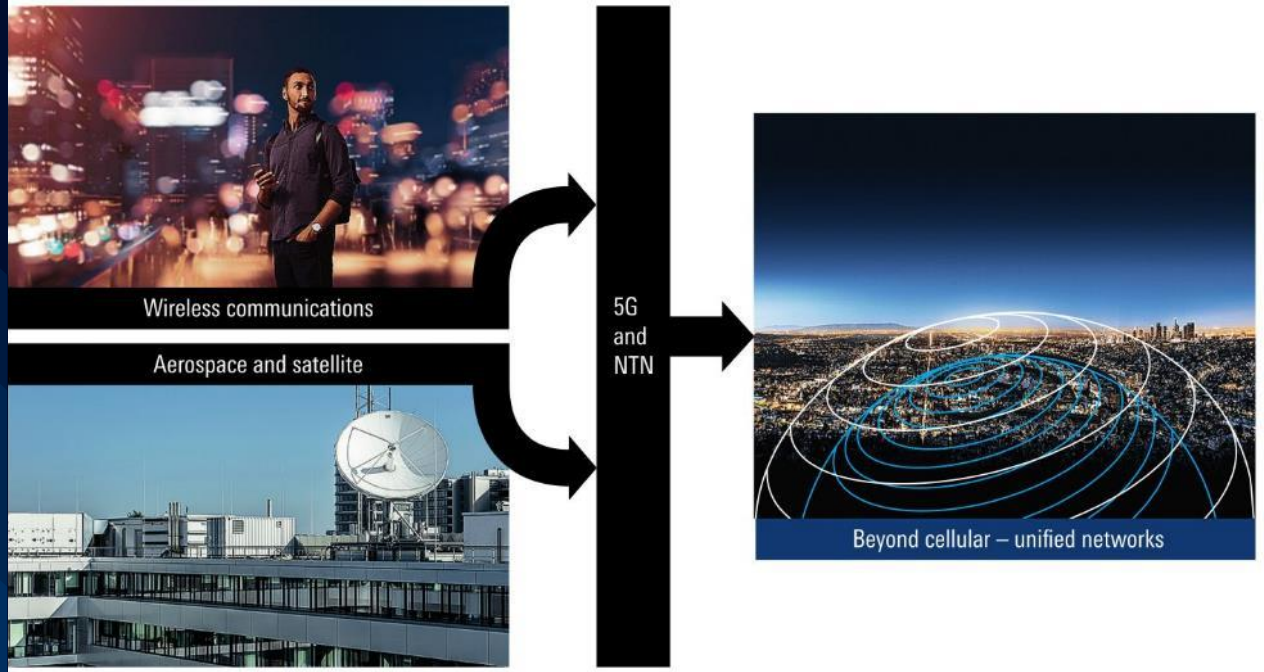
ENABLING ANTENNA TERMINAL TESTING FOR NEW SPACE

Günter Pfeifer
Rohde & Schwarz

ROHDE&SCHWARZ
Make ideas real

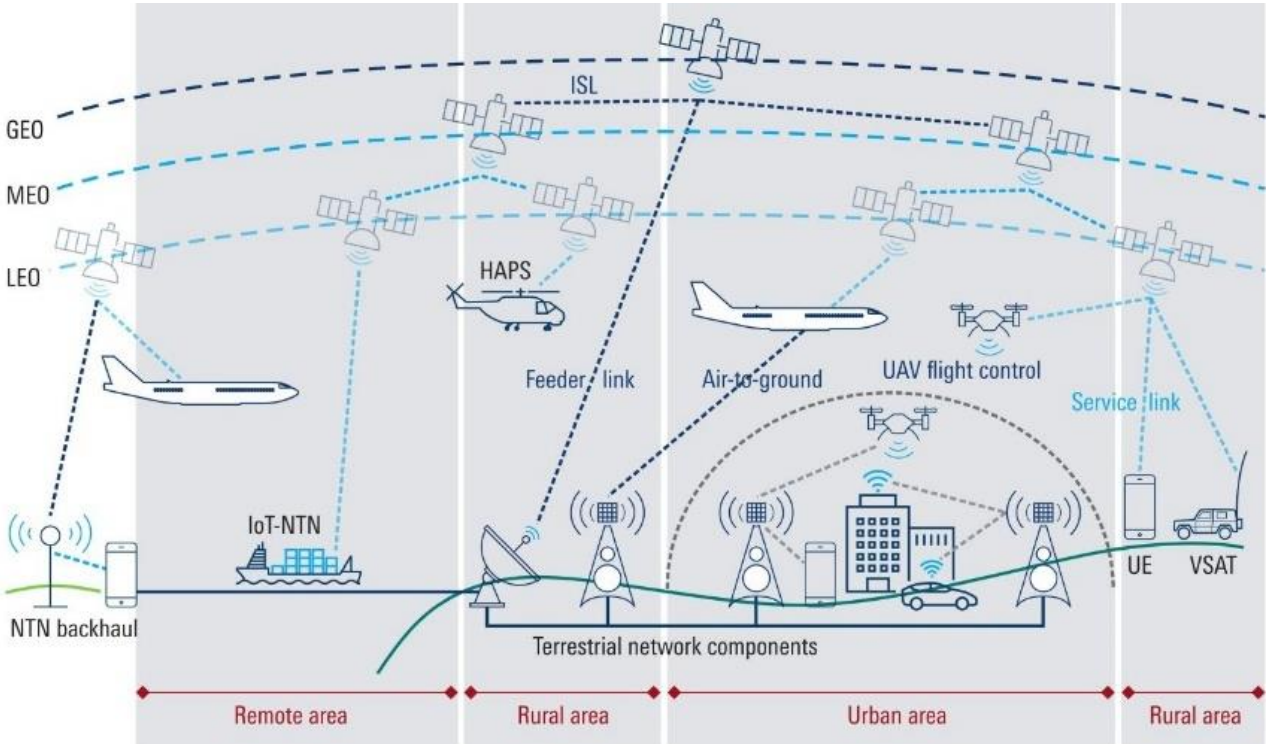
NEW SPACE NTN –

CONVERGENCE BETWEEN AEROSPACE AND WIRELESS ECOSYSTEMS



NTN

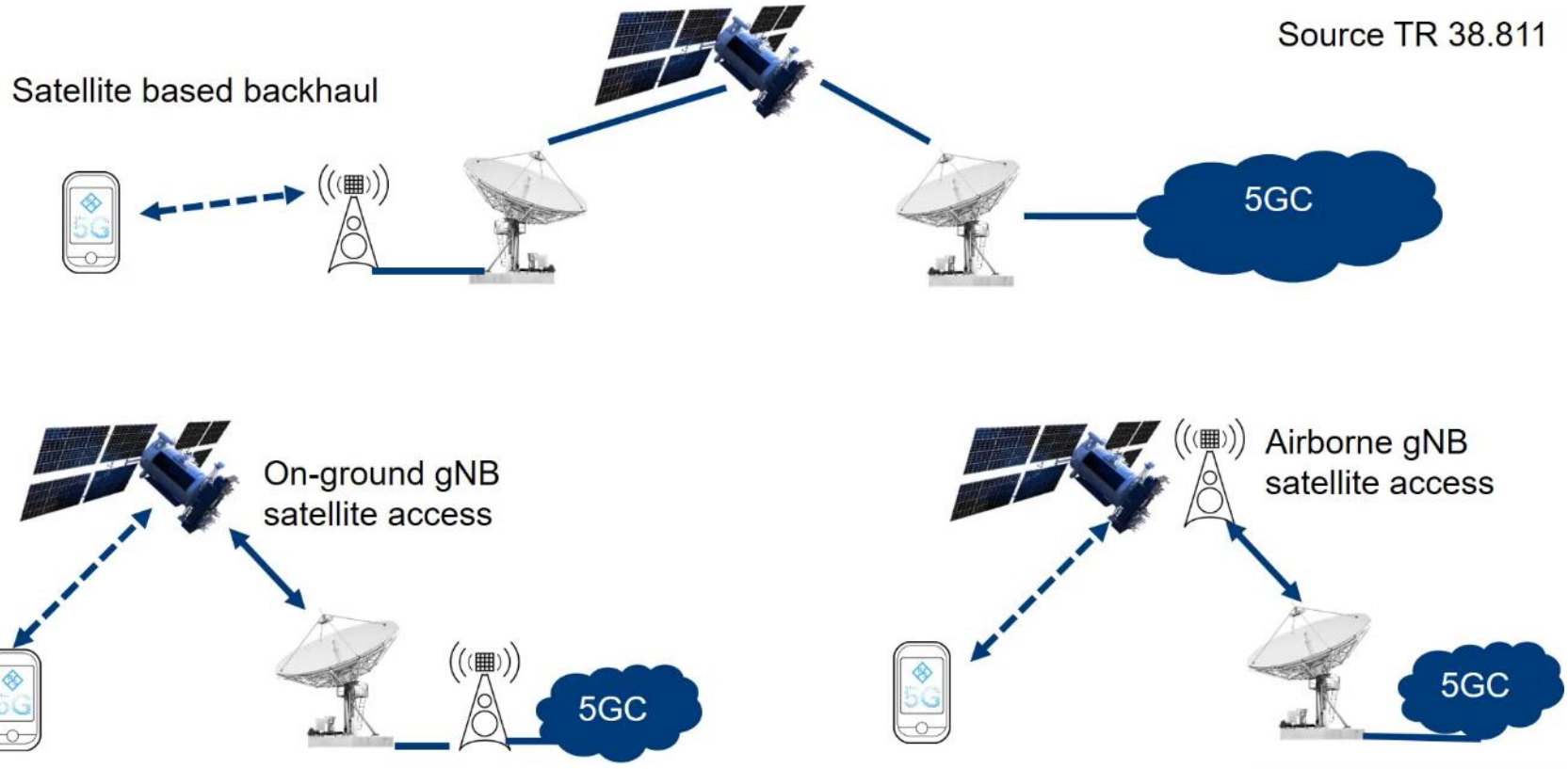
- **N**on **T**errestrial communication **N**etworks (voice, internet,…)
- Multiple different use cases
- Multiple different scenarios
- Multiple different terminals



NTN USE CASES

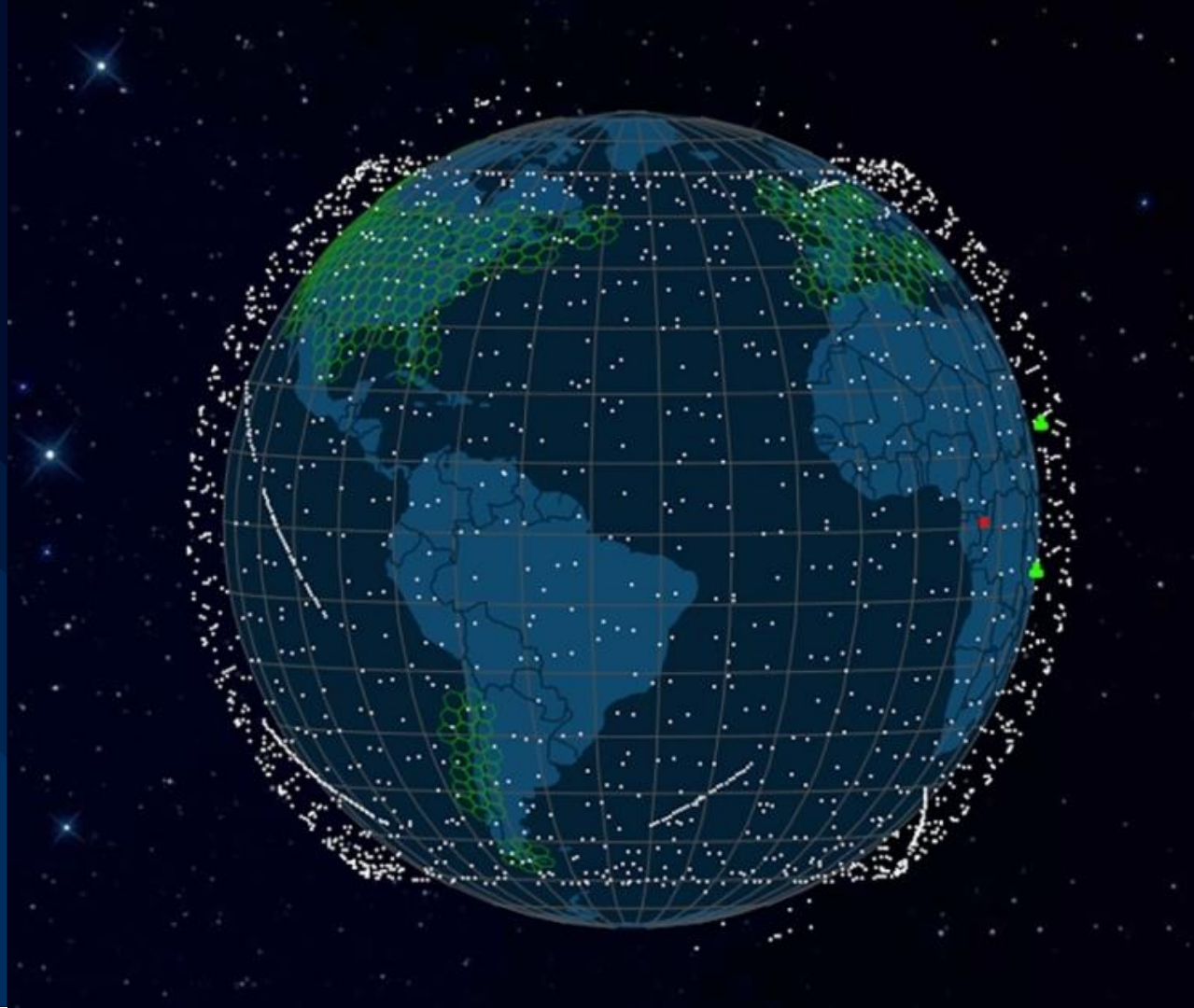
- NR-NTN
  - Remote area coverage
  - Public safety and disaster recovery
  - Temporary hotspot coverage
- IoT-NTN
  - Smart farming billabong water level
  - Animal tracking Project ICARUS
  - Container tracking off shore

NTN SCENARIOS



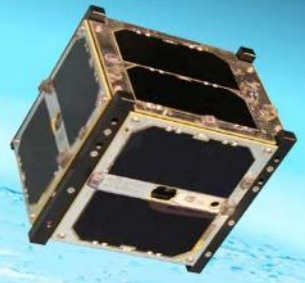
SATELLITES

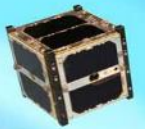
- Mega constellations
  - 300 Satellites (Lightspeed Canada)
  - 3.000 Satellites (Kuiper US)
  - 30.000 Satellites (Starlink US)

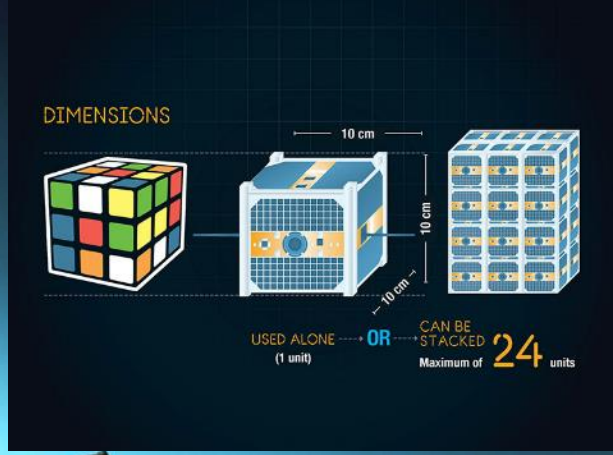


CUBE SATS


IPEX
PolySat






DIMENSIONS
10 cm
10 cm
10 cm
USED ALONE
(1 unit)
OR
CAN BE STACKED
Maximum of 24 units


HOW HEAVY
IS A SATELLITE?
LARGE SATELLITE
RADARSAT-2
>1000 kg
RHINO
MEDIUM SATELLITE
CASSIOPE
500-1000 kg
BUFFALO
MINI SATELLITE
SCISAT
100-350 kg
LION
MICRO SATELLITE
MONITet
10-100 kg
WOLF
NANO SATELLITE
including CUBESAT
Ex-Alta 1
1-10 kg
1 kg per unit
RACCOON
DUCK
Canada

VSAT (VERY SMALL APERTURE TERMINALS) APPLICATIONS

- Boats
- Busses
- RVs
- …

NTN PROPOSED FREQUENCY BANDS

	Region 1	Region 2	Region 3
Downlink (space to earth)	17.3 GHz to 20.2 GHz	17.7 GHz to 20.2 GHz	17.7 GHz to 20.2 GHz
Uplink (earth to space)	27.5 GHz to 30.0 GHz	27.0 GHz to 30.0 GHz	27.0 GHz to 30.0 GHz

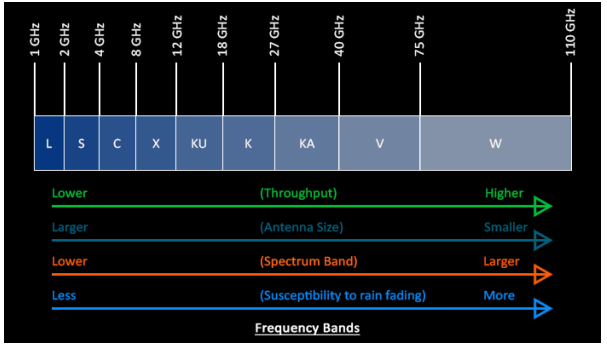
Ka-band: GEO

~17 GHZ … 30 GHz

K-/Ka-Band

	Region 1	Region 2	Region 3
Downlink (space to earth)	17.3 GHz to 20.2 GHz	17.7 GHz to 20.2 GHz	17.7 GHz to 20.2 GHz
Uplink (earth to space)	27.5 GHz to 29.1 GHz and 29.5 GHz to 30.0 GHz	27.5 to 29.1 GHz and 29.5 to 30.0 GHz	27.5 GHz to 29.1 GHz and 29.5 GHz to 30.0 GHz

Ka-band: non-GEO



	Region 1	Region 2	Region 3
Downlink (space to earth)	2170 MHz to 2200 MHz	2160 to 2200 MHz	2170 to 2200 MHz
Uplink (earth to space)	1980 MHz to 2010 MHz	1980 to 2025 MHz	1980 to 2010 MHz

S-band: GEO and non-GEO

~1.9 GHZ … 2.2 GHz

L-/S-Band

	Region 1	Region 2	Region 3
Downlink (space to earth)	2110 MHz to 2170 MHz	2110 to 2160 MHz	2110 to 2170 MHz
Uplink (earth to space)	1885 MHz to 1980 MHz and 2010 MHz to 2025 MHz	1885 to 1980 MHz	1885 to 1980 MHz and 2010 to 2025 MHz

S-band: HAPS

3GPP Proposed frequency bands for HAPS, GEO, non-GEO NTN for ITU regions 1, 2 and 3

NTN – SPECTRUM IN 5G FR1 AND FR2

	Band #	Uplink	Downlink	Duplex
First 3GPP NTN FR1 bands for L-Band and S-Band (IoT)	n255	1626.5 – 1660.5 MHz	1525 – 1559 MHz	FDD
	n256	1980.0 – 2010.0 MHz	2170 – 2200 MHz	FDD
Existing 3GPP FR2-1 Bands	n257	26.50 – 29.50 GHz	26.50 – 29.50 GHz	TDD
	n258	24.25 – 27.50 GHz	24.25 – 27.50 GHz	TDD
	n259	39.50 – 43.50 GHz	39.50 – 43.50 GHz	TDD
	n260	37.00 – 40.00 GHz	37.00 – 40.00 GHz	TDD
	n261	27.50 – 28.35 GHz	27.50 – 28.35 GHz	TDD
	n262	47.20 – 48.20 GHz	47.20 – 48.20 GHz	TDD
Proposed 3GPP NTN FR2-0/FR2-1 bands * for K-Band and Ka-Band (VSAT)	n510	17.70 – 20.2 GHz	27.50 – 28.35 GHz	FDD
	n511	17.70 – 20.2 GHz	28.35 – 30.00 GHz	FDD
	n512	17.70 – 20.2 GHz	27.50 – 30.00 GHz	FDD

From RAN4 #105 Nov.22 proposals
R4-2219076, R4-2220239

VSAT EXAMPLES

- K- / Ka-Band
- f= ~ 17 GHZ … 30 GHz
- λ= ~ 2cm …1cm
- Size= ~50…100 λ = ~1m ⌀
- Weight= few kg
- Typically tested radiated (OTA)

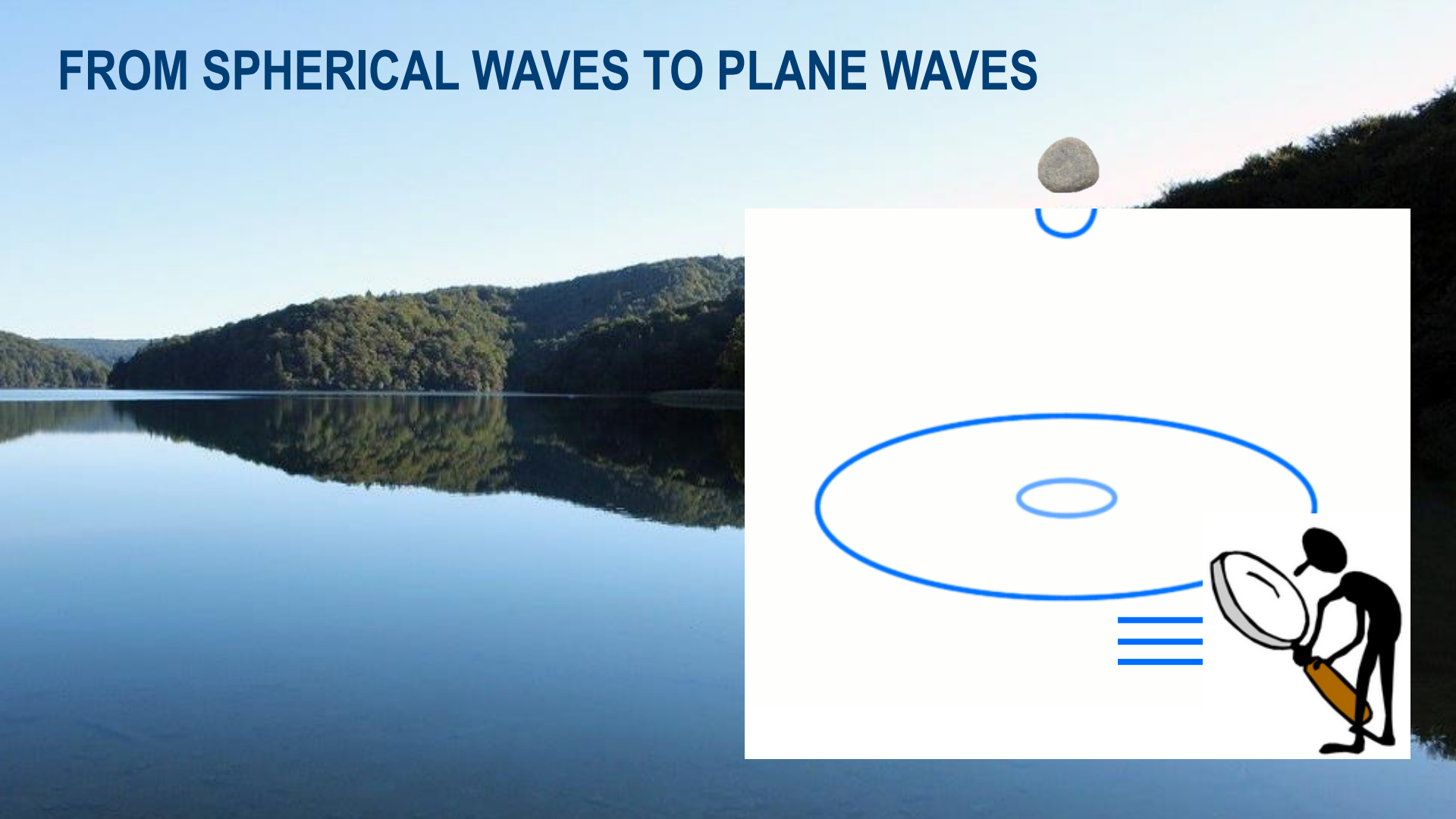
RF RADIATION PROPERTIES

- An antenna radiates spherical waves
- For testing we like plane waves

How to get from this to that?

- Why?
  Because it makes our life way more easy

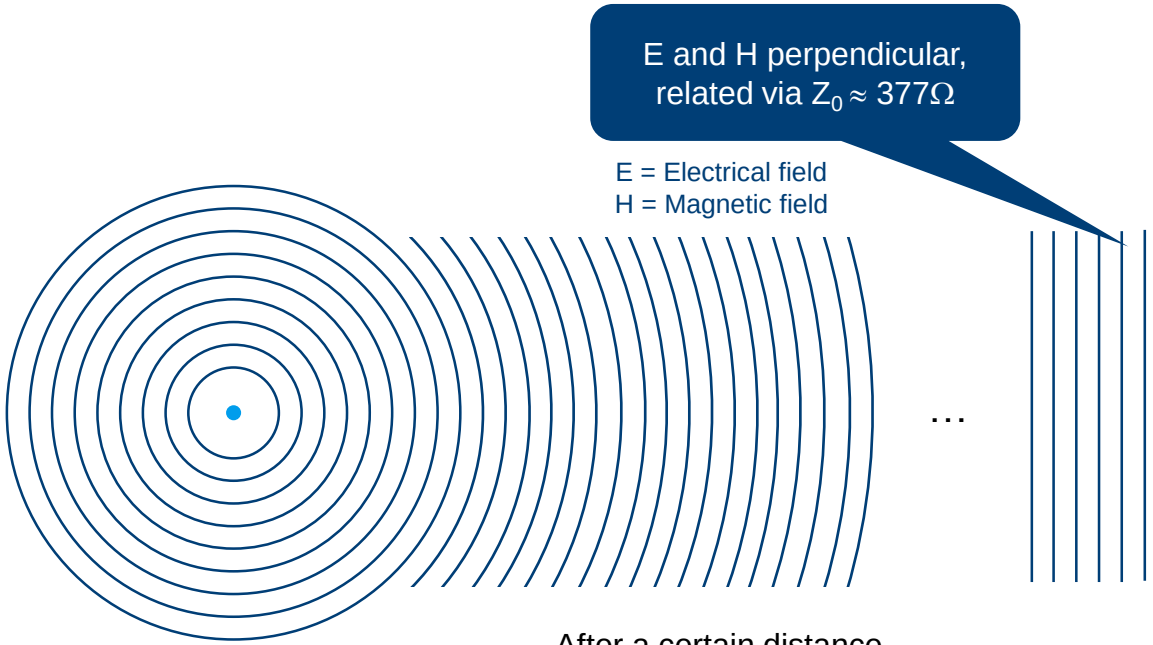
FROM SPHERICAL WAVES TO PLANE WAVES



WAVE PROPAGATION

Imagine that the origin of a waves is a single tiny point.

- Close to the source the front appears to be curved



- After a certain distance the front appears almost plane. This region is what we call Far Field Distance is the Fraunhofer distance $\frac{2D^2}{\lambda}$

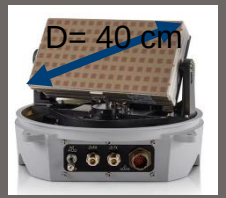
DISTANCE REDUCTION REQUIRES KNOWLEDGE OF ANTENNA LOCATION AND SUB-ARRAY TESTING

Quiet zone size (white box)

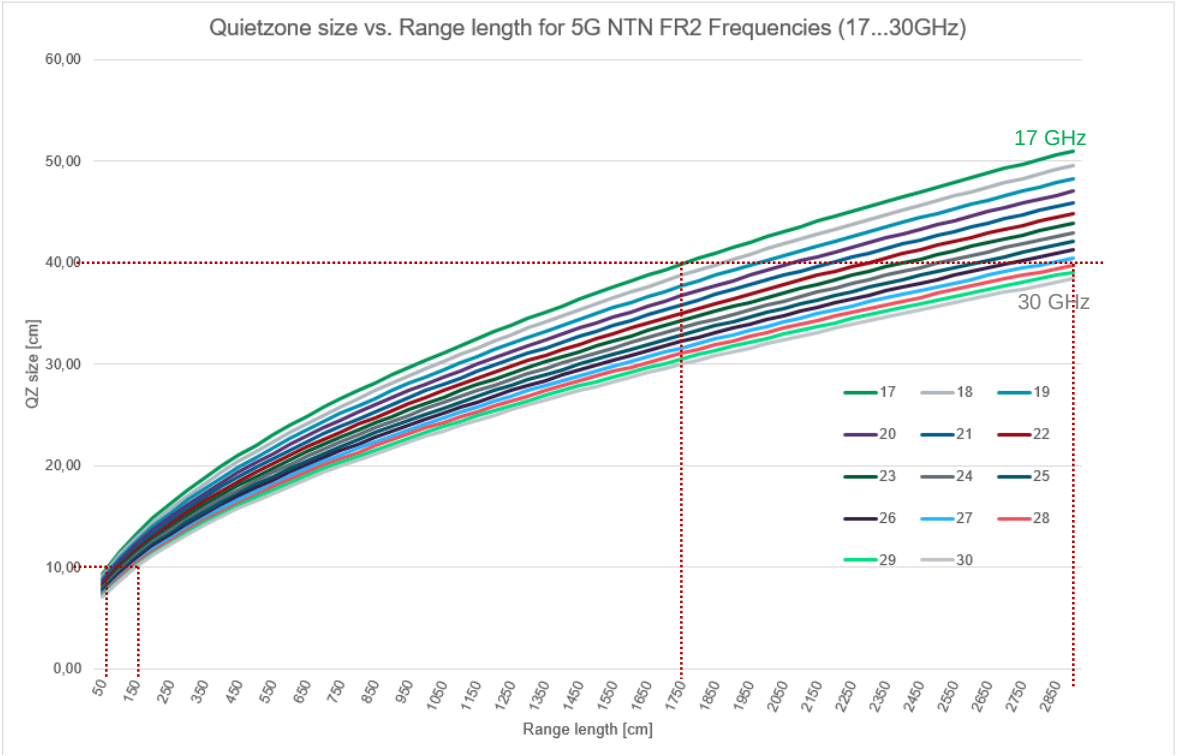
D=10 cm

Chamber size < 2 m

Quiet zone size (black box)

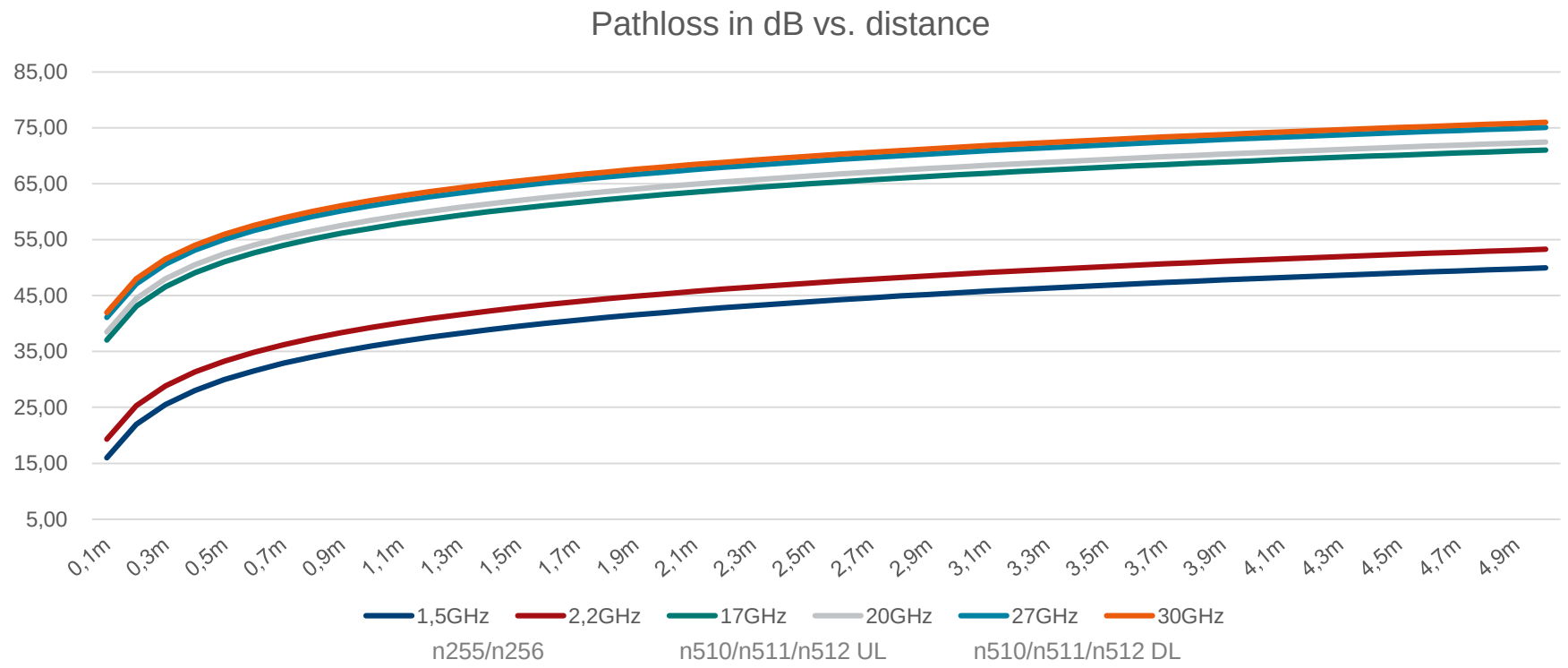


Chamber size ~ 20 m…30 m

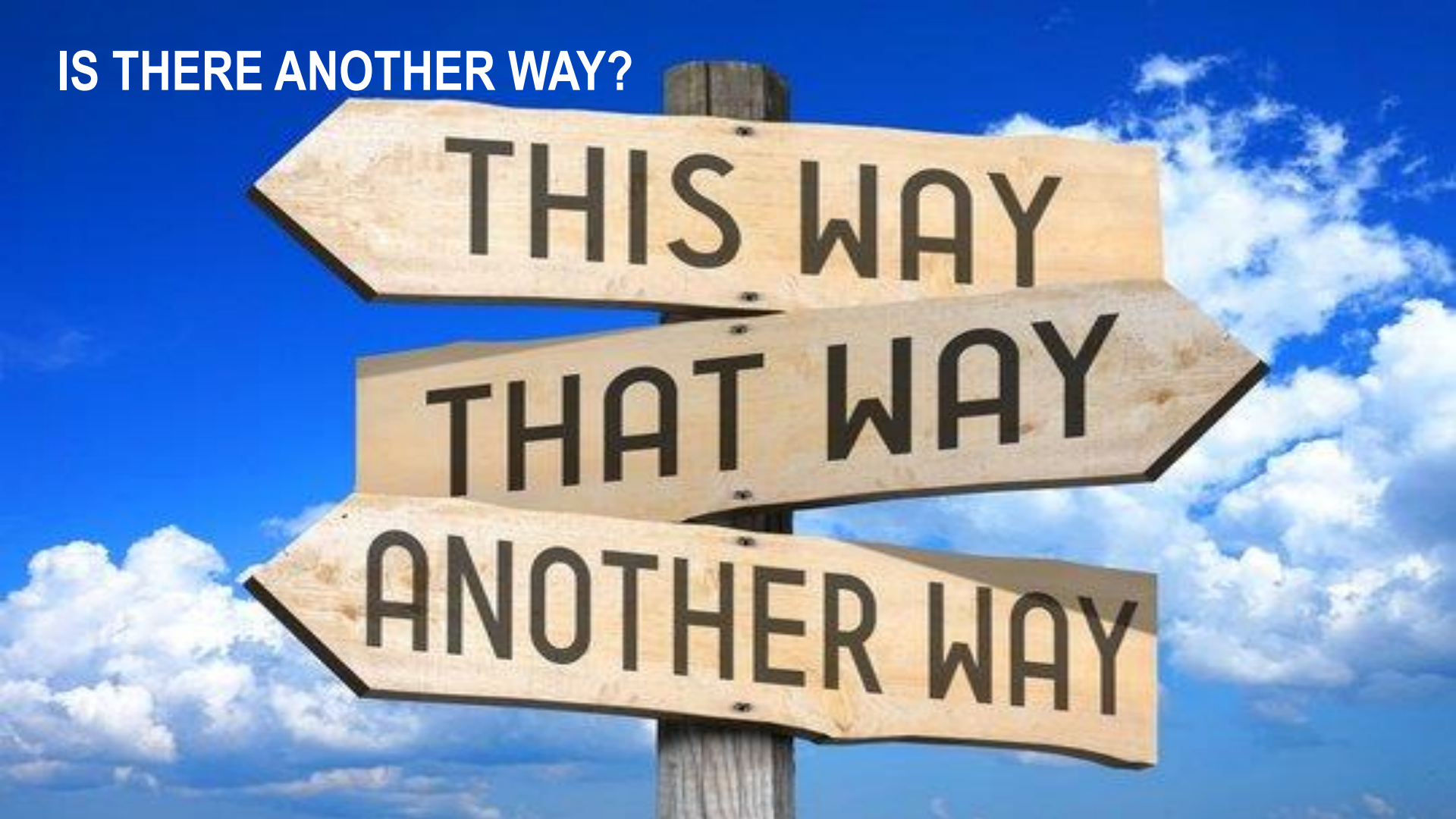


DISTANCE MEANS PATHLOSS

$$\mathrm{FSPL} = 20\log_{10}(d) + 20\log_{10}(f) + 20\log_{10}\left(\frac{4\pi}{c}\right)$$

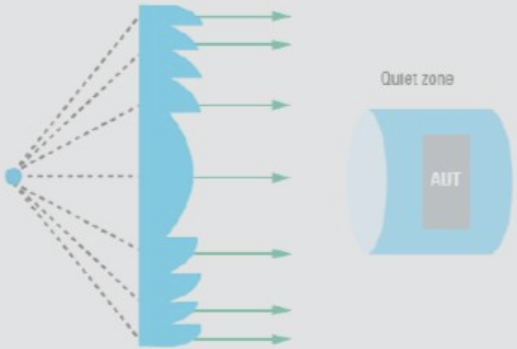


IS THERE ANOTHER WAY?

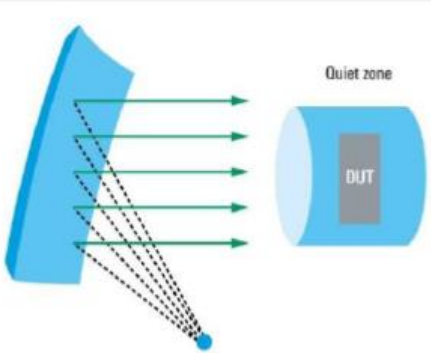


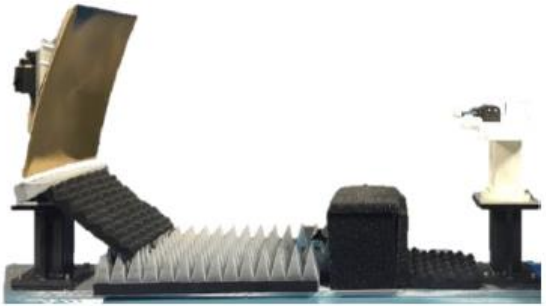
YES THERE IS – INDIRECT FAR FIELD

Fresnel lens (Fourier optics)

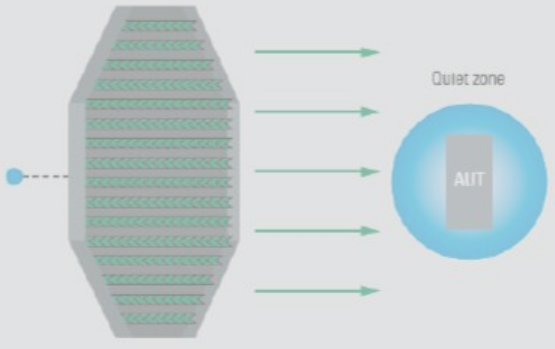


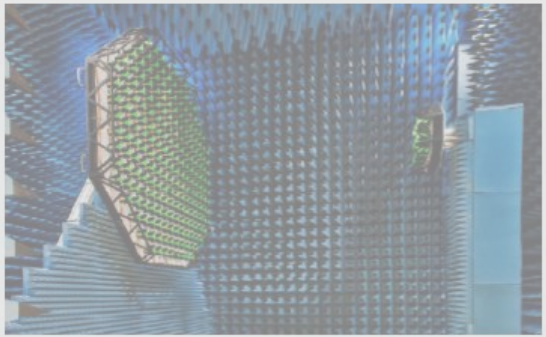
Reflector: compact antenna test range (CATR)



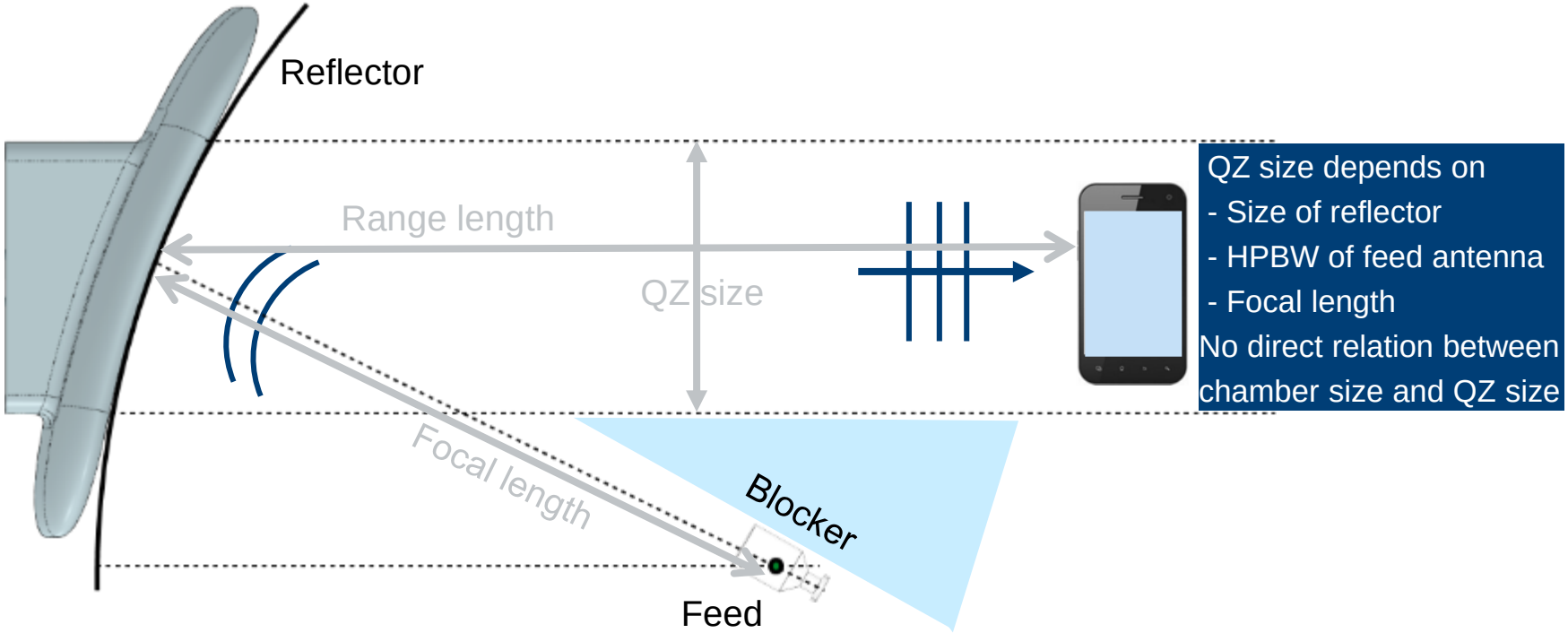


Plane wave converter (PWC)

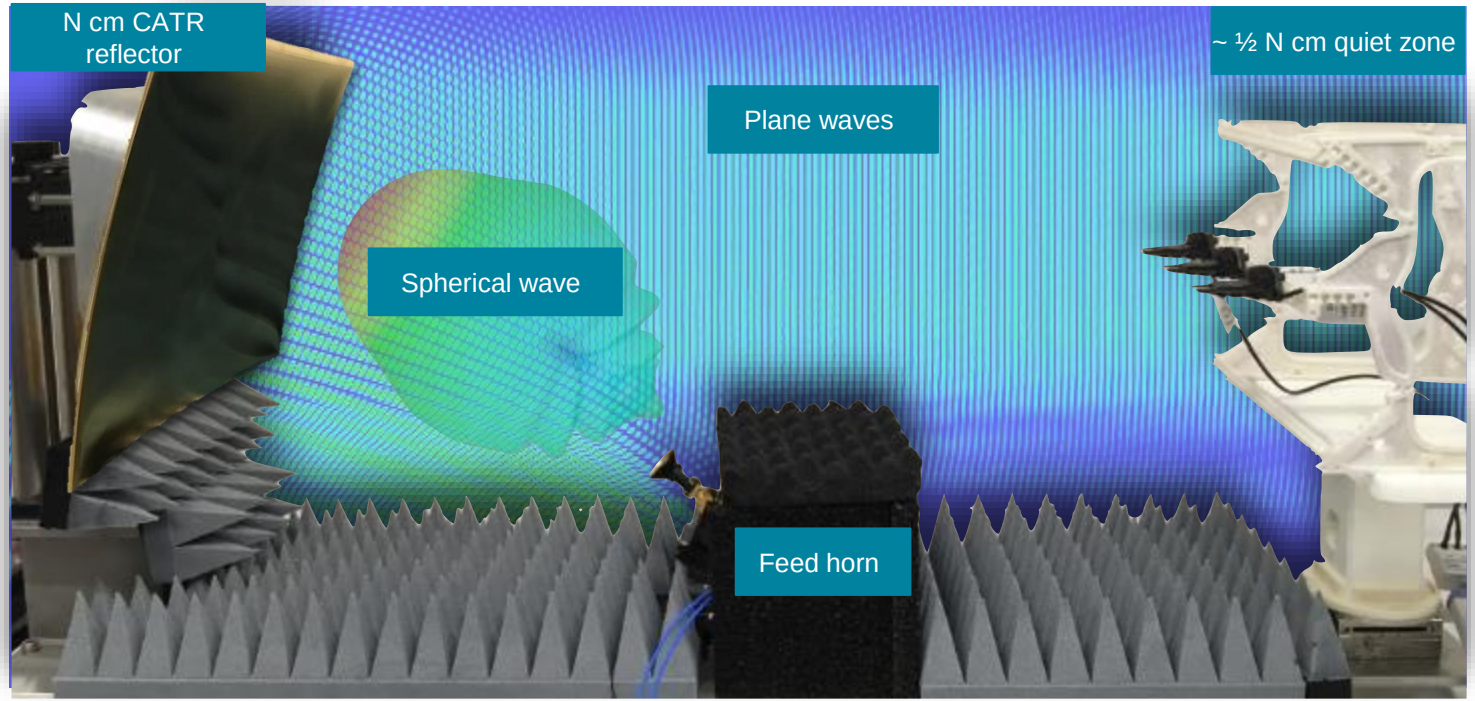




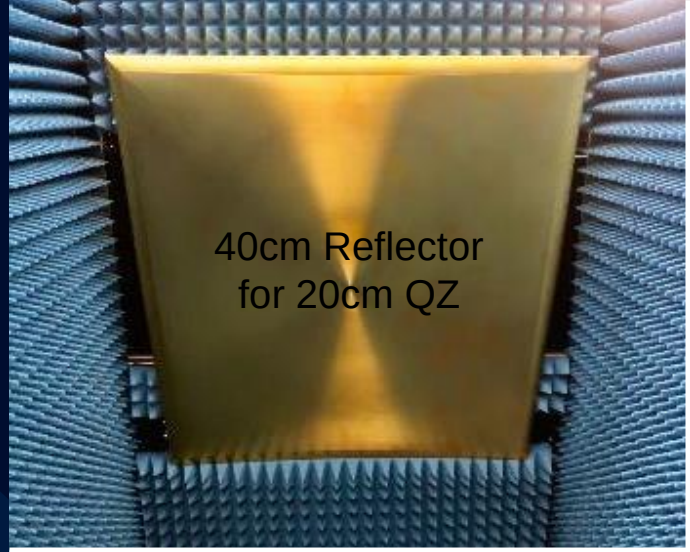
CATR – COMPACT ANTENNA TEST RANGE

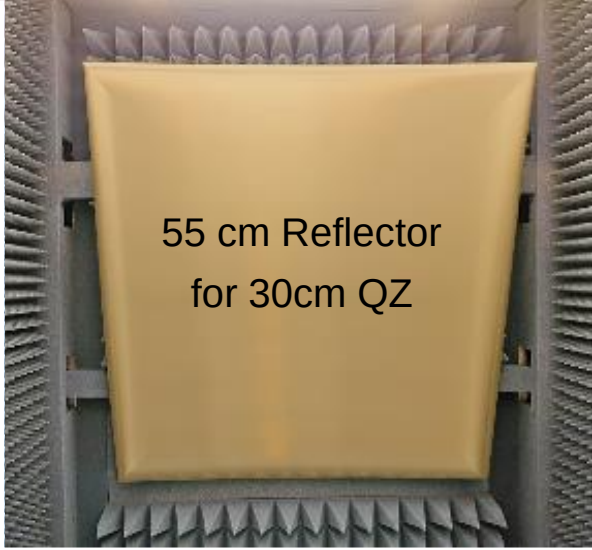


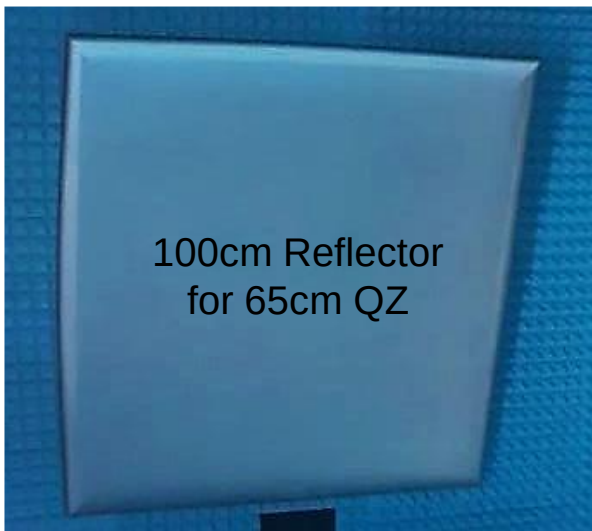
CATR – COMPACT ANTENNA TEST RANGE



QZ SIZE DEPENDS ON REFLECTOR SIZE







OTA Test Solution

R&S FR2 OTA IFF CATR SOLUTIONS OVERVIEW

	ATS800B	ATS800R	ATS1800C	ATS1800M	ATS1800XL (under development)
					
Dim. (WxHxD)	1.2 x 0.8 x 0.6	0.6 x 2.0 x 1.2	0.9 x 2.0 x 1.5	~3.5 x 2.0 x 1.5	~ 5 x 2.2 x 2.2
Max. DUT size	Ø xx cm	Ø 36cm (Posi.)	Ø 52cm	Ø 52cm	85 x 85 x 40cm
Max. DUT weight	2.5 Kg	2.5 kg (Posi.)	20 kg	20 kg	50 kg
Type	Black box CATR	Black box CATR	Black box CATR	Black box CATR	Black box CATR
Freq. Range	20 - 50 GHz	20 - 50 GHz	(6) 23 - 90 GHz	(6) 23 - 90 GHz	(6) ~15 - 90 GHz
Supported freq. Range	Full range	Full range	Full range (feed switcher)	Full range (multiple feeds)	Full range (feed switcher)
Quiet zone	Ø 20 cm	Ø 20 cm	Ø 30 /40 cm	4x Ø 30 cm	Ø 65 cm
Positioner	2D positioner (opt.)	3D Az over El (opt.)	3D Az over El	3D Az over El	3D GCC
Shielding Eff.	N/A	>60dB	>90 dB	>70dB	>70dB
Extreme Temp.	N/A	1D	3D	3D	3D

THANK YOU!
QUESTIONS?