Material meets millimeter wave (mmW)

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Product Manager Microwave Imaging
1 MIP

Prepared for

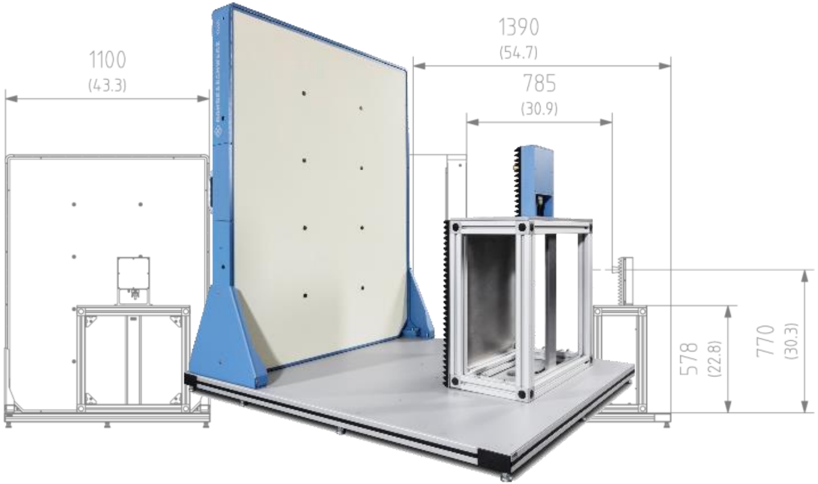
MATERIAL MEETS ENGINEERING
FRANKFURT 2019

lyondellbasell

ROHDE&SCHWARZ
Automotive

COMPANY RESTRICTED

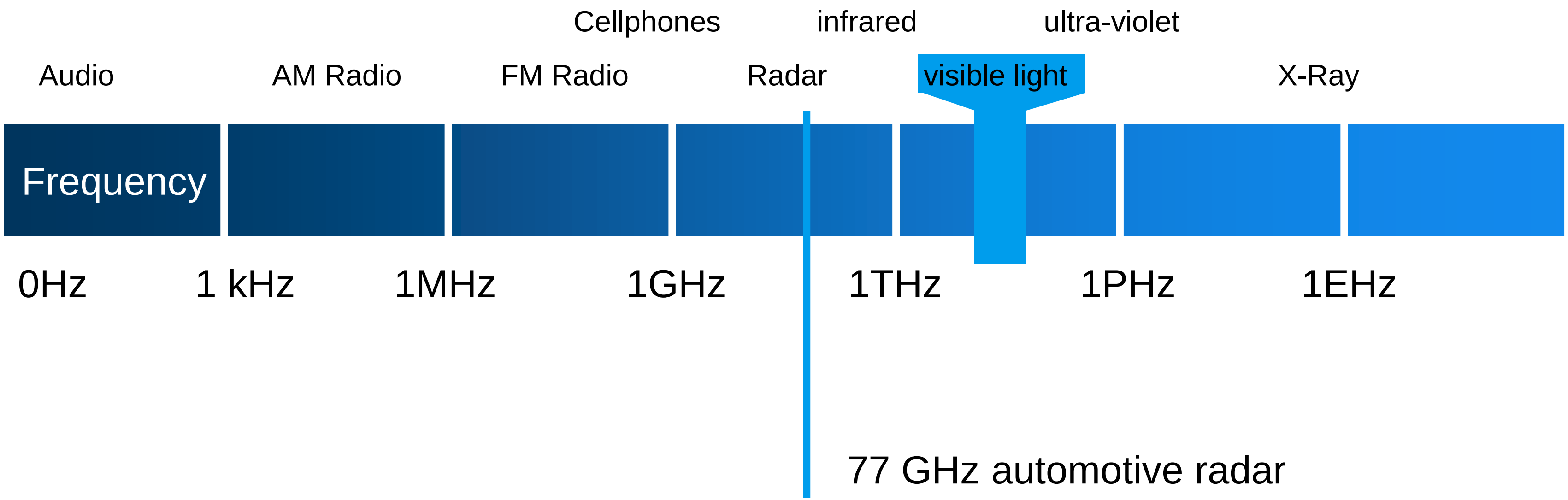
Overview



mmW Imaging

Applications in Plastics

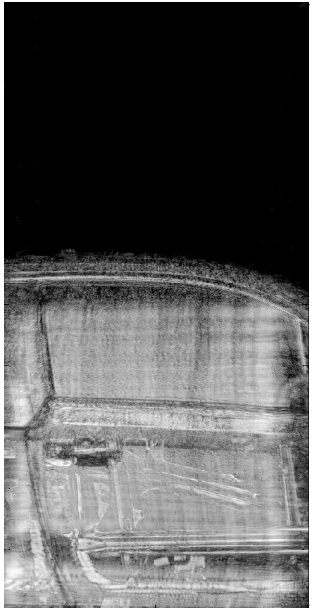
mmW Imaging


Cellphones
infrared
ultra-violet
Audio
AM Radio
FM Radio
Radar
visible light
X-Ray
Frequency
0Hz
1 kHz
1MHz
1GHz
1THz
1PHz
1EHz
77 GHz automotive radar

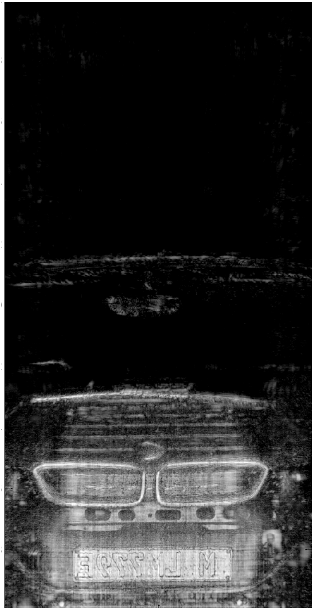
mmW Imaging

mmW Imaging

Honda CBR



BMW i3 - side

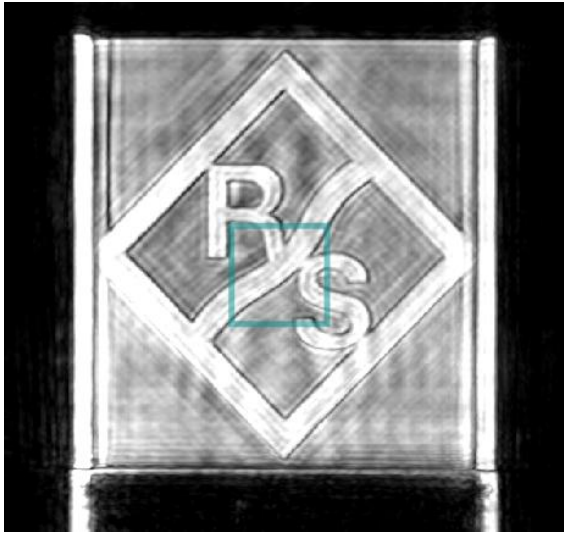


BMW i3 - front

QAR
Automotive Radome Testing

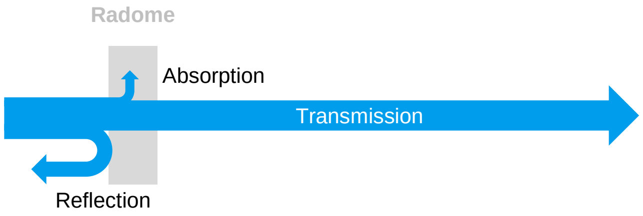
PCB sample with copper structure.

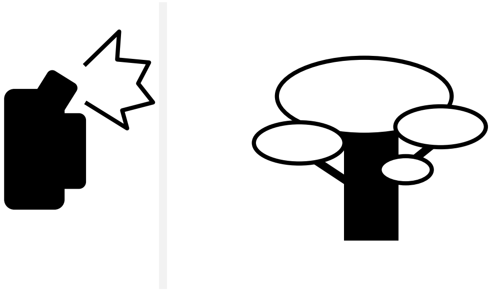
Find hidden structures in design radomes



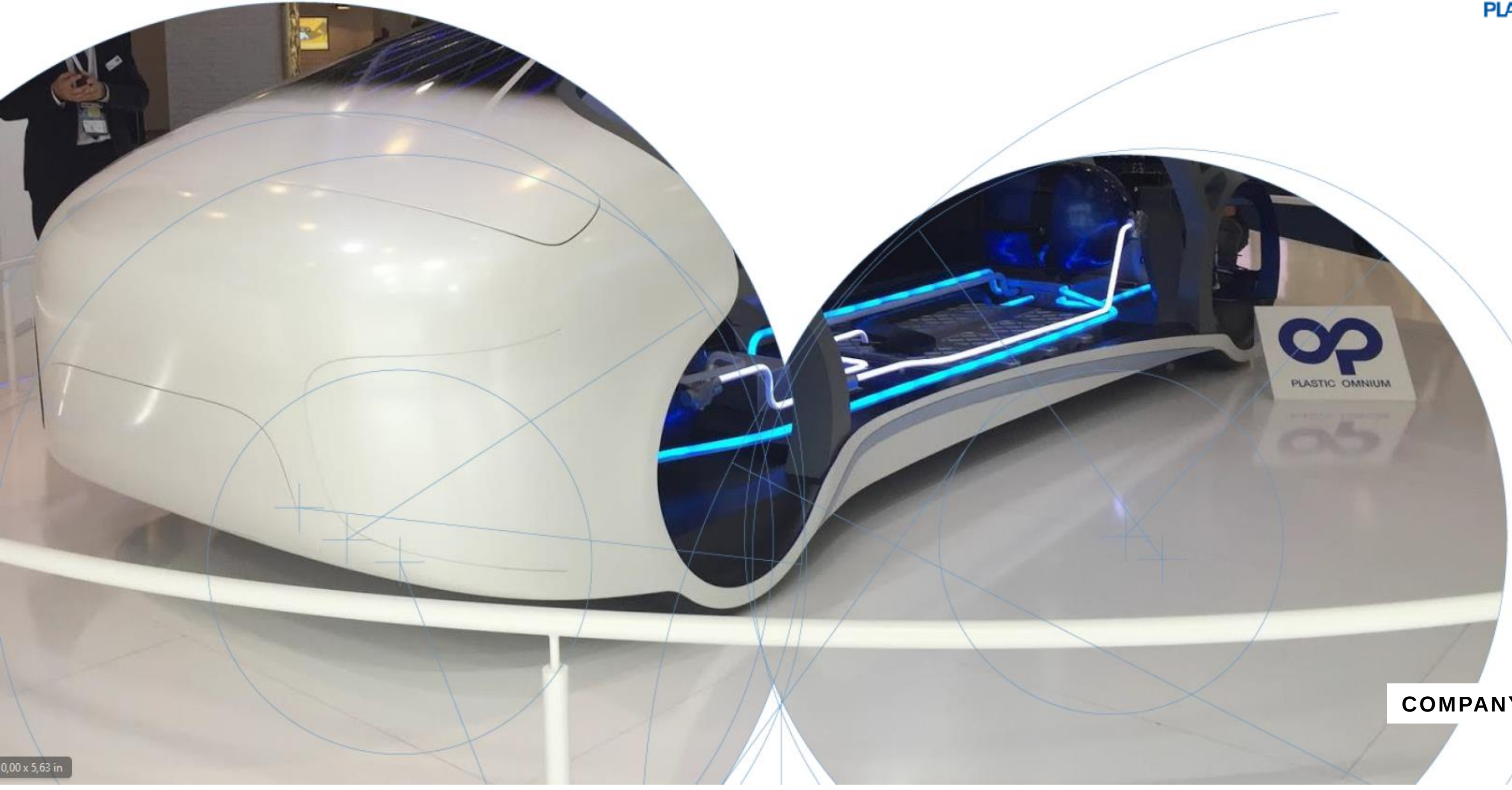
Reasons for blindspots within the radome

Why spatially resolved reflectivity images are important





NEW REQUIREMENTS FOR BODY PANELS



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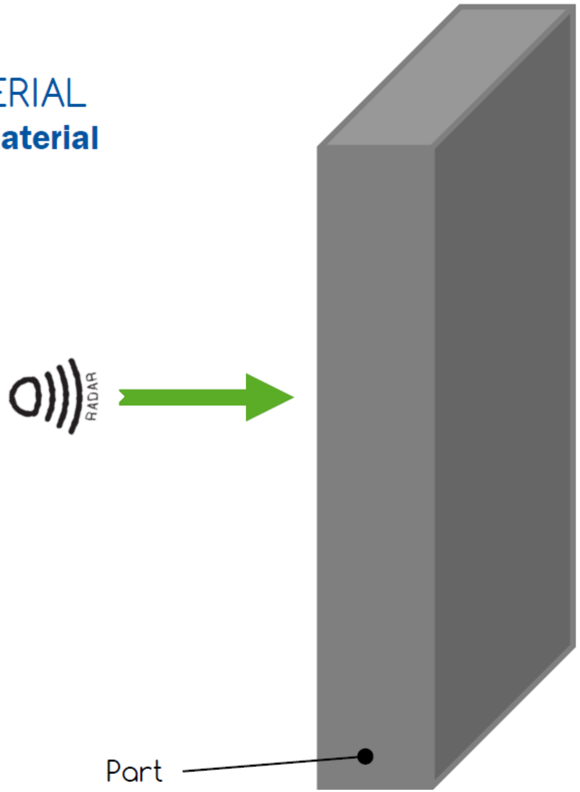
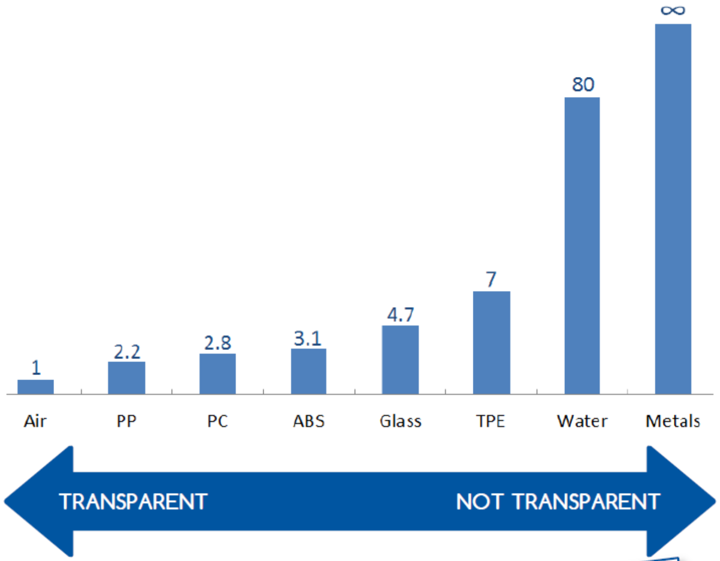
0,00 x 5,63 in

Radar compatibility - Influence factors for attenuation

- RAW MATERIAL
  - **Type of material**

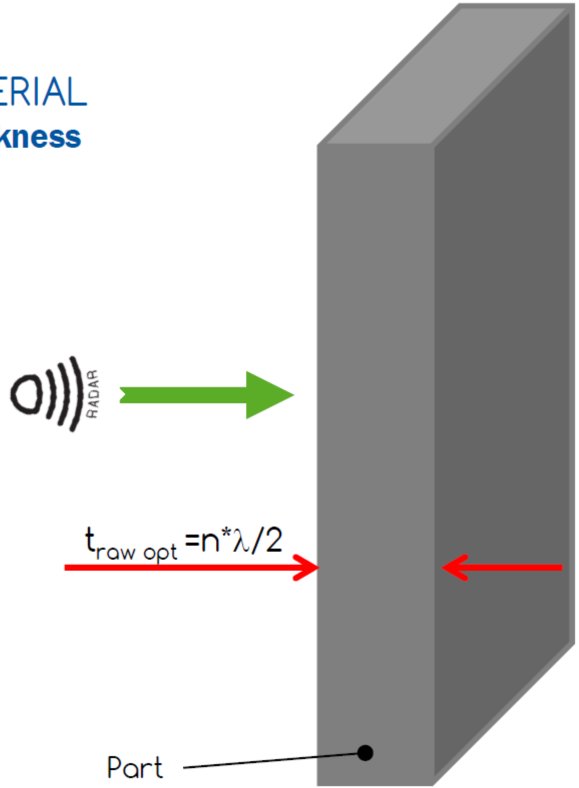


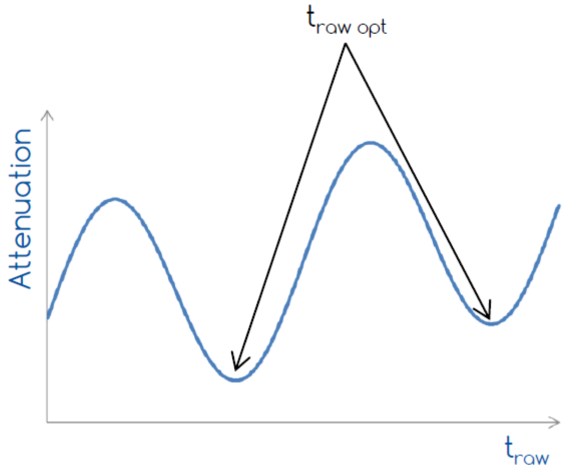


Common exterior parts are produced out of PP, PC and ABS

Radar compatibility - Influence factors for attenuation

- RAW MATERIAL
  - **Wall thickness**



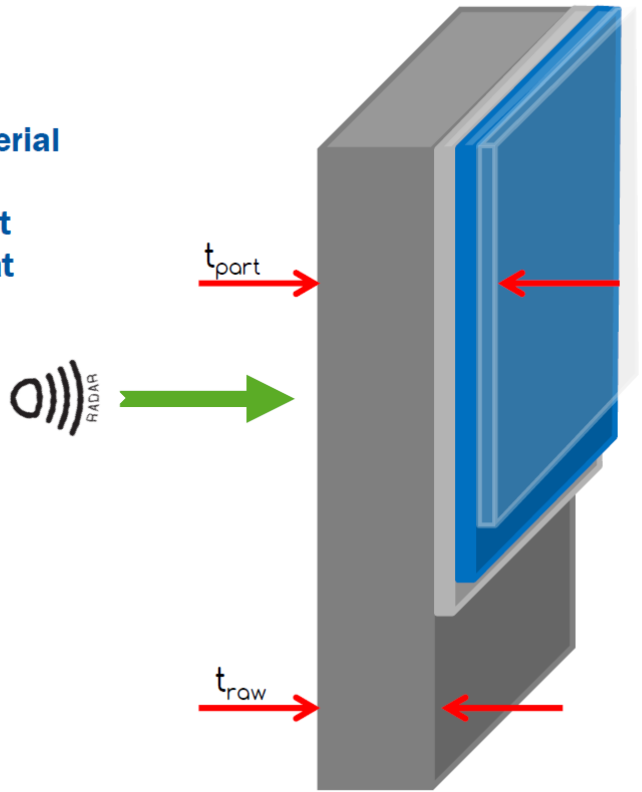


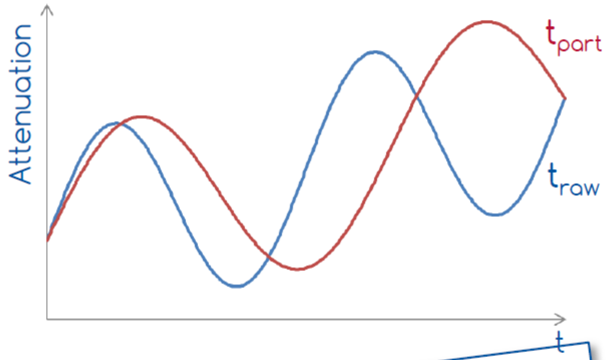
A common wall thickness is in the range from 2,6mm up to 3,5mm

λ = Wave length of the radar (76Ghz ≈ 3,9mm)

Radar compatibility - Influence factors for attenuation

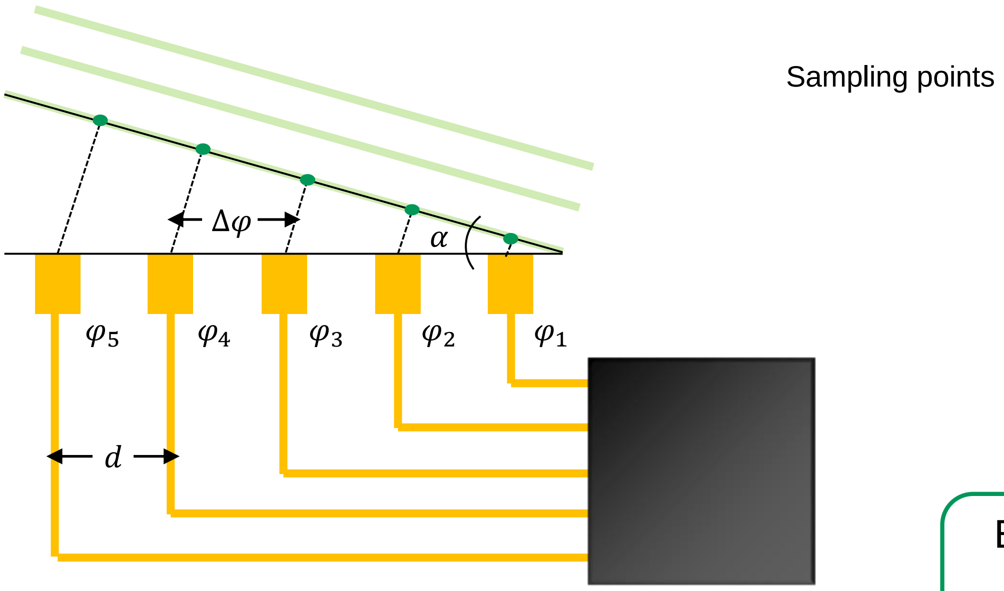
- PART
  - **Raw material**
  - **Primer**
  - **Base coat**
  - **Clear coat**





Important: an optimized t_{part} is different for each color and not the same as t_{raw}

Radar angular measurement technology

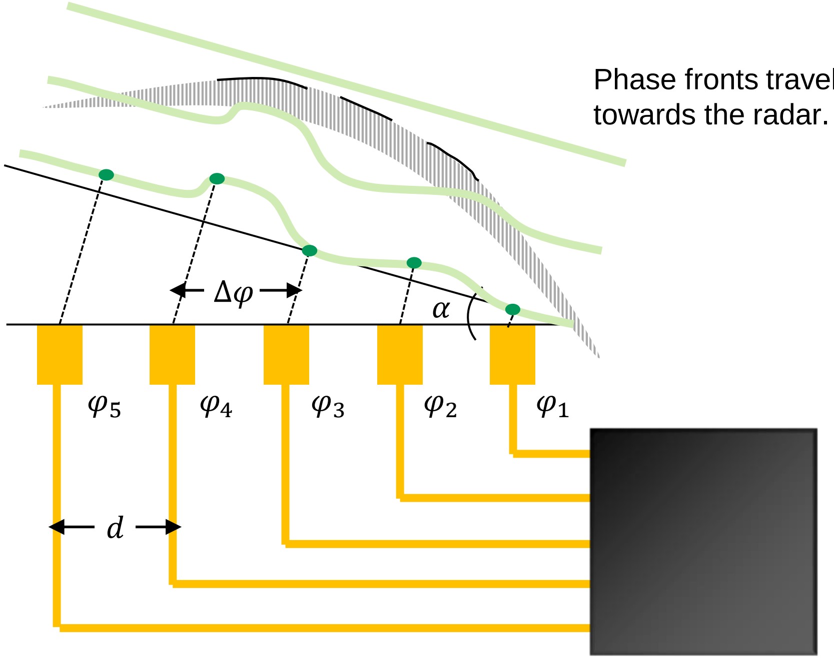


d	Physical distance between antennas
$\Delta\varphi$	Phase difference
α	Angle of arrival
λ	wavelength

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

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

Radar angular measurement technology



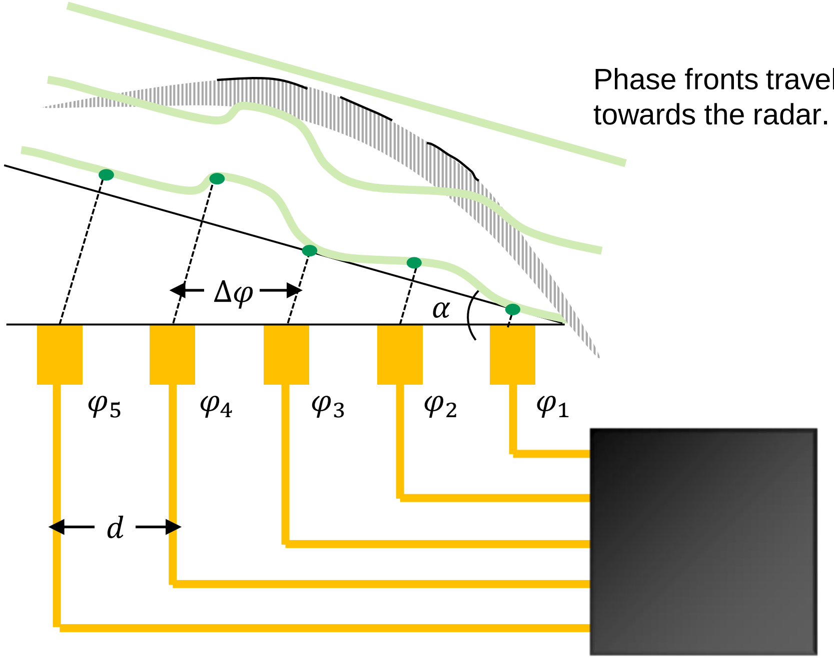
d	Physical distance between antennas
$\Delta\varphi$	Phase difference
α	Angle of arrival
λ	wavelength

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

$$\boxed{\Delta\varphi_1 \neq \Delta\varphi_2 \neq \Delta\varphi_3 \neq \Delta\varphi_4 \neq \Delta\varphi_5}$$

Phase estimation is wrong

Radar angular measurement technology



Phase fronts traveling towards the radar.

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

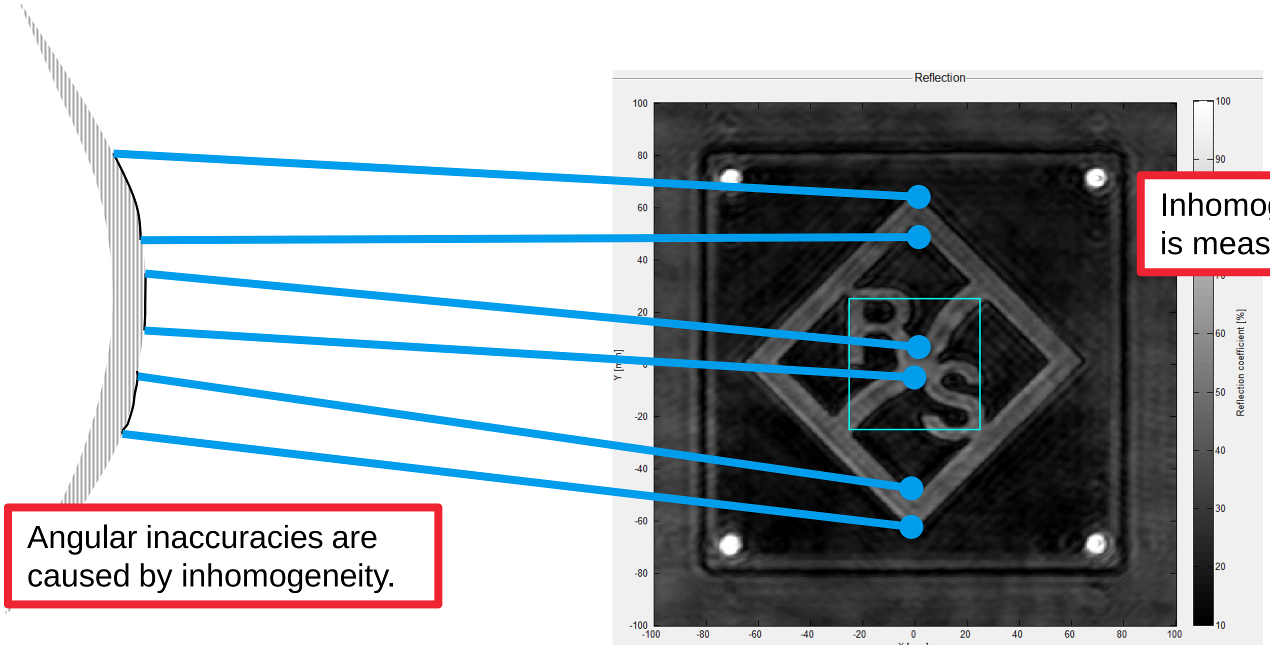
- The radar is slightly moved.
- The distance between the antennas is changed.
- Another algorithm is used for angle of arrival estimation during post processing.

Or, more general, if:

- Another radar / radome combination is used.

An alternative method has to be used.

Radar angular measurement technology



Inhomogeneity of the radome is measured by the QAR.

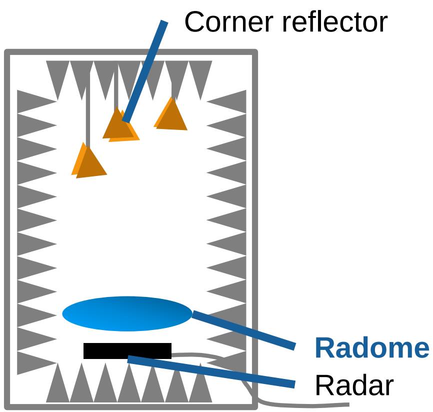
Angular inaccuracies are caused by inhomogeneity.

A threshold can be defined for either each car, or the whole fleet. Every radar is then measured using the same technique.

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°

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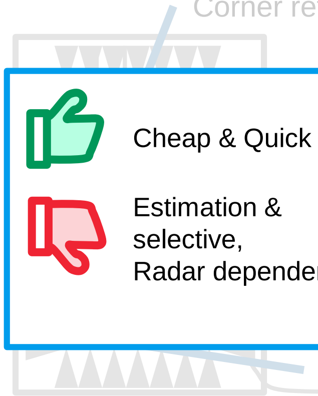

Cheap & Quick

Estimation & selective, Radar dependent

Result

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

Comparison of measurement methods

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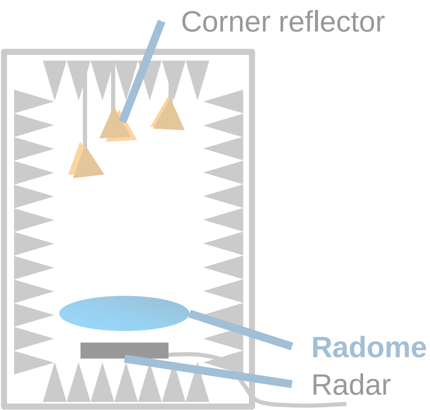

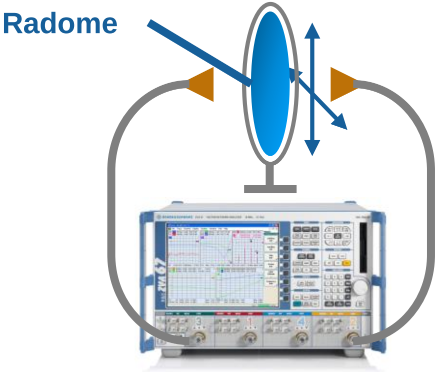

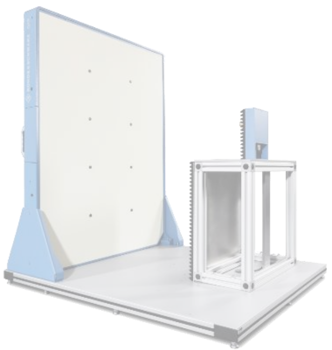

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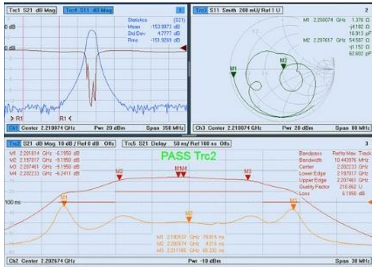

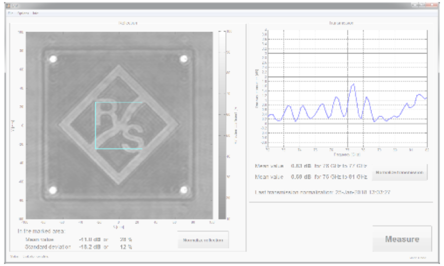

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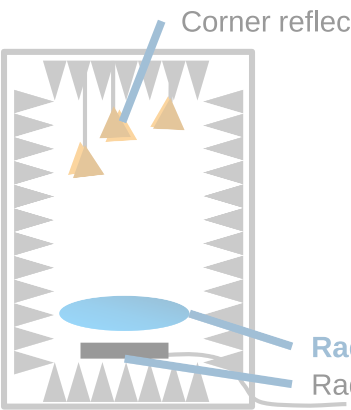
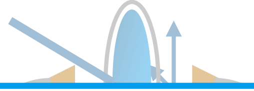
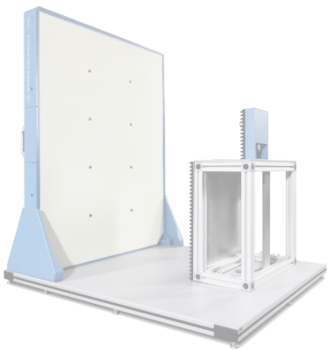




Precise measurement

Slow and selective
Calibration required
Experts for operation



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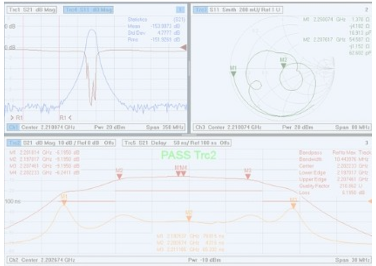

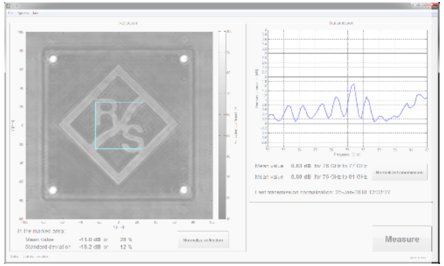

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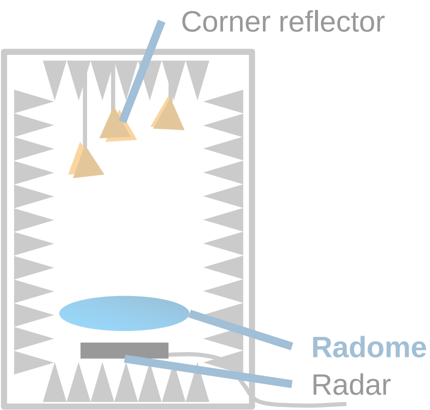
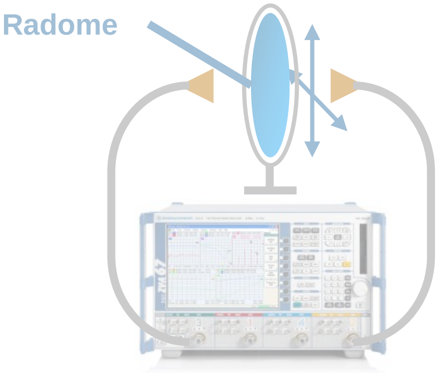
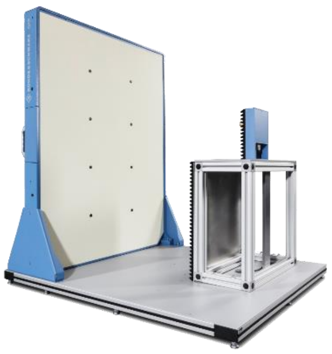
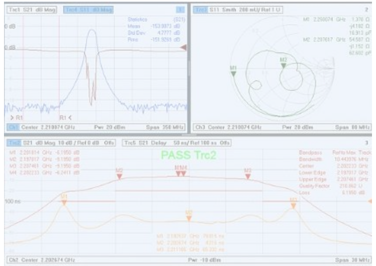
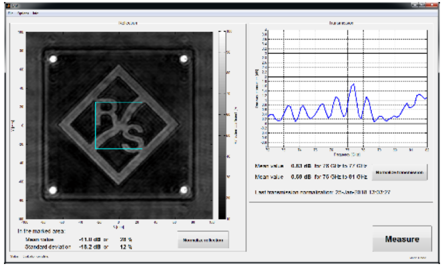
Descr.			
Result	see table below		

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Comparison of measurement methods

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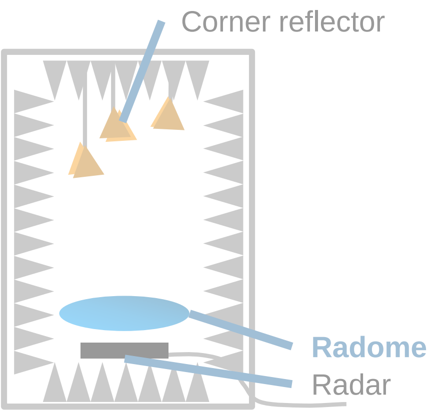
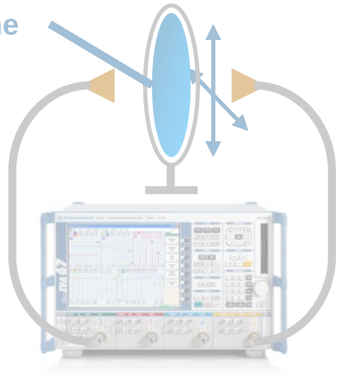
Descr.			
Result			





Spatially resolved
Easy to operate
Time saving

Equipment necessary

Corner reflectors result:

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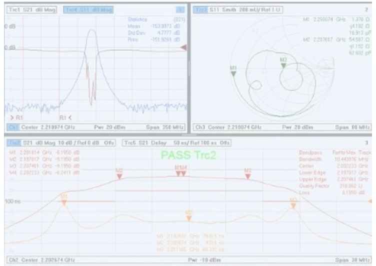

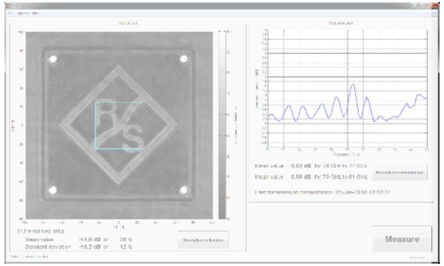

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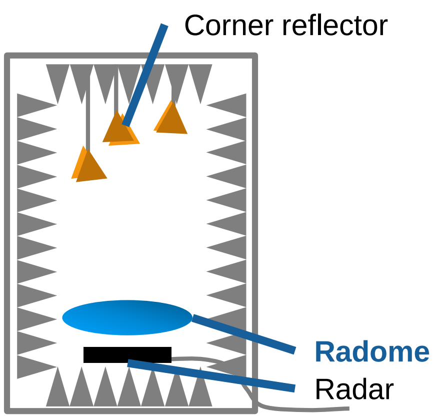

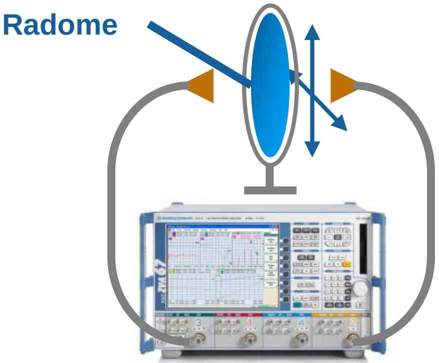

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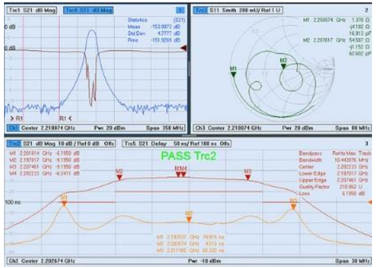
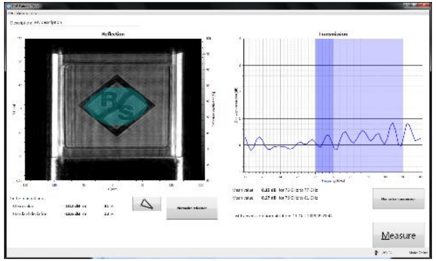
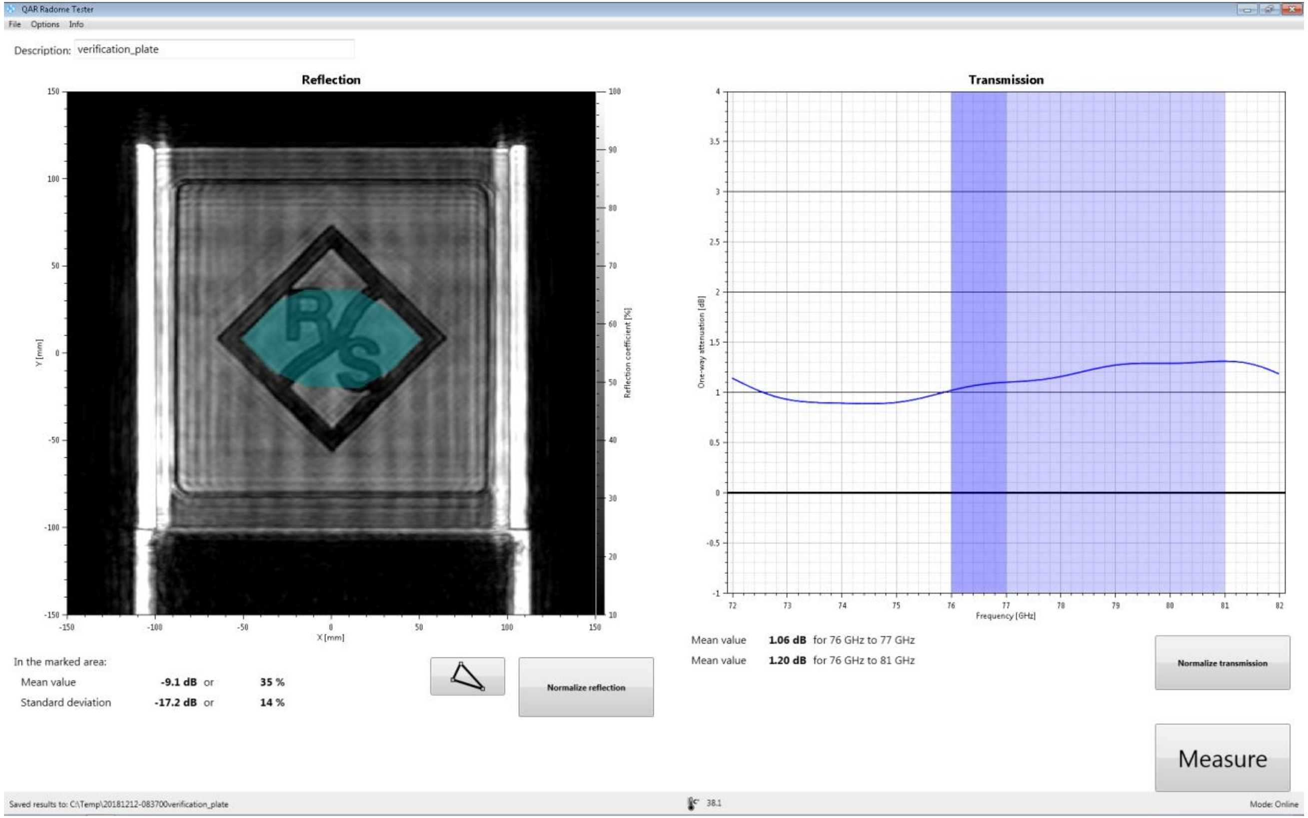




The R&S QAR radome tester



Summary
Your benefits

Increase quality

Due to the possibility of
100% testing in production

Reduce measurement time

Measurement cycle of the
instrument is ~ 7s

Reduced costs

Much easier to operate as
a vector network analyzer

Thank You