Mobile Radio Testers – Application Test

5G IP THROUGHPUT & 5G VOICE OVER NR (VONR) – DEPLOYMENT, TECHNOLOGY AND TESTING ASPECTS

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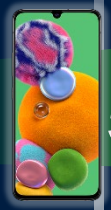
ROHDE&SCHWARZ
Make ideas real

AGENDA

- The cellular evolution
- Mobile Device Application Test
- Use case 1:
  - PERFORMANCE TEST: 5G THROUGHPUT TESTING
  - Theory and demo #1
- Use case 2:
  - FUNCTIONAL & PERFORMANCE TEST: 5G AUDIO SPEECH TESTING
  - Theory and demo #2
- Summary

THE CELLULAR EVOLUTION

All IP Networks



5G Voice, IM, Audio, Video, Social Media, Apps , AI/ VR eMBB, mMTC, URLLC …

4G Voice, IM, Audio, Video, Social Media, Apps , .

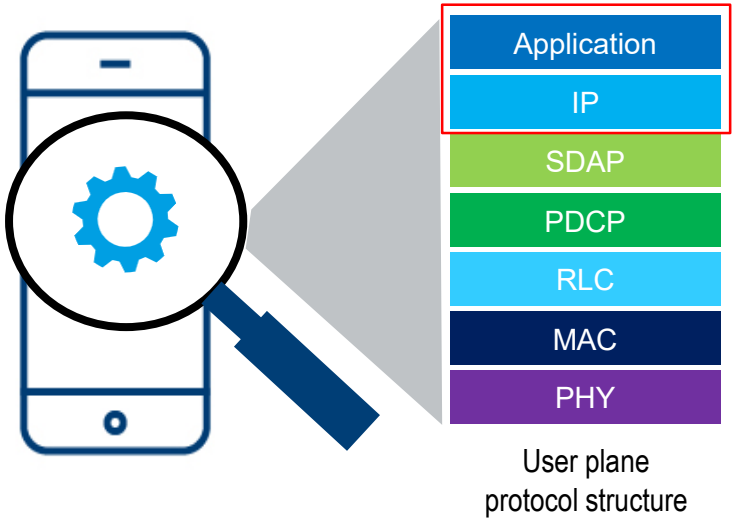
3G Voice, SMS, Web

2G Voice,SMS

1G Voice

1990 2000 2010 2020 2030

MOBILE DEVICE APPLICATION TEST



User plane
protocol structure

Application testing describes a process in which an application is tested for its functionality, usability and consistency.

- There are several types of tests that can be performed on a mobile device
  - ❑ Functional test
  - ❑ Performance test
  - ❑ Usability tests
  - ❑ Security tests
  - ❑ Certification tests

PHY – Physical Layer
MAC – Medium Access Control
RLC – Radio Link Control
PDCP – Packet Data Convergence Protocol
SDAP – Service Data Adaptation Protocol
IP – Internet Protocol
Application – User Application

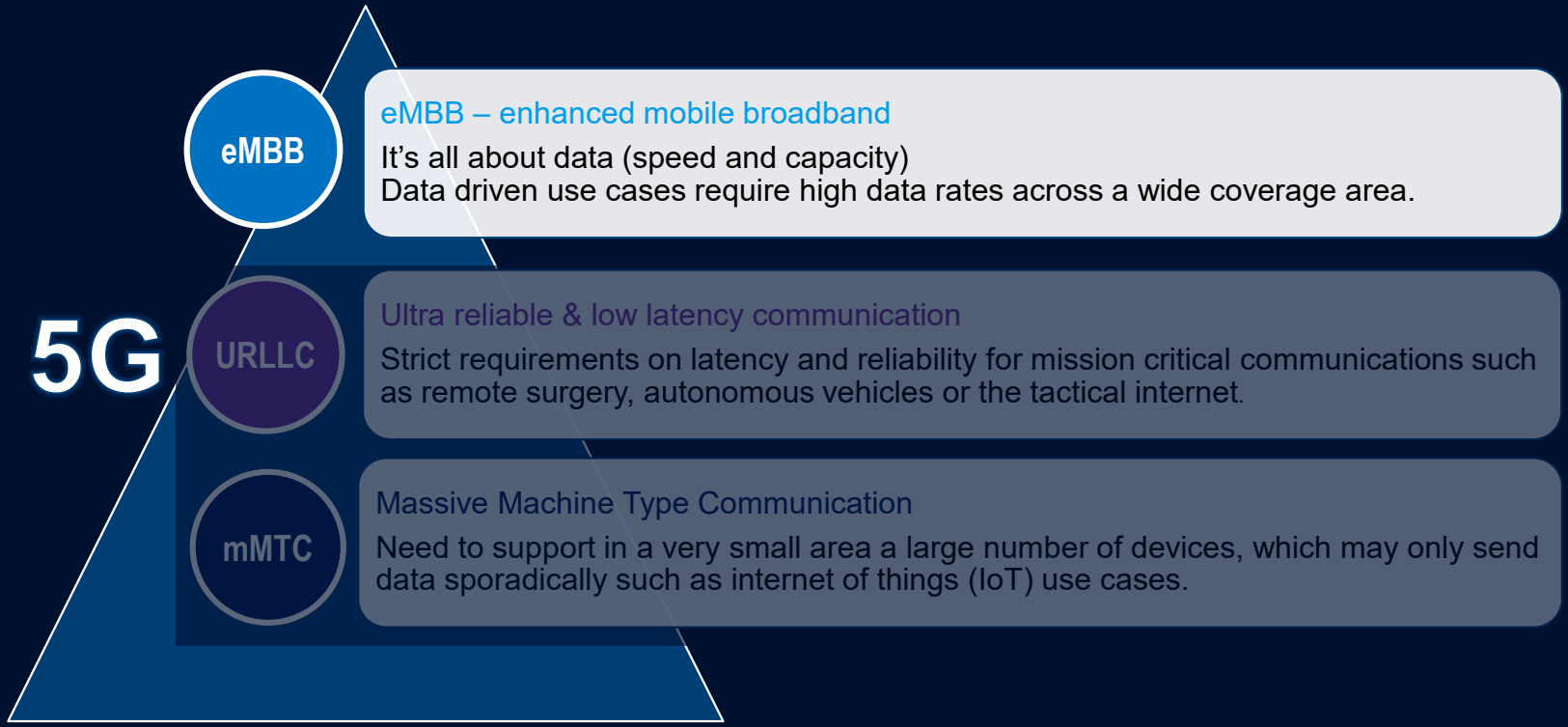
PERFORMANCE TEST:
5G THROUGHPUT TESTING

FUNCTIONAL & PERFORMANCE TEST:
5G AUDIO SPEECH TESTING

USE CASES

PERFORMANCE TEST:
5G THROUGHPUT TESTING

THE 5G USE CASES

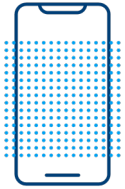


Modern phones rely on multiple technologies to achieve high throughput rates in 5G

MULTIPLE TECHNOLOGIES TO ACHIEVE HIGH THROUGHPUT IN 5G

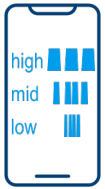
Higher frequency

Wider bandwidth

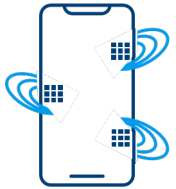


Higher modulation

More streams



Multi band



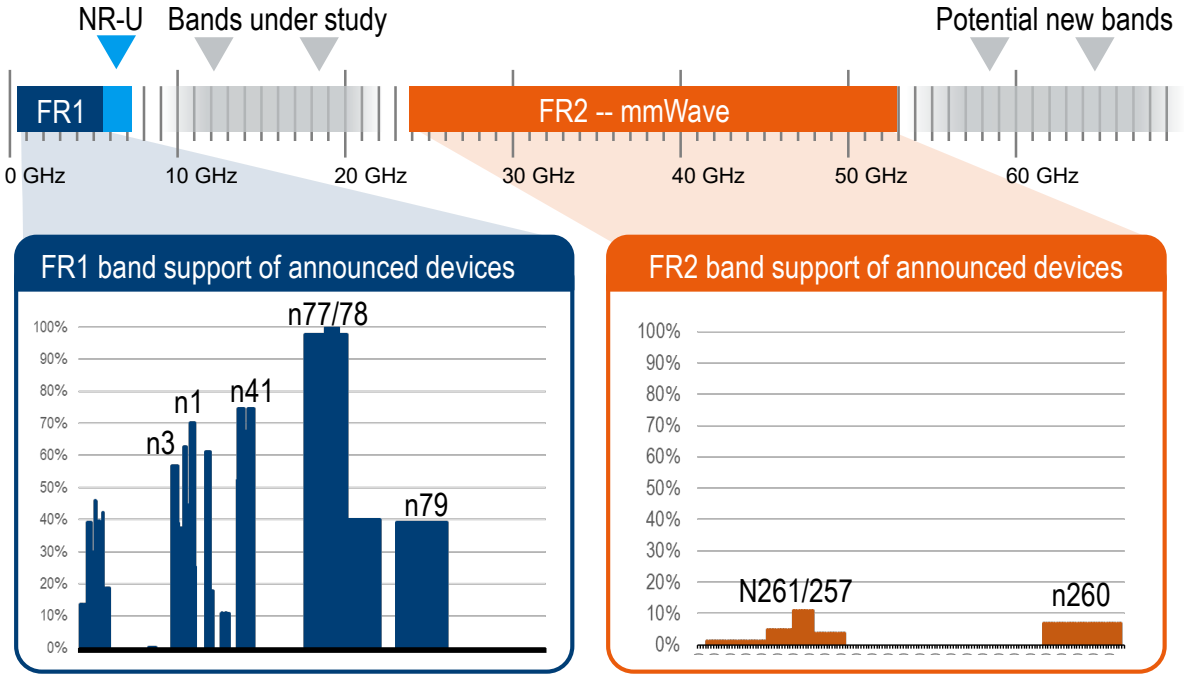
Multi antenna

HIGHER FREQUENCIES ENABLE WIDER BANDWIDTH

Two different frequency ranges are available for 5G

FR1 - frequency range 1
- 410 MHz – 7.125 GHz

FR2 - frequency range 2
- 24.25 – 52.6 GHz



Source: GSA – GAMBoD Jan. 2021

5G NEW RADIO (NR) AIR INTERFACE PARAMETERS

Higher frequency

Parameter	FR1 (410 MHz – 7.125 GHz)	FR2 (24.25 – 52.6 GHz)
Carrier aggregation	Multi band → Up to 16 carriers	Wider bandwidth
Bandwidth per carrier	5, 10, 15, 20, 25, 30, 40, 50, 60, 80, 90, 100 MHz	50, 100, 200, 400 MHz
Subcarrier spacing	15, 30, 60 kHz	60, 120, 240 (not for data) kHz
Max. number of subcarriers	3300 (FFT4096 mandatory)	
Modulation scheme	QPSK, 16QAM, 64QAM, 256QAM; Uplink also supports π/2-BPSK (only DFT-s-OFDM)	
Radio frame length	10 ms	Higher modulation
Subframe duration	1 ms (alignment at symbol boundaries every 1 ms)	
MIMO scheme	Max. 2 codewords mapped to max 8 layers in downlink and to max 4 layers in uplink	
Duplex mode	TDD, FDD	TDD
Access scheme	Downlink: CP-OFDM; Uplink: CP-OFDM, DFT-s-OFDM (network controlled)	

More streams

UE SUPPORTED MAXIMUM DATA RATE

Three components with a major influence on the maximum data rate

Available radio resources | Layers | Modulation/Coding

$$DR_{Mbit/s} = \sum_{j=1}^{J} \left\{ N_{PRB}^{BW(j),\mu} \cdot 12 / T_s^{\mu} \cdot (1 - OH) \cdot \nu_{layers}^{(j)} \cdot Q_m^{(j)} \cdot R_{max} \cdot f^{(j)} \right\} \cdot \frac{1\ Mbit}{10^6\ bit}$$

Number of subcarrier per RB

Average OFDM symbol duration

$$T_s^{\mu} = \frac{0.001\ s}{14 \cdot 2^{\mu}}$$

max # of layers

max modulation order (bits)

max. code rate

Number of aggregated component carriers J per band or band combination (≤ 16)

Overhead due to signaling

	FR1	FR2
DL	0.14	0.18
UL	0.08	0.10

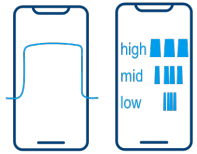
	Q_m	R_{max}
BPSK	1	314/1024
QPSK	2	679/1024
16QAM	4	658/1024
64QAM	6	948/1024
256QAM	8	948/1024

Scaling factor reflects the UE capabilities (layer, modulation dependent on band combination). Values 1, 0.8, 0.75, 0.4 signaled per band

Max. number of resource blocks (RB) per bandwidth for CP-OFDM based on TS 38.817-01

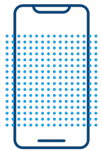
DATA THROUGHPUT

Three components with a major influence on the maximum data rate



Wider bandwidth Multi band

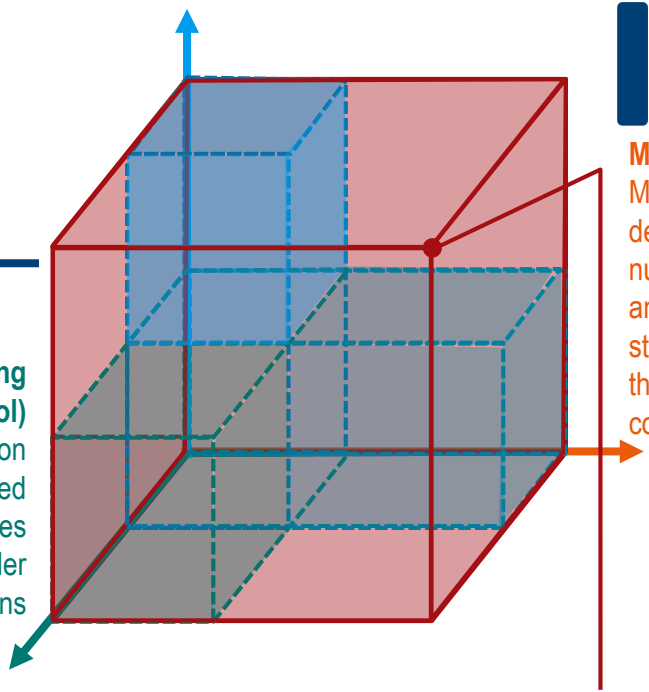
Available radio resources
S_{radio} (symbols / second)
Depends on the numerology (symbol duration T_s & signaling overhead OH) and the available bandwidth resources including carrier aggregation



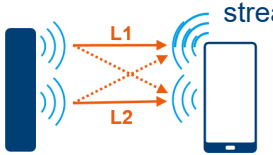
Higher modulation

Example:
256QAM
(8 bits/symbol)

Modulation / Coding
Q_{MR}(bits/symbol)
Depends on modulation scheme Q and applied code rate R. Max values only achievable under perfect radio conditions



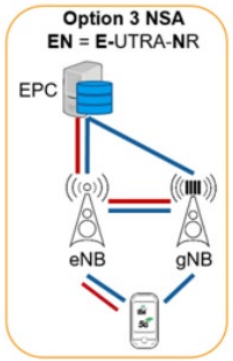
More streams

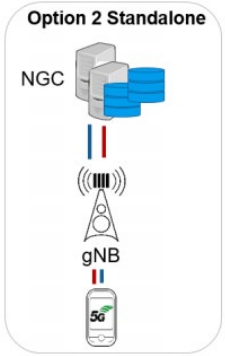


MIMO Layers (L)
MIMO Layers (L) is determined by the number of Tx and Rx antennas in the base station and UE and by the radio channel condition number

R&S®CMX500 FOR 5G NR

EN-DC (EUTRA-NR Dual Connectivity)





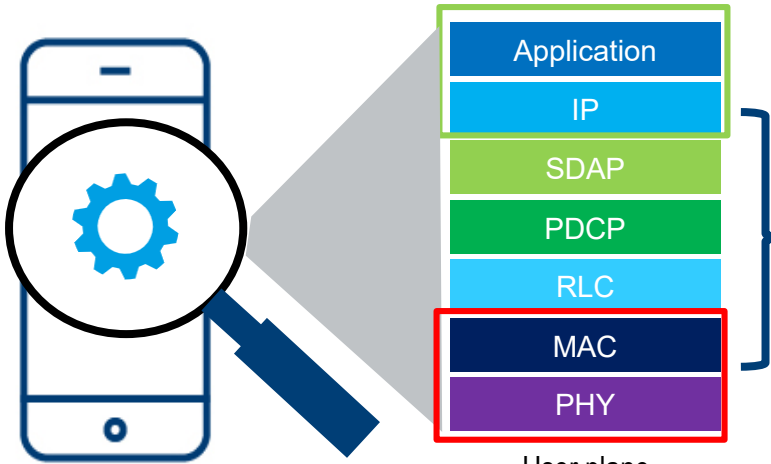
5G Standalone

CMW500:
- 4G LTE Baseband & RF
- FR1 RF
- DAU IP User Plane NR & LTE

CMX500:
- 5GNR L1/Stack (Baseband)
- 5GNR mmW IF (2 for MIMO)

Remote Radio Head - CMXHEAD30
- Supports all FR2 bands up to 43.5 GHz
- Up- and Down converter IF <-> FR2
- Integrated RF switch matrix for RX/TX paths

IP IS KEY! - MOBILE APPLICATION TESTING



User plane
protocol structure

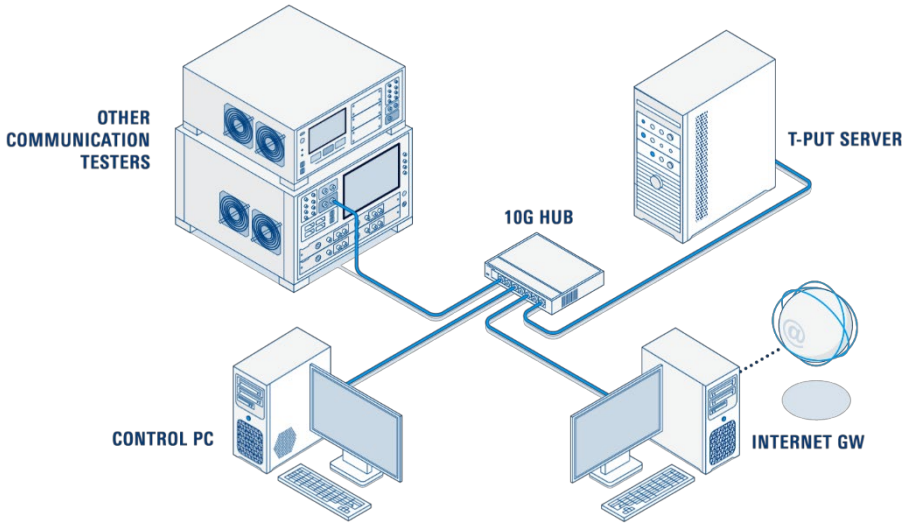
❑Performance test on IP Layer

End User: Quality of experience (QoE) and quality of Service (QoS)

Bottlenecks

❑Performance test on RF Layer

COMPLICATED TEST SETUP FOR APPLICATION TEST

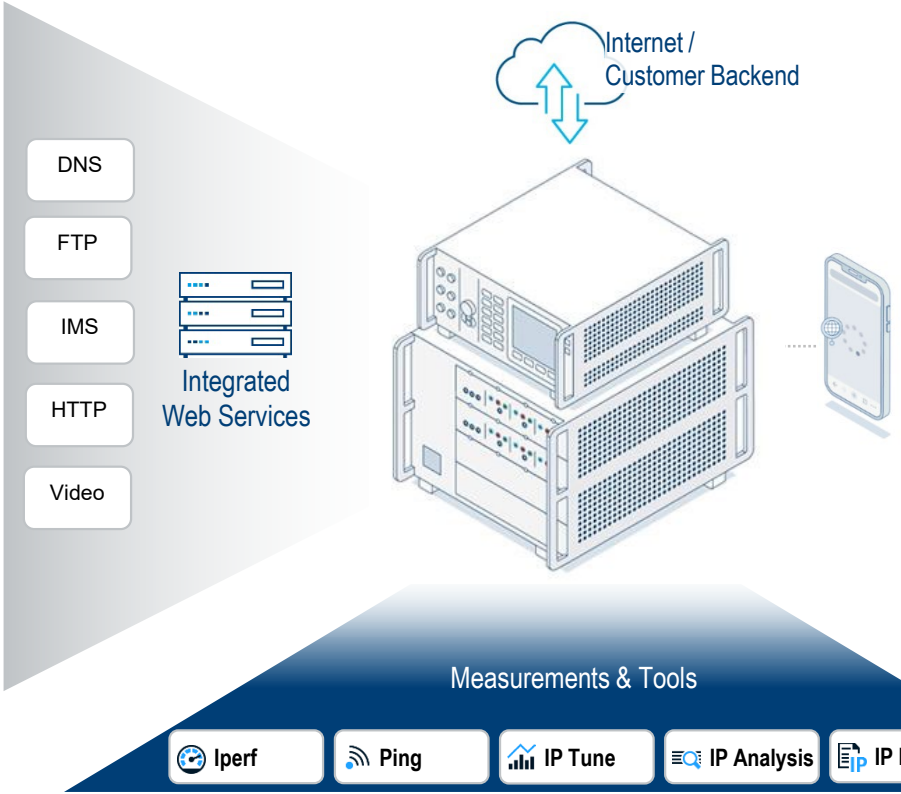


Consider:

- IP settings
- IPv4/IPv6 subnet configuration
  - IP Address
  - Subnet mask
- Firewall settings
- RAT compliant
  - TCP size
  - Data r
- Application specific port settings
- Remote control
- etc…

Trouble!

A SAMRT TEST SETUP FOR APPLICATION TEST R&S®CMX500 APPLICATION TEST SOLUTION



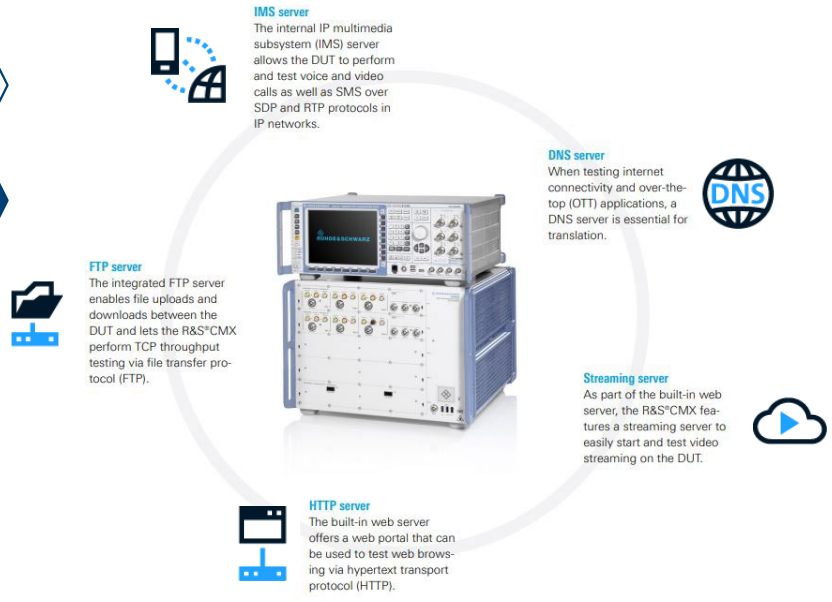
- **R&S®CMX500 offers a fully integrated setup for E2E data testing:**
  - IPv4 and IPv6 support preconfigured
  - Easy connection to the internet, customized tools or user backend to test over-the-top (OTT) applications
  - Pre-configured and optimized servers – ready for testing right away:→ DNS-, FTP-, IMS-, HTTP-Server
  - IP measurements and tools to enable 5G E2E IP throughput test and latency measurements
  - Simple to use and easy to configure interface in **R&S®CMsquares** interactive mode or via remote (SCPI & XLAPI) from CMsequencer.

FULLY INTEGRATED SERVERS

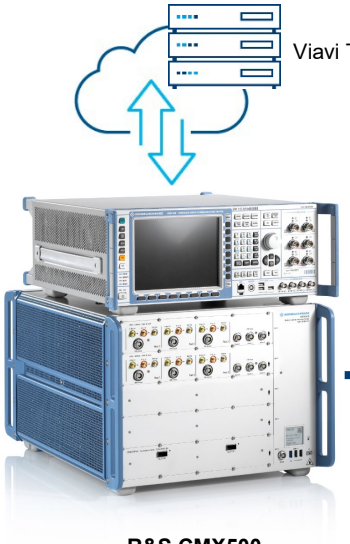
Comprehensive set of tools to enable you to reach the high throughput with your device

Best reproducibility and stability wherever you need it

Unique integrated solution – Simplify your test setup!



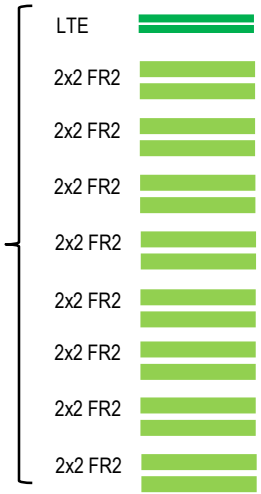
DEMO: THROUGHPUT PERFORMANCE TEST WITH NSA 1CC LTE + 8CC FR2 CELL CONFIG

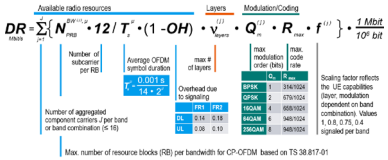


R&S CMX500
Minimum Footprint Setup

ATS1800C:
Everything including full compliance

NSA (EN-DC)





Example:
5G NR throughput: 7388 Mbps
DL TDD format 31, SCS120kHz,
256QAM@CR948/1024, 8CC 100MHz
FR2, 2 layers (2x2 MIMO)
+ a little LTE

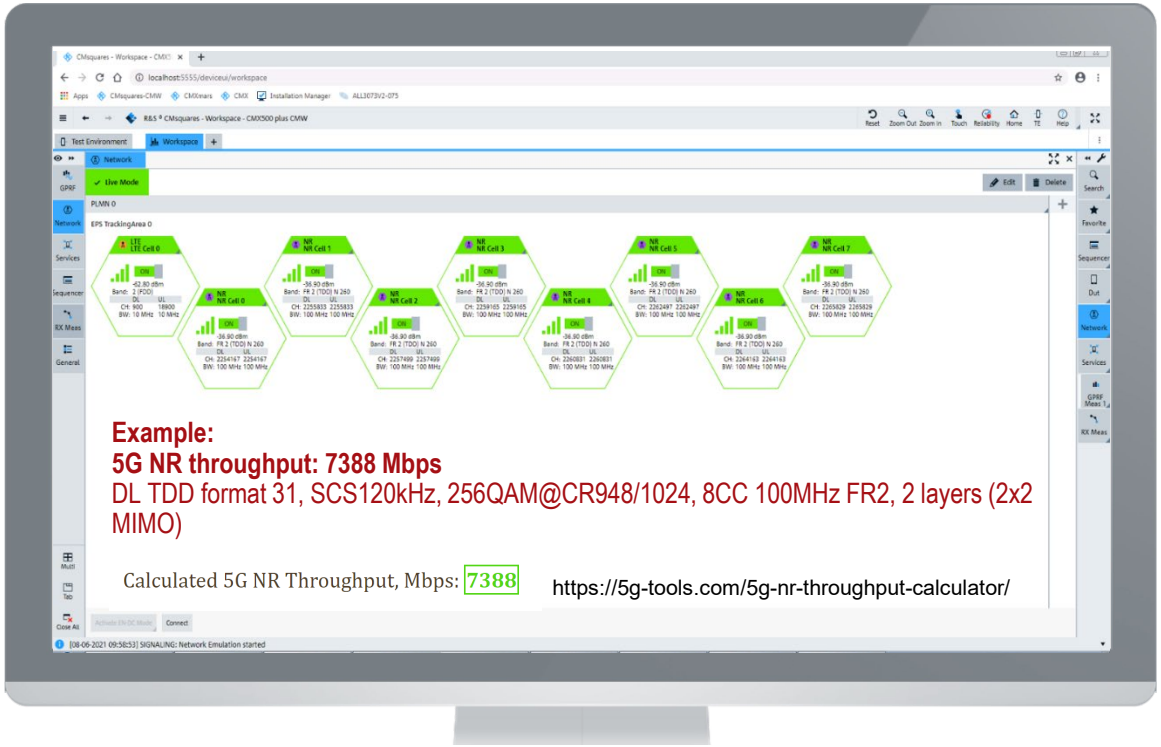
Internet:

Calculated 5G NR Throughput, Mbps: 7388

https://5g-tools.com/5g-nr-throughput-calculator/

DEMO #1

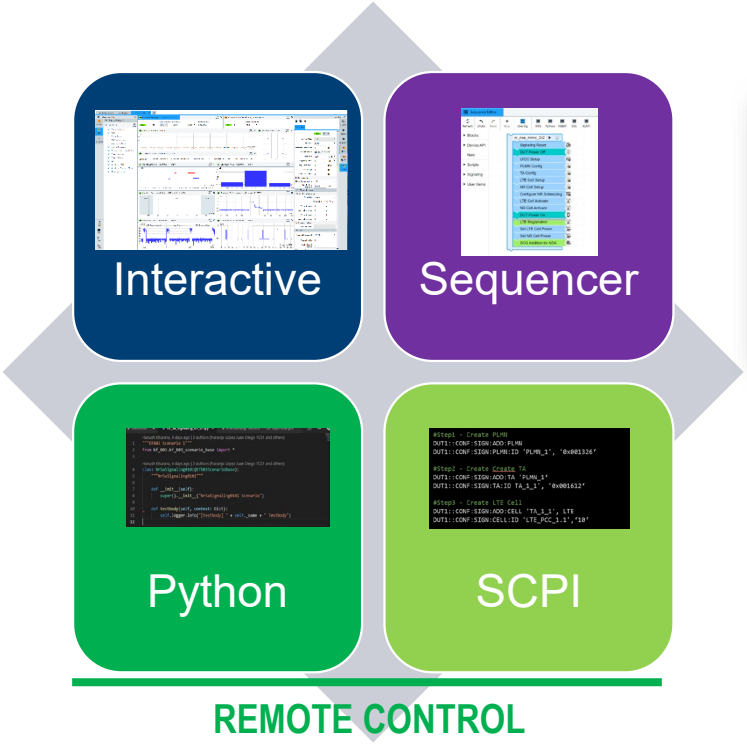
- eMBB ~7.4 Gbps high data throughput test using NSA LTE + 8CC FR2



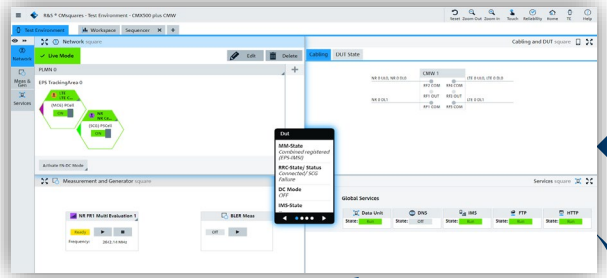
THE FLEXIBLE USER INTERFACE

CMSQUARES

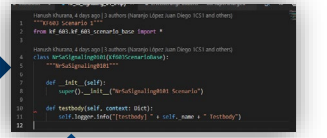
!! Unique in Wireless Testing Industry !!

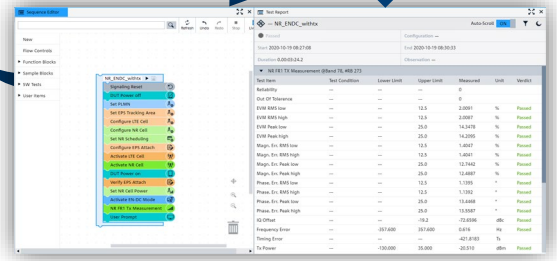


Interactive Mode



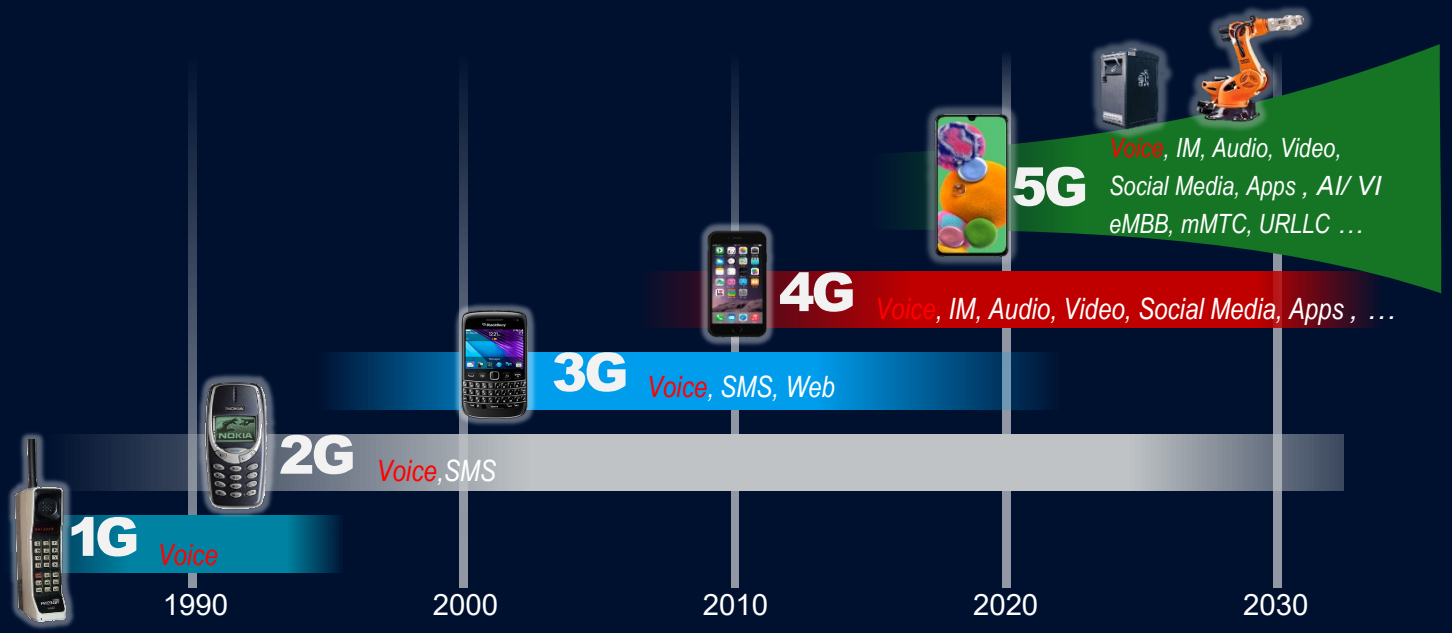
SCPI or XLAPI - Python





Sequencer Mode

FUNCTIONAL & PERFORMANCE TEST:
AUDIO SPEECH TESTING



A smartphone will stay a phone also in 5G!

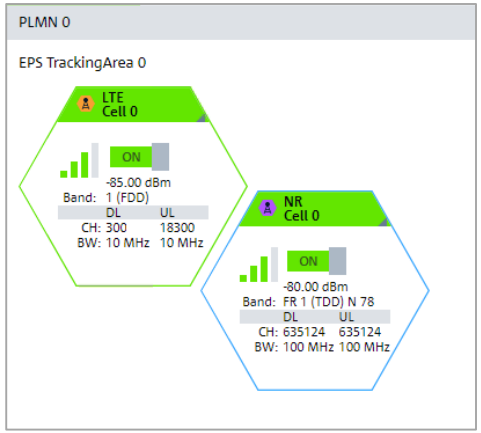
VOICE SERVICES WILL REMAIN CENTRAL IN MOBILE NETWORKS. ALSO IN 5G!

FACTS ABOUT - VOICE OVER 5G NR

- The way to 5G voice will be a multi step deployment strategy
- IMS will stay as infrastructure for 5G voice services
- EVS codec (HD voice+, Cristal clear voice) for great voice quality
- 5G will enable future voice-related use case innovation (real-time voice translation, real time interaction, etc.)

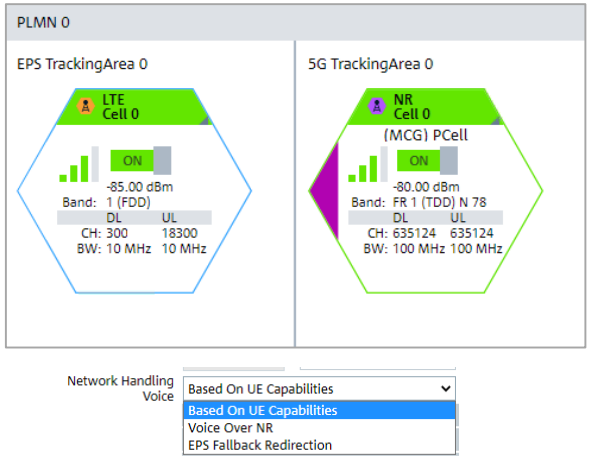
5G NR VOICE - A MULTI STEP DEPLOYMENT STRATEGY

5G EN-DC Voice support: VoLTE



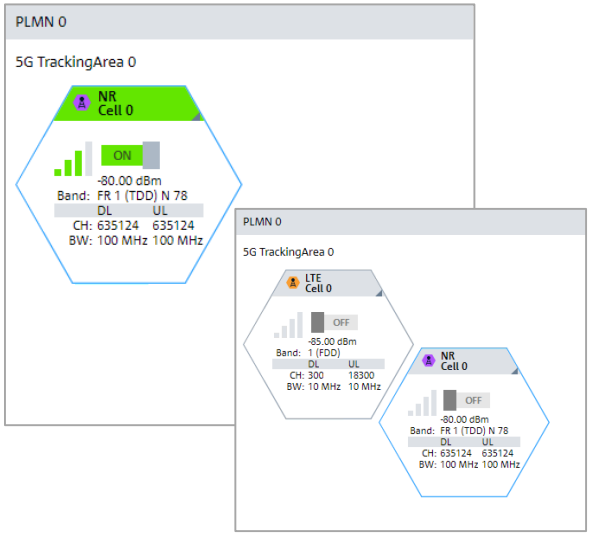
► Dual connectivity: VoLTE + 5G data

Voice as EPS fallback: VoLTE



► EPS fallback: VoLTE

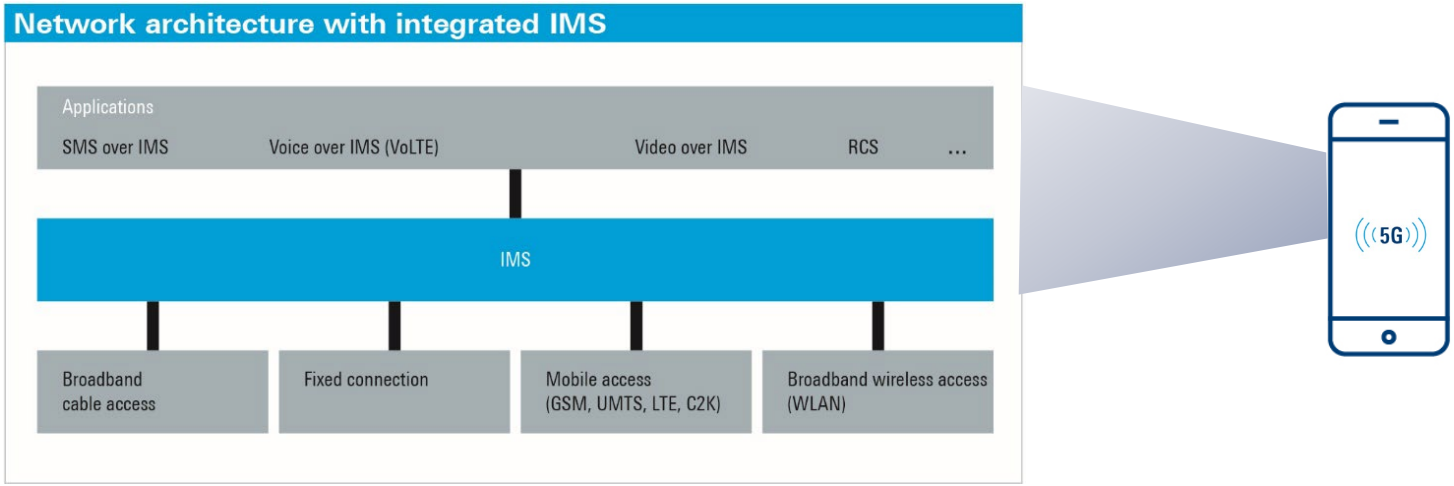
Voice using the 5G core VoNR (SA or NSA)



► VoNR (Voice over 5G)

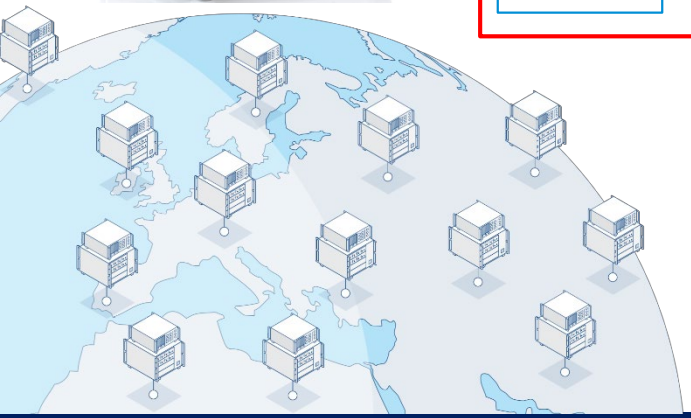
INTRODUCTION IMS – IP MULTIMEDIA SUBSYSTEM
DEFINITION

►IMS is a global access-independent and standards-based IP connectivity and service control architecture that enables various types of multimedia services to end-users using common Internet-based protocols.



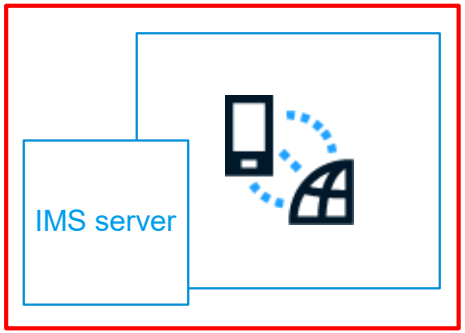
►IMS will stay as enabler for VoLTE & VoNR, SMS value adding services in 5G.

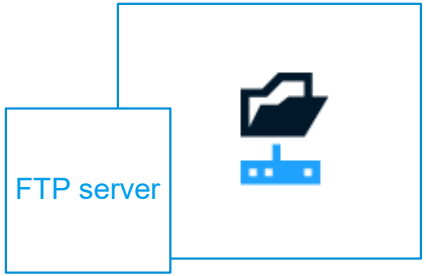
CMX500 - FULLY INTEGRATED SERVERS

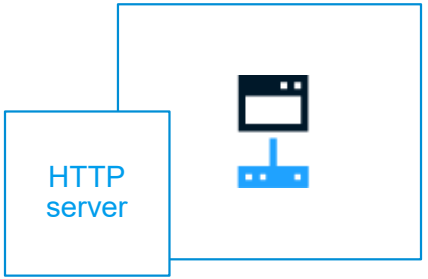


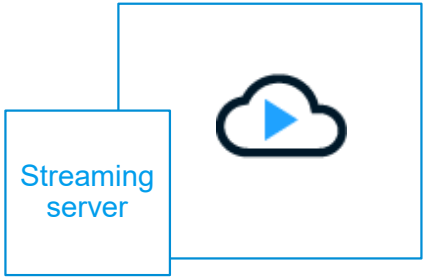
Best reproducibility and stability wherever you need it!

Unique integrated solution – Simplify your test setup!

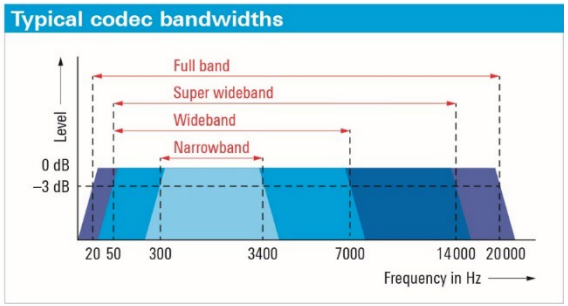








EVS CODEC – HIGH QUALITY AUDIO

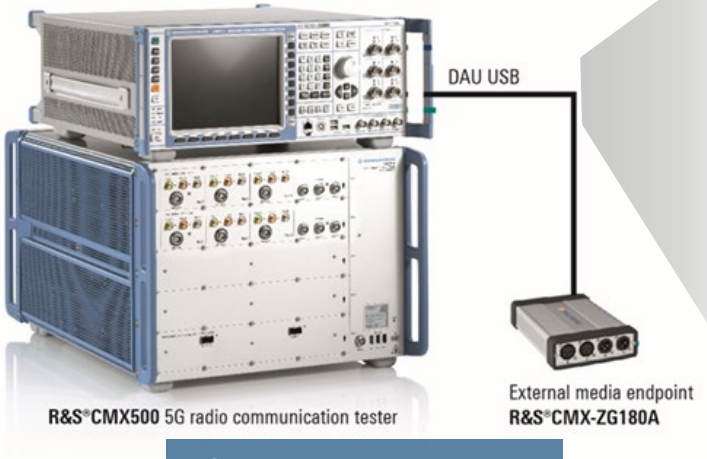


Codec	Bandwidth	Mode	Known as
AMR-NB	300 – 3400kHz	Narrowband	Standard voice
AMR-WB	50-7kHz	Wideband	HD voice
EVS	50-14kHz	Super wideband	HD+ or Ultra HD voice
EVS	20-20kHz	Fullband	?

The EVS-Codec enables devices go beyond the standard conversational voice use case!

Source: InDesign-Future-of-Voice-Feb-2021-1.pdf

CMX500 SUPPORTED EVS CODE RATE COMBINATIONS



CMX500 as well!

Mode	EVS Primary Mode							EVS AMR-WB IO Mode
Bandw.	NB		WB		SWB	FB		WB
Rate	Primary		Primary		Primary	Primary	Rate	AMR-WB IO
[kbps]	CBR	VBR	CBR	VBR			[kbps]	
5,9		(x)		(x)	n.a.	n.a.	6,6	x
7,2	x		x		n.a.	n.a.	8,85	x
8	x		x		n.a.	n.a.	12,65	x
9,6	x		x		x	n.a.	14,25	x
13,2	x		x		x	n.a.	15,85	x
13,2 (CA)	n.a		x		x	n.a.	18,25	x
16,4	x		x		x	x	19,85	x
24,4	x		x		x	x	23,05	x
32	n.a.		x		x	x	23,85	x
48	n.a.		x		x	x		
64	n.a.		x		x	x		
96	n.a.		x		x	x		
128	n.a.		x		x	x		

EVS offers more than 40 EVS code rate and bandwidth combinations incl. AMR-WB IO mode!

R&S is ready to support 5G mobile phone development with high quality audio!

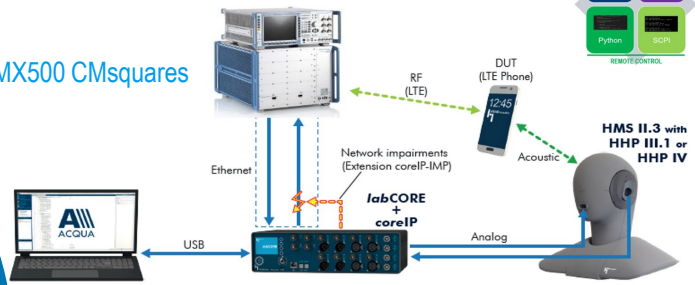
5G - VOICE OVER NR TESTING

- Attach procedures
- IMS registration
- Session Initiation Protocol (SIP)
- Audio: echo verification in loopback mode
- Emergency call
- EPS FB
- …

R&S®CMX500 CMsquares and/or CONTEST

- Audio Quality and Acoustics analysis
- POLQA® measurements 3GPP TS 26.132

R&S®CMX500 CMsquares



Head acoustics labCORE

Functional | Audio Quality | Performance | Field Testing

R&S®CMX500 CMsquares

- Loopback Audio performance POLQA® measurements
- End-to-end Audio performance POLQA® measurements
- Impact of noise and fading
- IP traffic impairment (Jitter, Packet loss, Delay)

R&S®TSMx Radio Network Analyzer
R&S®ROMES4 Optimization Software a.o.

SmartAnalytics

R&S®ROMES4

QualiPoc Android

R&S®TSMx

- Network performance analysis
- Field tests

R&S CARRIER ACCEPTANCE AND NETOP TEST SOLUTIONS INCLUSIVE VONR

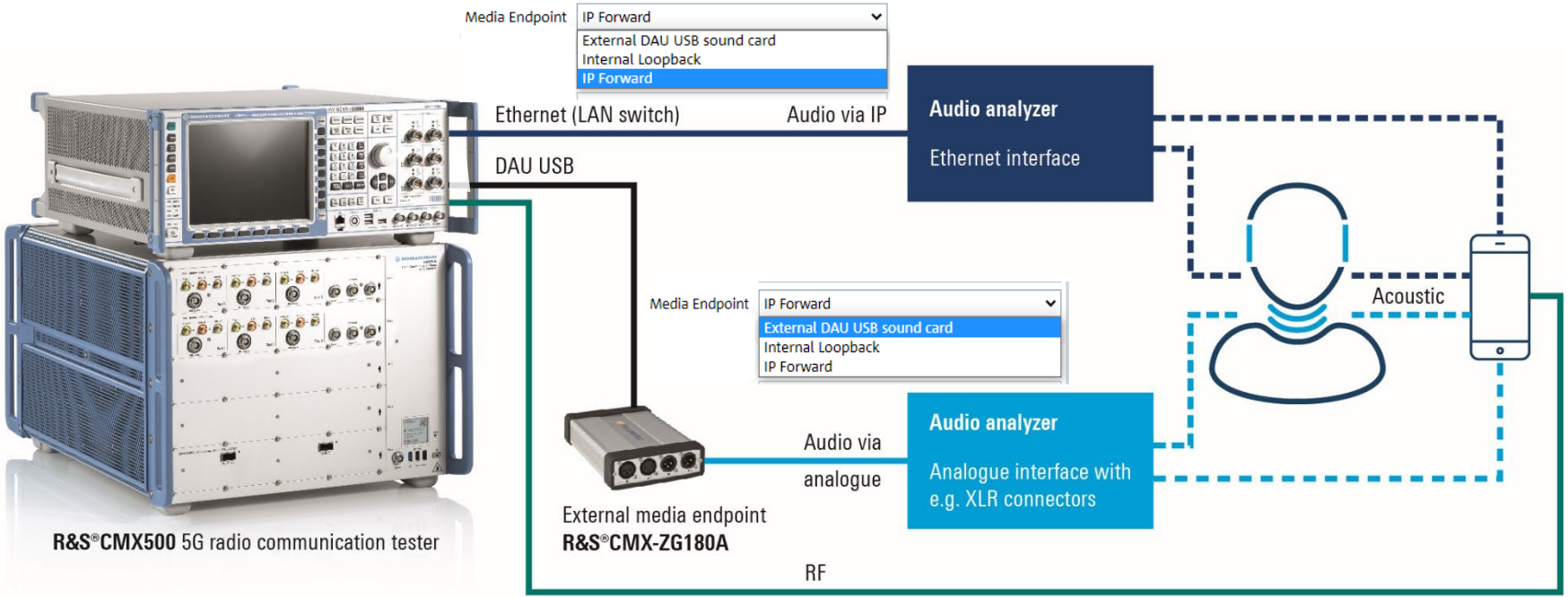
- Tier-1 network operator have established specific process and requirement for device accepting tests
- R&S works together with all Tier-1 operators globally with strong footprint in **US and China**
- Covering all aspects of testing to be **a one-stop shop**
- solutions for RF, RRM, performance, protocol, application as well as position (E911) related testing

RF, RRM, Perf, NetOP, IMS, VoNR, LBS/E911…

T-Mobile 5G · at&t 5G · 中国移动 China Mobile 5G · 中国电信 CHINA TELECOM 5G

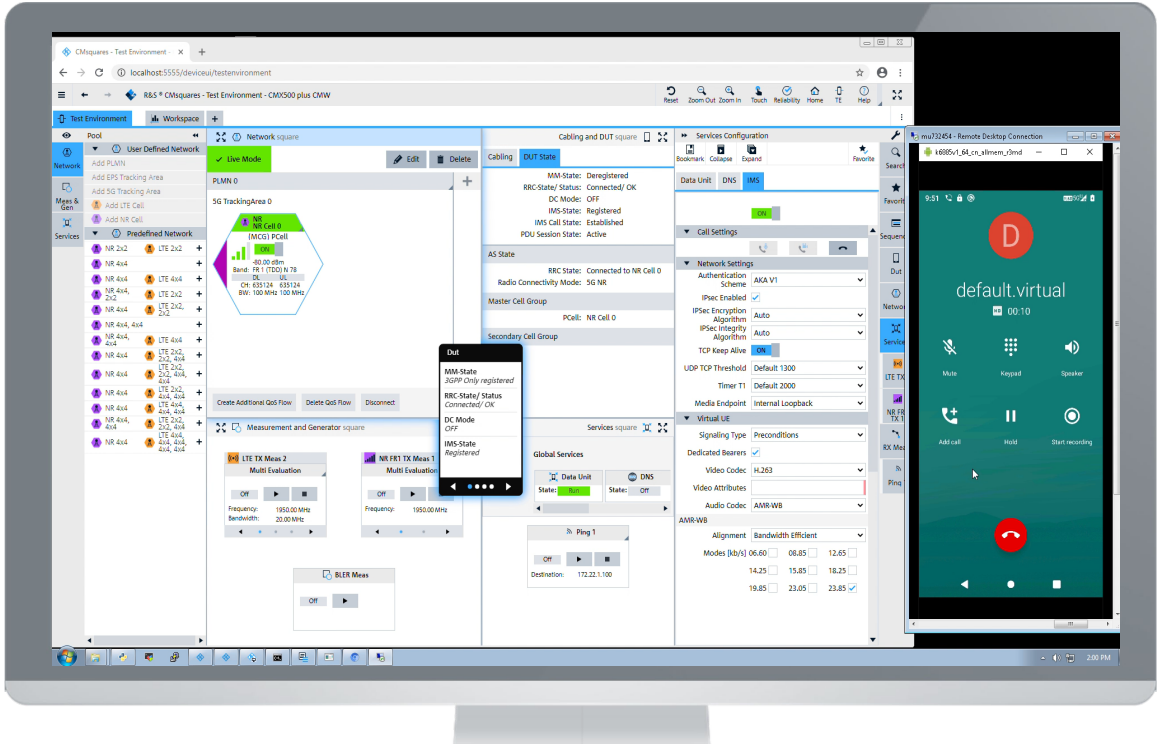
verizon 5G · dish 5G · China unicom 中国联通 5G

MAXIMUM FLEXIBILITY IN 5G AUDIO QUALITY ANALYSIS



DEMO #2

- 5G VoNR call using CMX500 in interactive mode



You are ready now...

… to design and test 5G devices…

… to deliver a great quality of experience (QoE) and quality of Service (QoS)!

… to maximized IP Throughput!

… to develop devices with high quality EVS audio!

R&S supports you to test high throughput in 5G and Voice over NR services!

Thank you !

ROHDE&SCHWARZ

Make ideas real