Webinar

AUTOMOTIVE RADAR COMPLIANCE TESTING USING A CATR (Compact Antenna Test Range) CHAMBER

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ROHDE&SCHWARZ
Make ideas real

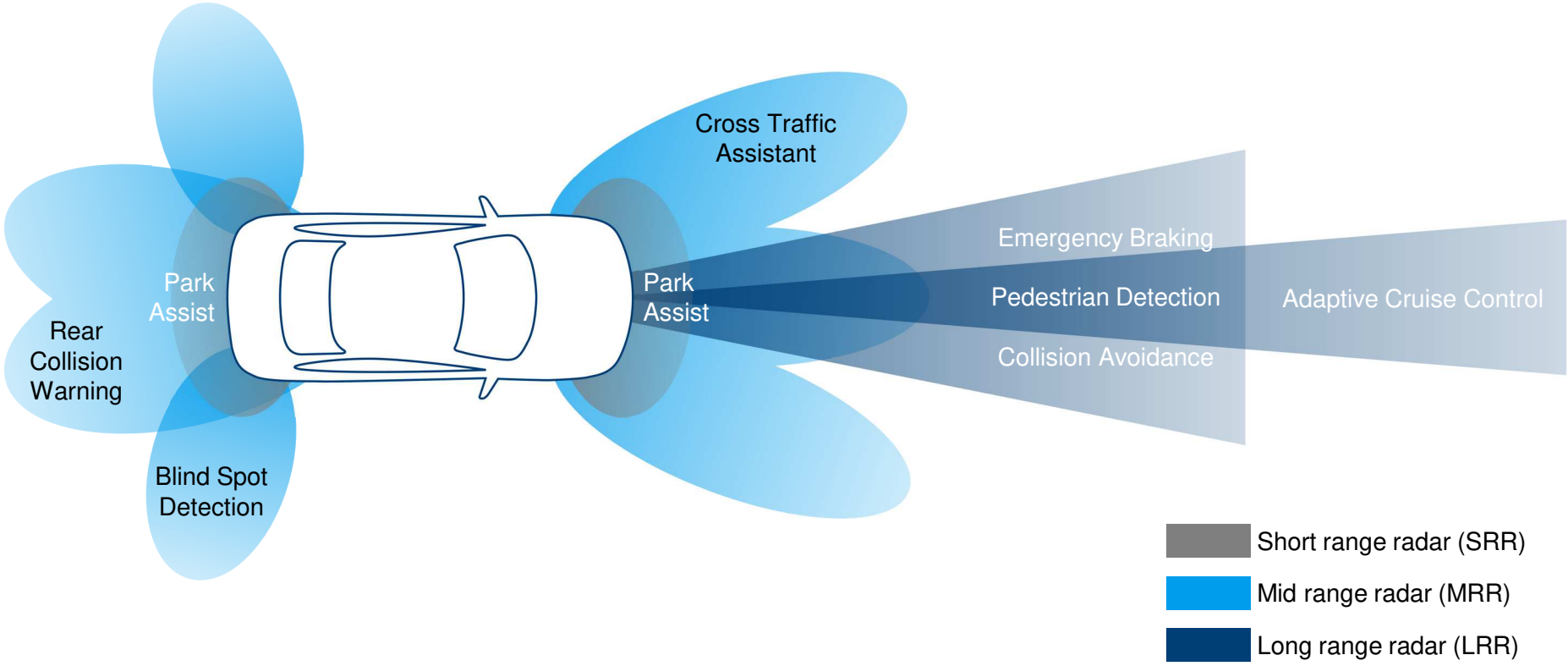
OVERVIEW

- Introduction to Automotive Radar
- What is a CATR chamber
- Direct Far-field vs Indirect far-field (DFF vs IFF)
- R&S® ATS1500C CATR chamber
- R&S® AREG800A Radar Target Simulator
- Demo of Automotive Radar testing using a CATR chamber
- Q&A

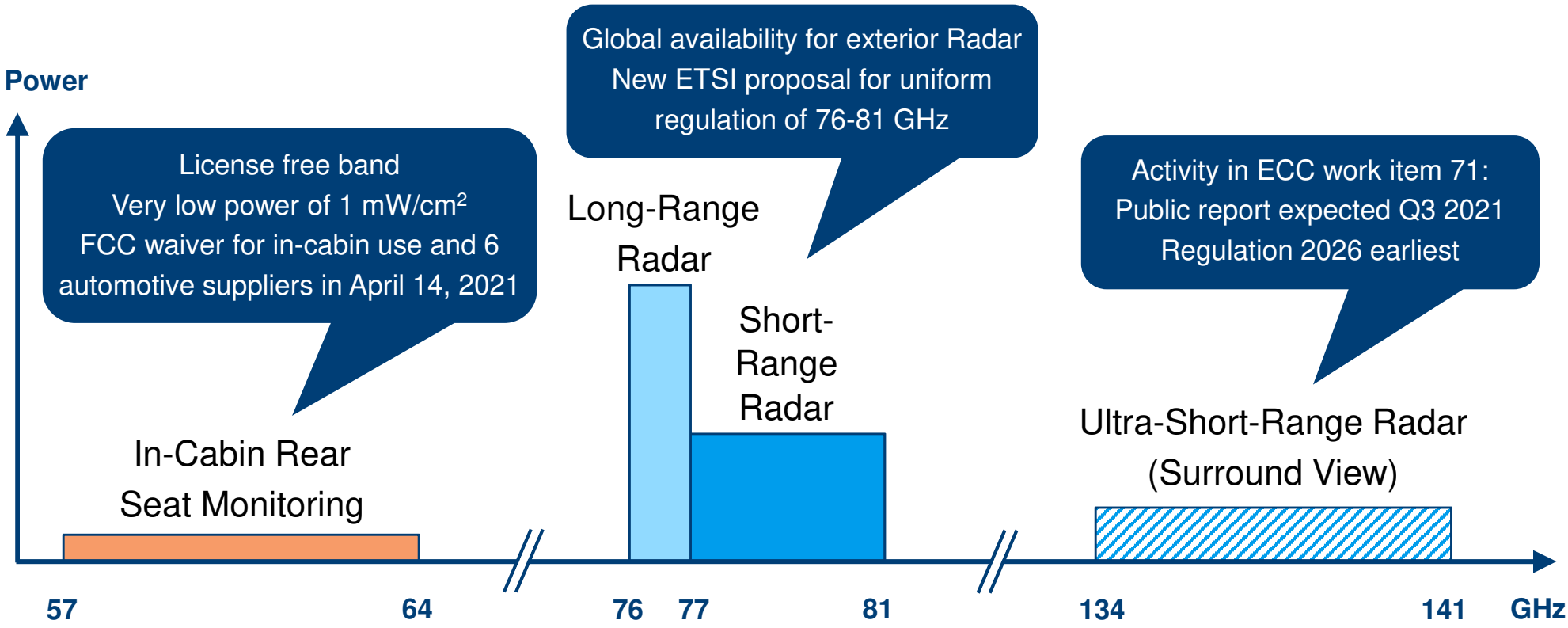
Webinar: Automotive Radar Compliance Testing using the Rohde & Schwarz CATR chamber

INTRODUCTION TO AUTOMOTIVE RADAR

RADAR BASED AUTONOMOUS DRIVING



AUTOMOTIVE RADAR FREQUENCY MAP
76-81 GHZ GLOBALLY AVAILABLE



VISION SYSTEMS AND LIDAR ARE NOT SUFFICIENT

Radar: All Weather Capable

Radar: Sun/Light Agnostic

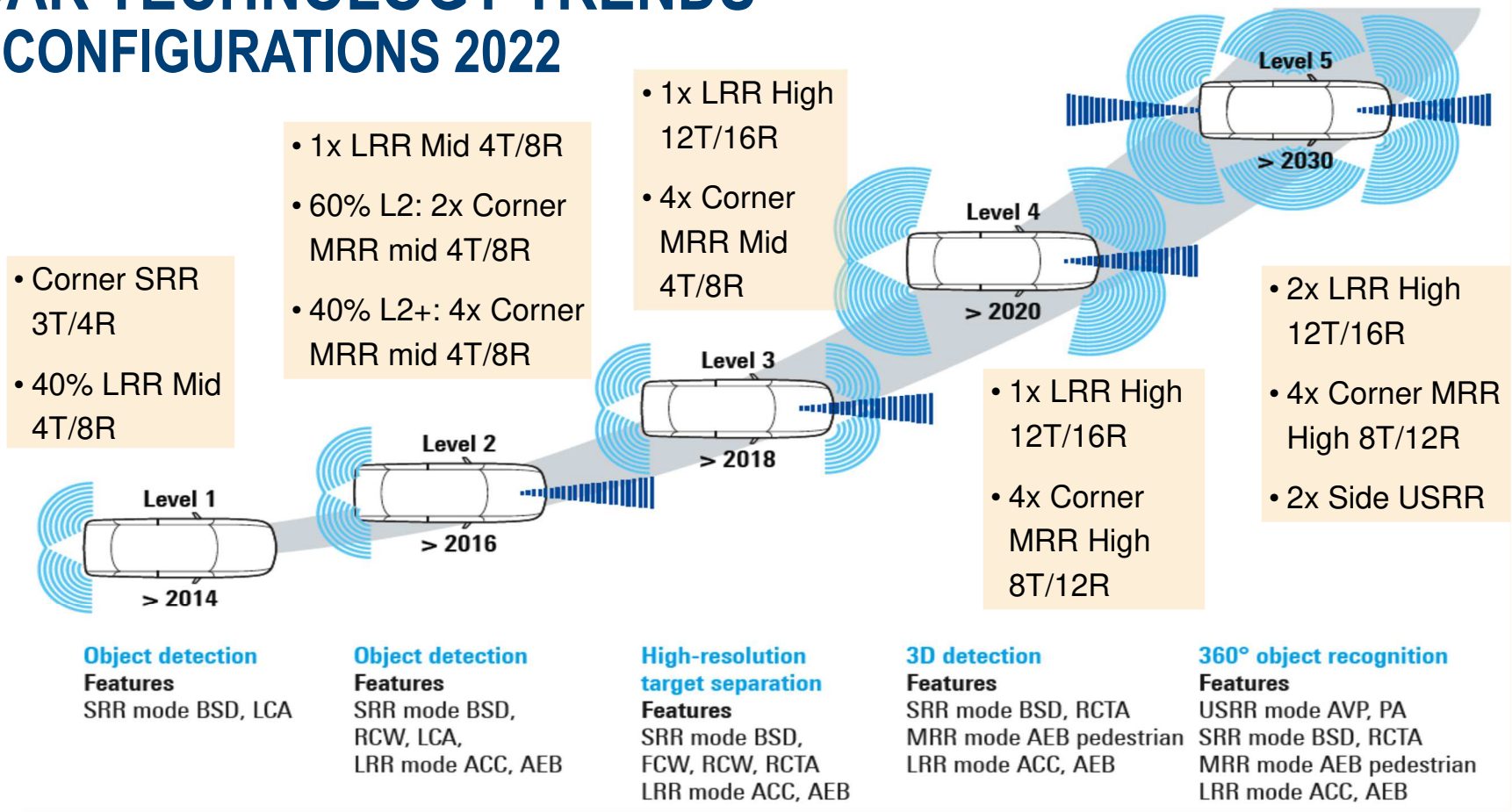
Radar: Distance & Doppler

Radar: Color Agnostic

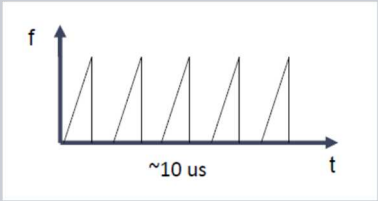
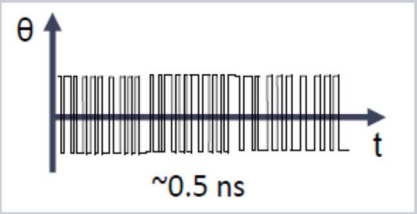
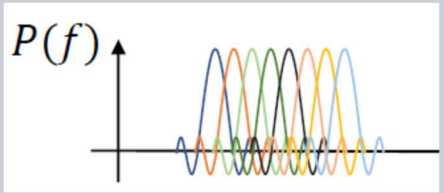
Radar is a Critical Sensor

Source: Uhnder (https://www.uhnder.com/)

RADAR TECHNOLOGY TRENDS
CAR CONFIGURATIONS 2022



RADAR TECHNOLOGY TRENDS
NEW MODULATION SCHEMES FOR BETTER INTERFERER ROBUSTNESS

Modulation Technique	Today: FMCW	Near Future: PMCW	Long term: OFDM
Waveform			
Waveform Duration	~10 µs	~1 µs	~1 µs
ADC Sample Rate	~50 MSample/s IQ	>1 GSample/s IQ	>1 GSample/s IQ
Interferer Robustness	Good	High	High
Massive MIMO	Multi-Phase, Chirp Coded	Phase Coded	Orthogonal Sub-Carrier

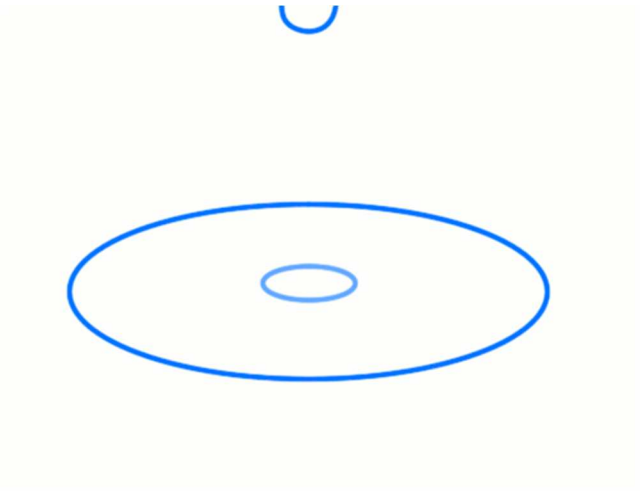
Automotive Radar Test using a CATR chamber

DIRECT FAR FIELD VS INDIRECT FAR FIELD MEASUREMENTS OF AUTOMOTIVE RADARS

RADIATION PROPERTIES

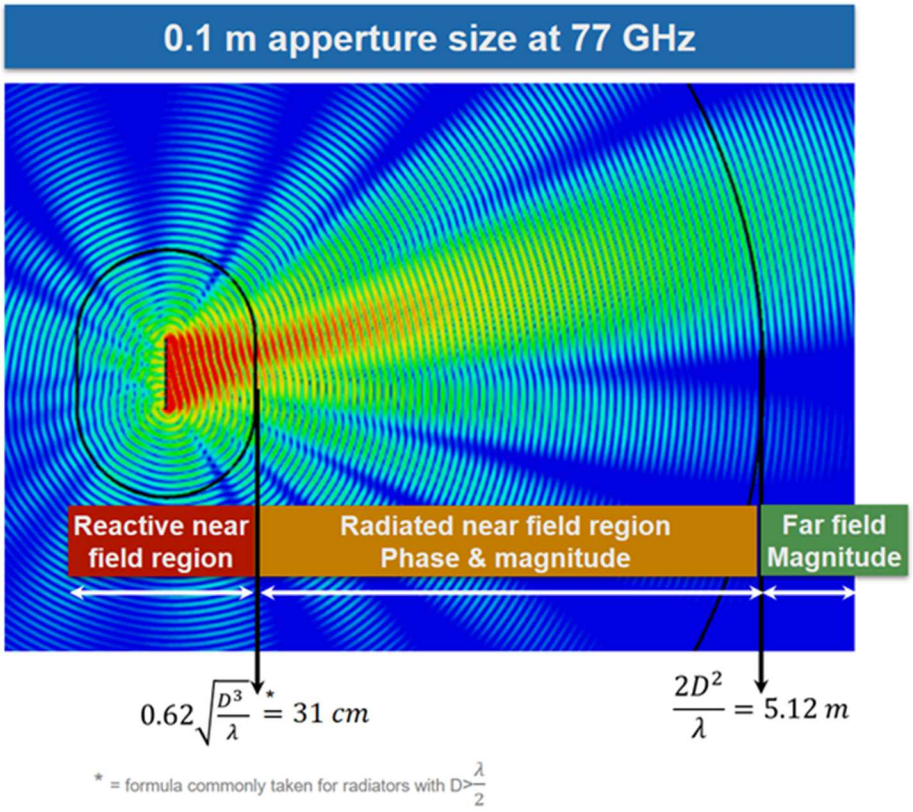
- Antenna emits a multitude of spherical waves
- As the waves are travelling away from the antenna their energy locally decreases with the distance from the antenna as it distributes over an increasing sphere
- At a given point far enough away from the antenna, the emitted wave looks plane within certain limits

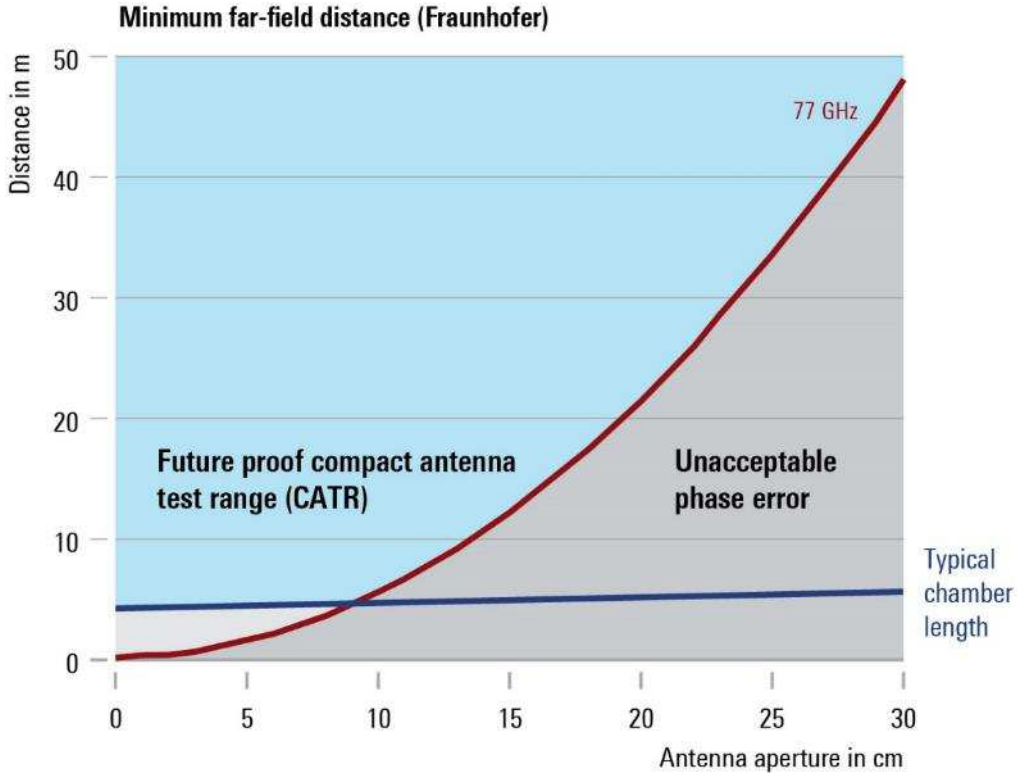
  → this region is called “quiet zone”, far-field condition fulfilled



Compare with throwing a stone into water

FAR FIELD BASED ON FRAUNHOFER DISTANCE

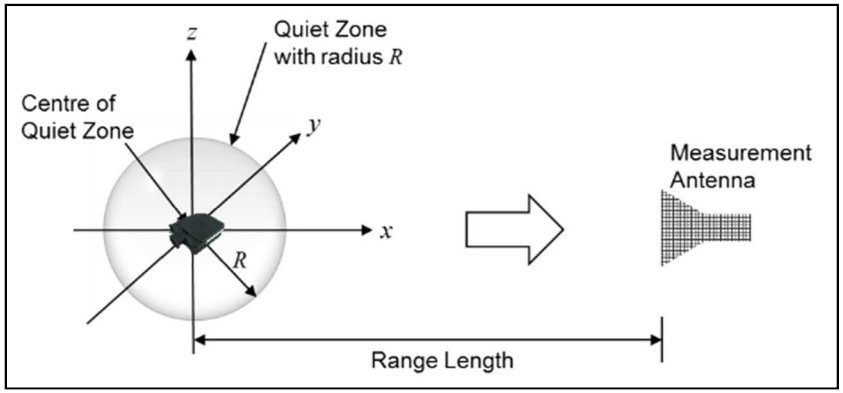




CATR REFLECTOR TRANSFORMS SPHERICAL FIELD TO PLANAR WAVES, REDUCING TEST DISTANCE

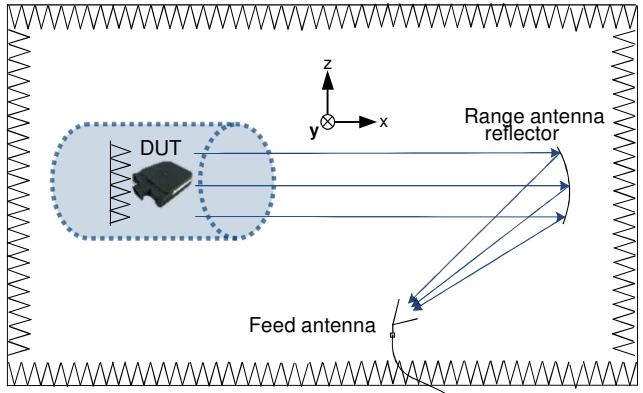
Direct Far Field (DFF)

Quiet zone typically **smaller,** require **bigger** test distance



Indirect Far Field (IFF)

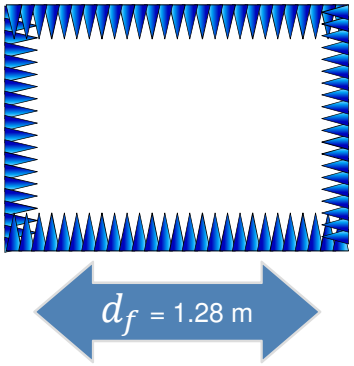
Quiet zone typically **bigger,** require **smaller** test distance



Indirect Far Field (IFF) ➔ Compact antenna test range (CATR):

- Path loss ~ 0 between reflector ⇔ DUT
- QZ diameter = 25…50% of reflector, cylindrical shape
- CATR reflector is a bi-directional device

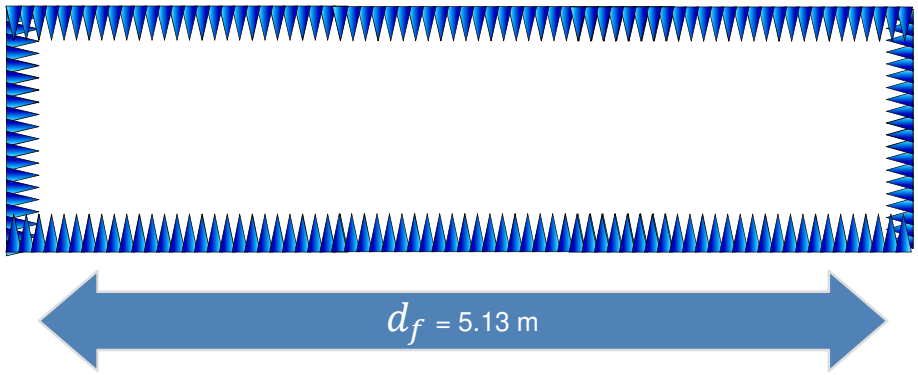
FAR FIELD WITH VARYING RADAR APERTURE SIZE AT 77 GHZ



$$d_f = \frac{2D^2}{\lambda}$$

D = 5 cm
d_f = 1.28 m

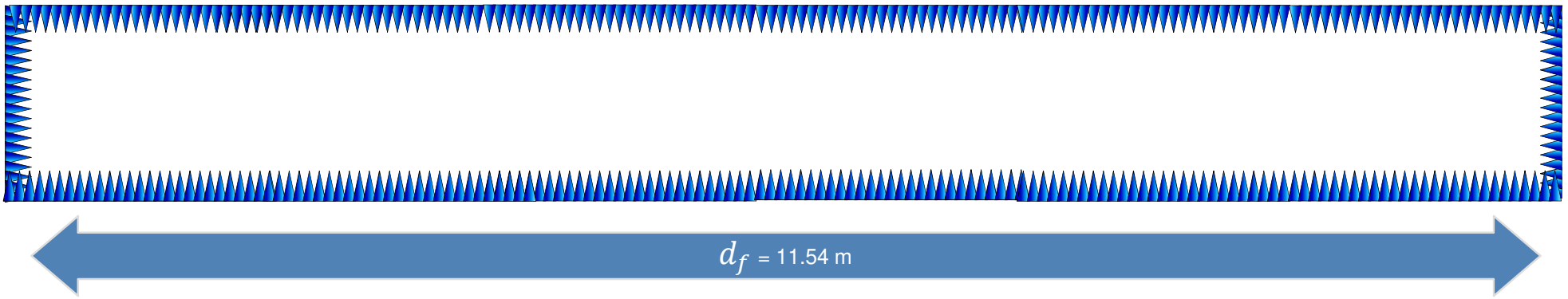
FAR FIELD WITH VARYING RADAR APERTURE SIZE AT 77 GHZ



$$d_f = \frac{2D^2}{\lambda}$$

D = 10 cm
d_f = 5.13 m

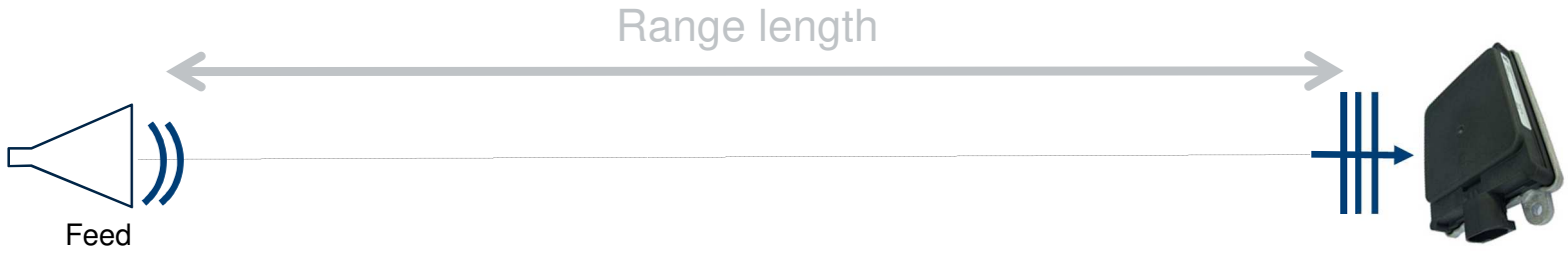
FAR FIELD WITH VARYING RADAR APERTURE SIZE AT 77 GHZ



$$d_f = \frac{2D^2}{\lambda}$$

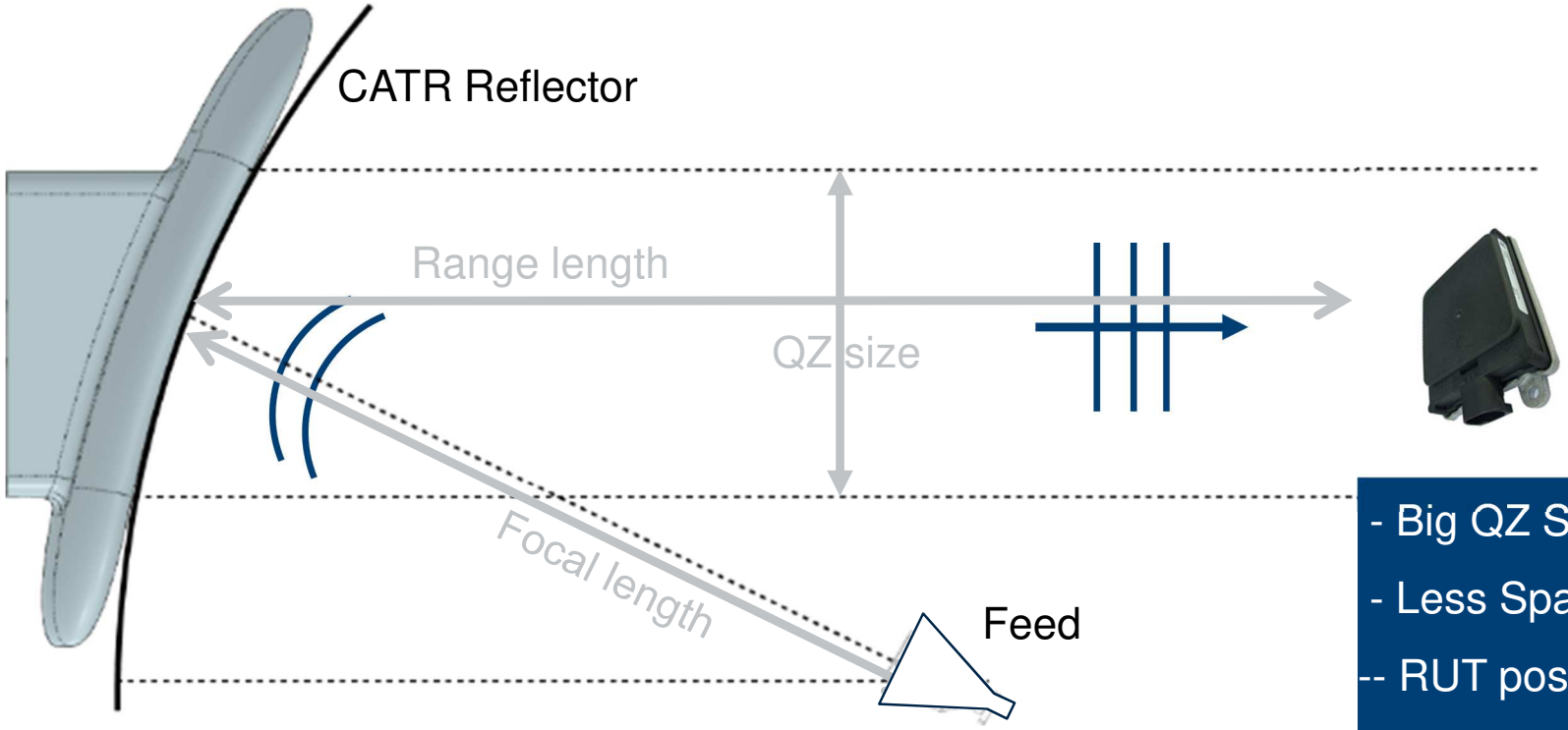
D = 15 cm
d_f = 11.54 m

DIRECT FAR FIELD MEASUREMENTS IN HUGE CHAMBERS



Huge space required	High Path Loss	Relatively Small QZ	Slight misalignment has huge influence on measurements

TESTING IN A COMPACT ANTENNA TEST RANGE (CATR)



- Big QZ Size
- Less Space Required
-- RUT positioning error has minimal effect

DFF VS. CATR APPROACH
RUT MEASUREMENTS WITH AZIMUTH OFFSET POSITIONS

Target Distance = 80.40 m

Angle of Arrival = 0

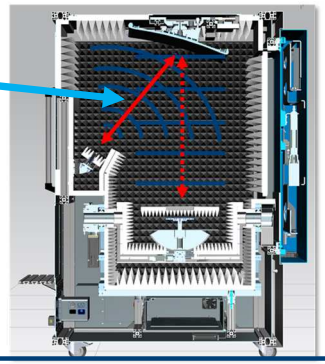
Direct:

Target distance and angle reading from DUT mounted with 15 cm offset

RUT Position	-15 cm	0 cm	15 cm
	80.24 m -8.31°	80.40 m 0.43°	80.53 m 8.71°

Additional 0.8 m air gap

CATR:



	81.20 m -0.42°	81.20 m 0.00°	81.20 m 0.42°

Automotive Radar Test using a CATR chamber

ROHDE & SCHWARZ AUTOMOTIVE RADAR CATR TEST SOLUTION

Automotive

OUR SOLUTION FOR AUTOMOTIVE RADAR SENSOR TESTING R&S®ATS1500C + R&S®AREG800A

CATR Chamber

Radar Echo Generator

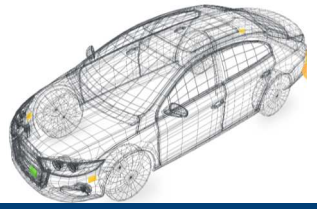
Automotive

R&S®ATS1500C CATR CHAMBER FOR WHO AND FOR WHAT?

Tier 1: Radar Manufacturer

Tier 2: Antenna/Chip Manufacturer

Test House/Regulator



OEM

R&D for devices, modules & antennas

- Angular tests
- Antenna characterization
- Chirp analysis
- Interference testing

Validation

- Sample testing in production
- Radar calibration

Regulatory requirements (in-band)

- ETSI
- FCC
- Etc…

Automotive

AREG800A BASE UNIT TARGET SIMULATOR

- ► Can be connected to 4-8 frontends, depending on the type of frontend.
- ► Can simulate up to 8 individual targets per frontend (32 total)
- ► Range, speed (doppler) and RCS can all be dynamically set and controlled.
- ► Can be used for scenario-based testing (HiL/ViL) when connected to QAT100 frontend
- ► Can be used in R&D, Validation, production and EOL Test

Generation of dynamic objects

Extremely short object distances

High instantaneous bandwidth

Multiple independent objects

Scalable solution

TEST SETUPS USING THE AREG800A

AREG8-81S/81D mm-Wave horn antenna frontends (DFF chamber)

- Comes in two versions: Mono-static and bi-static.
- Boresight point target simulation (up to 8)
- Can be used either in Direct Far Field (DFF) chamber or CATR chamber

CATR chamber- ATS1500C (IFF chamber)

- Compact Antenna Test Range (CATR) chamber.
- Frequency range: 18GHz to 110GHz+
- Can simulate up to 8 targets and accurately measure EIRP

R&S®ATS1500C CATR BASED AUTOMOTIVE RADAR CHAMBER OVERVIEW

Compact and movable

- 2 m x 0.9 m x 1.6 m (H x W x D)

High shielding effectiveness

- > 90 dB typically

Best in class Absorbers

- optimized absorber layout to minimize reflections → no ghost targets

R&S®ATS1500C CATR BASED AUTOMOTIVE RADAR CHAMBER INTERIOR

State-of-the-art CATR Reflector

- Gold Plated
- Ø 30cm quiet zone
- < 1µm RMS surface roughness

High precision 3D tilt-tilt Positioner

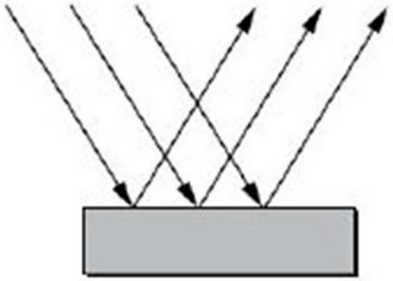
- Azimuth: +/-180º
- 0.03º Angular resolution
- 120º/s Max rotation speed

Elevation: +/- 45º
0.02º Std. Deviation

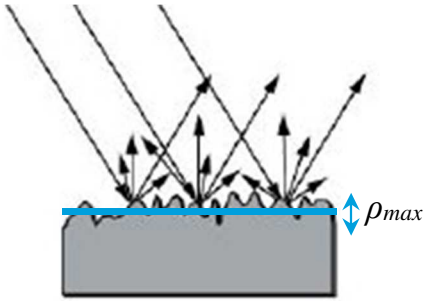
AREG Frontend as Feed Antenna

- Supports 77/79 GHz automotive radars
- Supports 4 GHz bandwidth

SURFACE DEVIATION & EDGE TREATMENTS AFFECT CATR REFLECTOR'S QUALITY



Ideal



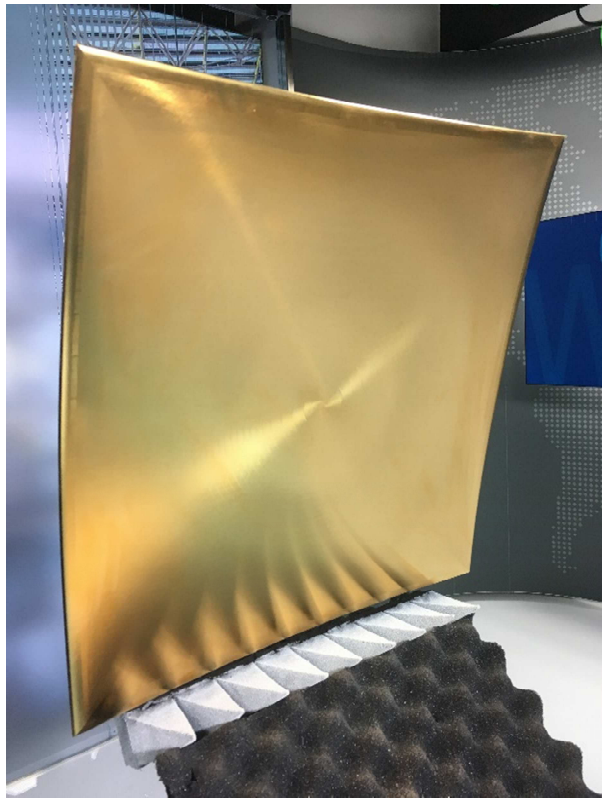
Actual

Maximum Surface Deviation

$\rho_{max} = 0.007\,\lambda$

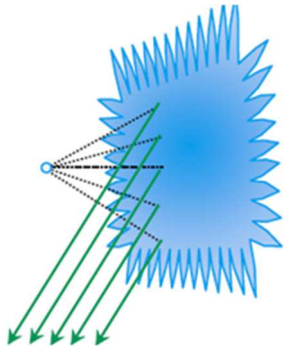
Maximum Frequency	Surface Deviation (µm)
28 GHz	75
43 GHz	**49**
77 GHz (λ = 3.9 mm)	27

W. Burnside "Curved Edge Modification of Compact Range Reflector", IEEE 1987

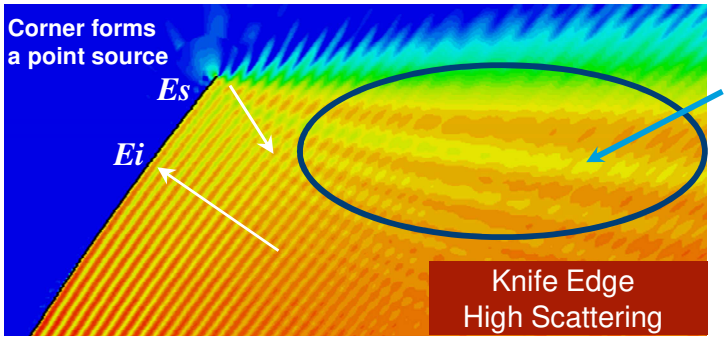


R&S CATR reflector has a surface deviation of 1µm

CATR REFLECTOR ERROR: EDGE TREATMENT

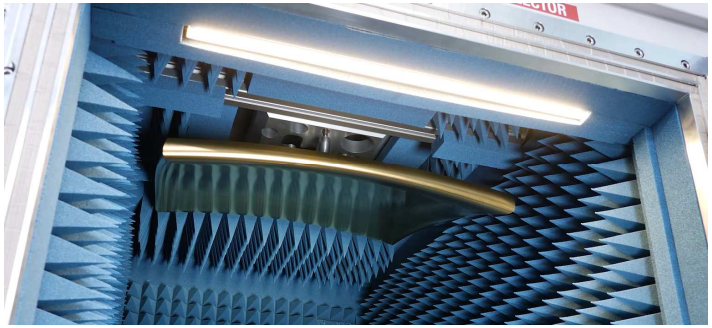


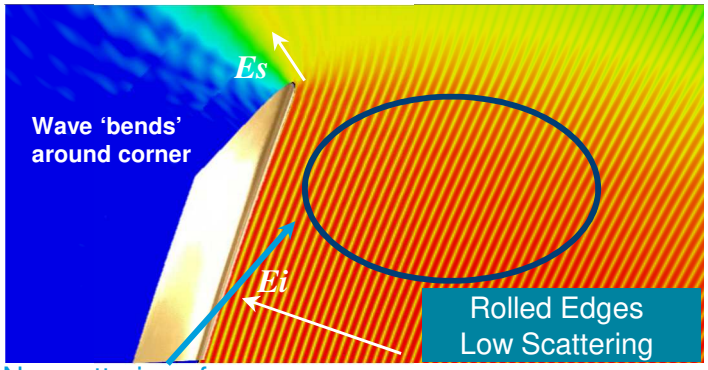
Ei: Initial EM field (from feed horn)



High scattering of energy into quiet zone

Es: Scattered EM field (from edges)

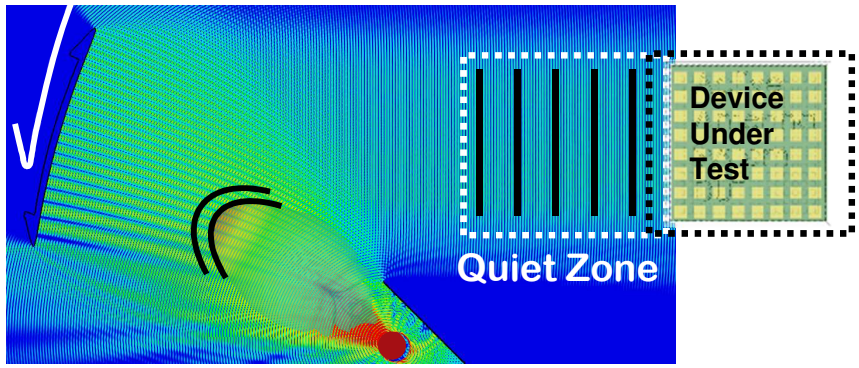




No scattering of energy back into quiet zone

CATR IS A BI-DIRECTIONAL DEVICE CRUCIAL FOR RADAR

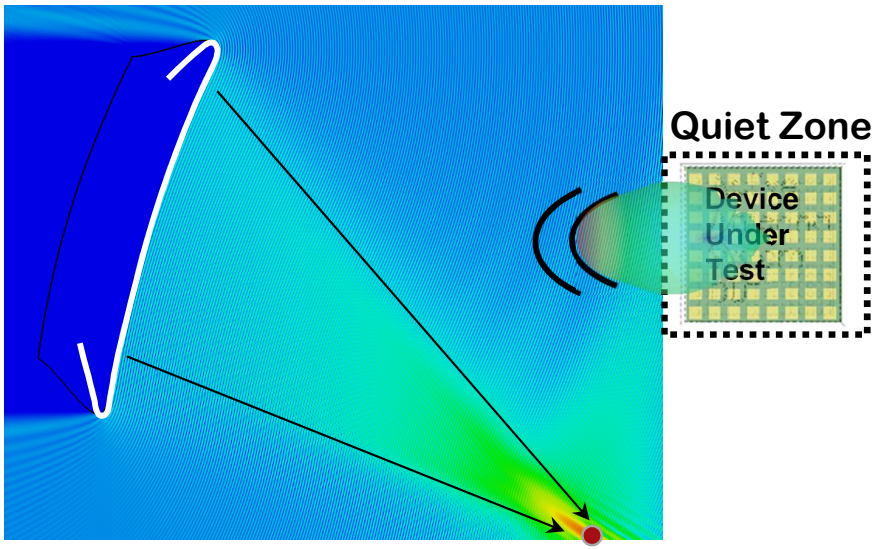
Forward: RUT Receives



From: Reflector Focal Point (Feed)
To: Reflector and DUT Quiet Zone

Reflector transforms spherical field from focal point (feed antenna) into a planar wave in front of reflector to quiet zone

Reverse: RUT Transmits



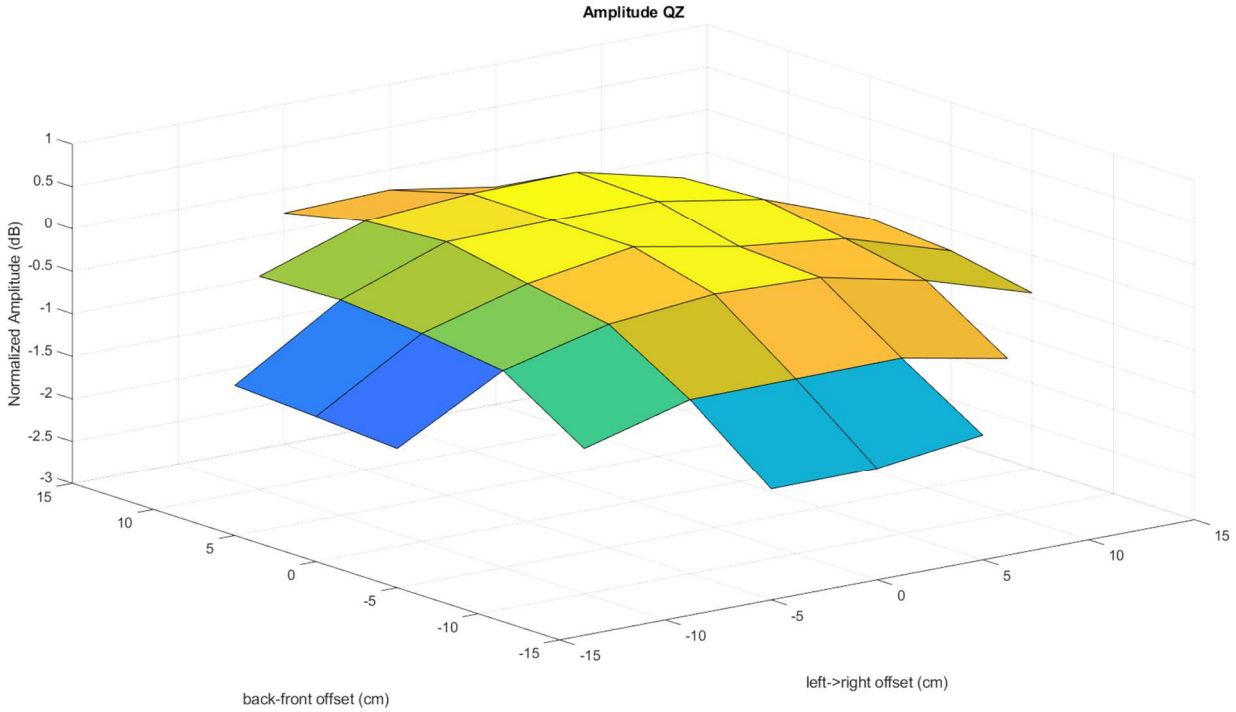
From: DUT Quiet Zone
To: Reflector Focal Point (Feed)

Reflector is a spatial filter that extracts the planar components of the spherical wave from RUT and focuses them at the focal point (feed antenna)

PREMIUM CATR REFLECTOR QUALITY
CONSISTENT PERFORMANCE WITHIN QUIET ZONE

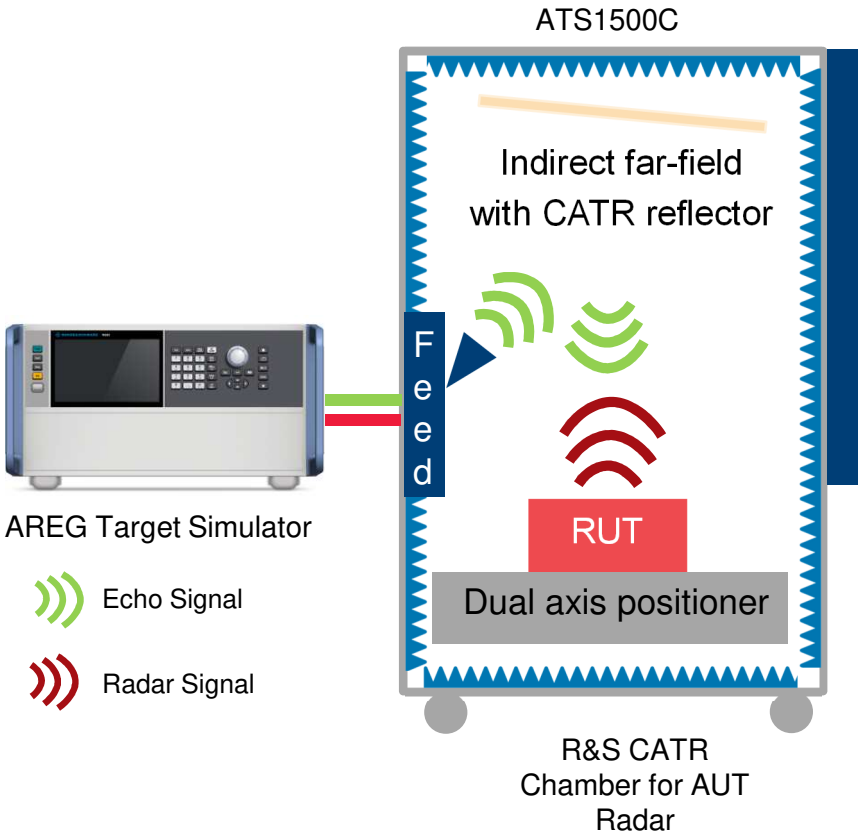
Ø 30 cm Quiet Zone

- Amplitude Taper < 1.5 dB
- Amplitude Ripple < 0.5 dB



R&S® Solutions for Automotive Radar

RADAR COMPLIANCE TESTING USING THE ATS1500C AND AREG800A



ATS1500C CATR BASED AUTOMOTIVE RADAR CHAMBER REAR VIEW AND FEEDTHROUGHS

RF shielded ventilation system

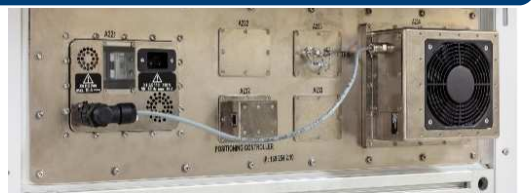
- Maintain internal temperature

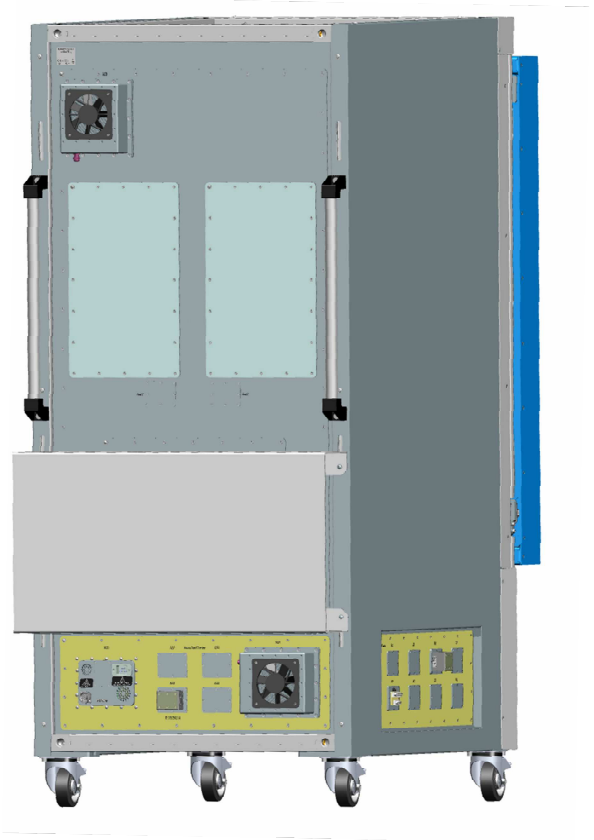
DUT Access Panel

- Ethernet
- DSUB 9 + 25
- USB 2.0 (Option)
- Banana Jacks (Option)

Chamber Access Panel

- Power filter
- Ethernet (to control positioner)
- BNC (Option for triggering)



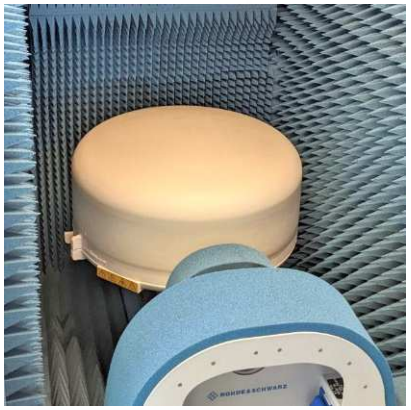


RF FEEDTHROUGHS FOR DUAL POLARIZATION

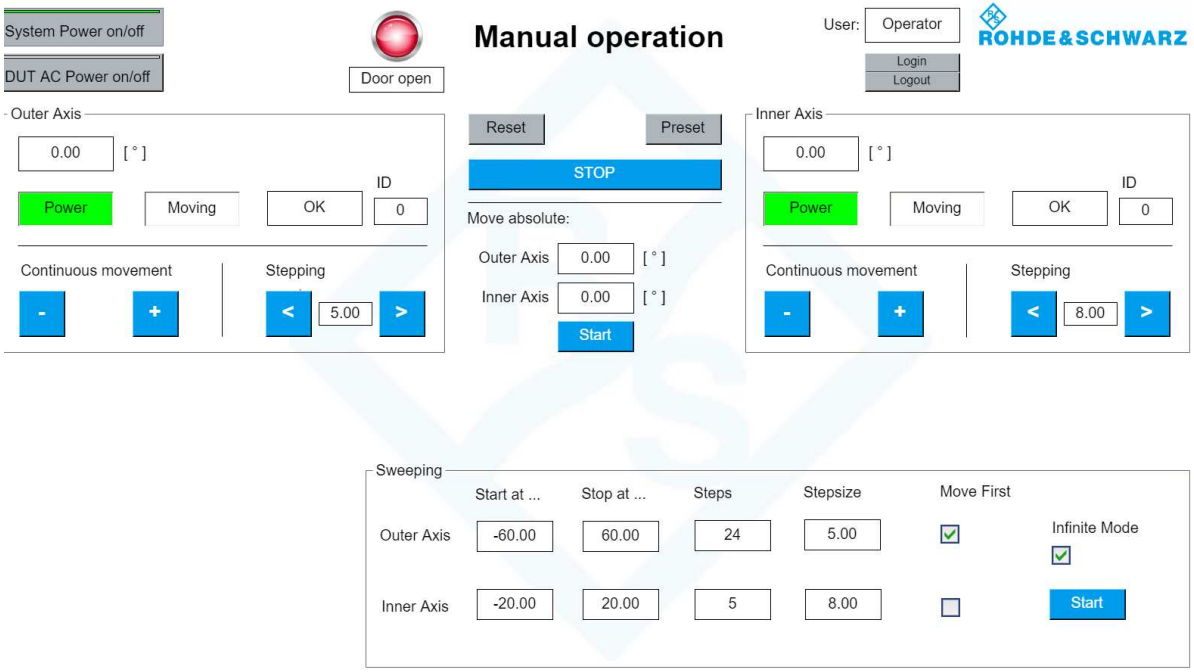
The flexible waveguide (also called as the “snake” waveguide), is used as a waveguide that connects the frontend (up-down converter) to the feed antenna. Because of the tight space behind the feed, this waveguide can be bent and curved in any direction to make connections. In the figure, this waveguide is used to connect to a feed antenna that supports both polarizations (horizontal and vertical)

CLIMATE OPTION ARC-TEMP

- Covering full automotive radar module temperature range -40 to 85°C
- Retrofittable on existing ATS1500C positioner: Rotation restricted to ±90° for outer and ±15° for inner axes with ARC-TEMP installed
- DUT sizes up to Ø 150 x 170 mm and Ø 375 x 135 mm including fixture
- DUT weight up to 4 kg centered including fixture
- Thermal airstream system has to be separately sourced (e.g. MPI ThermalAir TA-5000A)
- ARC-TEMP enables fully automated radar module characterization and significantly reduces test time compared to separate climate cabinet



HOW TO CONTROL POSITIONER?



- Simple Web GUI Interface
- SCPI Like Commands (to be integrated into Python, Matlab, C#, etc…)

AUT Radar testing using CATR chamber

LIVE DEMO

INSTRUMENTS USED FOR DEMO

R&S®ATS1500C CATR chamber

R&S®AREG800A
Automotive Radar Echo Generator (Target Simulator)

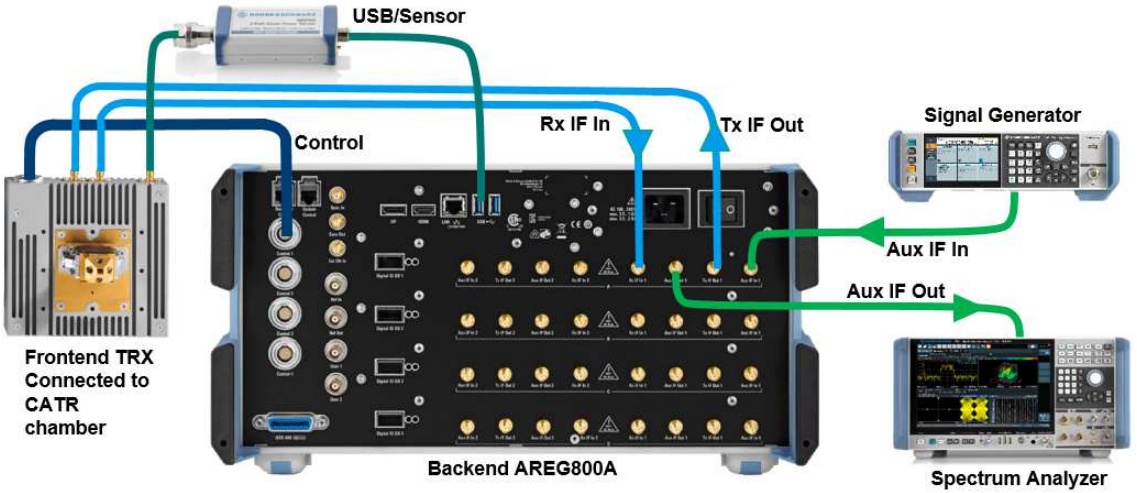
R&S®FSW43 Signal and Spectrum Analyzer

R&S®SMW200A
Vector Signal Generator

R&S®NRP33S(N)
Power Sensors

MEASUREMENT SETUP-RADAR COMPLIANCE TESTING USING THE ATS1500C AND AREG800A

- Frontend TRX is an up-down converter, and down-converts the 76-81GHz Radar frequency to <6GHz IF frequency for easy signal analysis. Hence, you do not need a high frequency Spectrum analyzer or signal generator for additional testing.



TESTS COVERED IN DEMO

The following tests are covered in the demo:

1. General target simulation using the CATR chamber and AREG800A target simulator
2. FOV (Field-of-View) test
3. EIRP and power level readings using the R&S NRP power meter
4. Interference Testing using the R&S SMW200A as the Vector Signal Generator
5. Signal and spectrum analysis using the R&S FSW Spectrum Analyzer

CHANGE IN DUT FOR TRANSIENT ANALYSIS

1. The Uhnder sensor used for target simulation and EIRP measurements has a different modulation scheme. Hence, transient analysis on the Spectrum Analyzer cannot be effectively performed unless it’s a chirp-based radar.
2. For Chirp-based transient analysis, we are changing the DUT to an NXP-RF Beam radar which operate in the 76GHz to 77GHz and is chirp based.

AUT Radar testing using CATR chamber

CONCLUSIONS

CONCLUSION

- **In a nutshell: testing high end radar sensors demands challenging testing requirements that are difficult to fulfill in conventional chambers. CATR chamber is a perfect future-proof methodology to test these requirements.**

This webinar has shown you:

- An introduction to CATR chamber.
- The advantages of CATR over a standard DFF chamber, and test chamber requirements to produce repeatable, accurate and precise measurement results
- Extensive and compact test solution not only for R&D, but also for high speed radar verification, calibration, and validation.

FURTHER INFORMATION
R&S WEBINARS / R&S NEWSLETTER / WEBSITES

- For more information, visit: www.rohde-schwarz.com/automotive-radar

- Free **WEBINAR** and **Video-Series** on various Automotive technologies.
  Test solutions for:
  - Radar FoV testing without moving the sensor
  - Scenario-based test like Hardware-in-the-loop (HiL)
  - Vehicle-in-the-loop (ViL)
  - Radome and Bumper testing

- Stay tuned and up-to-date with our monthly automotive **NEWSLETTER**

AUT Radar Testing using a CATR chamber

Q&A

COMPANY RESTRICTED

Find out more

www.rohde-schwarz.com/automotive-radar

THANK YOU FOR ATTENDING

ROHDE&SCHWARZ

Make ideas real