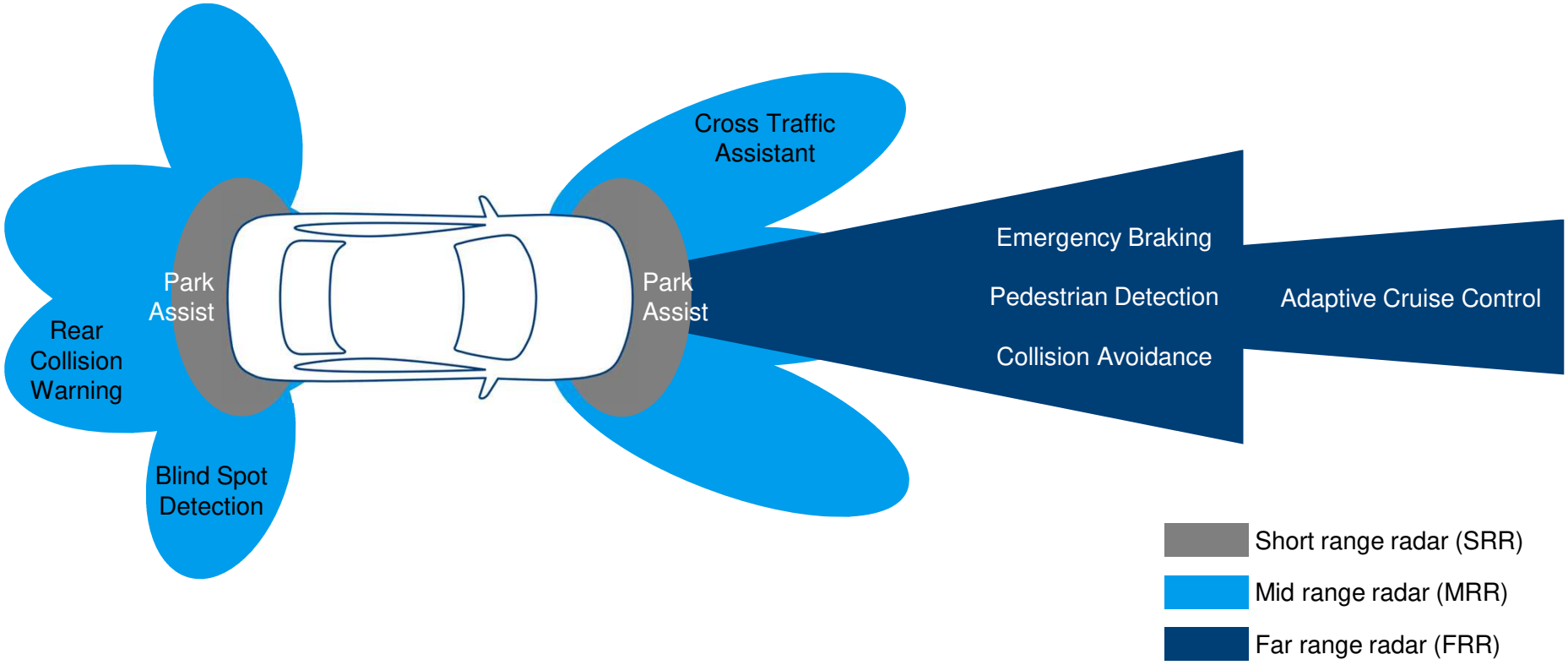
AGENDA

- **Automotive Radar Technology**
  - Radar based autonomous driving & Radar Technology Trends
- **Applications**
  - Exterior radar – testing chain
  - Current Challenges:
    - Validation at chip suppliers, Tier1s, OEM
    - End-of-line vehicle Test
    - PTI & Workshops
- **Operating principle**
  - Operating concept & measurements
  - Evaluation of sensor data & EIRP
- **Introduction R&S®RadEsT**
  - Key Features & Benefits
  - Specifications in brief
  - Operating methods
- **Use Cases & Benefits**

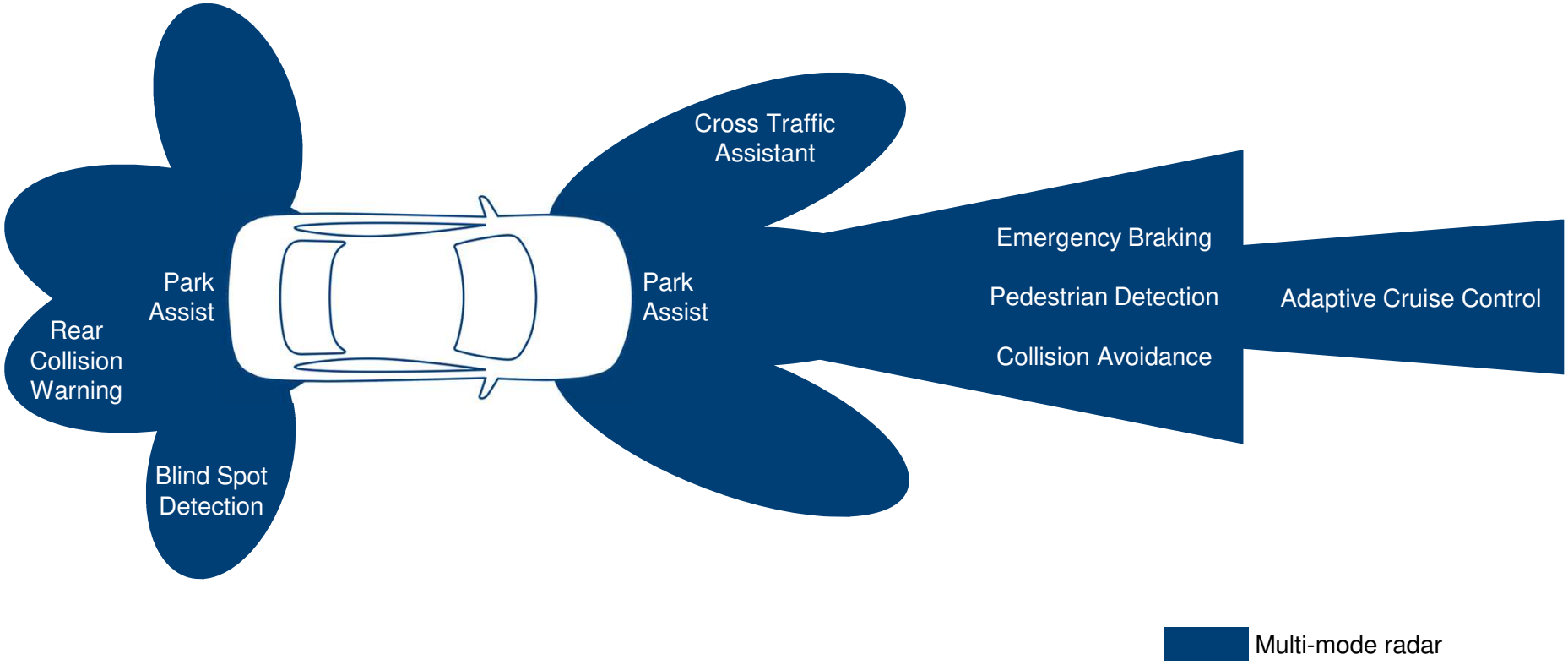
AUTOMOTIVE RADAR TECHNOLOGY

- Radar based autonomous driving
- Radar technology trends

RADAR BASED AUTONOMOUS DRIVING



RADAR BASED AUTONOMOUS DRIVING



RADAR TECHNOLOGY TRENDS
TYPICAL SENSOR PARAMETERS

Radar Module Parameters	Short-Range Radar	Standard Mid-Range Radar	Premium Mid-Range Radar	Standard Long-Range Radar	Premium Long-Range Radar
Frequency Range [GHz]	24,76-77,77-81	76-77	77-81	76-77	76-77
Typical Bandwidth [MHz]	200, 1000, 4000	1000	2000	500	1000
Range [m]	80	150	150	250	300
Range Resolution [cm]	300, 30, 3.5	30	7.5	75	30
FOV Azimuth / Elevation [°]	±60 / ±0	±30 / ±0	±50 / ±15	±15 / ±5	±15 / ±10
Typical Channel Number [Transmit / Receive]	3 TX / 4 RX	4 TX / 8 RX	8 TX / 12 RX	4 TX / 8 RX	12 TX / 16 RX

RADAR TECHNOLOGY TRENDS
TYPICAL SENSOR PARAMETERS

Radar Module Parameters	Multi-mode Radar
Frequency Range [GHz]	76-77, 77-81
Typical Bandwidth [MHz]	200, 500, 1000, 200, 4000
Range [m]	250, 300
Range Resolution [cm]	300, 30, 3.5
FOV Azimuth / Elevation [°]	±60 / ±15
Typical Channel Number [Transmit / Receive]	3 TX / 4 RX, 4 TX / 4 RX, 8 TX / 8 RX

APPLICATIONS

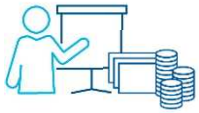
- Exterior radar – testing chain
- Current Challenges:
  - Validation at chip suppliers, Tier1s, OEM
  - End-of-line vehicle Test
  - PTI & Workshops

Applications

AUTOMOTIVE RADAR SENSOR LIFECYCLE – TESTING CHAIN
NEW POSSIBILITIES IN RADAR TESTING

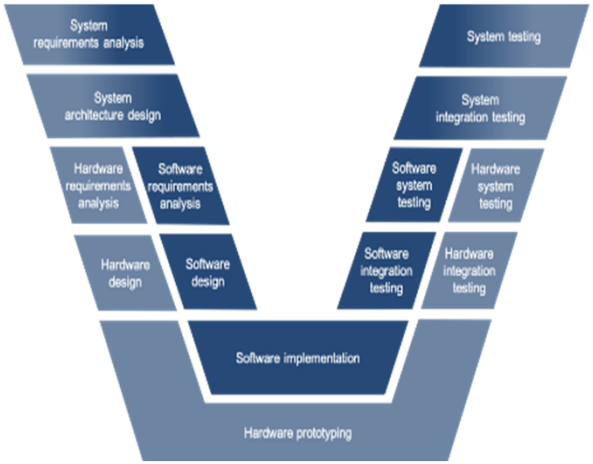
CURRENT CHALLENGES
VALIDATION AT CHIP SUPPLIERS, TIER1S, OEM

Quick analysis of target detection algorithms on the bench
"Is the algorithm working and what are the improvements?"
- Need to verify basic parameters on the radar SW directly
- Individually SW adjustments necessary



No need to check the full performance under test
basic features are available:
- E.g. correct angle & distance detection
- Doppler processing working as intended /
  target classification based on RCS values

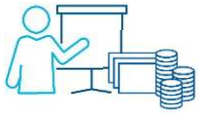
Today's test equipment for the radar frequency domain is
not designed for these specific needs:
- No chance in the current step to validate algorithms
- Tasks passed on to the next departments
  → additional time consuming iteration steps



Applications

CURRENT CHALLENGES
END-OF-LINE VEHICLE TEST

Simple method to qualify overall system with integrated sensor. Alignment / Calibration plus for higher autonomous level vehicles, testing of ADAS/AD functions.



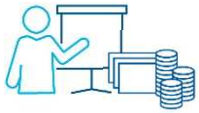
Test equipment for the radar frequency domain is currently inflexible and requires much floor space.
Requirements for such test equipment are:
- Compatibility with various sensors
- Defined test procedures (Ability to alter range, size, angles of the simulated target)
- Easy integration

Today's test equipment for the radar frequency domain is not designed for production environmental needs:
- Limited test scenarios
- Method must be stable versus external noise
- Consume too much floor space

Applications

CURRENT CHALLENGES
PTI & WORKSHOPS

After minor car damages, the performance of radar sensors supporting ADAS/AD needs to be verified.
Repainting of bumpers needs to be verified as well.



Test equipment for the radar frequency domain is currently very costly and requires extensive training.
Requirements for such test equipment are:
- Pass/Fail analysis
- Defined test procedures
- Compatibility with various sensors
- Intuitive operation

Today's test equipment for the radar frequency domain is not designed for harsh garage environmental needs:
- Extended temperature range
- Dusty environment
- Radar reflective environment

OPERATING PRINCIPLE

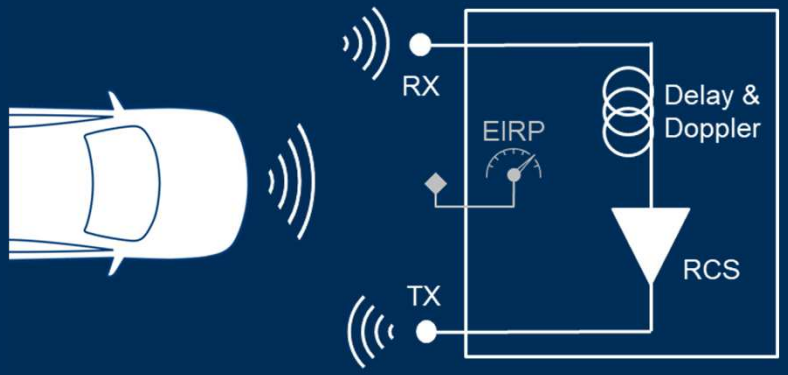
- Operating concept & measurements
- Evaluation of sensor data
- Evaluation of sensor EIRP

Operating principle

R&S®RADEST
OPERATING CONCEPT & MEASUREMENTS

Operating concept

- Radar tester receives signal from vehicle sensor
- Received signal will be manipulated to simulate radar object distance, velocity, angle & RCS
- Manipulated signal transmitted to vehicle sensor



- EIRP from vehicle sensor will be measured

Measurement capabilities

Cooperative system for ADAS/AD function test

- Radar distance simulation
- Object angle simulation
  - In azimuth
  - In elevation
  - Angular distortion
- Object size variation

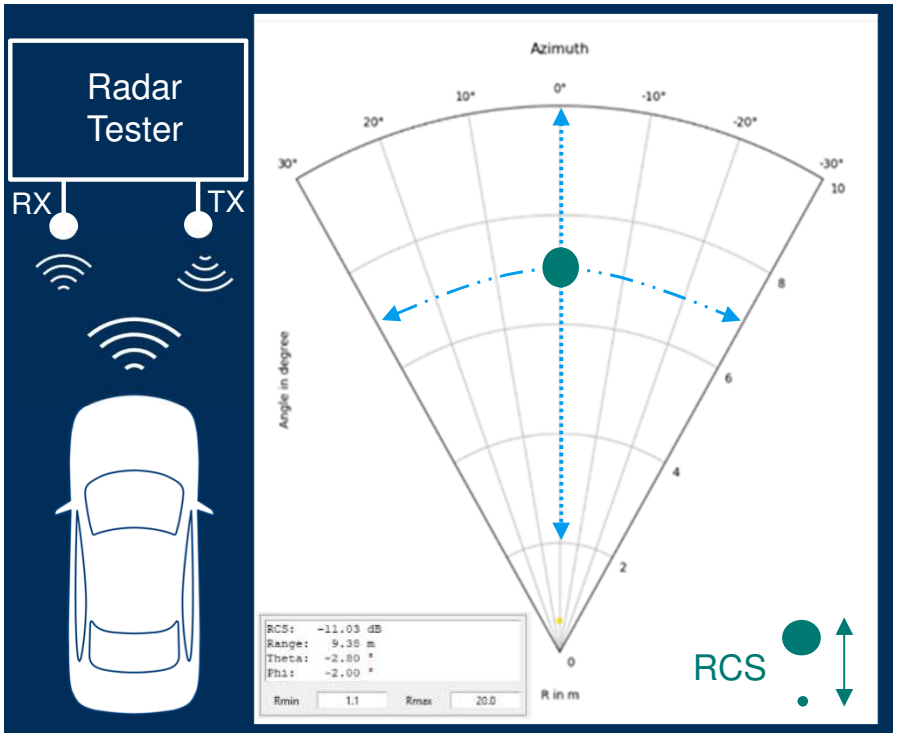
Independent system

- Radar performance verification
  - Transmission coefficient
  - EIRP measurement

Operating principle

R&S®RADEST
EVALUATION OF SENSOR DATA

Evaluation of sensor data



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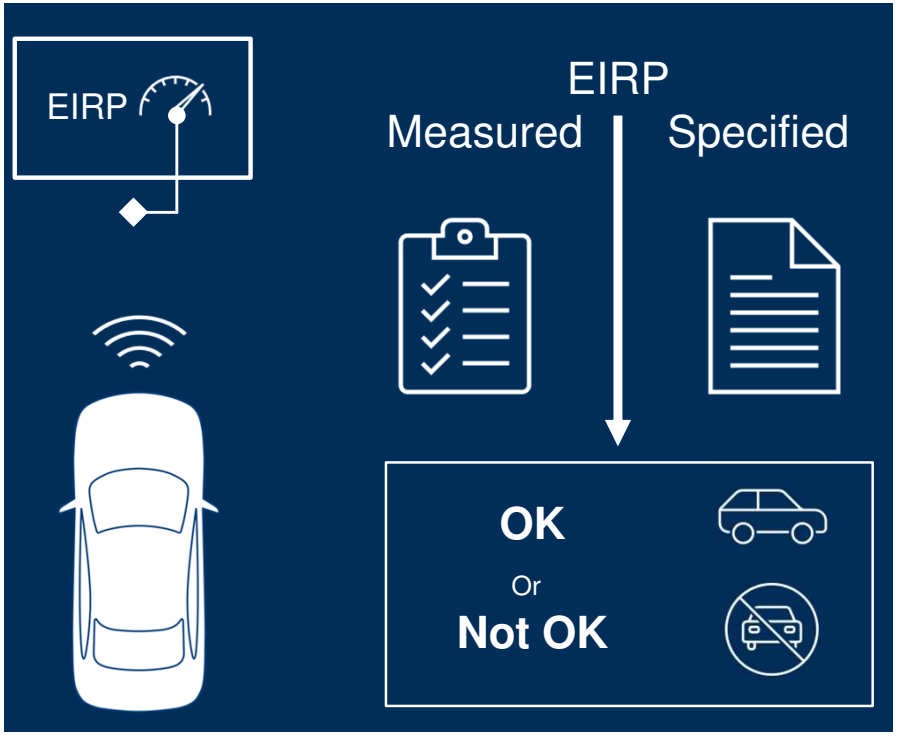
Operating principle

R&S®RADEST
EVALUATION OF SENSOR EIRP

Evaluation of sensor EIRP



Measurement capabilities

Cooperative system for ADAS/AD function test

- Radar distance simulation
- Object angle simulation
- Object size variation

Independent system

- **Radar performance verification**

  a) **Transmission coefficient**
  - Measuring bumper before & after repair
  - Measure deviation of transmission coefficient

  b) **EIRP measurement**
  - Measure radiated power thru bumper
  - Compare with EIRP sensor values
  - Check within compliance limits

INTRODUCTION R&S®RADEST

- Key Features & Benefits
- Specifications in brief
- Operating methods

R&S®RADEST KEY FEATURES

Dynamic & precise target simulation

Adjust distances & velocity (Doppler)

Simulate reflections from different types of road users

Fully compatible with MIMO sensors; Built in polarization mechanism

Verify radar sensors signal level (EIRP)

Integrated power level measurement for 76-81 GHz & 24 GHz sensors

Determine occupied bandwidth

Integrated bandwidth estimation

Self-check capability

Internal diagnostics to ensure operational integrity and accuracy

Battery powered

Optional battery-powered
Increased portability and flexibility

R&S®RADEST
KEY FEATURES & BENEFITS

Broad compatibility

Different polarized antennas;
Compatible with multiple sensor models
& seamless operation from lab to vehicle

Compact size & light weight

Compact size, light weighted
& easy to integrate

Quick setup & easy to use

Optional battery-powered
Increased portability and flexibility

Consistent & reliable results

Self-check capability maintains
measurement accuracy
& ensures consistent and reliable results

Outstanding value

High-end features at an
unmatched price point

R&S®RADEST
SPECIFICATIONS IN BRIEF

Antennas		
Number of antennas	Antennas grouped in 3 segments for angular object simulation	12 TX channels & 12 RX channels
RX / TX antenna distances		3.70 mm (within segment) 51.86 mm (between segment)
Antenna Types		Patch antennas with 45° polarization / horizontal & vertical polarization
RX detectors	RX channels for power detection / EIRP measurement	EIRP for 24 GHz EIRP for 76 GHz to 81 GHz
Target Generation		
Target generator type		static & dynamic artificial object generation (one target with individual azimuth, distance, RCS, Doppler)
Generation concept		analog stepped delay line
Measurement Capabilities		
Power Level (EIRP)		24 GHz 76.0 GHz to 81.0 GHz
Occupied Bandwidth		76.0 GHz to 81.0 GHz

R&S®RADEST
SPECIFICATIONS IN BRIEF

Frequency		
RF frequency range	Object simulation	76.0 GHz to 81.0 GHz
	Power measurement	24 GHz, 76.0 GHz to 81.0 GHz
Object simulation		
Distance	Range	2.5 m to 250 m
	Resolution	0.04 m (typ.)
Doppler	Range	0 to ±500 km/h
	Resolution	1 km/h
Attenuation (RCS)	Range	>40 dB
	Resolution	1 dB (typ.)
System phase noise	At maximum range	>-115 dBc
Power measurement range		
	24 GHz	–60 dBm to –25 dBm (-5 dBm to 30 dBm EIRP)[1]
	76 GHz to 79 GHz	–54 dBm to –24 dBm (10 dBm to 40 dBm EIRP)[1]
	79 GHz to 81 GHz	–49 dBm to –24 dBm (15 dBm to 40 dBm EIRP)[1]
Level		
Maximum ratings	RX power at frontend[1]	+55 dBm EIRP
	TX power at frontend	+10 dBm EIRP

[1]At 0.5 m distance from the DUT.

R&S®RADEST
SPECIFICATIONS IN BRIEF

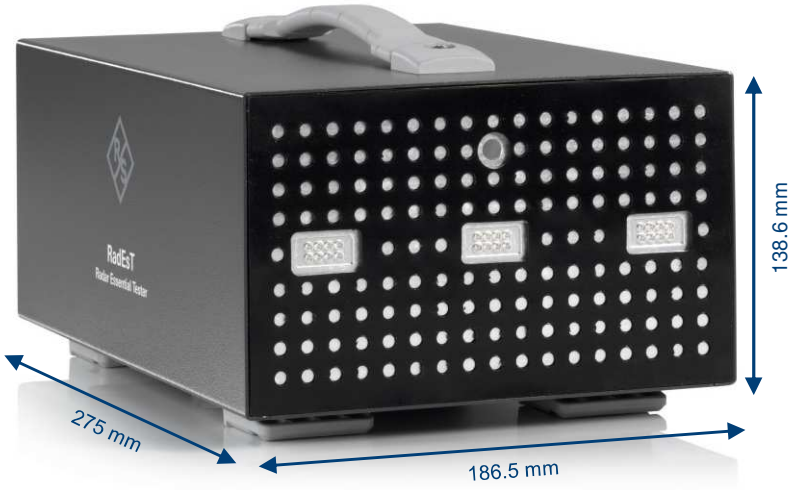
Dimensions (W x H x D)
(186.5 mm × 138.6 mm × 275 mm)

Weight ~3.2 kg

Equipped with battery package optional

Remote control interfaces
Ethernet 10/100BASE-T

Remote control command set
SCPI 1999.5 or compatible command sets



R&S®RADEST OPERATION METHODS

Manual operation

- Buttons on rear side
- Direct selection of antennas
- Target configuration: distance, Doppler & RCS
- Power level measurement & normalization

Remote Control

- Python GUI via LAN
- Configuration of targets & scenarios
- Access to all measurement capabilities

Automated testing

- SCPI support and Python libraries
- Hardware based test sequencing

LIVE DEMO

USE CASES & BENEFITS

- All-rounder from lab to vehicle level
- Tier 2: System check & debugging of radar designs
- Tier 1: Software verification & functional tests
- OEM:
  - Evaluation of radar sensors
  - Production:
    - Radar sensor calibration and alignment
    - Testing of ADAS/AD functions

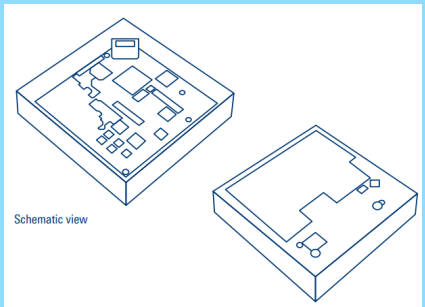
Use cases & Benefits

THE ESSENTIAL IN RADAR TESTING:
YOUR ALL-ROUNDER FROM LAB TO VEHICLE LEVEL

Tier 2: System check & debugging of radar module reference designs

Radar module check of reference designs

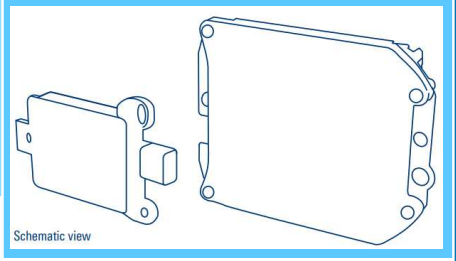
Debugging support for FAE's



Tier 1: Software verification & functional tests on the radar module

R&D: Radar FW verification

SW-verification on system-level
(Functional Tests ACC, AEB)



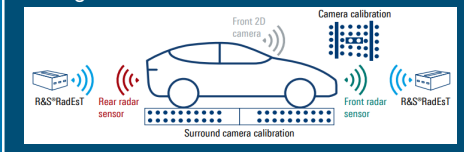
OEM: Evaluation of radar sensors

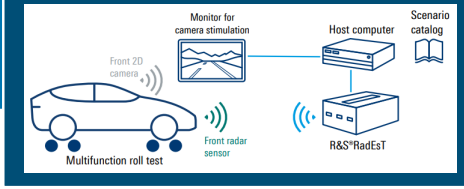
Evaluation of incoming Tier1 sensors
(Functional Tests ACC, AEB etc..)

OEM production

Sensor calibration & alignment

Testing of ADAS/AD functions

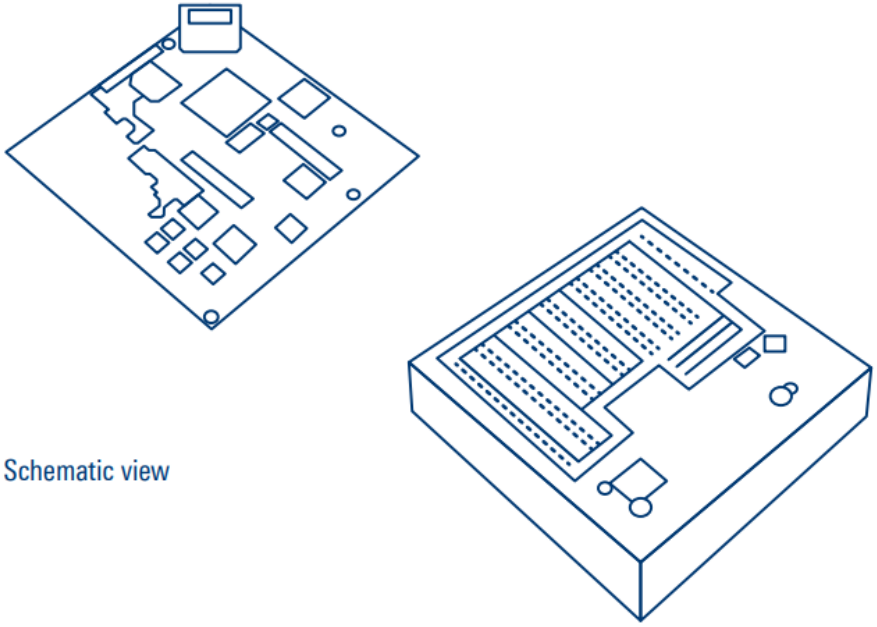




TIER 2: SYSTEM CHECK & DEBUGGING OF RADAR DESIGNS

- **Engineers must evaluate performance of basic features:**
  - Range calculation
  - Doppler processing for reference designs

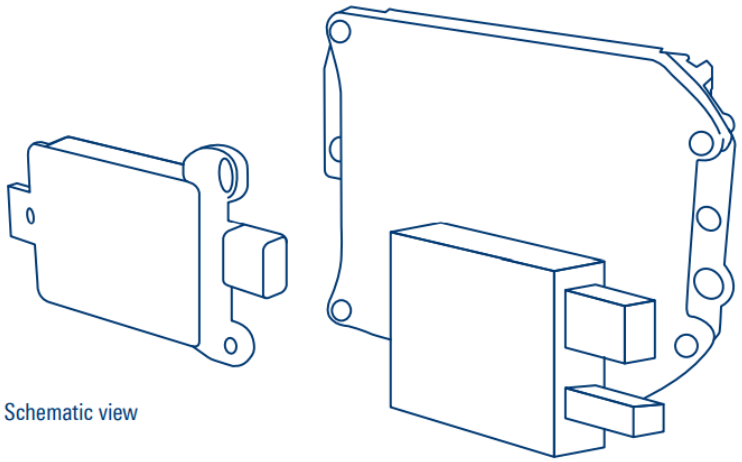
- **R&S®RadEsT: Flexible & Reliable Solution**
  - Quick, accurate assessment of reference designs
  - Simplifies design validation
  - Supports Field Engineers in real-time debugging



Schematic view

TIER 1: SOFTWARE VERIFICATION & FUNCTIONAL TESTS

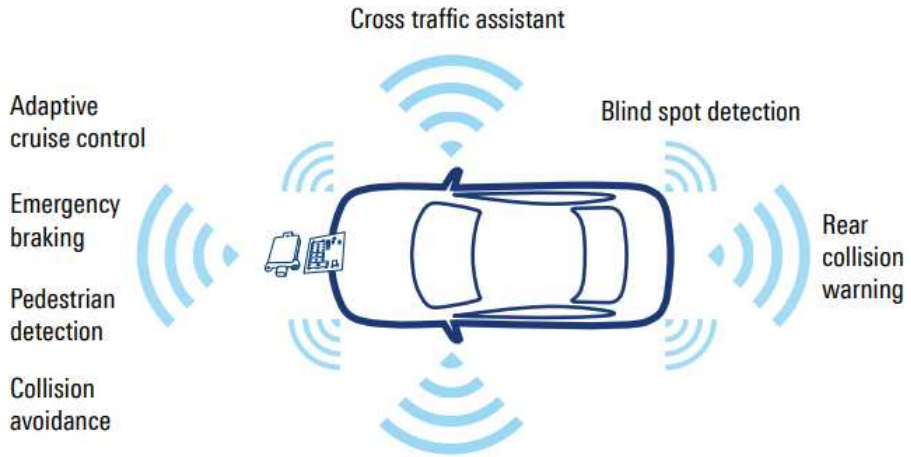
- **Key Verification Tasks:**
  - Qualify radar sensor at target level
  - Simulate radar objects at varying distances & angles
  - Adjust Radar Cross Section (RCS)
  - Analyze velocity/ Doppler effects
- **Challenges:**
  - Complex radar test setups
  - Time-consuming iterations for algorithm changes
- **R&S®RadEsT Advantages:**
  - Quick, direct radar target simulation on the bench
  - New testing methods for increased efficiency
  - Reduces verification time



Schematic view

OEM: EVALUATION OF RADAR SENSORS

- **Critical Decision-Marking Factors:**
  - Radar feature performance
  - Sensor design quality
- **Current Tools:**
  - Easy to use but limited in functions
  - Complex and time-consuming options
- **R&S®RadEsT Solution:**
  - All-in-one flexible, radar target simulator
  - Quick and easy feature evaluation
  - Overcomes constraints in existing evaluation tools

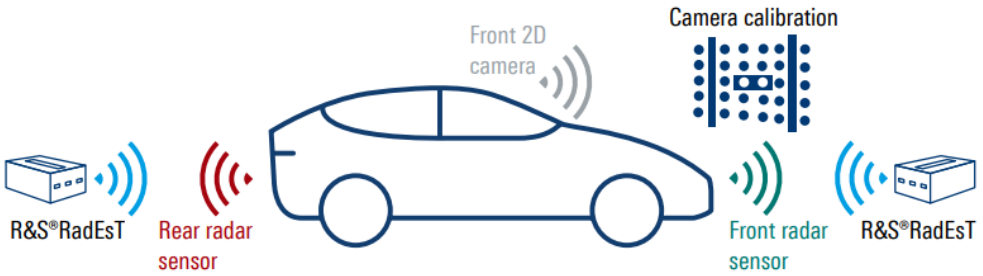


Use cases & Benefits

OEM PRODUCTION:
RADAR SENSOR CALIBRATION AND ALIGNMENT

- **Calibration and alignment requirements:**
  - All radar sensors require calibration
  - Each sensor assigned a specific target
- **R&S®RadEsT Advantages:**
  - Stimulates static and dynamic radar objects for calibration and alignment
  - Requires minimal physical distance for testing
  - Simulated targets can be configured based on:
    - Calibration distance
    - Velocity/Doppler adjustments
    - Attenuation/RCS settings
- **R&S®RadEsT a future proof solution:**
  - Meet current and future calibration/alignment needs

Integration OEM ADAS/AD calibration and alignment test stand



COMPARISON
PASSIVE ELEMENTS VS R&S®RADEST

Passive Elements:
Metal Plates, Corner Reflectors & Doppler Generator

- No modification of parameters
  → Cannot qualify advanced parameters of newer radar sensor generations e.g. quality factor
- Requires floor space of approx. 10m
- Positioning accuracy is difficult
- Unstable due to external noise
- Doppler generators become inaccurate over lifetime

R&S®RadEsT:
Static & dynamic artificial object generation

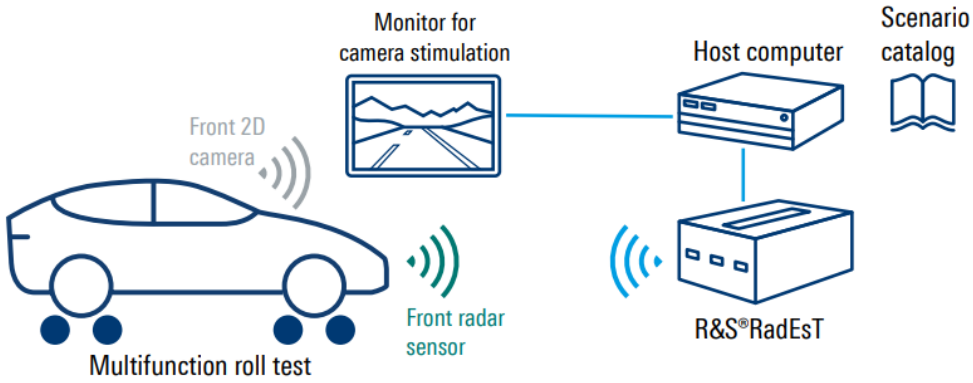
- Modification of radar parameters:
  Distance, doppler, RCS and angle
  → Qualify advanced radar sensor parameters of newer radar sensor generations
- Requires floor space of approx. 1m
- Antenna systems allows flexible positioning
- Small footprint with shielded environment to minimize external noise
- Self-check capability of RadEsT ensures accuracy over lifetime
- Further tests: e.g. EIRP & occupied bandwidth possible

Use cases & Benefits

OEM PRODUCTION:
TESTING OF ADAS/AD FUNCTIONS

- **System Performance for AE Level 2+ Autonomous Vehicles**
  - Simultaneous stimulation of all radar, camera, and lidar sensors
- **Comprehensive testing of ADAS/AD functions:**
  - Automatic Emergency Braking (AEB),
  - Adaptive Cruise Control (ACC)
  - Blind Spot Detection (BSD)
  - Lane Keep Assistance Systems (LKAS)
- **R&S®RadEsT Advantages:**
  - Compact and lightweight
  - Integrated polarization detection
  - Easy integration into existing end-of-line (EoL) testing
  - Supports all radar sensor types

Integration into OEM ADAS/AD functional test stand



https://www.rohde-schwarz.com/ADAS/AD Video

R&S®RADEST: RADAR TARGET SIMULATOR

Radar Module Functional Test on Target Level	End-of-Line Vehicle Calibration / Alignment	End-of-Line Vehicle Functional Testing

- **Comprehensive Testing Capabilities**

  Supports testing of radar distance, angular accuracy, MIMO sensors, and reflection simulations from various road users
  Extendable for longer distances, velocity, and power level measurement

- **Outstanding value for money proportion**

  Maximizes investment across the radar sensor lifecycle

- **Versatile & Modular Concept**

  Adapts to emerging market needs, compatible with multiple radar models and manufacturers, and can easily integrated into existing applications or lab environments

- **Future-Proof & Reliable**

THANK YOU