

ADAS - Innovations in Automotive Radar testing

Automotive Technology Day

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ROHDE & SCHWARZ

Automotive Radar Testing

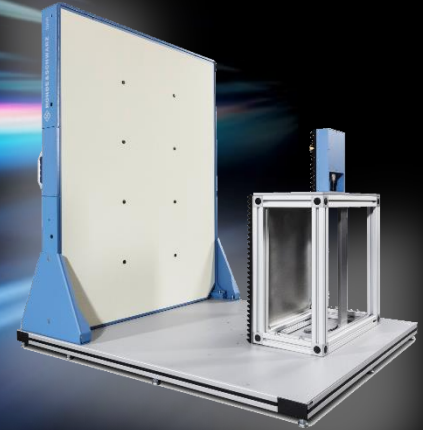
Target Generation



Interference Testing



Radome Testing



Signal Analysis

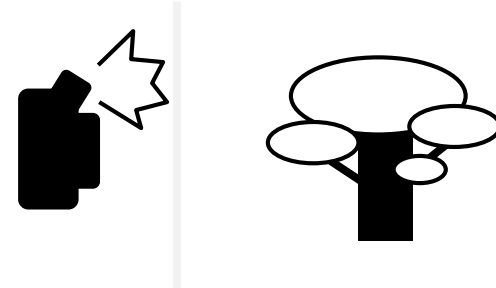
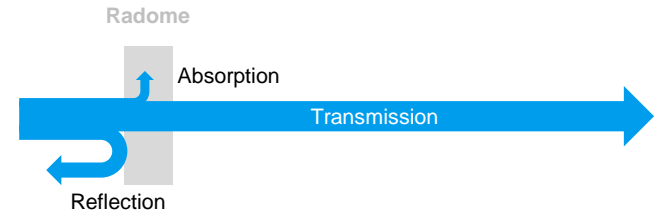


Radomes and Bumpers

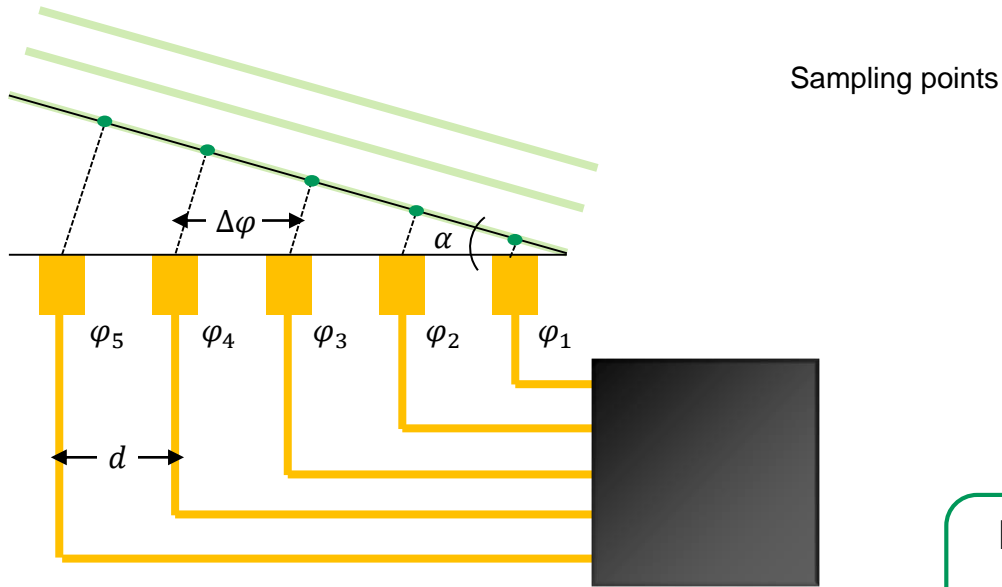


Reasons for blindspots within the radome

Why spatially resolved reflectivity images are important



Radar angular measurement technology

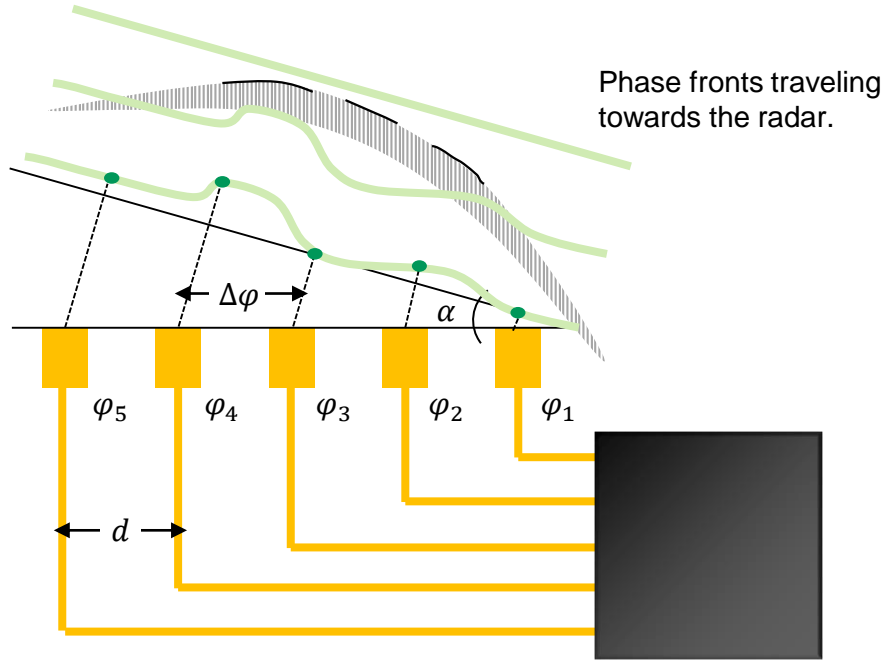


- d Physical distance between antennas
- $\Delta\varphi$ Phase difference
- α Angle of arrival
- λ wavelength

$$\alpha = \sin^{-1} \left(\frac{\lambda \cdot \Delta\varphi}{2\pi d} \right)$$

Estimate azimuth / elevation angles from phase differences / amplitudes at the receive antennas of the phased array

Radar angular measurement technology



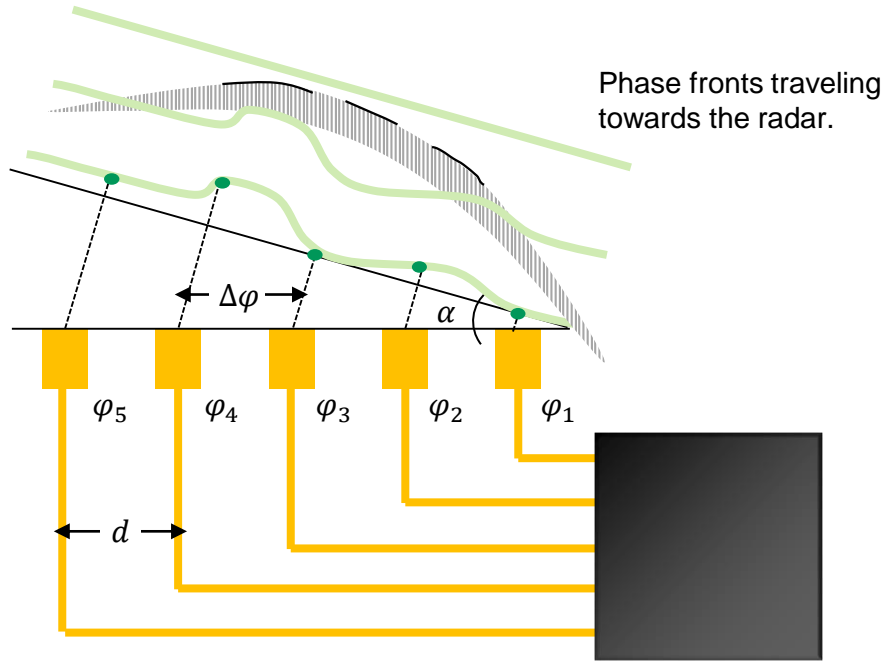
d Physical distance between antennas
 $\Delta\varphi$ Phase difference
 α Angle of arrival
 λ wavelength

$$\alpha = \sin^{-1} \left(\frac{\lambda \cdot \Delta\varphi}{2\pi d} \right)$$

$$\Delta\varphi_1 \neq \Delta\varphi_2 \neq \Delta\varphi_3 \neq \Delta\varphi_4 \neq \Delta\varphi_5$$

Phase estimation is wrong

Radar angular measurement technology



Measuring the angle error does not lead to useful results, if:

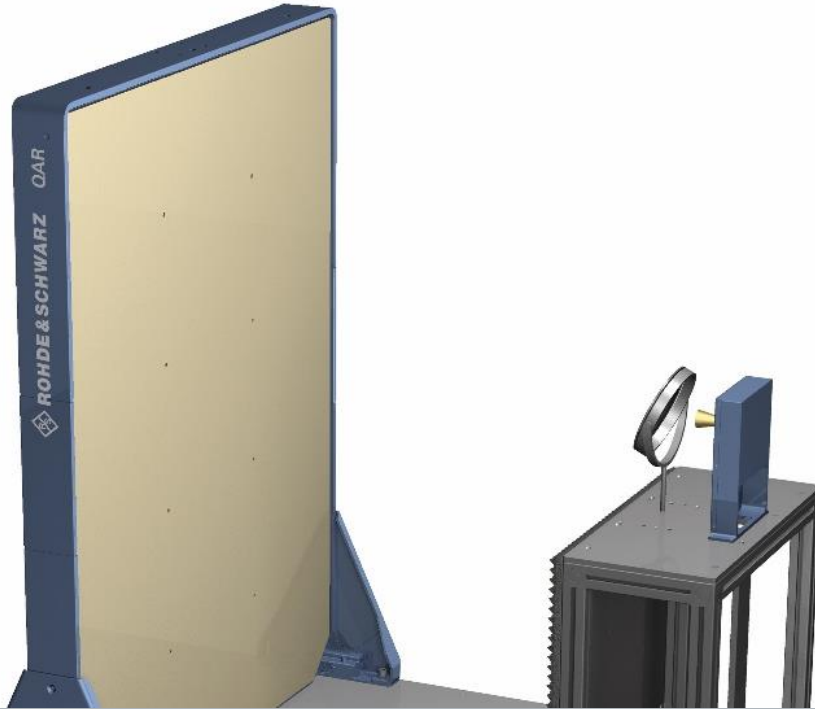
- The radar is slightly moved.
- The distance between the antennas is changed.
- Another algorithm is used for angle of arrival estimation during post processing.

Or, more general, if:

- Another radar / radome combination is used.

An alternative method has to be used.

QAR measurement principle



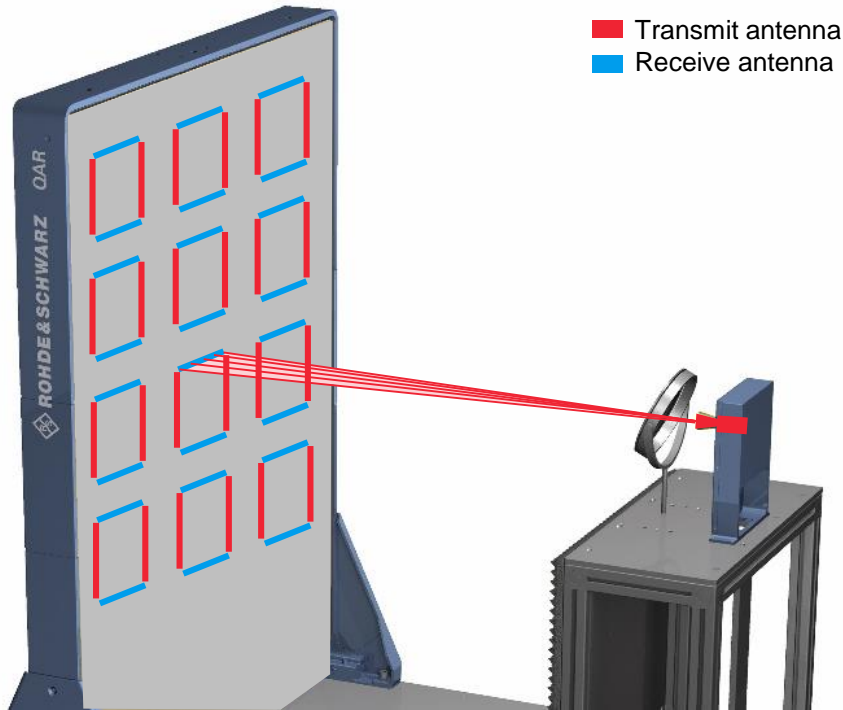
- Transmission measurement
 - Normalization of the transmission measurement
- Reflection measurement
 - Normalization of the transmission measurement

Transmission measurement



QAR measurement principle

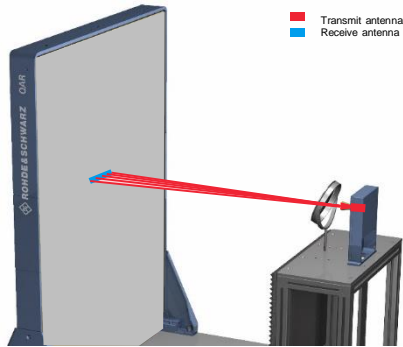
transmission measurement



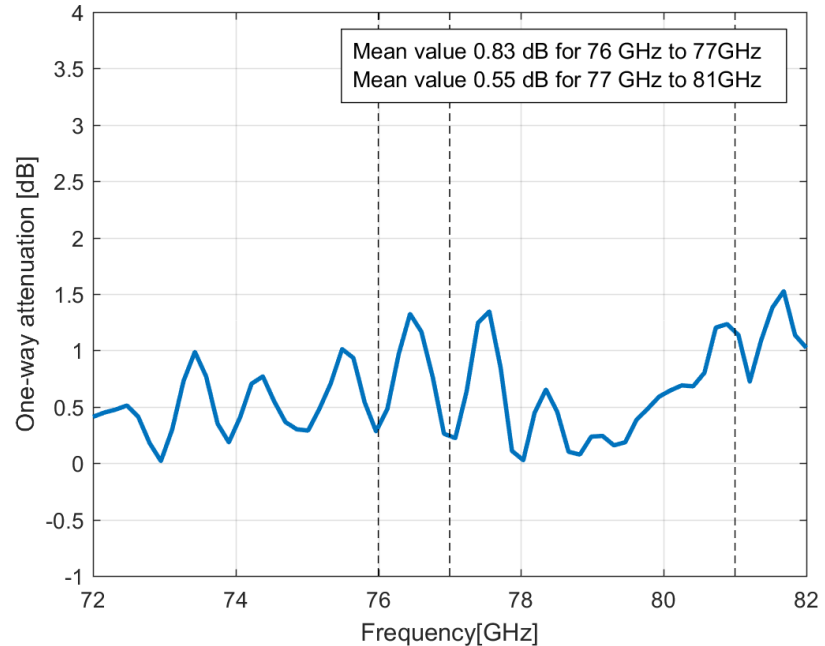
- I The R&S®QAR features 12 antenna arrays with 96 individual transmit and receive antennas.
- I For transmission measurement, only a single receiver line is used.
- I The external transmit antenna is switched on and the received power level is measured at each of the antennas in the line.

QAR measurement principle

transmission measurement



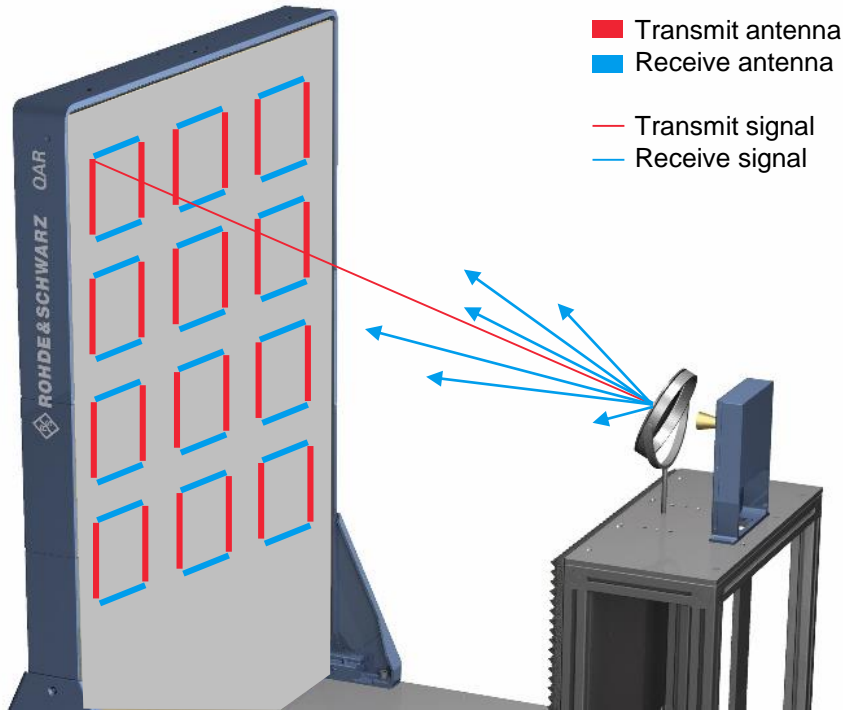
- I For each of the 64 frequency steps, the mean value of all receive antennas is used as one-way attenuation.
- I Two-way attenuation is obtained by doubling the one-way attenuation.



Reflectivity measurement

QAR measurement principle

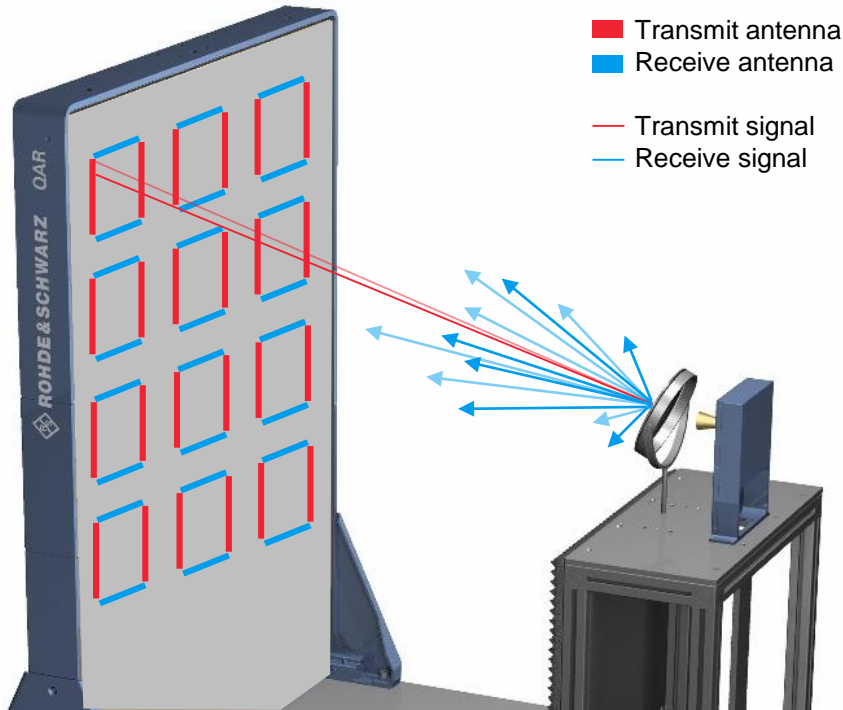
reflectivity measurement



- I The R&S®QAR features 12 antenna arrays with 96 individual transmit and receive antennas.
- I For reflection measurement, each transmit antenna is switched on sequentially.
- I The complex wave quantities are measured coherently at each single receive antenna.

QAR measurement principle

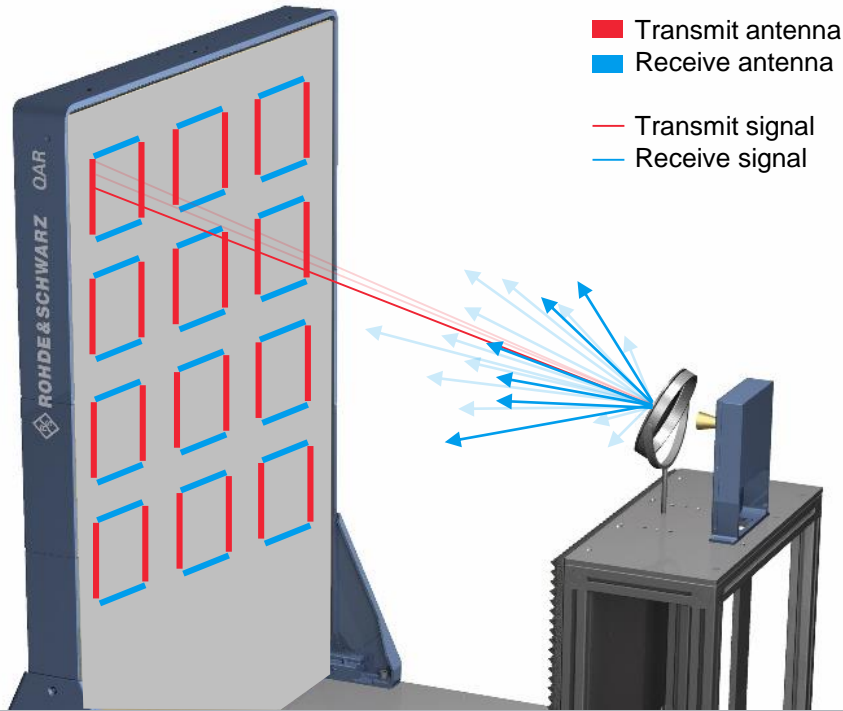
reflectivity measurement



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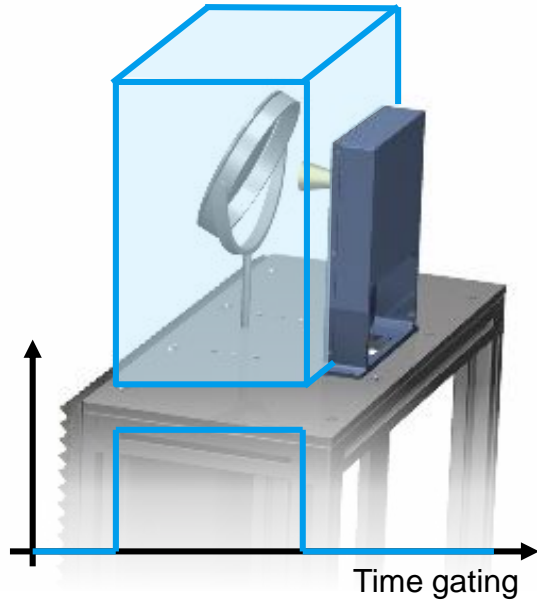
reflectivity measurement



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QAR measurement principle

reflectivity measurement

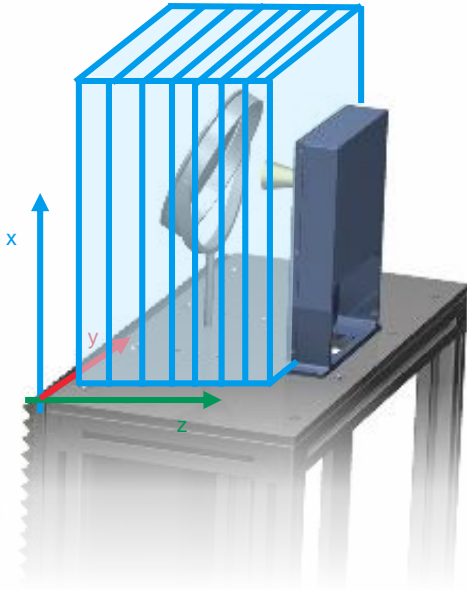


- A time gating is applied to the measurement, such that only the area of interest is taken into consideration.



QAR measurement principle

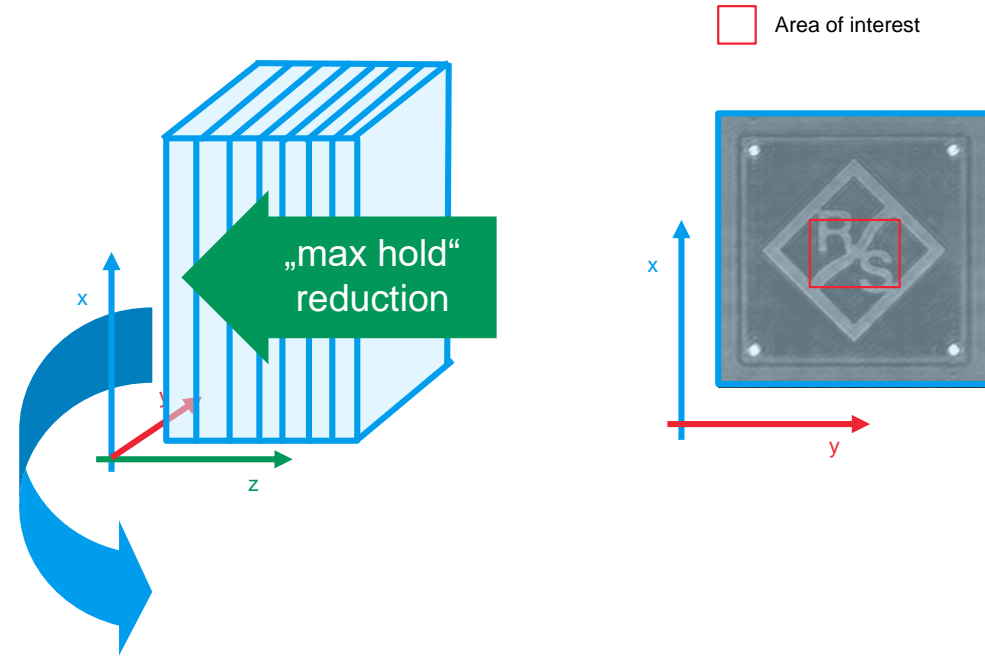
reflectivity measurement



- I A time gating is applied to the measurement, such that only the area of interest is taken into consideration.
- I Microwave imaging algorithms are used to reconstruct the image around the radome position.

QAR measurement principle

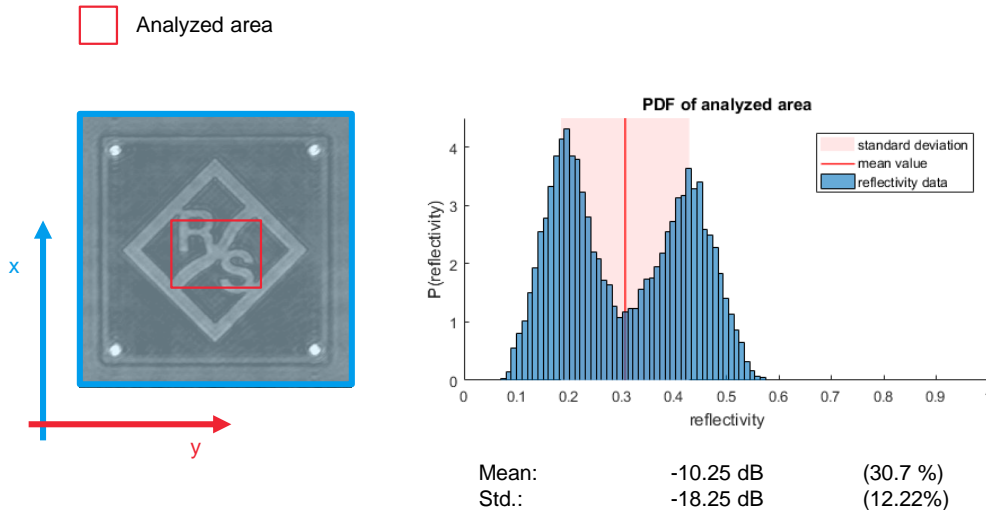
reflectivity measurement



- The 3D voxels are then reduced to a 2D space by using a “max hold” algorithm along the z-axis.
- An “area of interest” is defined which is taken into consideration for further analysis.

QAR measurement principle

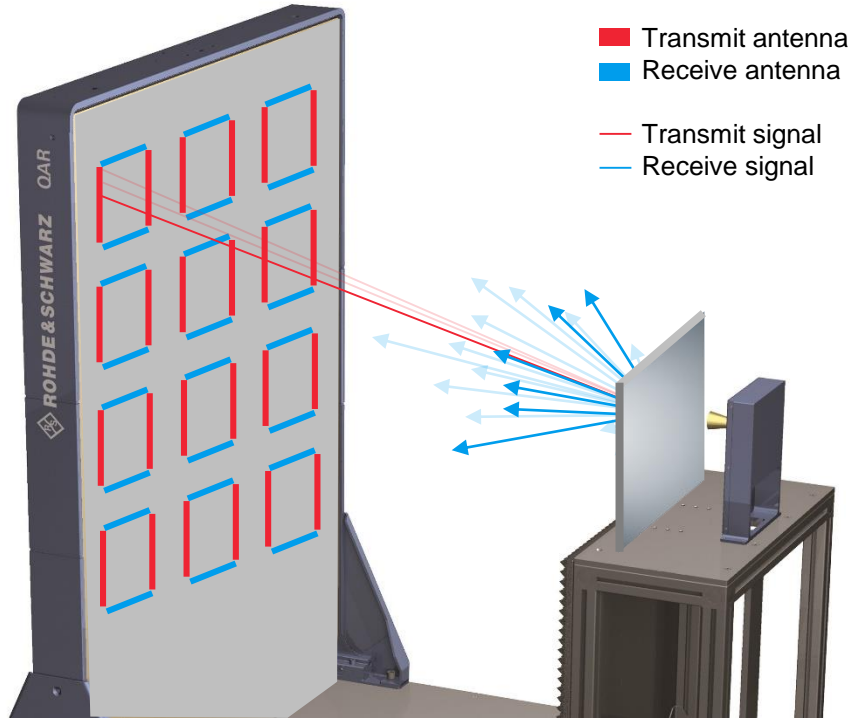
reflectivity measurement



- The histogram of the “analyzed area” is numerically evaluated.
- The mean value and the standard deviation are displayed in the GUI.
- The combination of both values allows an accurate, but quick evaluation of the quality of the radome.

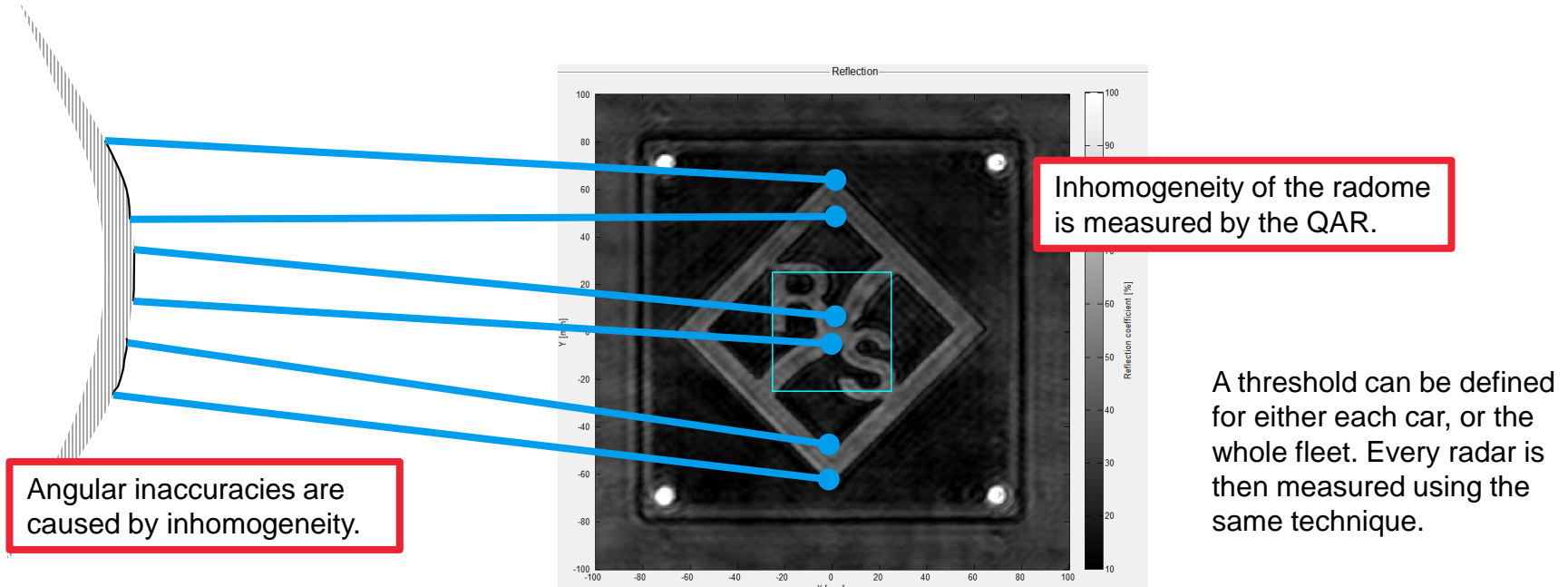
QAR measurement principle

normalization of the reflection measurement

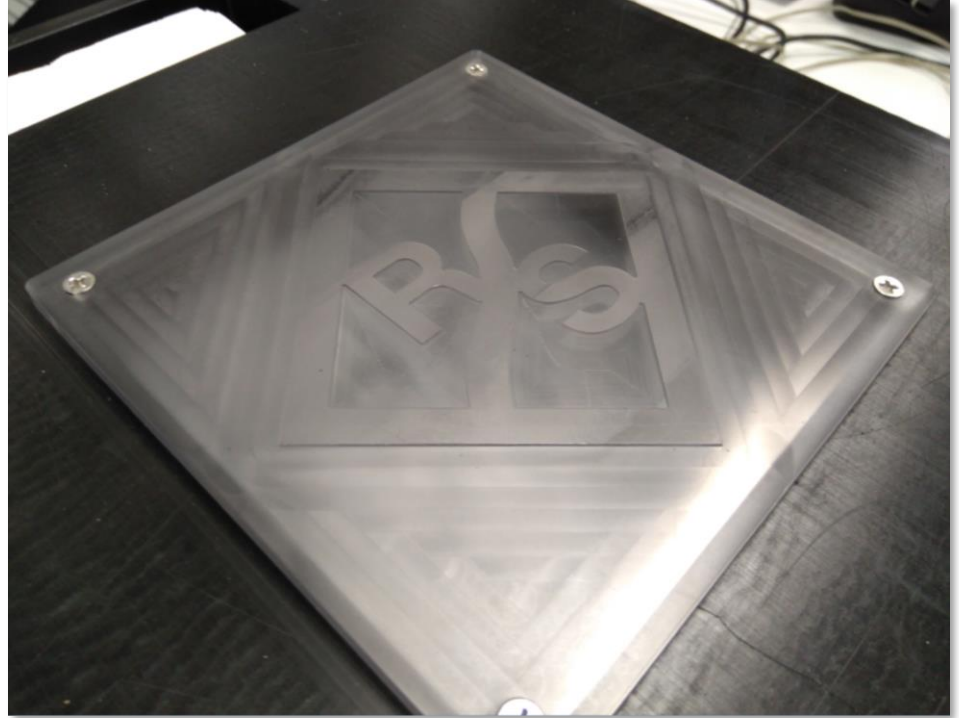
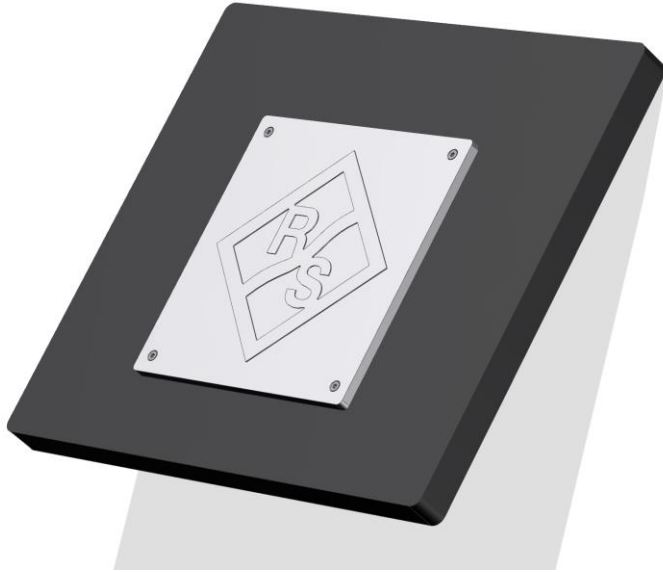


- A metallic surface is placed in front of the receive panel. The surface is at the exact same position as the radome is placed.
- A normalization measurement is taken, assuming that the reflectivity of the metallic surface is 1 (100% reflective).
- All measurements are now referenced to the 100% reflective surface.

Radar angular measurement technology



R&S Radome under Test



Comparison of measurement methods

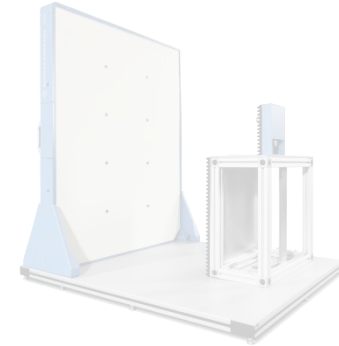
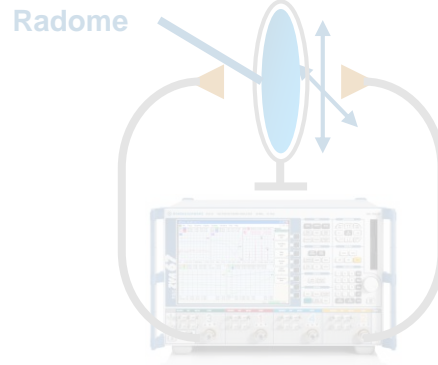
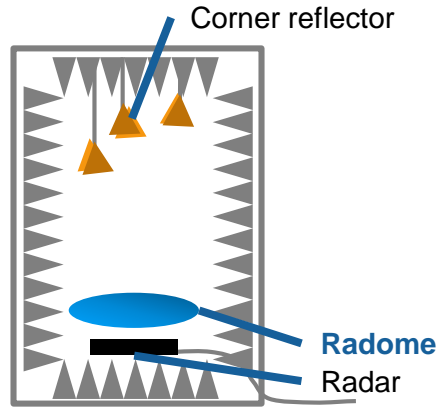
Method

Corner reflectors

Network Analyzer

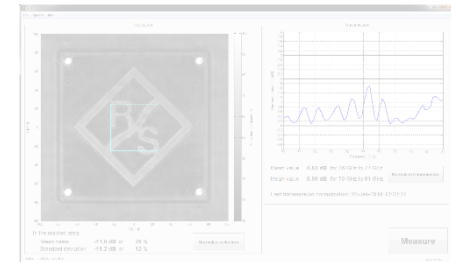
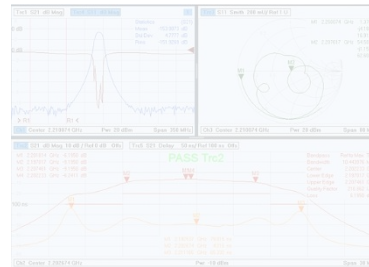
R&S®QAR

Descr.



Result

Meas. Point	2way att.	Azimuth Error
#1	1.2dB	0.2°
#2	1.4dB	0.1°
#3	1.6dB	0.3°



Comparison of measurement methods

Method

Corner reflectors

Network Analyzer

R&S®QAR

Descr.



Cheap & Quick

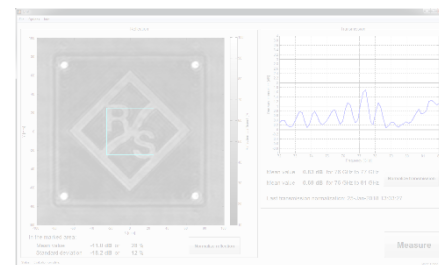
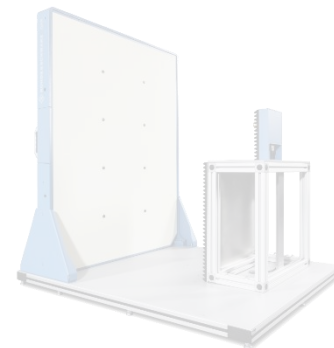
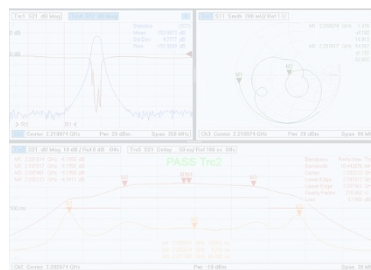
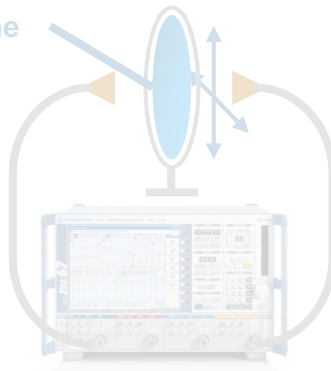


Estimation & selective,
Radar dependent



Radar

Radome



Result

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26

Comparison of measurement methods

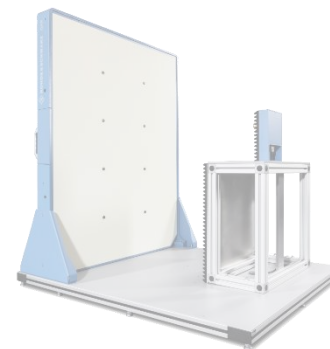
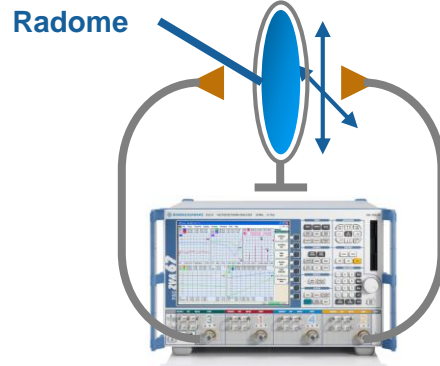
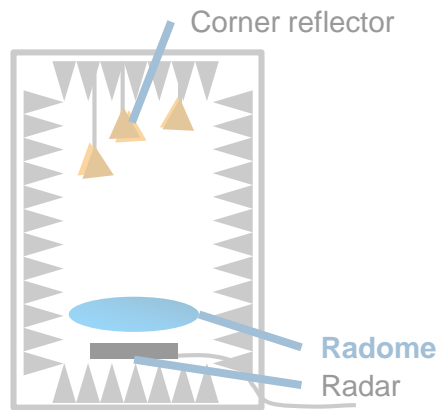
Method

Corner reflectors

Network Analyzer

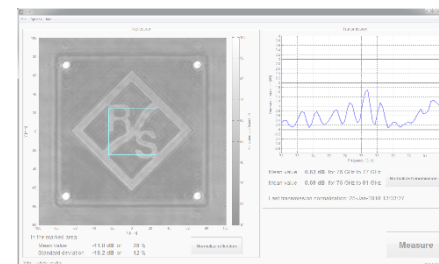
R&S®QAR

Descr.



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Comparison of measurement methods

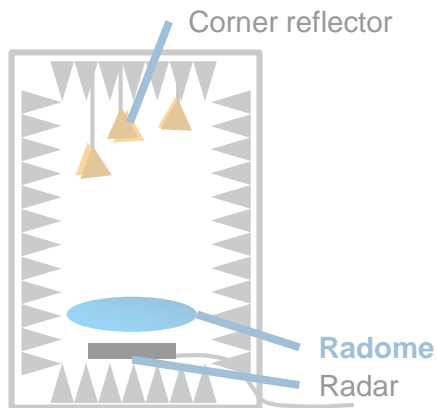
Method

Corner reflectors

Network Analyzer

R&S®QAR

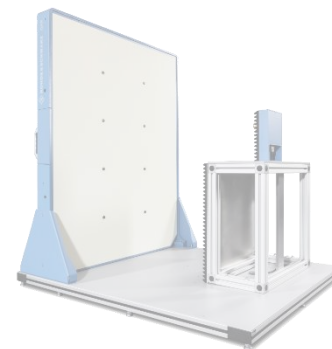
Descr.



Precise measurement

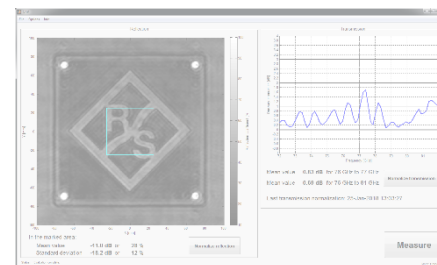
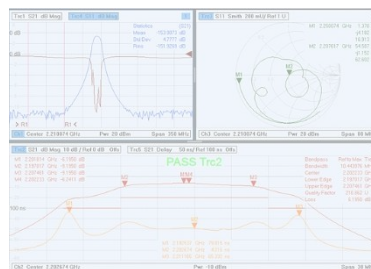


Slow and selective
Calibration required
Experts for operation



Result

Meas. Point	2way att.	Azimuth Error
#1	1.2dB	0.2°
#2	1.4dB	0.1°
#3	1.6dB	0.3°



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28

Comparison of measurement methods

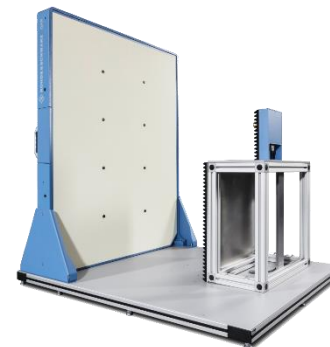
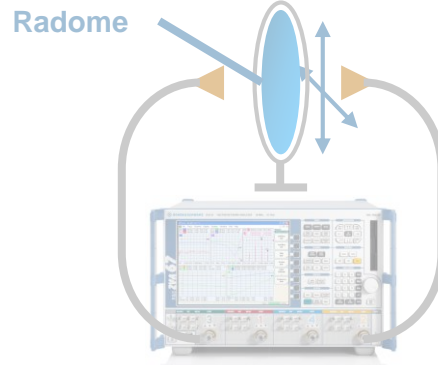
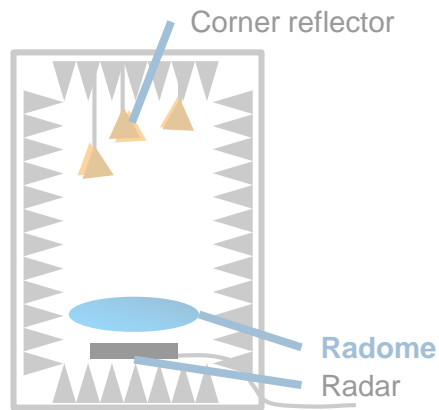
Method

Corner reflectors

Network Analyzer

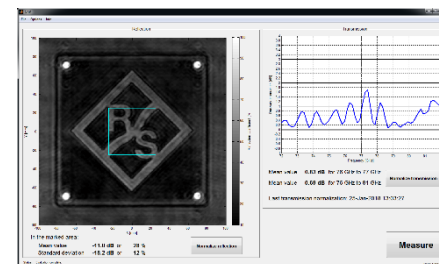
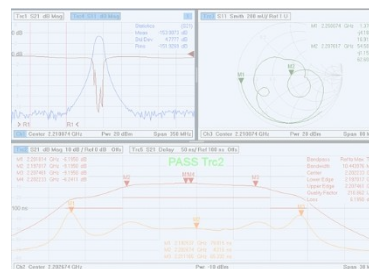
R&S®QAR

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Comparison of measurement methods

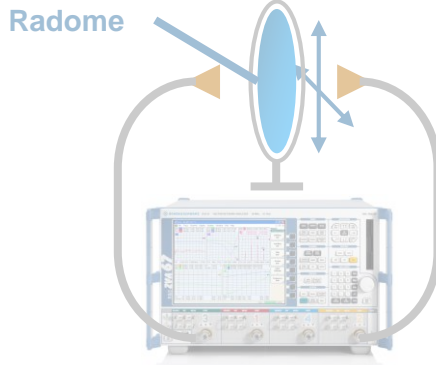
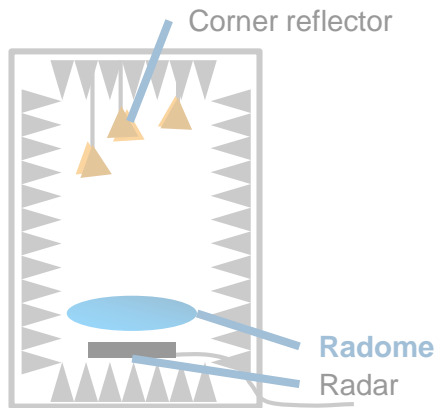
Method

Corner reflectors

Network Analyzer

R&S®QAR

Descr.



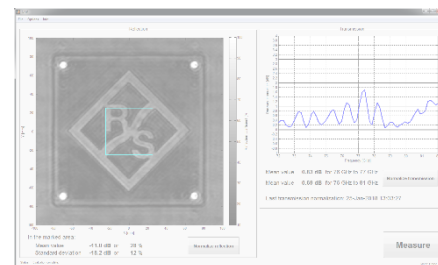
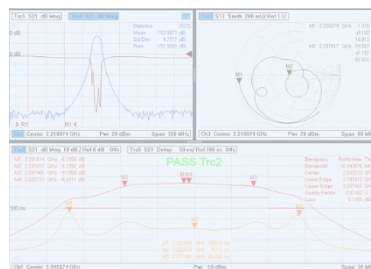
Spatially resolved
Easy to operate
Time saving



Equipment necessary

Result

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Comparison of measurement methods

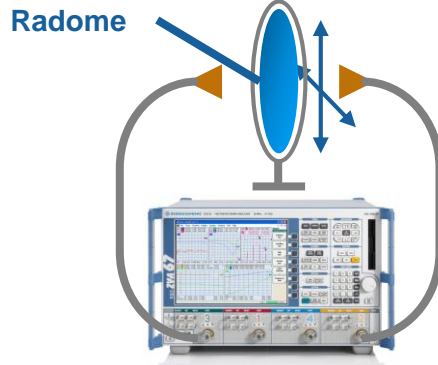
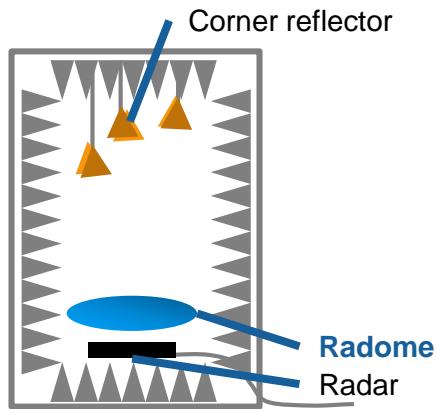
Method

Corner reflectors

Network Analyzer

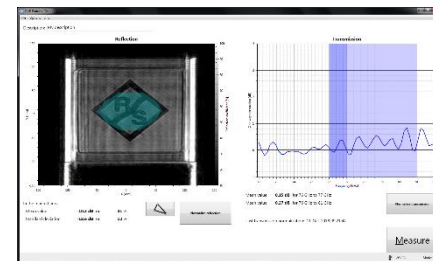
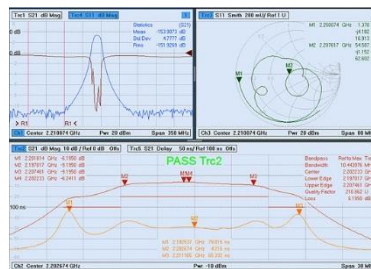
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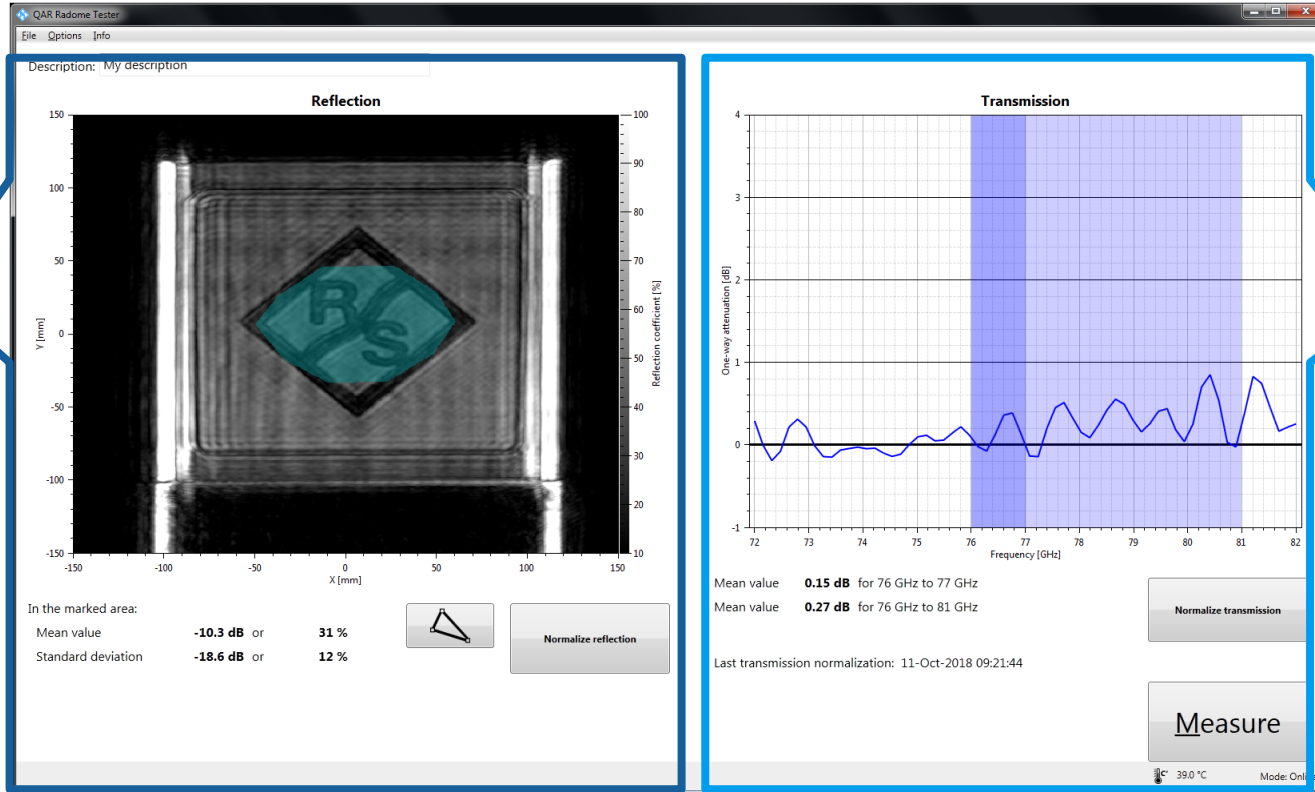
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31

Measurement result - radomes

reflection

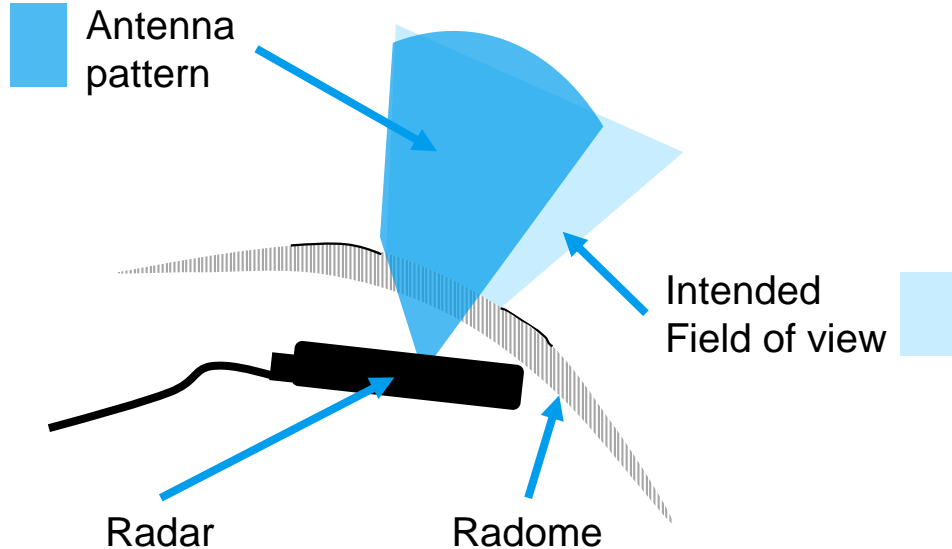


transmission

Mounting accuracy

Mounting accuracy measurement

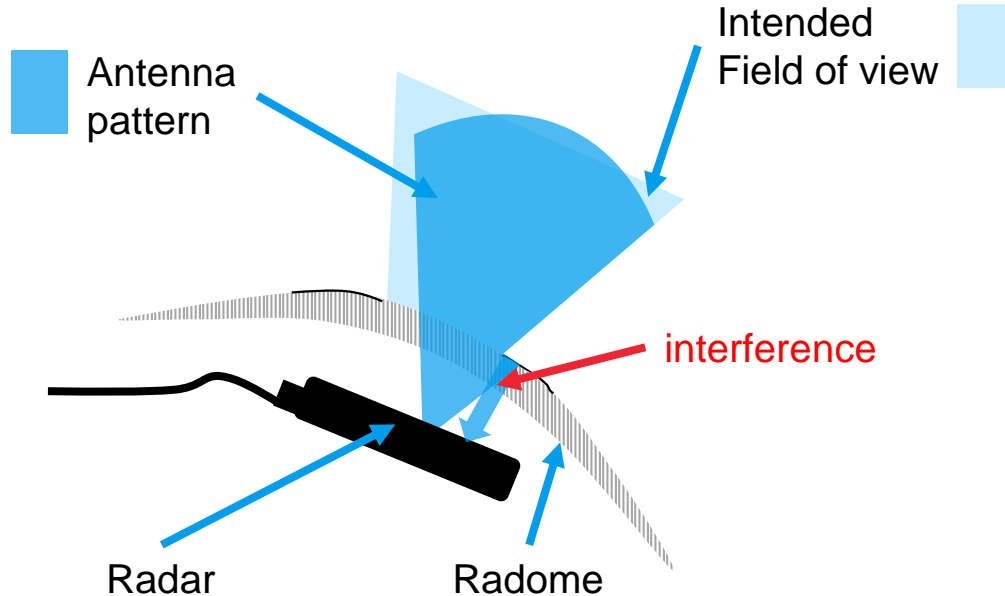
Why is it necessary?



- The radar is not necessarily fixed to the bumper or radome.
- It has to be ensured that the antenna pattern lies inside the intended FOV.

Mounting accuracy measurement

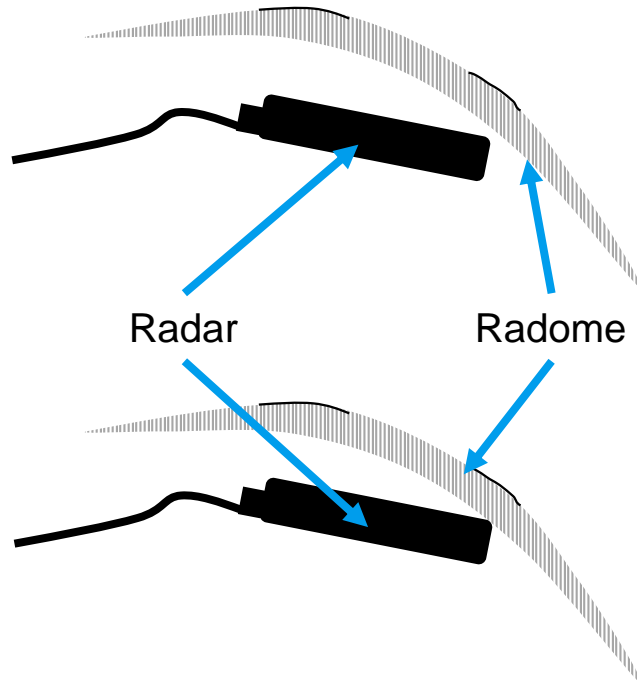
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Mounting accuracy measurement

What can possibly happen?



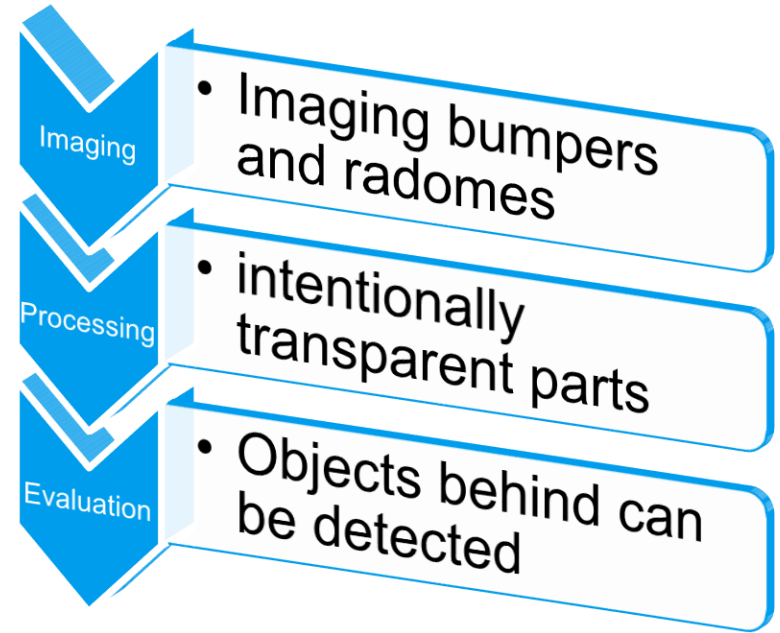
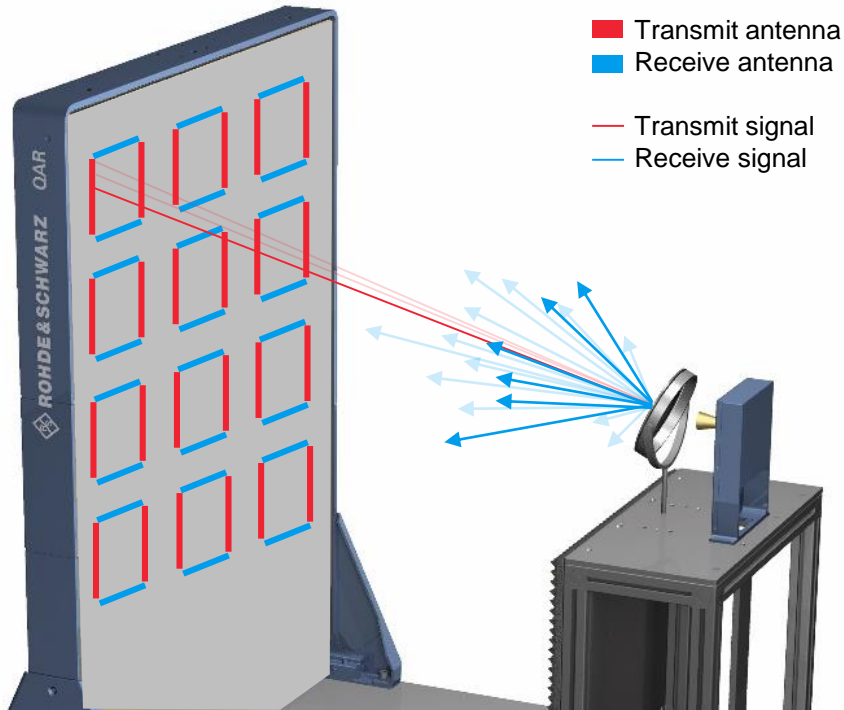
Possible misalignment
in azimuth or elevation.



Possible misalignment
in absolute positioning.

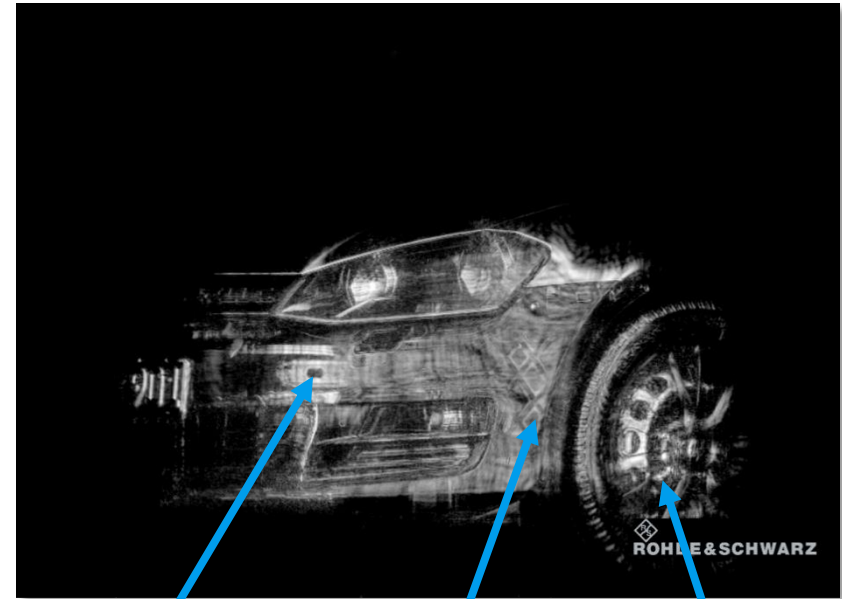
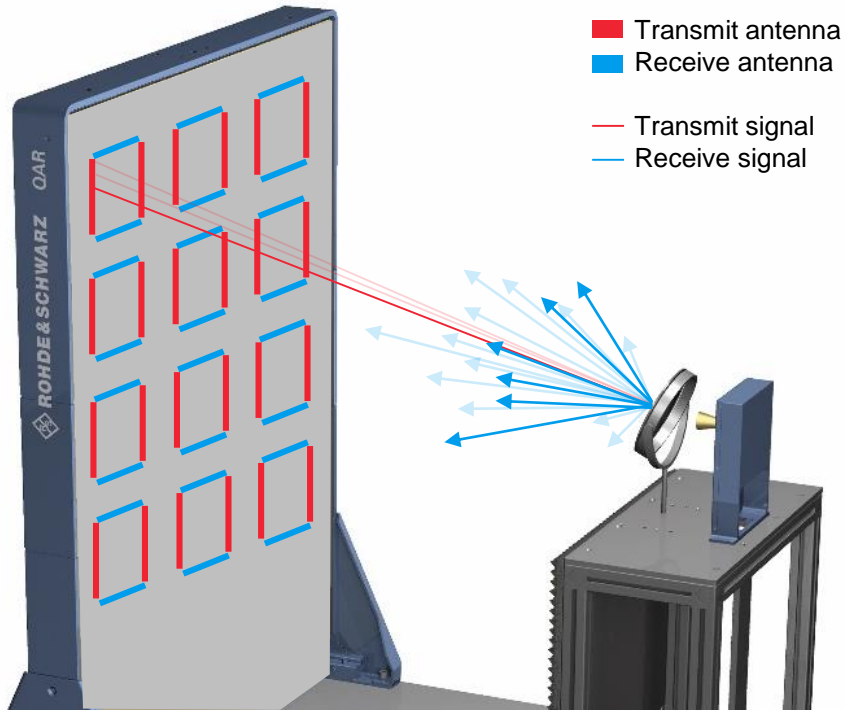
Mounting accuracy measurement

How can the QAR be of help?



Mounting accuracy measurement

How can the QAR be of help?



Mounting accuracy measurement

How can the QAR be of help?

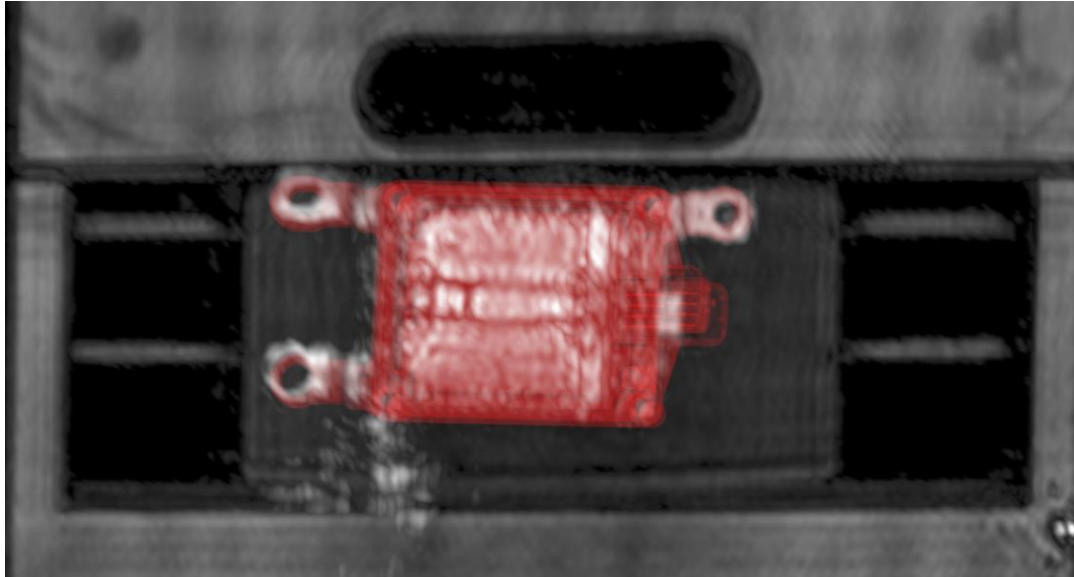


- The QAR can look through the bumper.
- Raw data is used to locate x, y and z-position of the radar together with azimuth and elevation angle of the device.
- CAD data is necessary for correct classification.



Mounting accuracy measurement

How can the QAR be of help?



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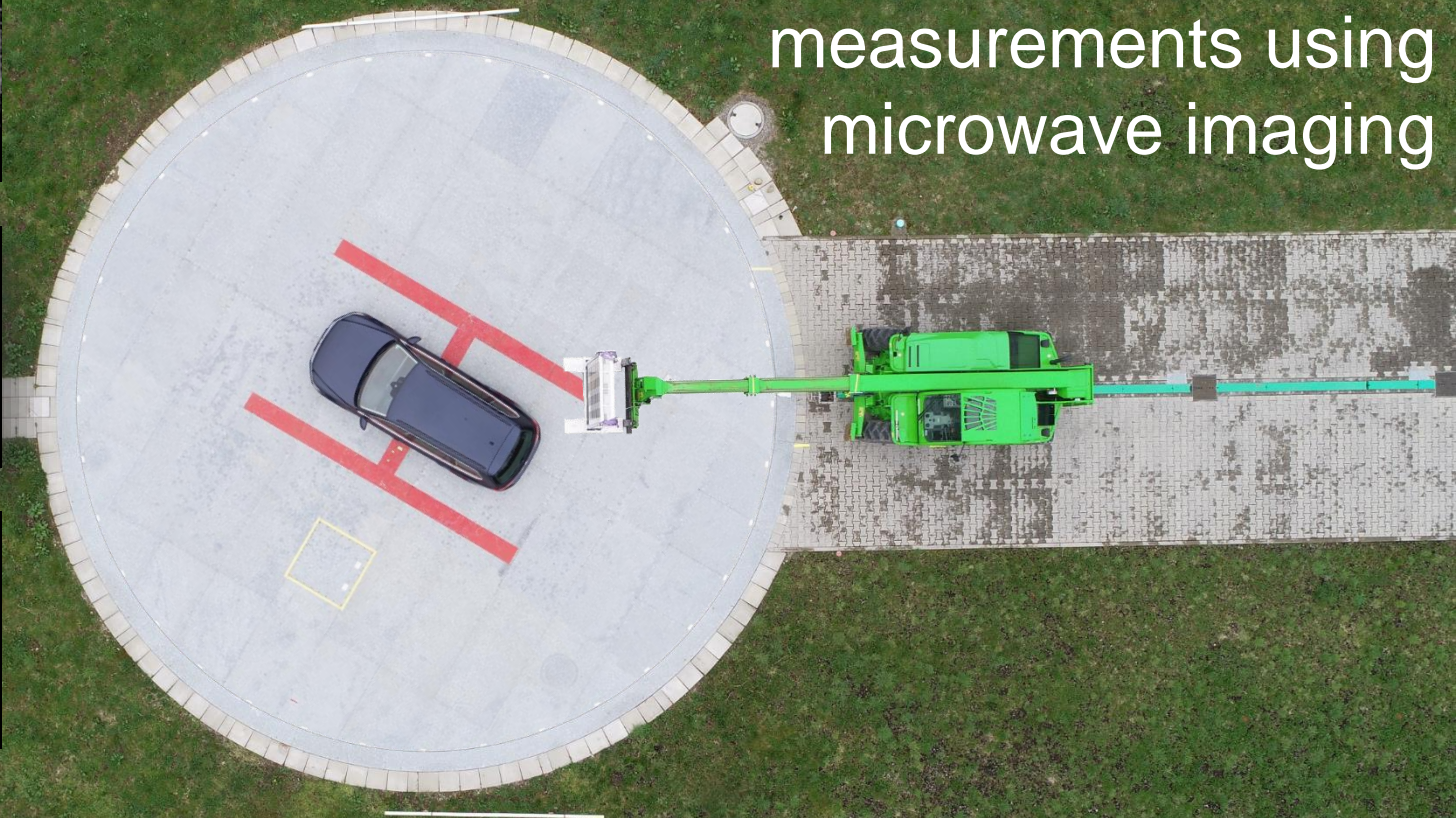
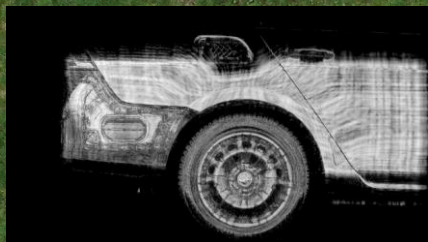


Radar Cross section measurement

Radar Cross section measurement

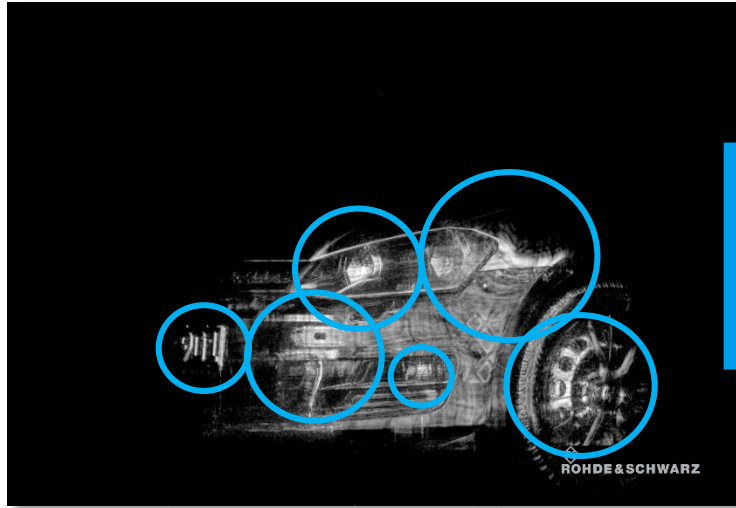


Precise RCS measurements using microwave imaging



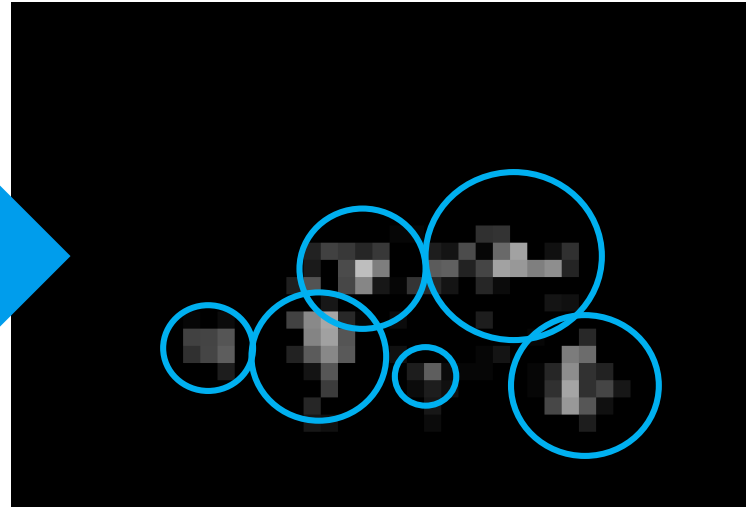
Localize object scatter points of complex radar objects

- Creation of more complex RCS models based on actual measurements



High azimuth / elevation
resolution

Information
reduction



Low azimuth / elevation
resolution



Automotive radar technology, market and test requirements

White paper

Download from R&S website:
www.rohde-schwarz.com

1 Introduction	3
2 Automotive radar market trends	5
3 Radar measurement	7
3.1 Range and radial velocity	7
3.2 Azimuth and elevation	8
3.3 Radar resolution and why signal bandwidth is required	11
3.4 Radial velocity resolution and why high frequencies are favorable	13
4 Test and measurement of automotive radar sensors	14
4.1 ETSI tests	15
4.1.1 Test site requirements	16
4.2 Transmitter tests	17
4.2.1 Operating frequency range	17
4.2.2 Total power, peak EIRP and mean (average) EIRP	18
4.2.3 Spectrum access duty cycle	19
4.2.4 Dwell time and repetition time	19
4.2.5 Frequency modulation range	19
4.2.6 Unwanted emissions in the out-of-band and spurious domain	19
4.3 Receiver tests	21
4.3.1 Receiver spurious emissions	21
4.3.2 Receiver in-band, out-of-band and remote-band signal handling	21
4.4 Antenna tests	22
4.4.1 Unwanted vertical plane transmitter emissions	22
4.5 Tests during research and development	23
4.5.1 Signal quality	23
4.5.2 Antenna pattern measurements	26
4.6 Integration tests	28
4.6.1 Reflectivity measurement	29
4.6.2 Transmission loss	30
4.7 Production tests	31
4.7.1 Near field and far field	32
5 Automotive radar trends	33



Automotive Radar Testing

Target Generation



Interference Testing

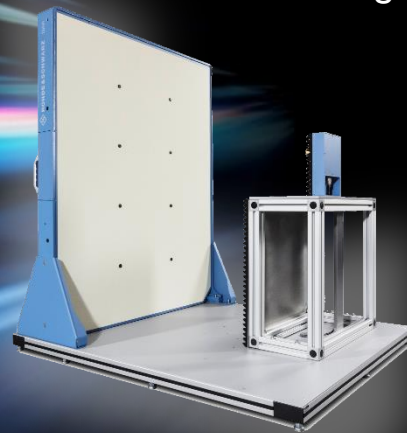


Thank you!

Signal Analysis

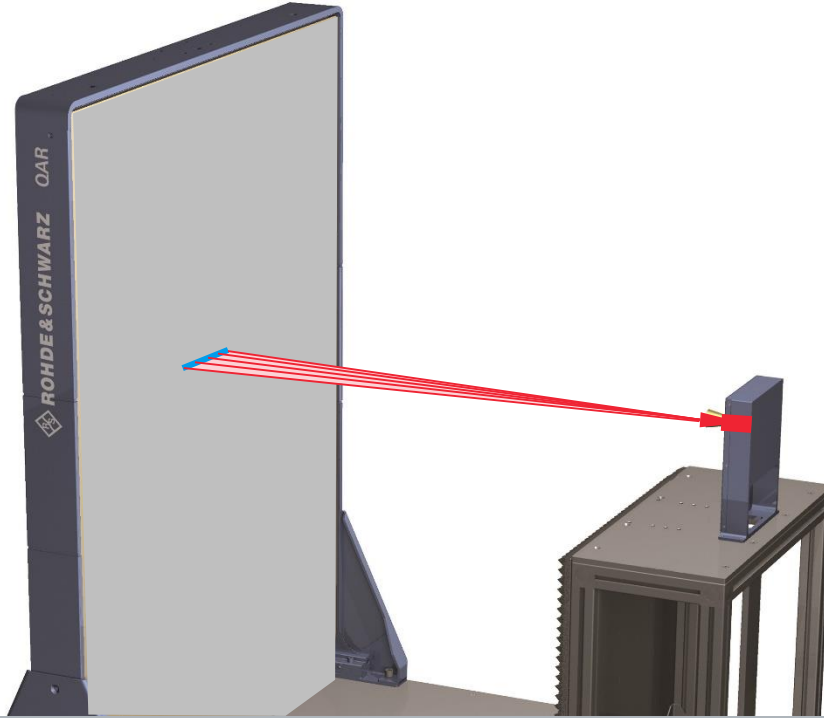


Radome Testing



QAR measurement principle

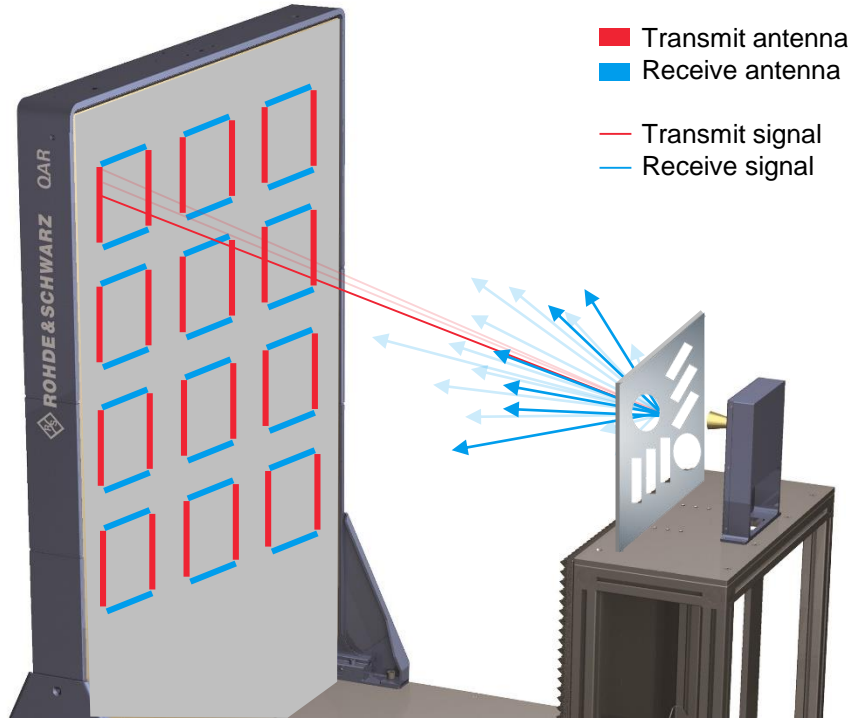
normalization of the transmit measurement



- Normalization of the transmission measurement is relative to the air loss between the transmit and receive antennas.
- The object between the external transmit and the receive antennas is removed.
- All measurements are now referenced to the air loss measurement.

QAR measurement principle

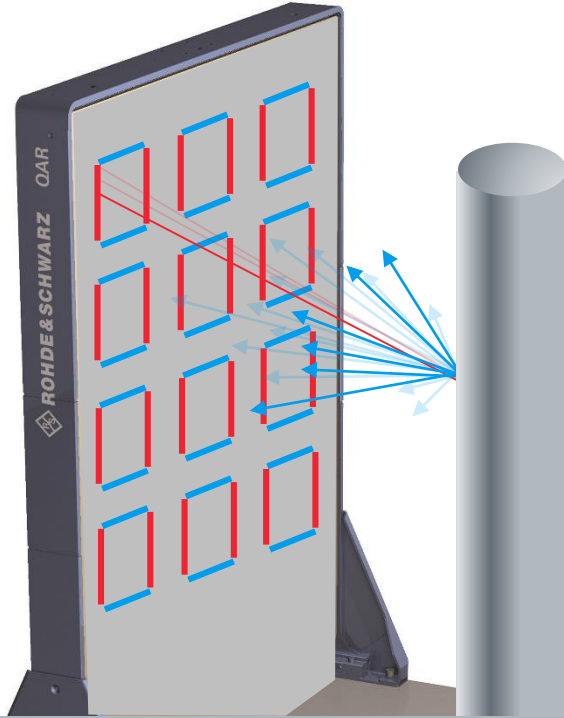
normalization of the reflection measurement



- I A metallic surface is placed in front of the receive panel. The surface is at the exact same position as the radome is placed.
- I A normalization measurement is taken, assuming that the reflectivity of the metallic surface is 1 (100% reflective).
- I All measurements are now referenced to the 100% reflective surface.

QAR measurement principle

normalization of the reflection measurement



- I A metallic surface is placed in front of the receive panel. The surface is at the exact same position as the radome is placed.
- I A normalization measurement is taken, assuming that the reflectivity of the metallic surface is 1 (100% reflective).
- I All measurements are now referenced to the 100% reflective surface.