The most advanced automotive radar object simulation solution

REALISTIC TESTS ON VIRTUAL ROADS

ACCELERATE YOUR AUTOMOTIVE RADAR TESTING WITH THE MOST ADVANCED SOLUTION

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Product Manager for Signal Generation

ROHDE&SCHWARZ
Make ideas real

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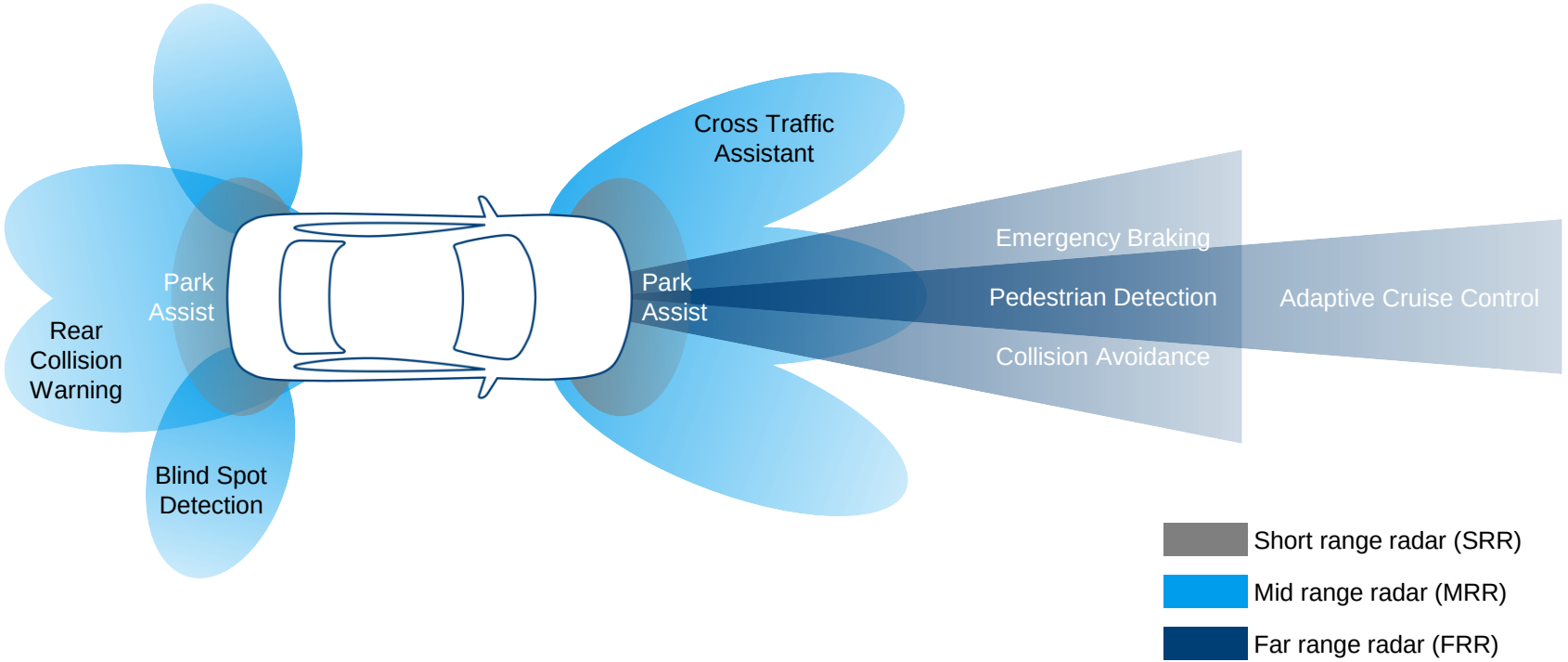
AGENDA

- Introduction
- R&S®RTS
  - R&S®QAT100
  - R&S®AREG800A
- Exemplary configurations
- Summary

RADAR BASED AUTONOMOUS DRIVING

THE SITUATION



CUSTOMER CHALLENGES

Roadworthy prototype required

Limited test capabilities

Limited scenario testing

OTA stimulation missing

… OUR SOLUTION

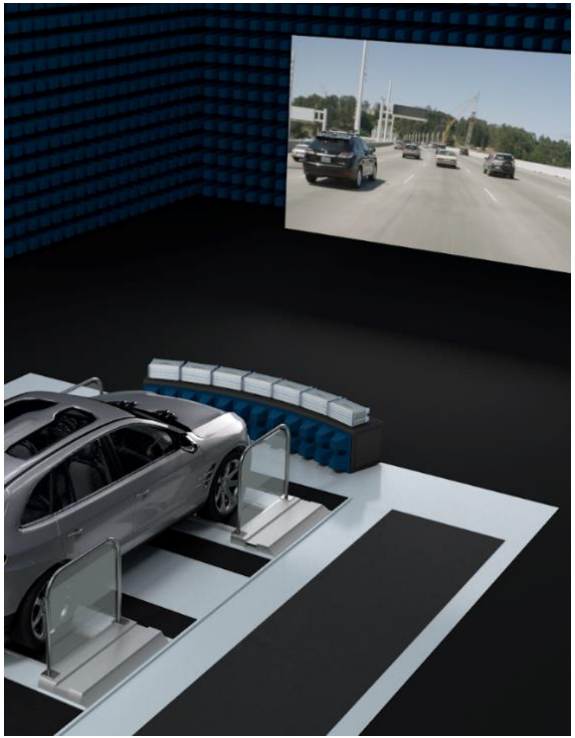
Speed up development cycle

Scalable solution

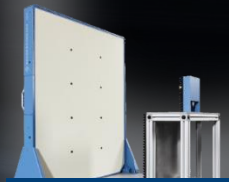
OTA stimulation included

Built-in realt-time interface

Complex scenario testing



Signal Generation



Radome Testing

Advanced echo generation

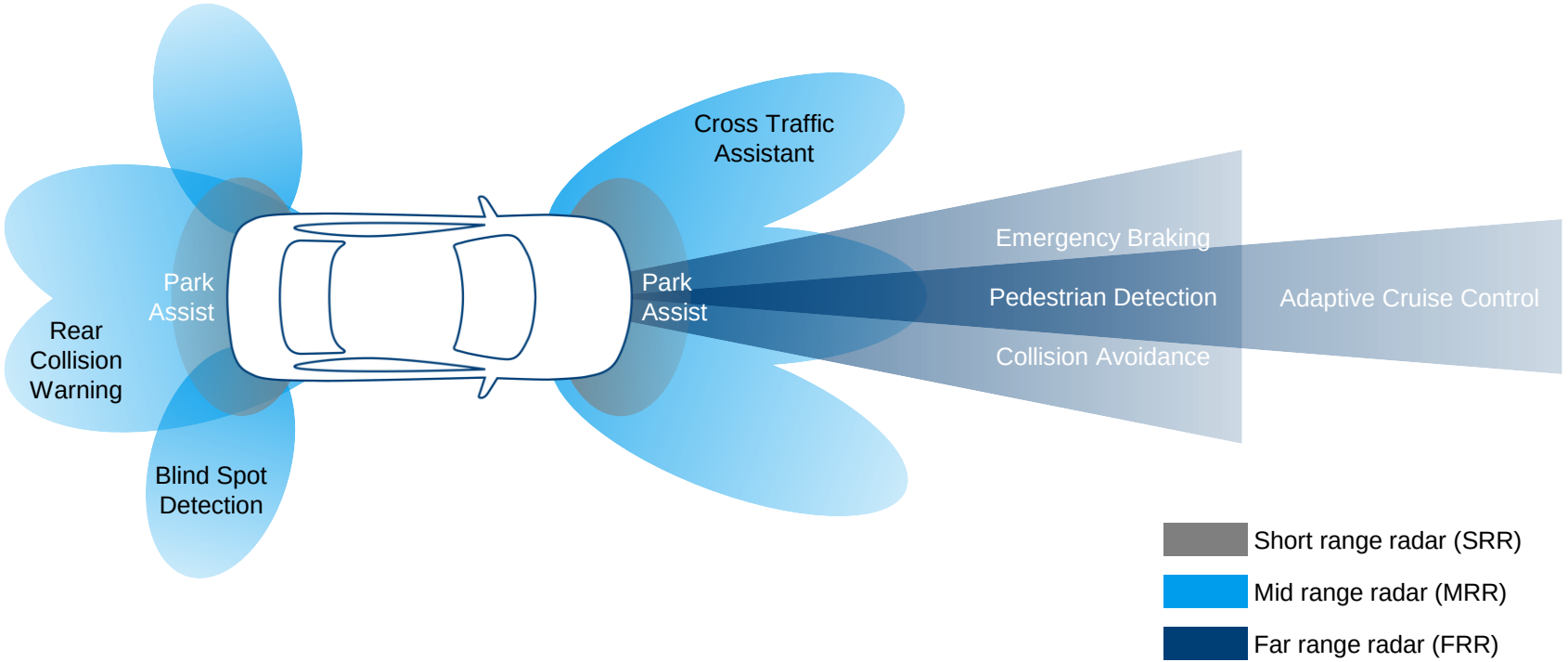
Static echo generation

Signal Analysis

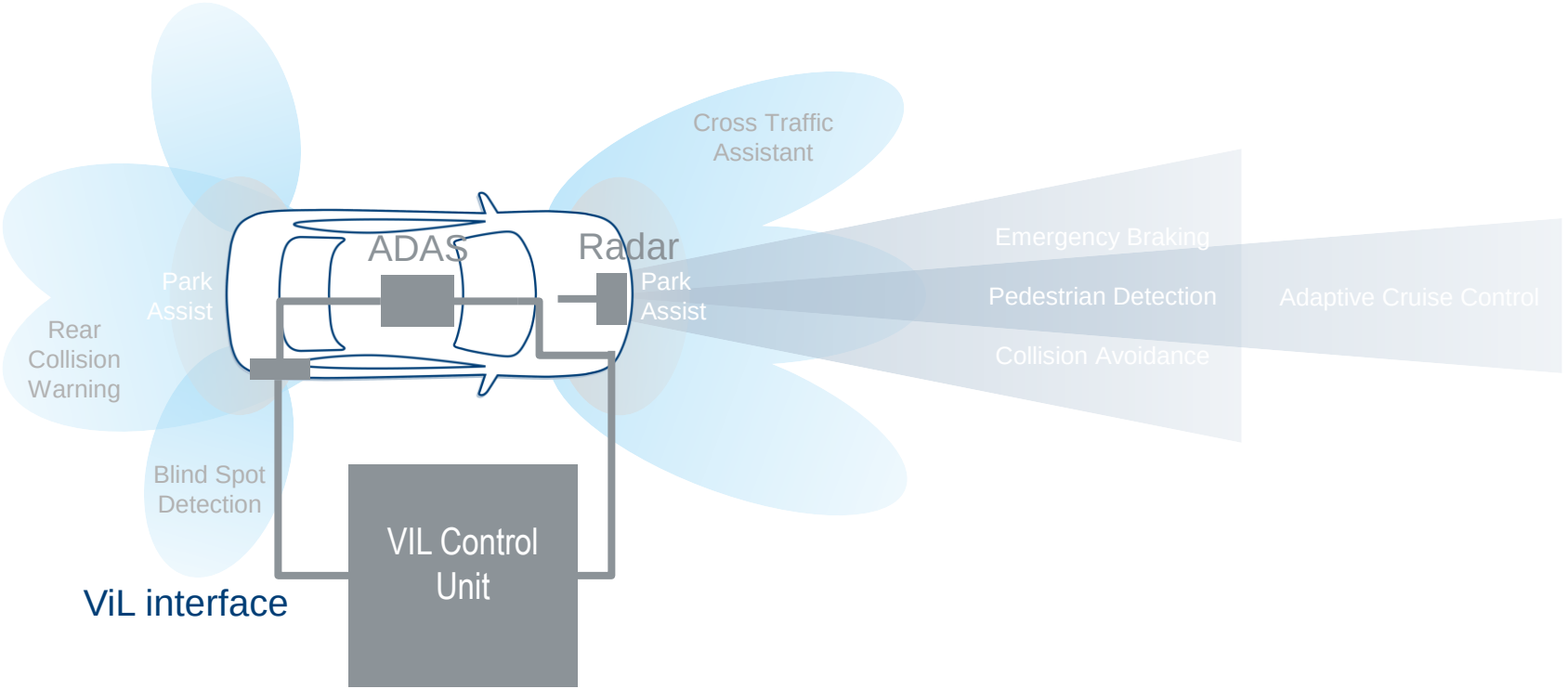
Shielded chambers

Advanced Automotive Radar Echo Generation

RADAR BASED AUTONOMOUS DRIVING



ADAS / AD RADAR CONFIGURATION - PAST



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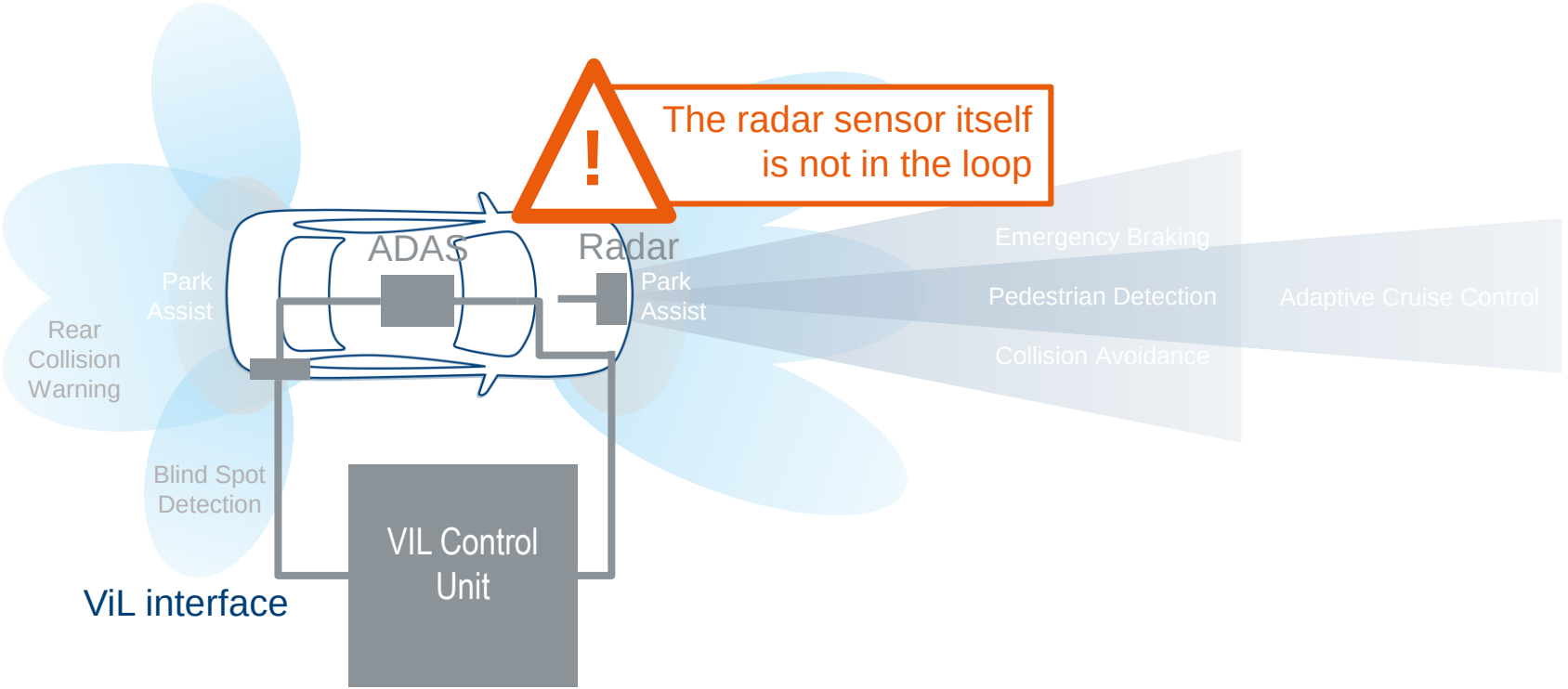
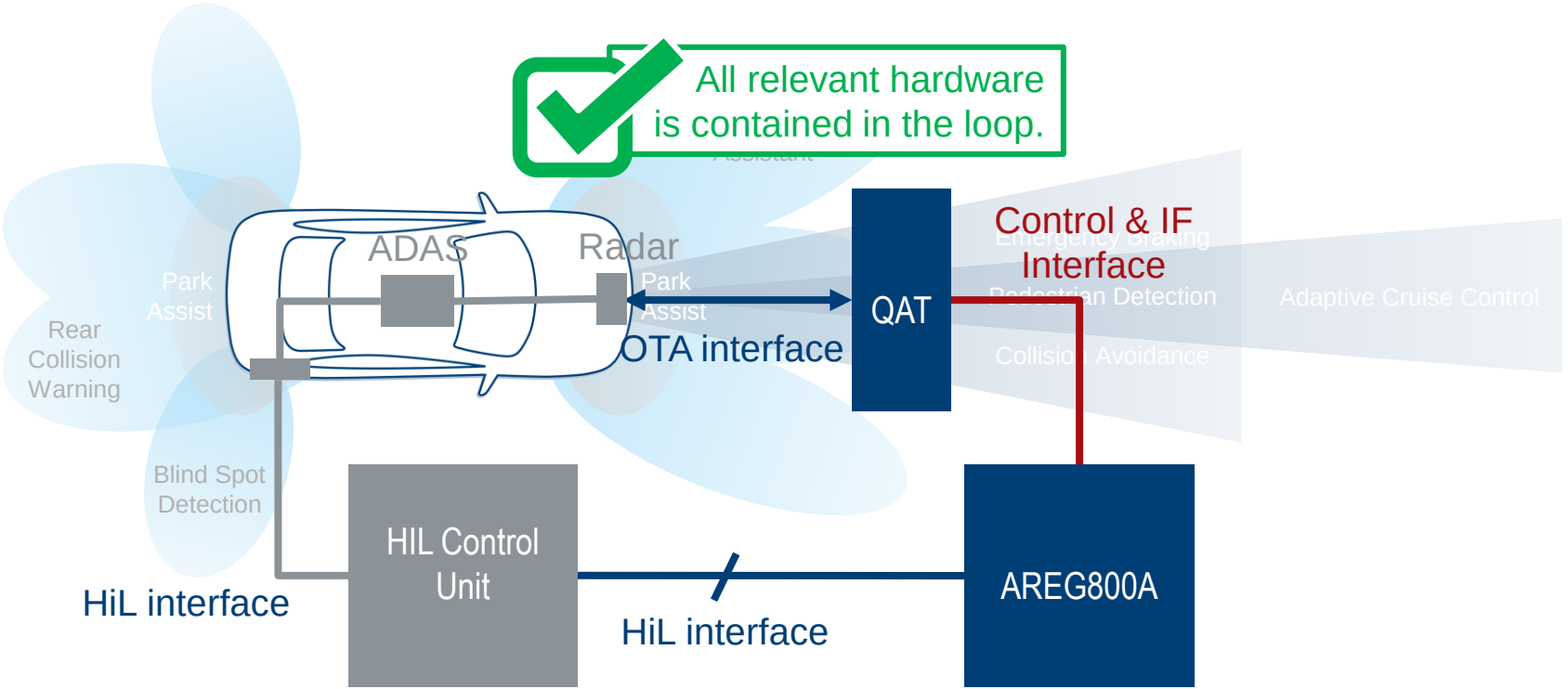


ADAS / AD RADAR CONFIGURATION - FUTURE



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AVL

R&S TOGETHER WITH AVL

A SUCCESSFUL PARTNERSHIP FOR A GAME-CHANGING VIL SOLUTION

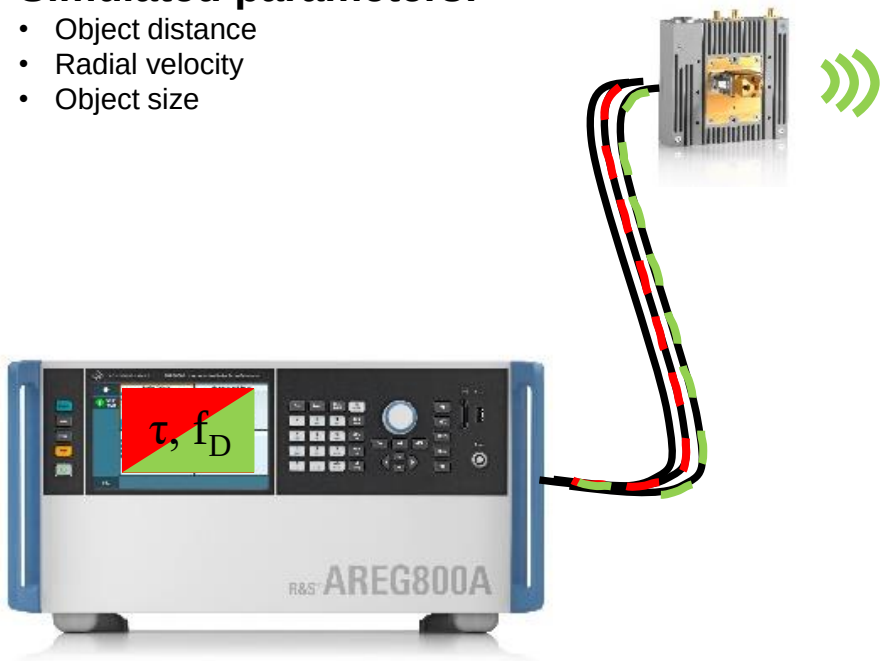
REALISTIC TESTING ON VIRTUAL ROADS

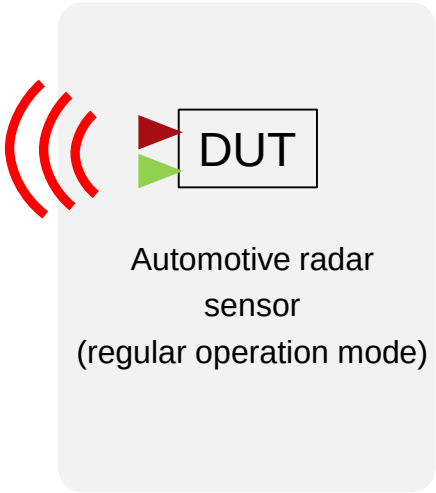
Part II

THE SYSTEM

Simulated parameters:

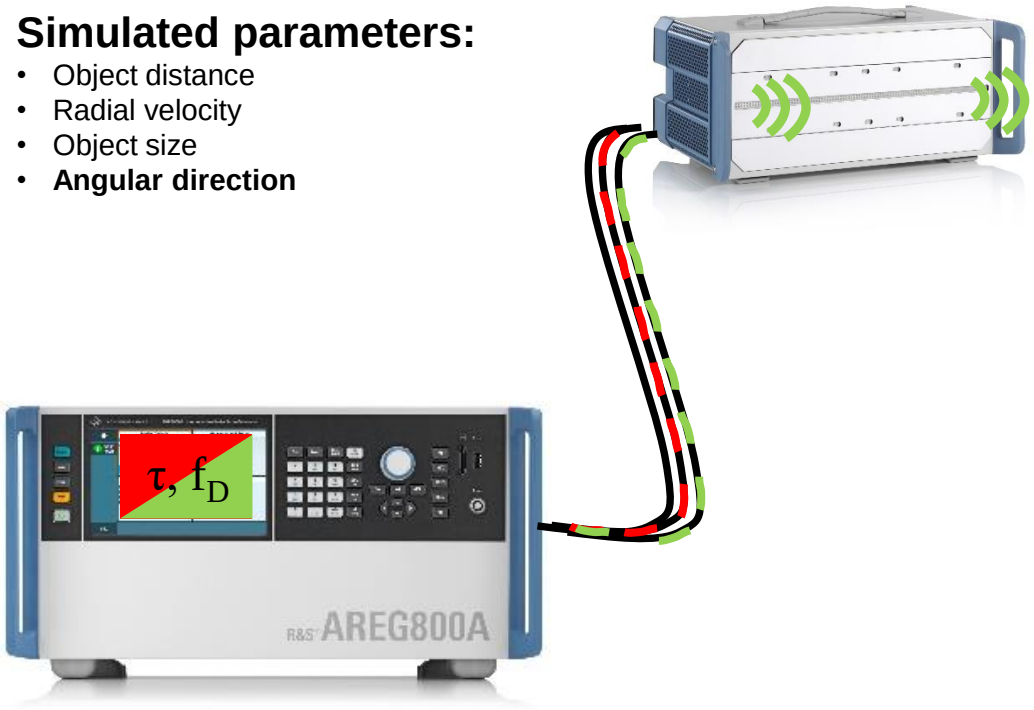
- Object distance
- Radial velocity
- Object size

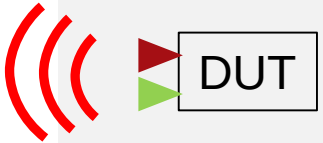




Simulated parameters:

- Object distance
- Radial velocity
- Object size
- **Angular direction**





Automotive radar sensor (regular operation mode)

Radar Signal

Echo Signal

UNIQUE FEATURES – AREG800A TOGETHER WITH QAT100

Performance optimized system

Scalable solution

360° simulation possible

3 level service and support structure

One stop solution from R&S

Seamless integration via Open Simulation Interface

Worldwide service and support

EXEMPLARY DRIVING SCENARIOS

MATCHING 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.

EXEMPLARY DRIVING SCENARIOS

MATCHING 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.

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R&S®QAT100 AND R&S®AREG800A

THE MISSING PUZZLE PIECES FOR TESTING RADAR BASED AUTONOMOUS DRIVING FUNCTIONS

R&S®AREG800A
Automotive Radar Echo Generator

R&S®QAT100
Advanced Antenna Array

Part III

FRONTEND - R&S®QAT100 ADVANCED ANTENNA ARRAY

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R&S®QAT100 UNIQUE FEATURES

No mechanical movement

Immune to vibration

96 TX antennas per frontend

4GHz instantaneous bandwidth

Extremely short distances

Scalable solution

Azimuth and elevation simulation

Precise and repeatable

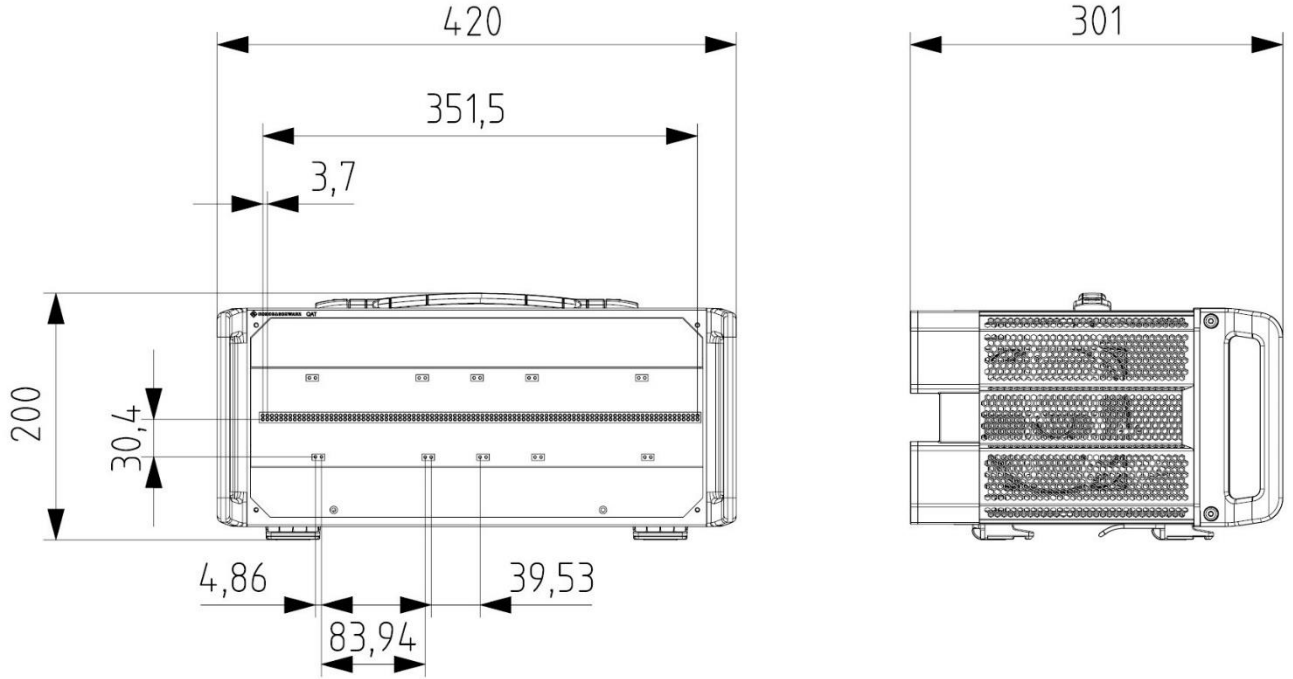
Clean RF - no reflections from FE

R&S®QAT100
OVERVIEW

Front panel with two lines of TX antennas. The offsetted RX antennas operate with their respective segments.

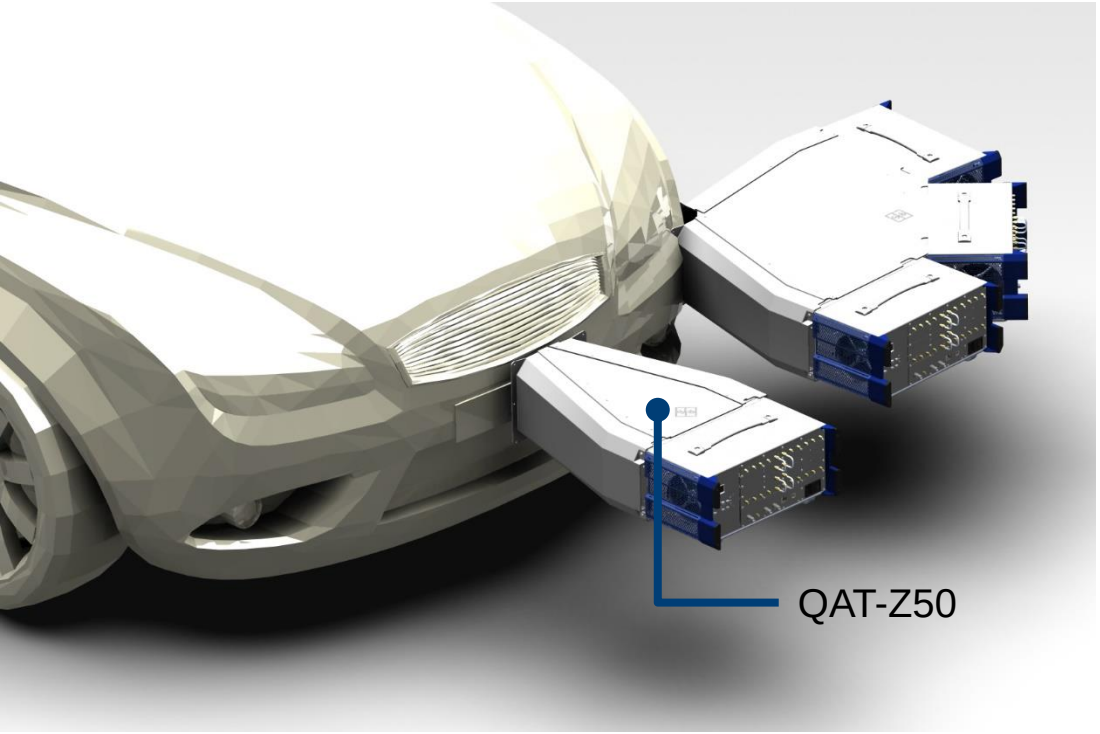
Back panel with SMA connectors for the individual segments. LCD display for direct interaction with the panel.

R&S®QAT100
MECHANICAL OUTLINE



R&S®QAT100 ADVANCED ANTENNA ARRAY

QAT-Z50 SHIELDING SYSTEM



- **QAT-Z50 shielding system**
  - 50 cm long, 10° opening
  - Direct mounting kit for QAT
- **Challenges**
  - Car mounting kit respectively QAT stand in front of car
  - Customization based on e.g. CAD required

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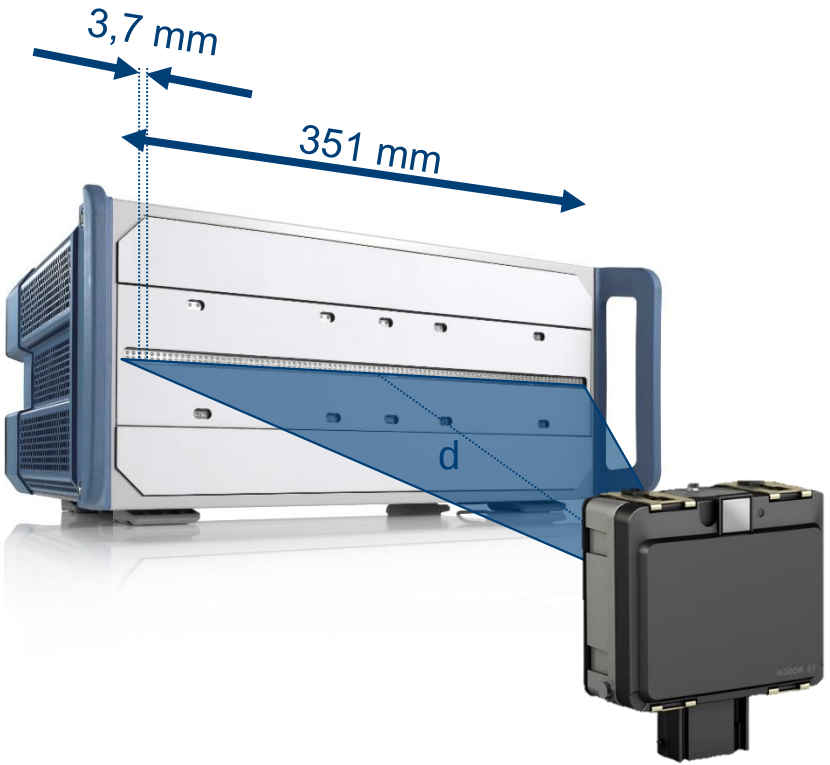
ANGULAR RESOLUTION & FIELD-OF-VIEW



The field-of-view (FOV) and angular resolution achievable with the R&S®QAT100 are dependent on the setup but can be calculated as follows:

Field-of-view:

$$\alpha = 2 \cdot \tan^{-1}\left(\frac{351mm}{d}\right)$$

Angular resolution:

$$\Delta\alpha = \tan^{-1}\left(\frac{3{,}7mm}{d}\right)$$

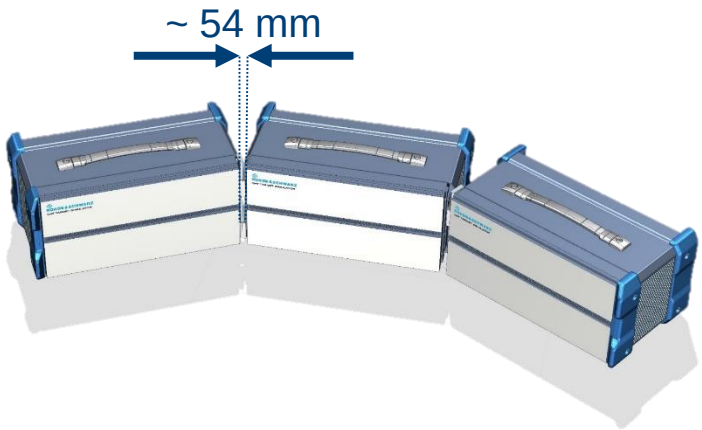
ANGULAR RESOLUTION & FIELD-OF-VIEW

Distance (d)	Field-of-view (α)	resolution ($\Delta\alpha$)
500 mm	38,7°	0,42°
700 mm	28,1°	0,30°
1000 mm	19,9°	0,21°
1500 mm	13,34°	0,14°
2100 mm	10,0°	0,10°

$$\Delta\alpha = \tan^{-1}\left(\frac{3{,}7mm}{d}\right)$$

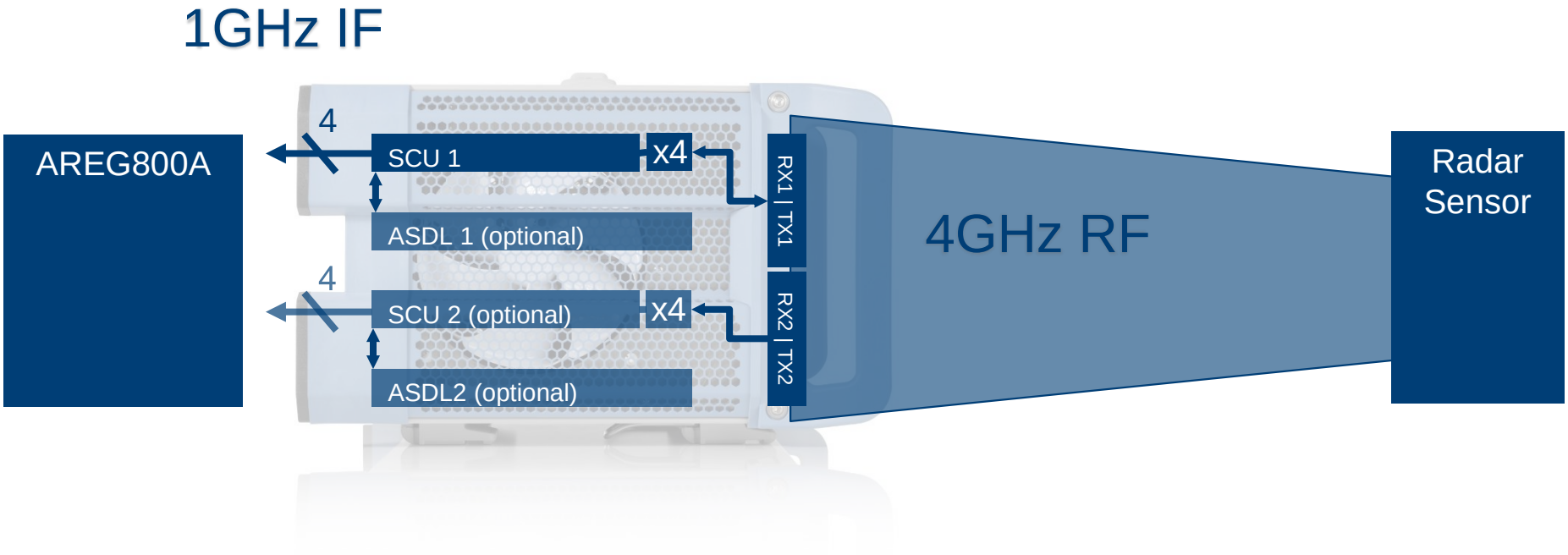
$$\alpha = 2 \cdot \tan^{-1}\left(\frac{351mm}{2 \cdot d}\right)$$

ANGULAR RESOLUTION AND FIELD-OF-VIEW



- There is an airgap of about 27 mm from the outer-most antenna to the edge of the QAT.
- When positioned next to each other, this results in a gap < 54 mm between the two instruments.
- It is therefore advisable to use an uneven number of QATs in the setup to not have the gap in the middle of the FOV.

R&S®QAT100
CONFIGURATION



Part IV

BACKEND - R&S®AREG800A AUTOMOTIVE RADAR ECHO GENERATOR

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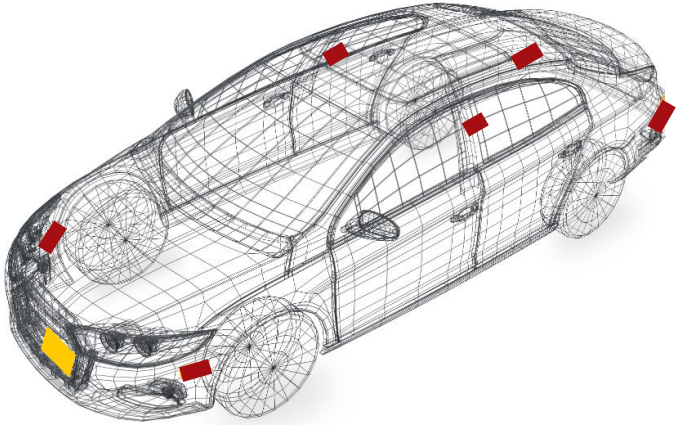
RADAR OBJECT SIMULATION FOR ADVANCED SCENARIOS
APPLICATIONS AND T&M CHALLENGES

- Advanced tests during R&D of automotive radar sensors and testing of ADAS features require dynamic variation of artificial objects
- These artificial objects must be dynamic in terms of:
  - Distance
  - Size (Radar Cross Section – RCS)
  - Radial velocity (Doppler frequency shift)
  - Angular direction
- Higher levels of autonomous driving require multiple radar sensors in a single vehicle which have to be stimulated simultaneously



installation point of SRR sensors
installation point of LRR sensor

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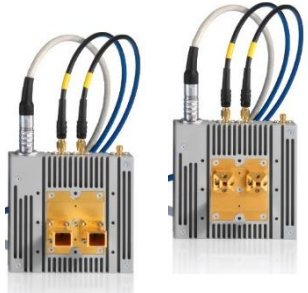
AREG800A – SUPPORTED FRONTENDS

1)

mmW Remote Frontends



R&S®AREG800A

IF Interface

Ctrl. Interface

HIL Interface

2)

R&S®QAT100

IF Interface

RTC Interface

R&S®AREG800A

HIL Interface

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R&S®AREG800A - UNIQUE FEATURES

Generation of dynamic objects

Extremely short object distances

Multiple independent objects

High instantaneous bandwidth

Synchronization of multiple QATs and AREG800As

Built-in real time interface

Fully harmonized with frontend

Scalable solution

THE APPLICATIONS

Production

Bench top R&D

Hardware-in-the-Loop

Vehicle-in-the-Loop (together with AVL)

THE SOLUTIONS

Production

R&S®AREG100A or R&S®AREG800A

Bench Top R&D

R&S®AREG800A with all supported frontends

Hardware-in-the-Loop

R&S®AREG800A and R&S®QAT100

Vehicle-in-the-Loop (together with AVL)

R&S®AREG800A and R&S®QAT100

R&S®AREG800A AUTOMOTIVE RADAR ECHO GENERATOR

OVERVIEW BASE UNIT

5 HE

19 “

Weight: 16 – 25 kg
(depending on options)

Power Consumption: up to 1300W
(depending on options)

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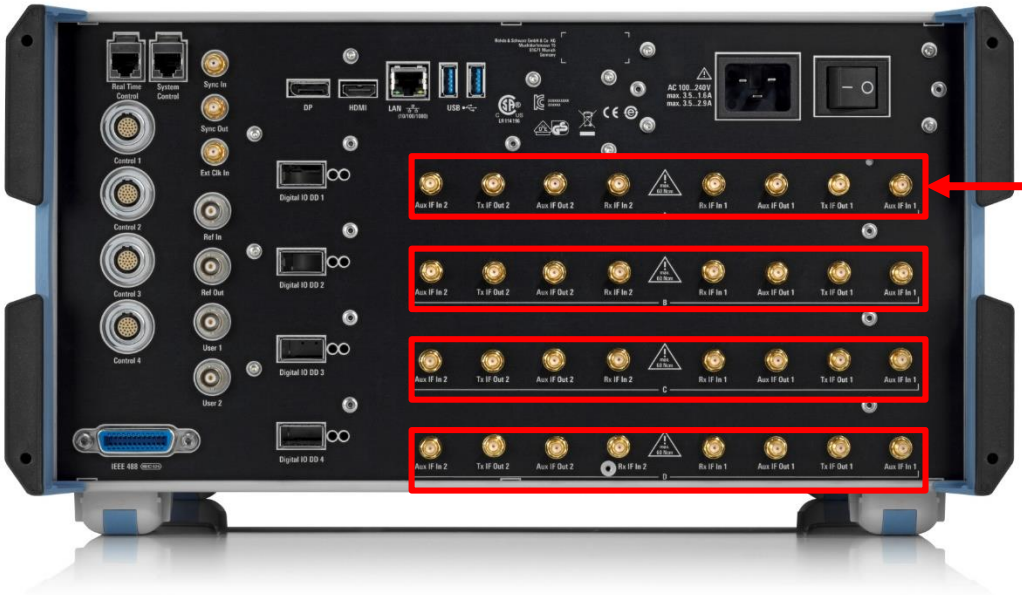
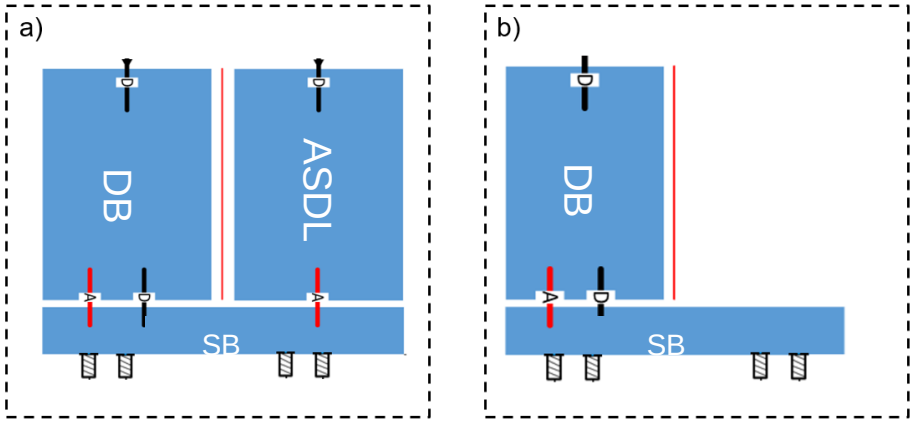
R&S®AREG800A – SCALABILITY AND FLEXIBILITY
TECHNICAL INSIGHTS

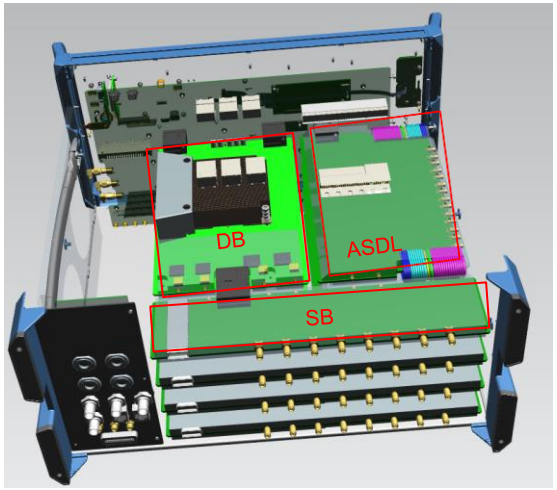


R&S®AREG800A – SCALABILITY AND FLEXIBILITY

MODULAR CONCEPT

- The digital board (DB), the IF switching board (SB) and the optional analog stepped delay line board (ASDL) are forming the smallest backend module
- A module has one (for 5GHz bandwidth) or two (for 2GHz bandwidth) IF paths, each with individual A/D and D/A conversion
- Each module provides the IF connection and control interface for mmW frontends (e.g. AREG8-77S frontend covering the 76-77 GHz automotive radar band)

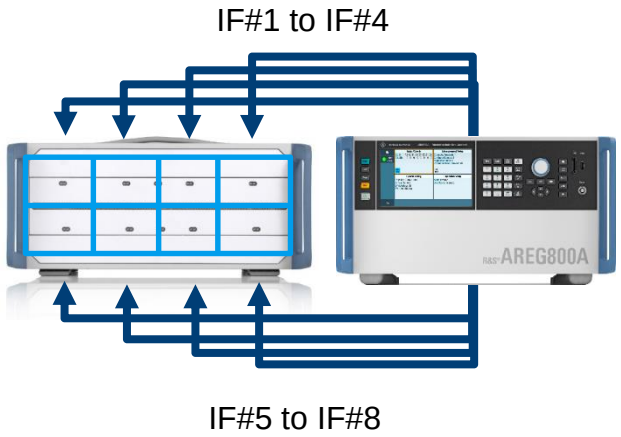




OPERATION - AREG800A WITH QAT100

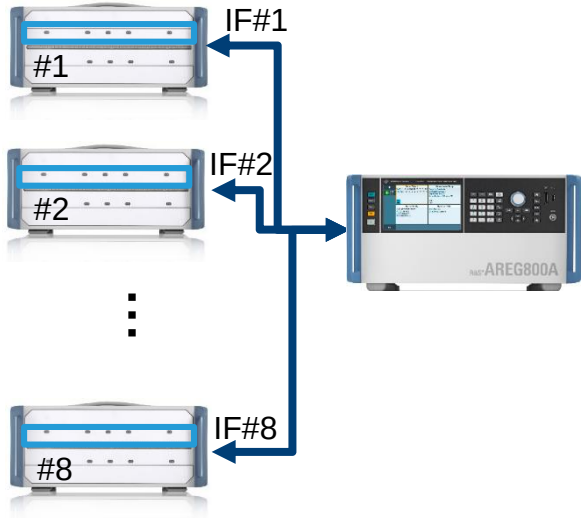
SIGNAL DISTRIBUTION OVERVIEW

A – One QAT100 and one AREG800A
For simulation of dense scenarios



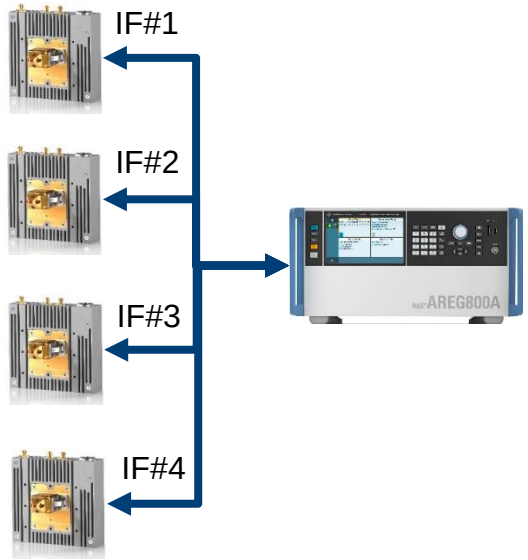
Individual IF path for each of the 8 array segments of the QAT (each containing 24 TX antennas)

B – Multiple QAT100s and one AREG800A
For covering wide Field-of-Views



Individual IF path per QAT addressing one full antenna line (containing 96 TX antennas)

C – mmW Frontends and AREG800A
For bench top test cases



Individual IF path per mmW frontend

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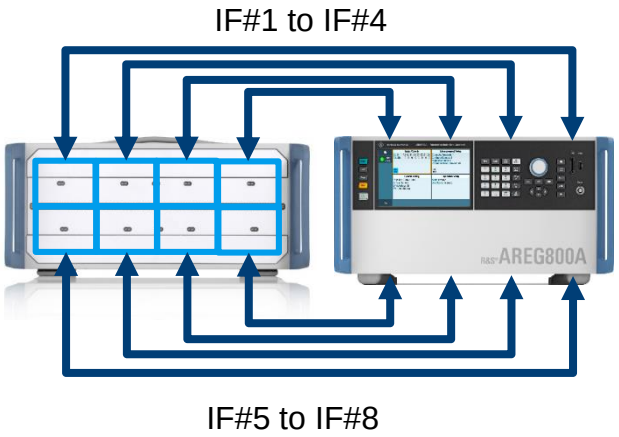
OPERATION - AREG800A WITH QAT100

SIGNAL DISTRIBUTION OVERVIEW

A – One QAT100 and one AREG800A
For simulation of dense scenarios



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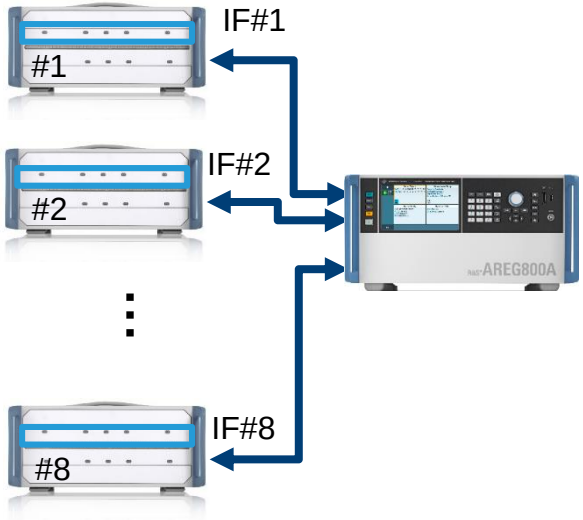
For covering wide Field-of-Views



Individual IF path per QAT addressing one full antenna line (containing 96 TX antennas)

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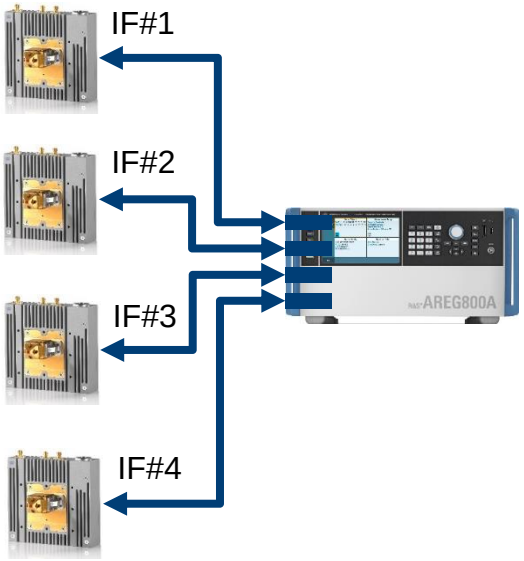
For bench top test cases



Individual IF path per mmW frontend

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OPERATION – AREG800A WITH QAT100

A - SIGNAL DISTRIBUTION

AREG800A – Base Unit

IF#1

IF#2

IF#8

Parameter:
- Distance
- Angle
- Velocity
- RCS

1 indiv. object → Dig #1

1 indiv. object → Dig #2

Dig #3

Dig #4

Dig #8

1 indiv. object → ASDL #1

1 indiv. object → ASDL #2

1 indiv. object → ASDL #4

OPERATION - AREG800A WITH QAT100

B - SIGNAL DISTRIBUTION

AREG800A – Base Unit

IF#1

IF#2

IF#8

Parameter:
- Distance
- Angle
- Velocity
- RCS

Dig #1 — 1 indiv. object

Dig #2 — 1 indiv. object

Dig #3

Dig #4

Dig #8 — 1 indiv. object

ASDL #1 — 1 indiv. object

ASDL #2 — 1 indiv. object

ASDL #4 — 1 indiv. object

OPERATION - AREG800A WITH MMW FRONTENDS

C - SIGNAL DISTRIBUTION

AREG800A – Base Unit

IF#1

IF#2

IF#4

Parameter:

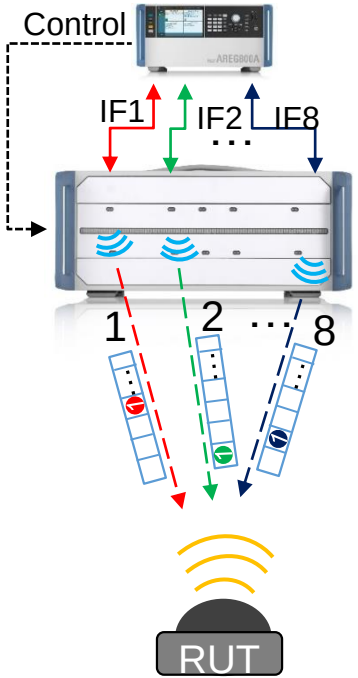
- Distance
- Angle
- Velocity
- RCS

up to 8 indiv. objects — Dig #1 — 1 indiv. object — ASDL #1

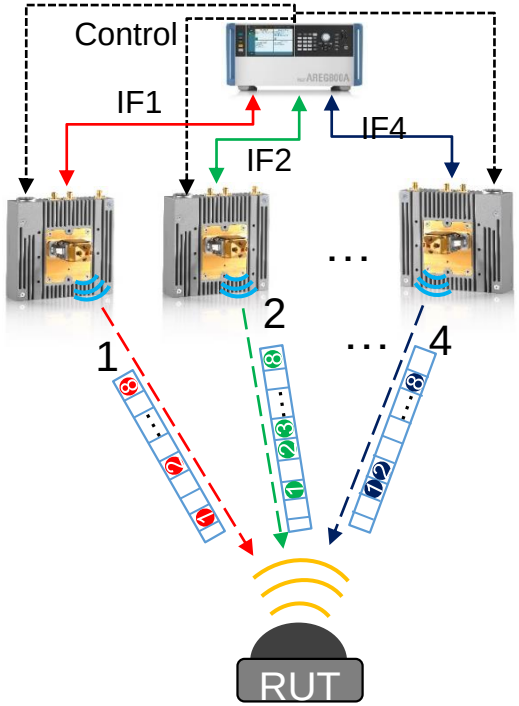
up to 8 indiv. objects — Dig #2 — 1 indiv. object — ASDL #2

up to 8 indiv. objects — Dig #4 — 1 indiv. object — ASDL #4

SUMMARY – R&S®AREG800A OPERATION



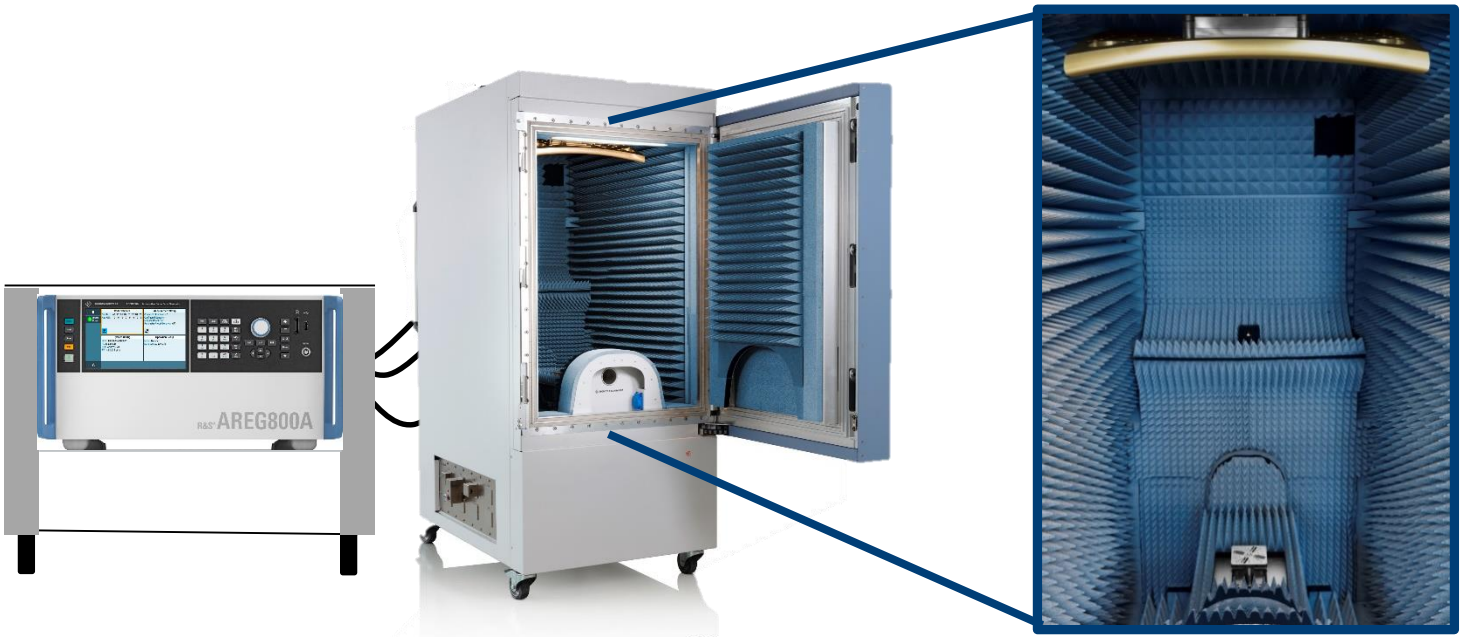
R&S®AREG800A together with R&S®QAT100 – Up to 8 independent angular directions with max. 1 individual artificial object each.



R&S®AREG800A together with mmW remote frontends – Up to 4 mmW frontends can be connected to a single base unit with up to 8 individual artificial objects each.

OUR SOLUTION FOR TESTING OF AUTOMOTIVE RADAR

UNIQUE SOLUTION FOR TESTING LARGE APERTURE AUT RADAR SENSORS

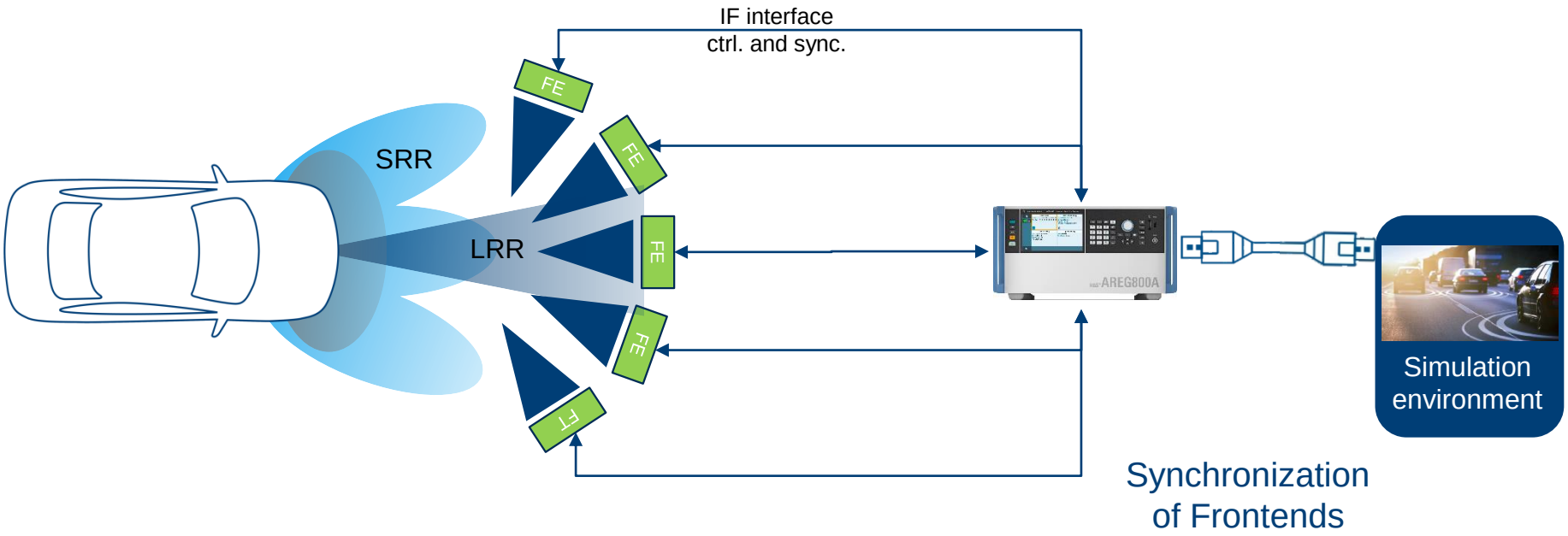


AREG800A together with ATS1500C shielded chamber

AREG8 mmW remote frontend mounted in chamber

R&S®AREG800A – SCALABILITY AND FLEXIBILITY

SYNCHRONIZATION OF MULTIPLE FRONTENDS



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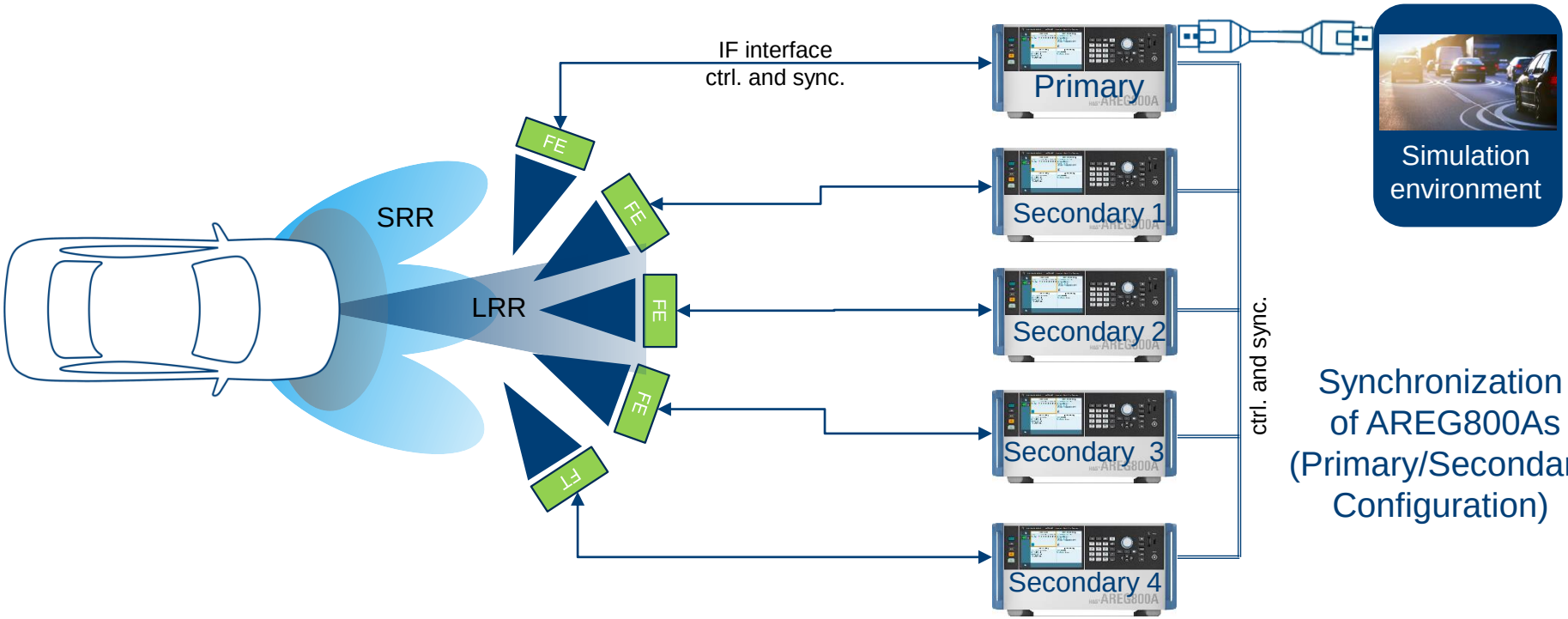
R&S®AREG800A – SCALABILITY AND FLEXIBILITY

SYNCHRONIZATION OF MULTIPLE FRONTENDS & BACKENDS TO GENERATE LARGE SCENARIOS



Synchronization of AREG800As (Primary/Secondary Configuration)

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Part V

RECOMMENDED CONFIGURATION

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EXEMPLARY CONFIGURATION I

BASIC BENCH TOP AND R&S®ATS1500C USAGE

Consists of:

1. R&S®AREG800A Automotive Radar Echo Generator
2. One mmW frontends (multiple frontends possible)

Key features:

- 4 GHz bandwidth with mmW frontend
- Fully harmonized with ATS1500C and CATR
- Dynamic artificial objects with individual distance, RCS and radial velocity
- Dynamic objects:
  - 1 object down to < 4m
  - Up to 8 objects in the range of <15m to >1000m
- IF input, IF output and HiL interface

EXEMPLARY CONFIGURATION II

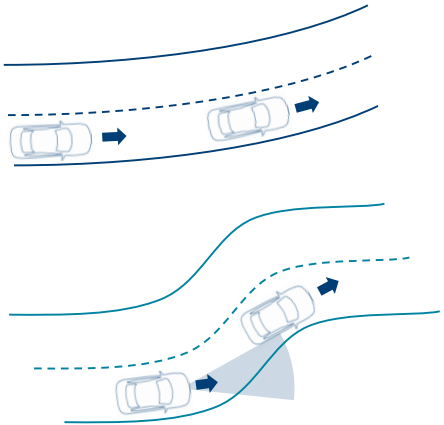
BASIC ADAS FEATURE TEST

Consists of:

1. R&S®AREG800A Automotive Radar Echo Generator
2. One R&S®QAT100 advanced antenna array

Key features:

- 4 GHz bandwidth with R&S®QAT100A advanced antenna array
- Dynamic artificial objects with individual distance, RCS and radial velocity and **azimuth**
- Dynamic objects:
  - 1 object down to < 4m
  - 2 objects in the range of <15m to >1000m
- IF input, IF output and HiL interface



EXEMPLARY CONFIGURATION III

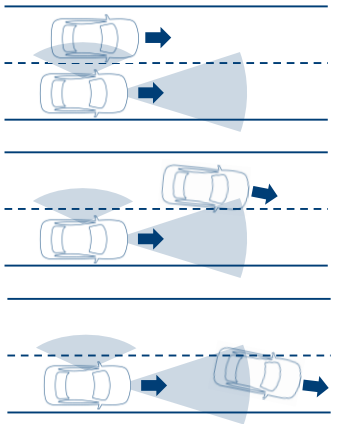
ADVANCED ADAS FEATURE TEST

Consists of:

1. R&S®AREG800A Automotive Radar Echo Generator
2. Three R&S®QAT100 advanced antenna arrays (up to 8 possible)

Key features:

- 4 GHz bandwidth with R&S®QAT100A advanced antenna array
- Dynamic artificial objects with individual distance, RCS and radial velocity and **azimuth**
- Dynamic objects:
  - 2 objects down to < 4m (up to 4 objects possible)
  - 4 objects in the range of <15m to >1000m (up to 8 possible)
- IF input, IF output and HiL interface
- Capability to stimulate multiple radar sensors in parallel



Part VI

SUMMARY

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SUMMARY

Extremely short distances

Multiple independent objects

High instantaneous bandwidth

Generation of dynamic objects

No mechanical movement

One stop solution from R&S

Precise and repeatable

Worldwide service and support

HiL interface via Open Simulation Interface

Scalable solution

For more information please visit our webpage:

www.rohde-schwarz.com/automotive/target-simulation

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