

5G SIGNALING DEVICE TEST WITH THE CMX500 ONE BOX TESTER (OBT)



Christian Hof

Product Manager – Application Test



Stefan Diebenbusch

Director of Engineering – Application Test

ROHDE & SCHWARZ

Make ideas real



COMPANY RESTRICTED

Conformance

High Throughput

Performance

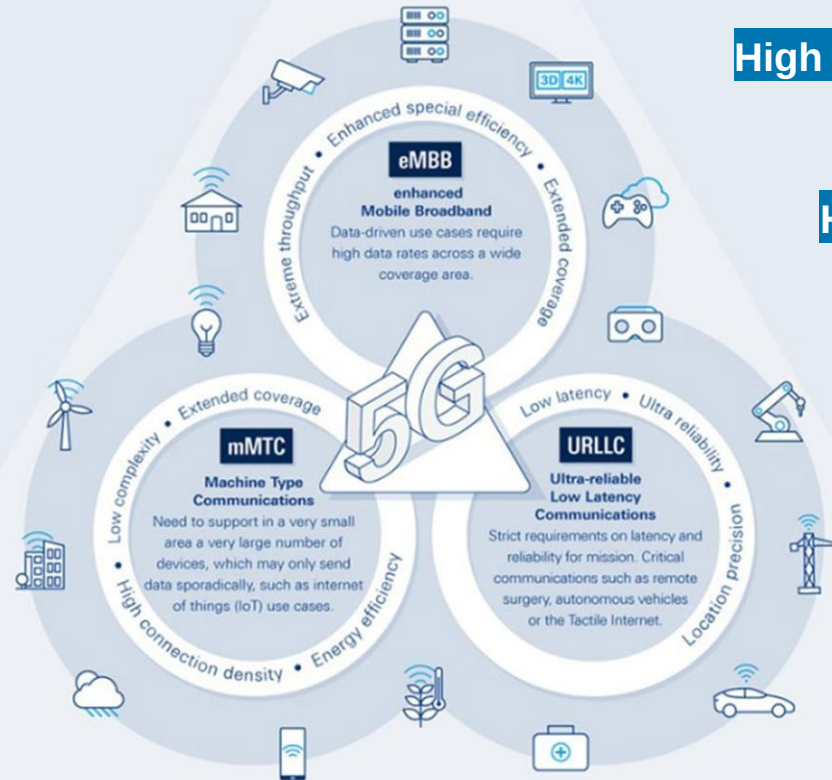
High Reliability

Security

New Applications

Energy efficiency

Low Latency



VERIFICATION OF 5G DEVICES IS A COMPLEX TASK

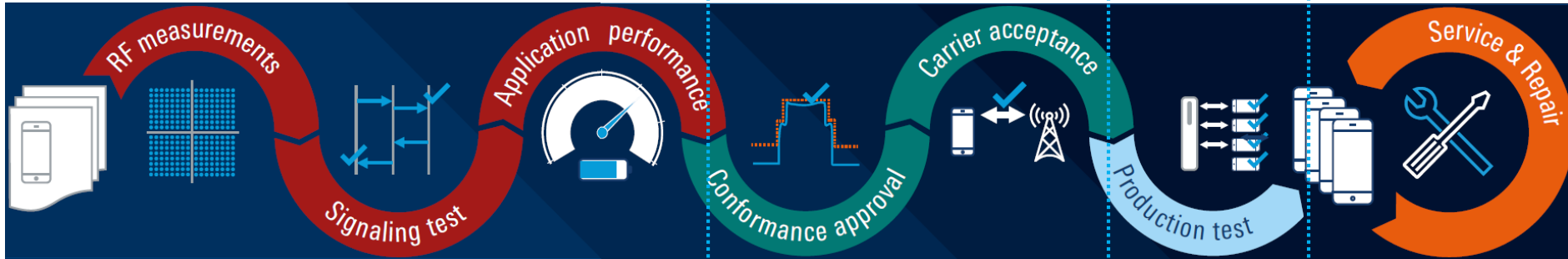
TESTING PHASES

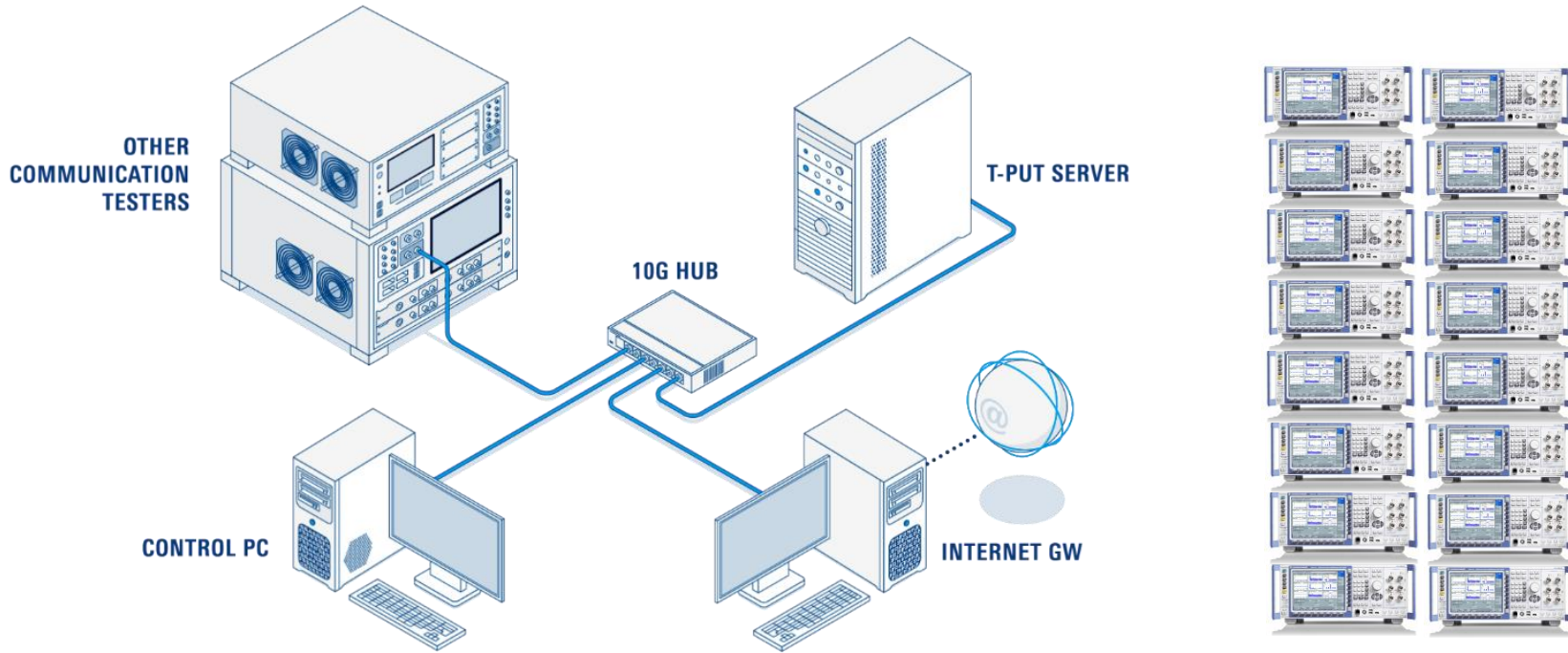
R&D Testing

Conformance Testing

Non-Sig Testing

Go / No-go Testing





TRADITIONAL SYSTEM SETUP TO ADDRESS 5G COMPLEXITY

AGENDA OF THIS SESSION



CMX500 Hardware Overview



User Interfaces



Use Cases



Summary

5G NR RADIO COMMUNICATION TESTER



CMX500 5G NR Signaling Tester

Future proof 5G NR signaling test platform

up to **64 FR1/FR2/LTE Layers** | **14 GHz** RF iBW

Modular and scalable HW-Architecture

LTE and FR1 multiband capabilities up to 8 GHz

FR2 Multiband Remote Radio Support (24 – 50GHz)

20 Gbps+ End-to-End IP Data Performance capability

Single Web-based GUI for RF, Protocol and App Tests

Extensive IP and Application Test feature set onboard

Multiple Remote Interfaces including SCPI

FLEXIBLE & UPGRADEABLE CMX500 PLATFORM – FR1



OBT lite

- FR1/LTE 4x4 MIMO
- SA / NSA support
- **3GPP RF pre-conformance**
- **Application testing** (VoNR etc.)
- Signaling functional tests
- **Service and Repair**
- 3GPP Rel-17 **RedCap**
- 4 GHz RF DL iBW
- Sub8: 400 MHz - 8 GHz
- FR2 extendable



OBT

- adds capabilities like:
- RF testing with **internal fading**
 - FR1 CA over 2 GHz iBW
 - Up to 32 NR Layers
 - Up to 32 LTE Layers
 - 48 layers on air simultaneously
 - 8 GHz RF DL iBW
 - Sub8: 400 MHz - 8 GHz
 - FR2 extendable



OBT plus

- adds capabilities like:
- Higher order CA (**massive band combos**)
 - **High throughput testing**
 - FR1 CA over 3 GHz iBW 4x4 DL MIMO
 - Up to 16CC LTE/NR
 - Up to 64 FR1/LTE layers on air
 - 12 GHz RF DL iBW
 - Sub8: 400 MHz - 8 GHz
 - FR2 extendable



OBT FR1 specialist

- adds capabilities like:
- FR1 CA over 4 GHz iBW
 - **Extensive Fading**
 - Higher order CA testing (**all band combos**)
 - 16 GHz RF DL iBW
 - Sub8: 400 MHz - 8 GHz
 - No FR2 upgrade

NEW

FLEXIBLE & UPGRADEABLE CMX500 PLATFORM – FR1 + FR2



OBT lite

OBT lite FR1 features +
FR2 capabilities like:

- Supports **FR2 SISO** + FR1
- 5 GHz RF DL iBW
- Sub8: 400 MHz - 8 GHz
- mmW: 22 ... 50 GHz



OBT

OBT FR1 features + FR2 capabilities:

- Support for FR2 2x2 MIMO up to 8 CC
- CB RF test up to 50 GHz and 8CC FR2 2x2 + 4CC FR1 4x4 8CC FR2 2x2 + 8CC LTE 4x4
- **10 Gbps Data Throughput**
- 3GPP pre-conformance tests



OBT plus

OBT plus FR1 features FR2 capabilities:

- Support for FR2 2x2 MIMO up to 8 CC
- CB RF test up to 50 GHz and 8CC FR2 2x2 + 4CC FR1 4x4 8CC FR2 2x2 + 8CC LTE 4x4
- High order CA Testing (massive band combos) **FR1 combined with FR2**



OBT FR2 specialist

capabilities like:

- FR2 10CC
- 4x4 AoA RRM testing
- High order CA testing (massive band combos) some FR1 combined with massive FR2

NEW

easy-to-use, web user interface



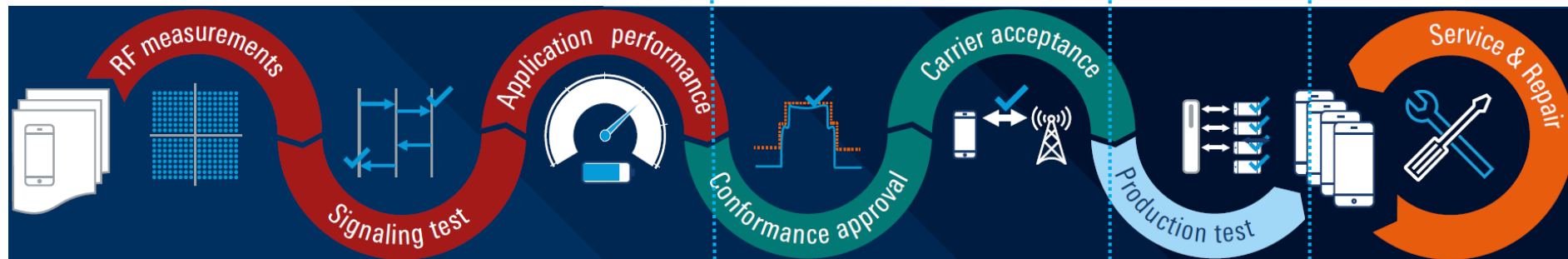
TESTING PHASES

R&D Testing

Conformance Testing

Non-Sig Testing

Go / NoGo Testing



CMsquares

CMsequencer

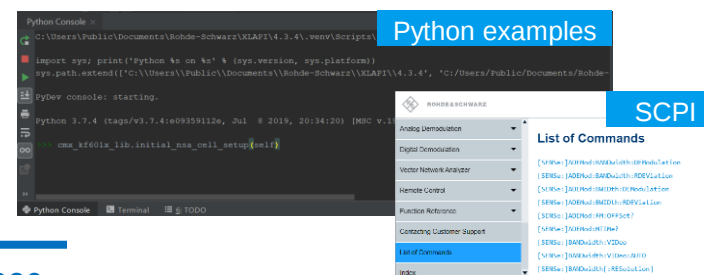
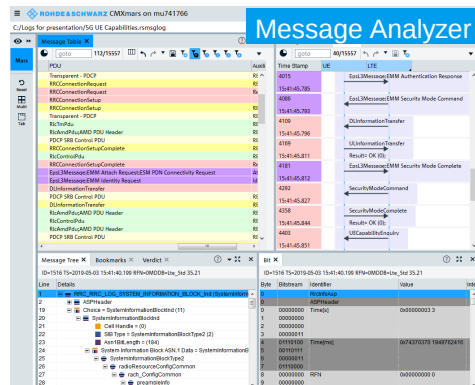
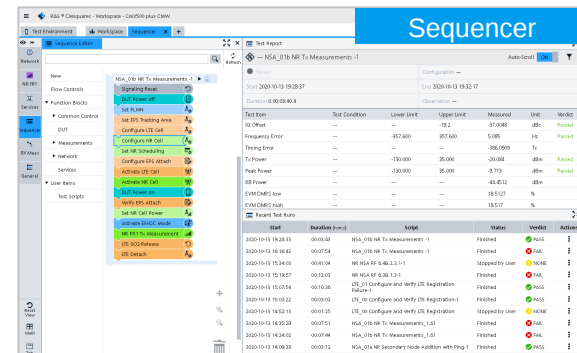
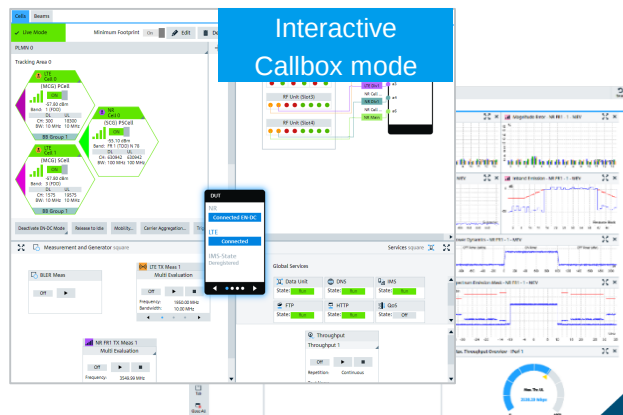


CONTEST



CMsequencer

MORE THAN JUST AN USER INTERFACE!



The all in one - User interface

THE TEST ENVIRONMENT

► Configure your test setup

- Network & measurements
- Cabling
- IP services
- DUT status
- Prepare snippets
- etc.

► DUT management

- UE database
- SIMprofile database
- DUT connection management
- etc.

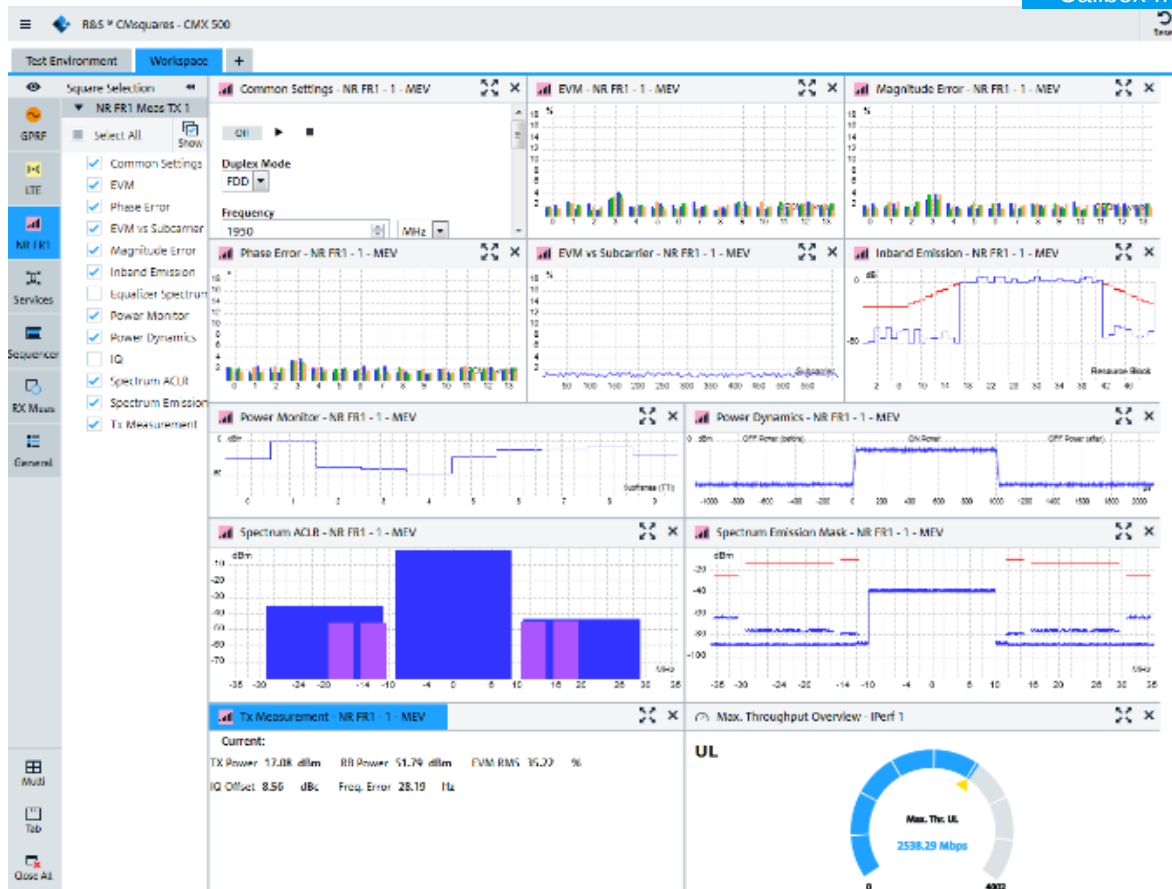
The screenshot displays the 'Callbox mode' interface for configuring a test environment. The interface is divided into several panels:

- Cells Panel:** Shows 'Live Mode' and 'Minimum Footprint' settings. It displays a map of 'Tracking Area 0' with three cells: 'LTE Cell 0 (MCG) PCell', 'NR Cell 0 (SCG) PSCell', and 'LTE Cell 1 (MCG) SCell'. Each cell shows its band, power, and channel information.
- Cabling Panel:** Shows the 'DUT State' and 'Edit Connections' options. It displays a diagram of the 'CMX500 (100106)' device with various units (IF Unit, RF Unit) and their connections to the DUT.
- DUT Panel:** Shows the 'DUT' (Device Under Test) status. It displays 'NR' and 'Connected EN-DC' status, along with 'LTE' and 'Connected' status. The 'IMS-State' is shown as 'Deregistered'.
- Measurement and Generator square:** Contains 'BLER Meas' and 'LTE TX Meas 1' (Multi Evaluation) sections. The 'LTE TX Meas 1' section shows 'Frequency: 1950.00 MHz' and 'Bandwidth: 10.00 MHz'.
- Services square:** Contains 'Global Services' and 'Throughput' sections. The 'Global Services' section shows 'Data Unit', 'DNS', 'IMS', 'FTP', 'HTTP', and 'QoS' status. The 'Throughput' section shows 'Throughput 1' and 'Repetition' settings.

The interface is designed for configuring and managing the test environment, including network settings, DUT status, and measurement configurations.

FLEXIBLE WORKSPACE

- ▶ Place of the **measurements**
- ▶ User defined configuration & easy mixing of all types of measurements
 - RF, IP or DUT status
- ▶ Real time results
- ▶ Compare LTE and 5G
- ▶ ...or FR2
- ▶ ...or end-to-end (IP)



CMSEQUENCER

- ▶ Place for automation and scripting
- ▶ Includes comprehensive test sequence campaign management
- ▶ Complete Coverage of 5G NR R&D tests incl. 3GPP RF in one application
- ▶ Automatic band combination tests
- ▶ Reporting and test report generation

The screenshot displays the CMSEQUENCER software interface, which is used for managing test sequences and generating reports. The interface is divided into several sections:

- Sequence Editor:** This section shows a list of test items for the sequence "NSA_01b NR Tx Measurements -1". The items include: Signalling Reset, DUT Power off, Set PLMN, Set EPS Tracking Area, Configure LTE Cell, Configure NR Cell, Set NR Scheduling, Configure EPS Attach, Activate LTE Cell, Activate NR Cell, DUT Power on, Verify EPS Attach, Set NR Cell Power, Activate EN-DC Mode, NR FR1 Tx Measurement, LTE SCG Release, and LTE Detach.
- Test Report:** This section displays the results of the test sequence. It includes a summary table and a detailed table of test items.

Test Report Summary:

Test Item	Test Condition	Lower Limit	Upper Limit	Measured	Unit	Verdict
IQ Offset	---	---	-19.2	-37.0048	dBc	Passed
Frequency Error	---	-357.600	357.600	5.085	Hz	Passed
Timing Error	---	---	---	-386.0909	Ts	---
Tx Power	---	-130.000	35.000	-20.084	dBm	Passed
Peak Power	---	-130.000	35.000	-9.713	dBm	Passed
RB Power	---	---	---	-44.4512	dBm	---
EVM DMRS low	---	---	---	18.5127	%	---
EVM DMRS high	---	---	---	18.517	%	---

Recent Test Runs:

Start	Duration (h:m:s)	Script	Status	Verdict	Actions
2020-10-13 19:28:33	00:03:43	NSA_01b NR Tx Measurements -1	Finished	✓ PASS	⋮
2020-10-13 16:16:42	00:07:54	NSA_01b NR Tx Measurements -1	Finished	✗ FAIL	⋮
2020-10-13 15:34:03	00:41:04	NR NSA RF 6.4B.2.3.1-1	Stopped by User	⚠ NONE	⋮
2020-10-13 15:19:57	00:12:03	NR NSA RF 6.3B.1.3-1	Finished	✗ FAIL	⋮
2020-10-13 15:07:54	00:10:36	LTE_01 Configure and Verify LTE Registration Failure-1	Finished	✓ PASS	⋮
2020-10-13 15:03:22	00:03:02	LTE_00 Configure and Verify LTE Registration-1	Finished	✓ PASS	⋮
2020-10-13 14:52:13	00:01:25	LTE_00 Configure and Verify LTE Registration	Stopped by User	⚠ NONE	⋮
2020-10-13 14:35:29	00:07:51	NSA_01b NR Tx Measurements_1.61	Finished	✗ FAIL	⋮
2020-10-13 14:24:02	00:07:44	NSA_01b NR Tx Measurements_1.61	Finished	✗ FAIL	⋮
2020-10-13 14:09:38	00:03:12	NSA_01a NR Secondary Node Addition with Ping-1	Finished	✓ PASS	⋮

SNIPPETS - CREATE INFINITE SHORTCUTS IN WEBUI

The screenshot displays the CMSequencer web interface. On the left, the 'Actions' panel is open, showing a list of snippets. Two snippets are highlighted with dashed green boxes: 'MaxPower 3GPP' and 'NR 6.2B.1.3 Maximum output power for inter-band ...'. The main area shows a network configuration for 'PLMN 0' with 'EPS TrackingArea 0'. It includes two cells: 'LTE Cell 0' and 'NR Cell 0', both with power levels of -88.00 dBm. The 'NR Cell 0' configuration shows Band: FR 1 (TDD) N 78, DL CH: 630942, UL CH: 630942, and BW: 100 MHz. On the right, a 'DUT' (Device Under Test) status panel shows 'NR' as 'Idle' and 'LTE' as 'Idle'. The bottom right corner indicates 'GPRF Gen 1'.

Test Environment Workspace Sequencer x +

Pool Actions

General Sequencer

Snippets

DC_string Cell Setup with NR Max Scheduling

Start NR FR1 meas

MaxPower 3GPP

NR 6.2B.1.3 Maximum output power for inter-band ...

Start IP UDP Client with 300 Mbps

MaxPower 3GPP

Network square

Cells Beams

Edit Mode

Go Live Delete

PLMN 0

EPS TrackingArea 0

LTE Cell 0

-88.00 dBm

Band: 1 (FDD)

DL UL

CH: 300 18300

BW: 20 MHz 20 MHz

NR Cell 0

-88.00 dBm

Band: FR 1 (TDD) N 78

DL UL

CH: 630942 630942

BW: 100 MHz 100 MHz

DUT

NR

Idle

LTE

Idle

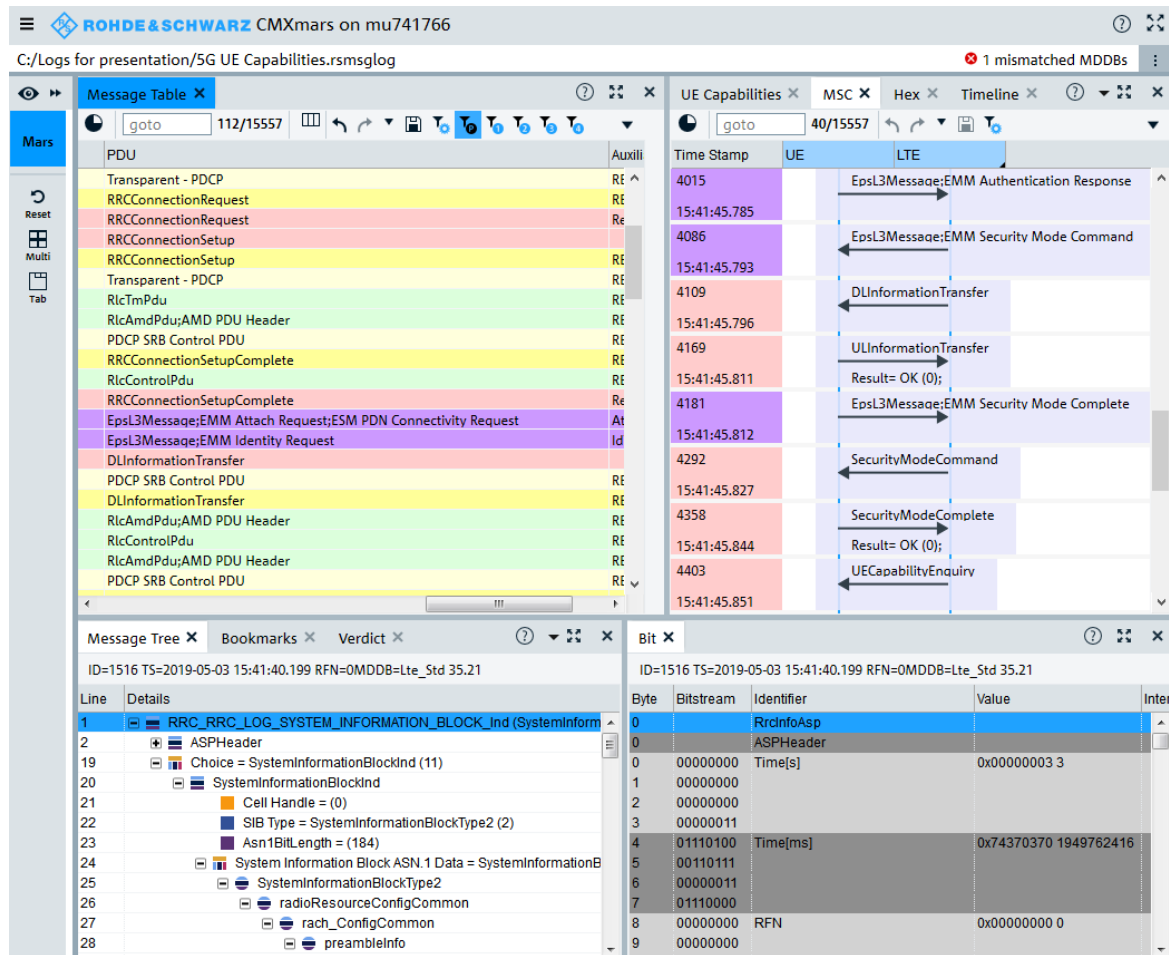
IMS-State Registered

GPRF Gen 1

Frequently used actions can be added as snippets from the CMsequencer to the interactive GUI

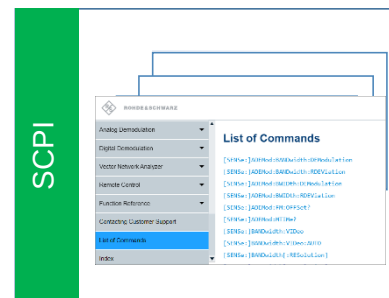
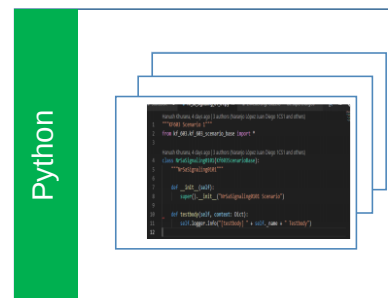
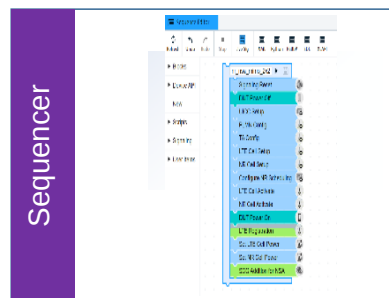
MESSAGE ANALYZER

- ▶ Place of **real time tracing** and **post processing** (online and offline)
- ▶ Evolution of well-established CMWmars
- ▶ Message tracing between network tester and UE from PHY to IP and IMS
- ▶ UE capabilities
- ▶ Message compare function



CUSTOMER INTERFACES

REMOTE CONTROL



CMX500 SUPPORTS MANY USE CASES



3GPP RF TESTING



MOBILITY, FAILURE &
REJECT SCENARIOS



IMS AUDIO &
VIDEO TESTING



IP THROUGHPUT
TESTING inc. FR2



BATTERY LIFE
TESTING

REDcap Rel.17



Security Analysis



Backend Service Test



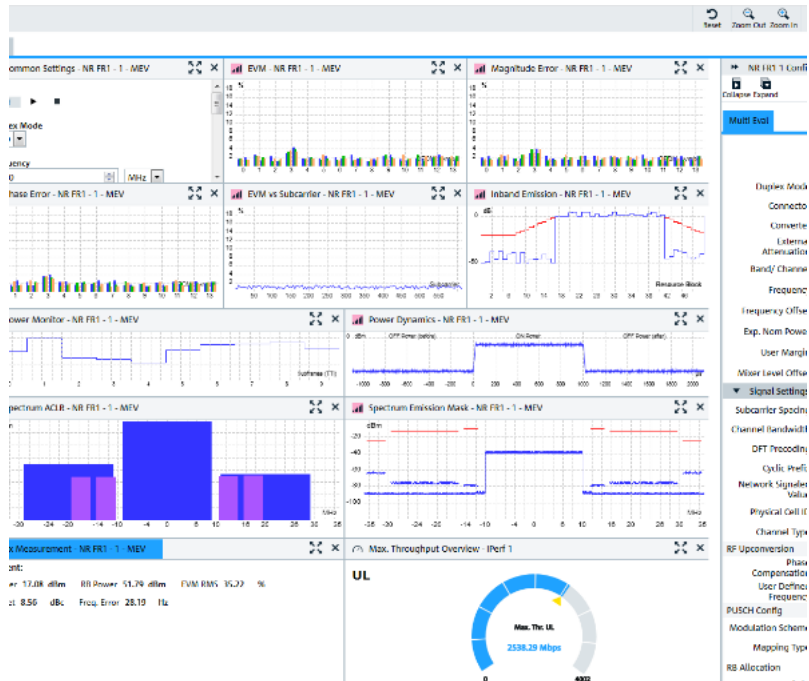
WLAN Offloading



Many more...

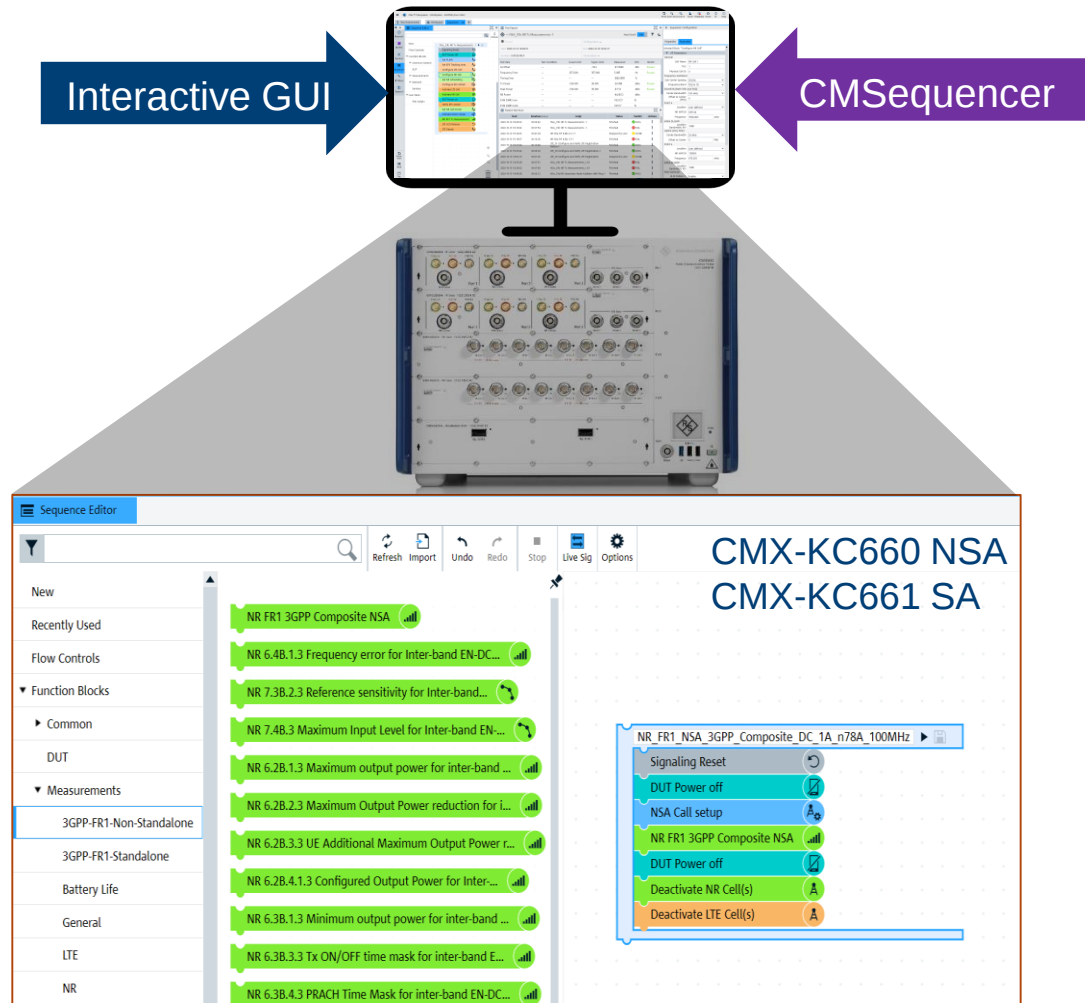


3GPP RF PRE- CONFORMANCE TESTS



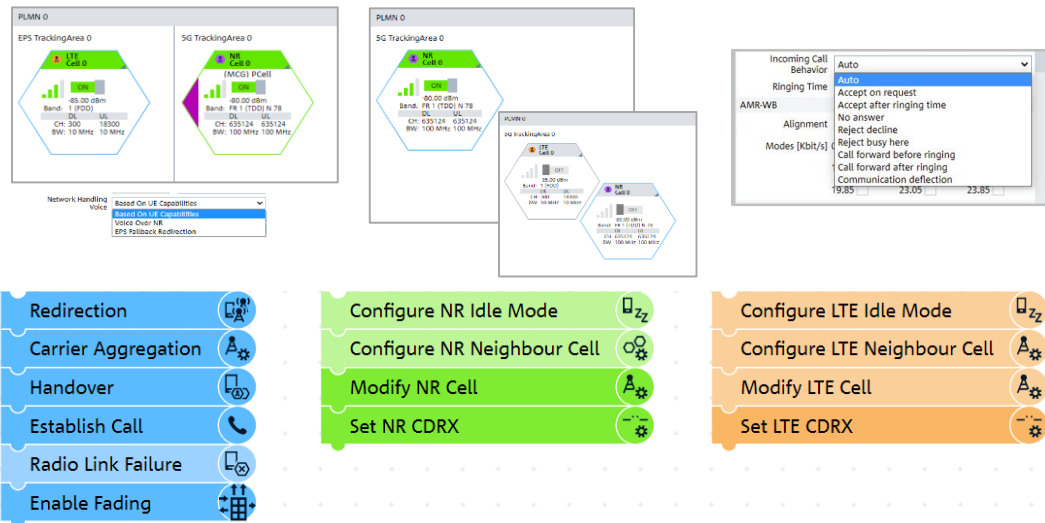
3GPP PRE-CONFORMANCE TESTS

- ▶ 3GPP 38.521 Tx and Rx manual and automates tests for 5G FR1 NSA and SA
 - Interactive GUI
 - CMsequencer
- ▶ Pre-defined test scripts with allowed variations available
- ▶ Comprehensive test reports with measurement verdicts, tables and graphs
- ▶ Automated RF attenuation tuning for clean RF path
- ▶ And many more features



ALL FLAVORS OF MOBILITY & VOICE

- ▶ Intra & Inter RAT Handover
- ▶ Fast Frequency Change (FR1 & FR2)
- ▶ Idle mode mobility (cell selection / reselection)
- ▶ Radio Link Failure
- ▶ Redirection
- ▶ Roaming scenarios
- ▶ VoLTE / VoNR / EPS-FB
- ▶ Enhance mobility with fading too



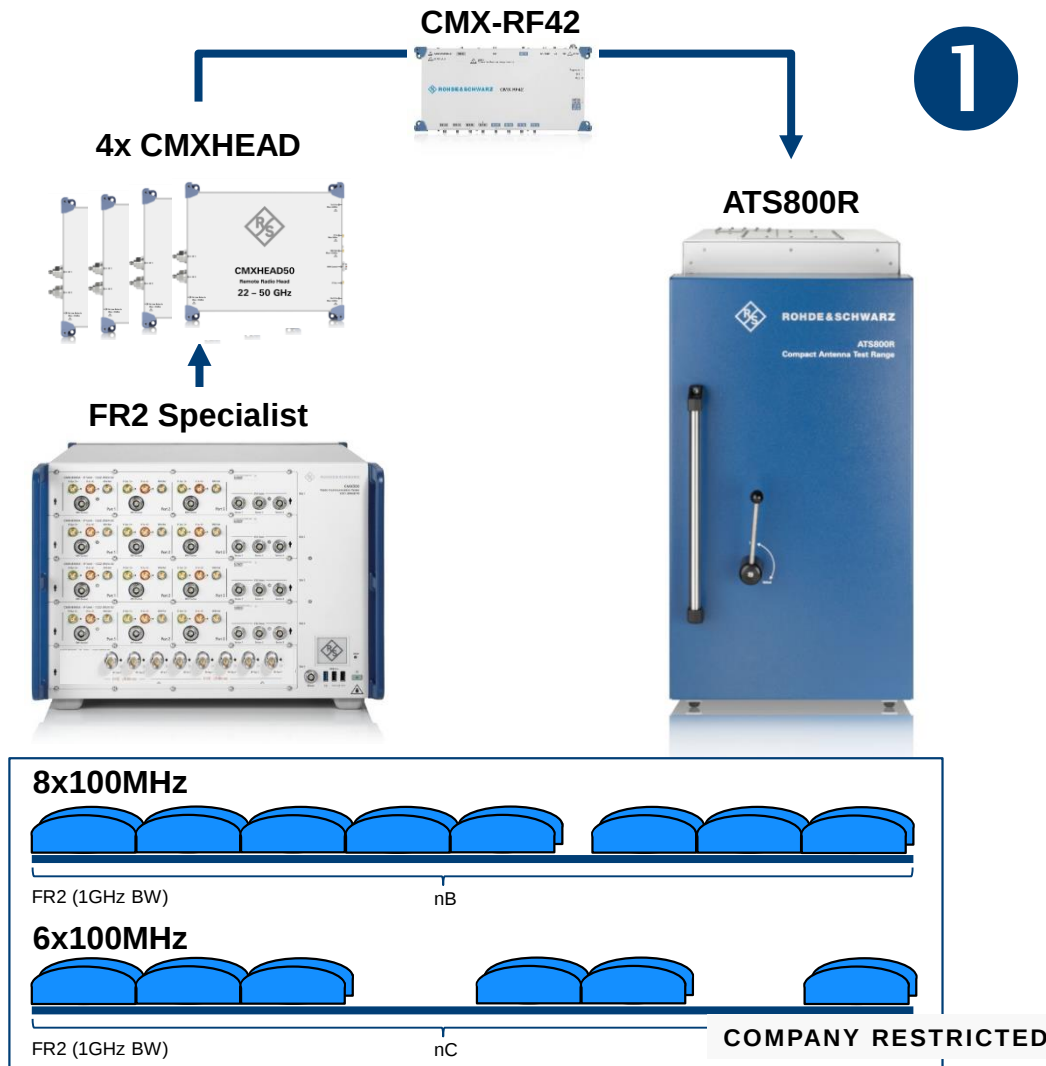
NEW FR2 SPECIALIST

► Advanced FR2 testing:

- Up to 14 CC FR2 with 2x2 + FR1
- >10 Gbps E2E Data TP

► Additional Use Cases

- Interband CA with 2x2 (e.g. 28 + 39 GHz)
- Intra-band CA with 2x2 (>1GHz)



R&S FR2 OTA CHAMBER SOLUTIONS OVERVIEW

	CMQ200	CMQ500	ATS800R	ATS1800C	ATS1800M
					
WxDxH [m]	0.45 x 0.7 x 0.6	0.45 x 0.7 x 0.6	0.6 x 1.2 x 2.0	0.9 x 1.5 x 2.0	~3.5 x 1.5 x 2.0
Application	R&D, production, 5G FR2 device/components	R&D, production, 5G FR1 & FR2 device/components LBS, NPT	R&D, pre-conformance (RF, LBS, Netop, PCT, PQA)	R&D, Conformance & pre-conformance (RF, LBS, Netop, PCT, PQA)	R&D, Conformance & pre-conformance RRM multiple AoA
Type	White box DFF/NF	DFF(FR2)/NF(FR1)	Black box CATR	Black box CATR	Black box CATR
Freq. Range	20 - 77 GHz	700 MHz - 77 GHz	20 - 50 GHz	(6) 23 - 90 GHz	(6) 23 - 90 GHz
Supported freq. Range	Full range	Full range	Full range	23 - 44 GHz (Feed antenna)	23 - 44 GHz (Feed antenna)
Quiet zone	Ø 2 cm @ 40GHz	Ø 2 cm @ 40GHz	Ø 20 cm	Ø 30 cm	4x Ø 30cm
Positioner	-	-	3D Az over EI (opt.)	3D Az over EI	3D Az over EI
Shielding Eff.	> 60 dB	> 80 dB	>60dB (also FR1)	>90 dB	>70dB
Extreme Temp.	4/19/2023	-	1D	3D	

COMPANY RESTRICTED

IP & APPLICATION TESTING

Unique integrated solution – Simplify your test setup!



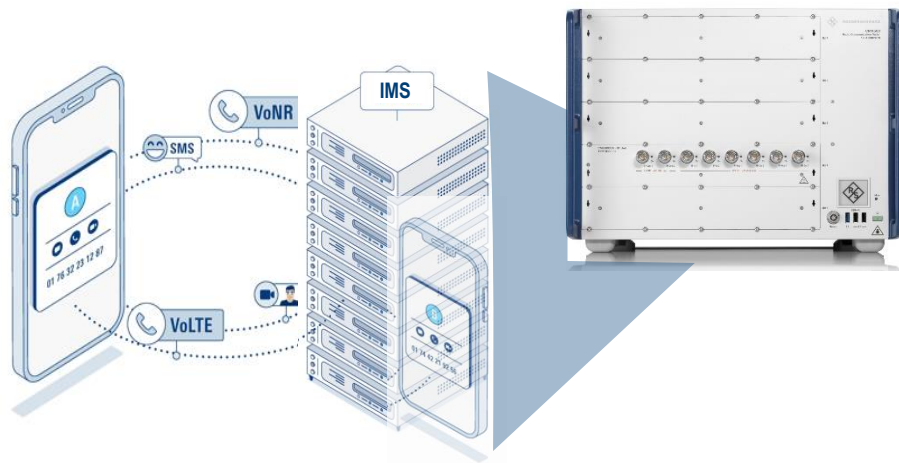
USE CASE - VONR IMS SERVER

Key features:

- fully integrated server

Test capabilities:

- IMS registration & call setup procedures
- VoLTE, VoNR and fallback or handover support
- Voice & Video audio testing
 - All audio codecs & code rates supported (AMR-NB/WB, EVS)
- IP Forward mode for HEAD acoustics labCORE
- Internal POLQA measurement scenarios
- SMS over IMS
- ... and many other features are supported



CMX500 comes with an internal IMS server for IMS, VoLTE & VoNR audio and video call testing

5G AUDIO QUALITY ANALYSIS

R&S CMX500 OFFERS MAXIMUM FLEXIBILITY

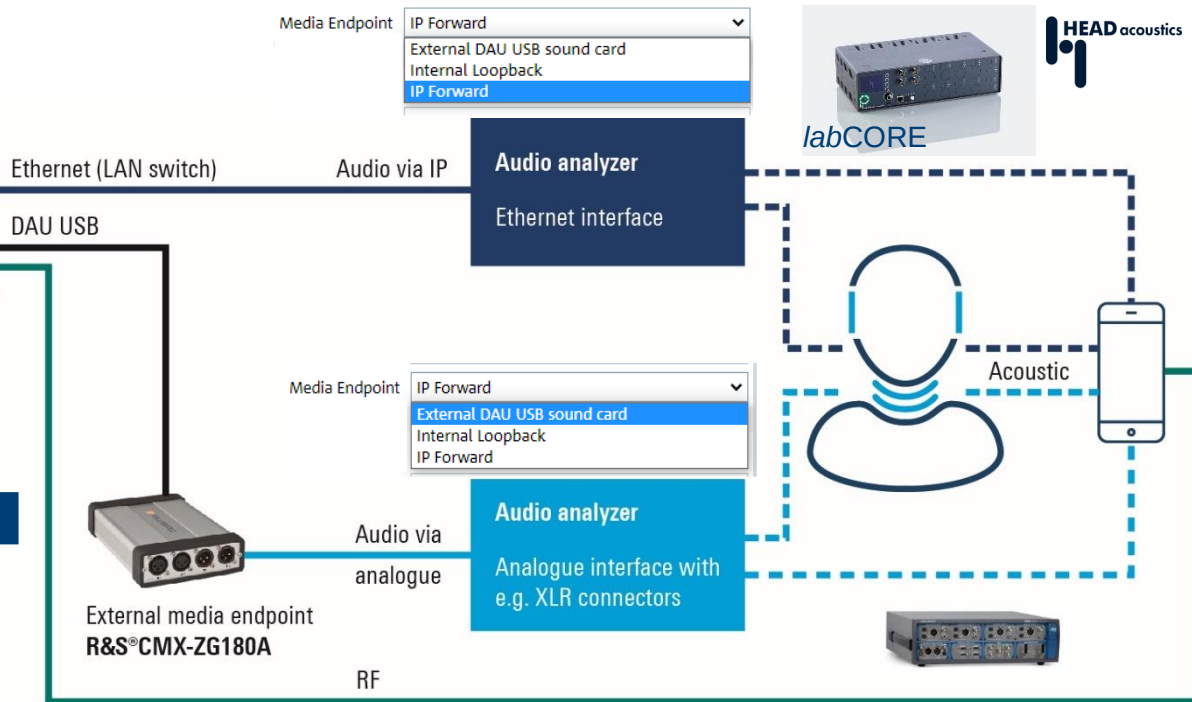
POLQA³



AMR-NB ✓

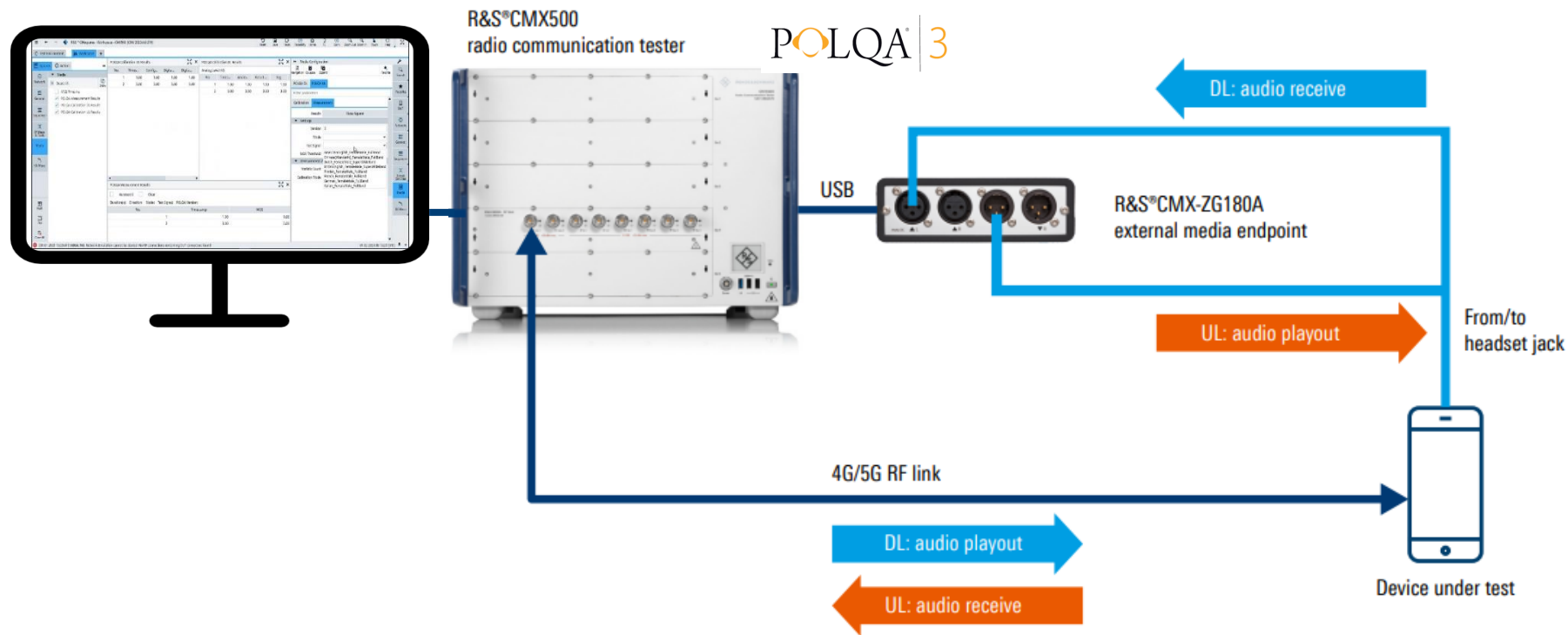
AMR-WB ✓

EVS ✓

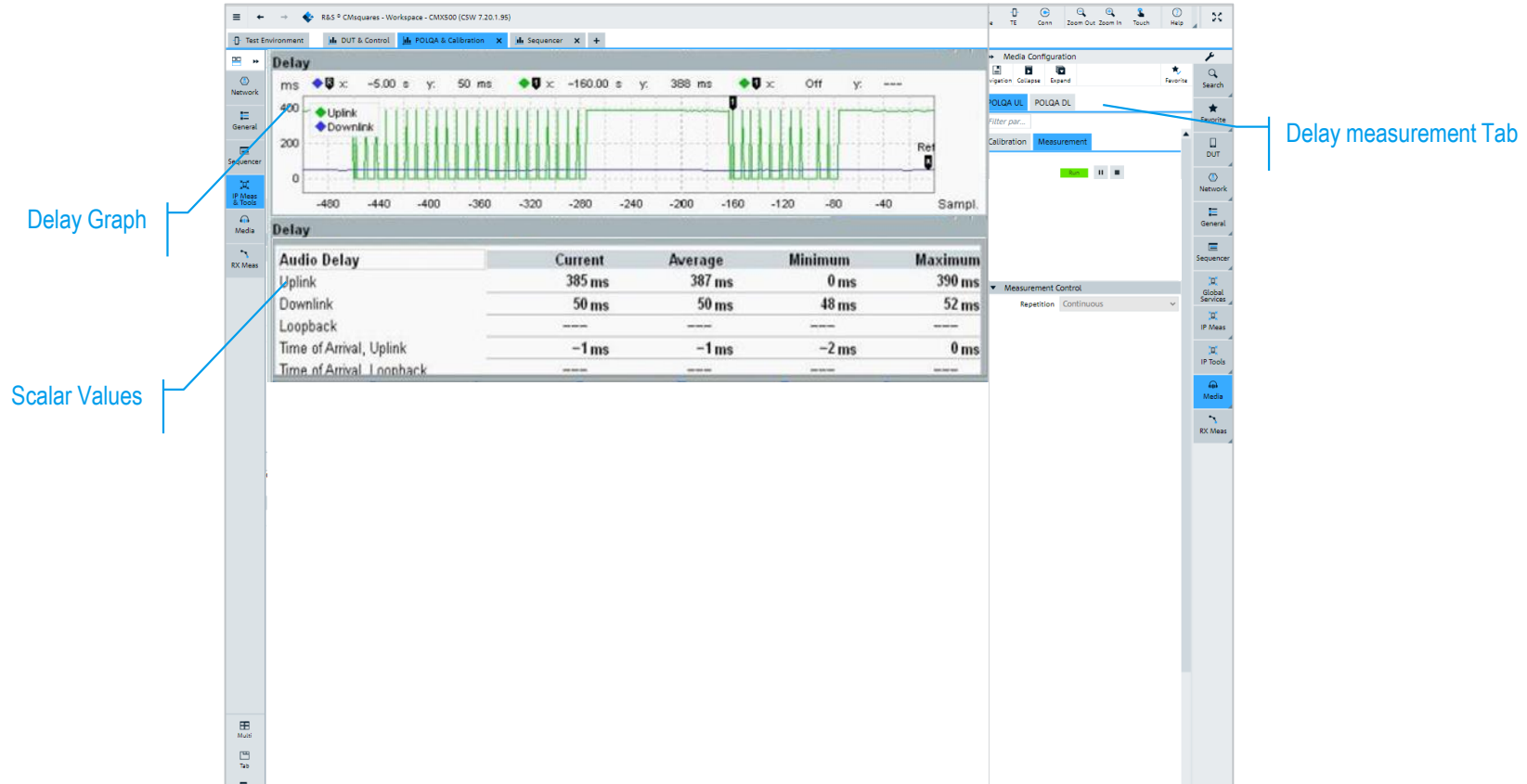


e.g. UPV, Audio Precision, customized solutions a.o.

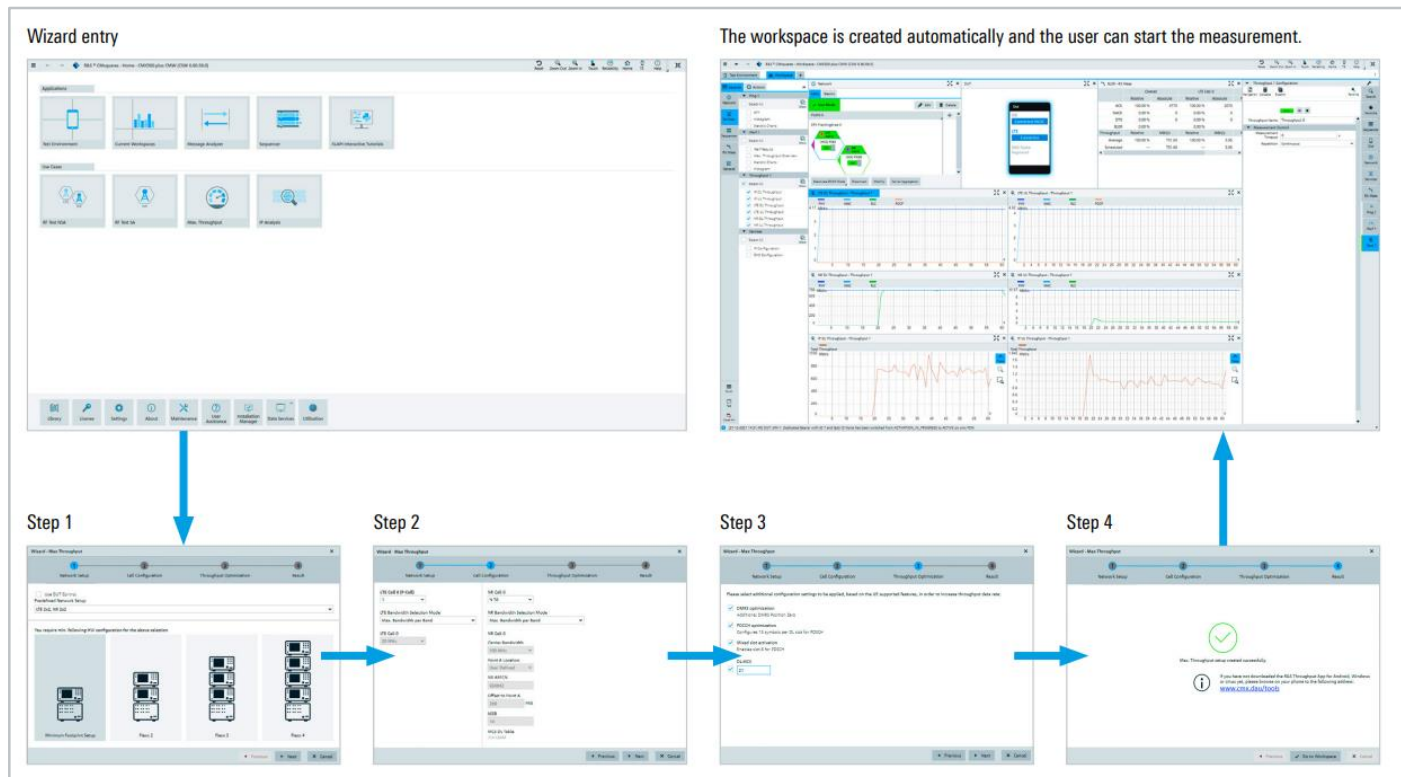
INTERNAL POLQA AUDIO QUALITY MEASUREMENT



AUDIO DELAY MEASUREMENT



USE CASE - MAXIMUM THROUGHPUT TESTING



Wizard (setup assistant) for network and workspace creation for the interactive GUI

IP-TUNE OVERVIEW

- ▶ Easy to use
- ▶ First impression on of the channel characteristics
- ▶ Problem to solve:
 - DUT with unclear capabilities
 - No overview on how to achieve high throughput



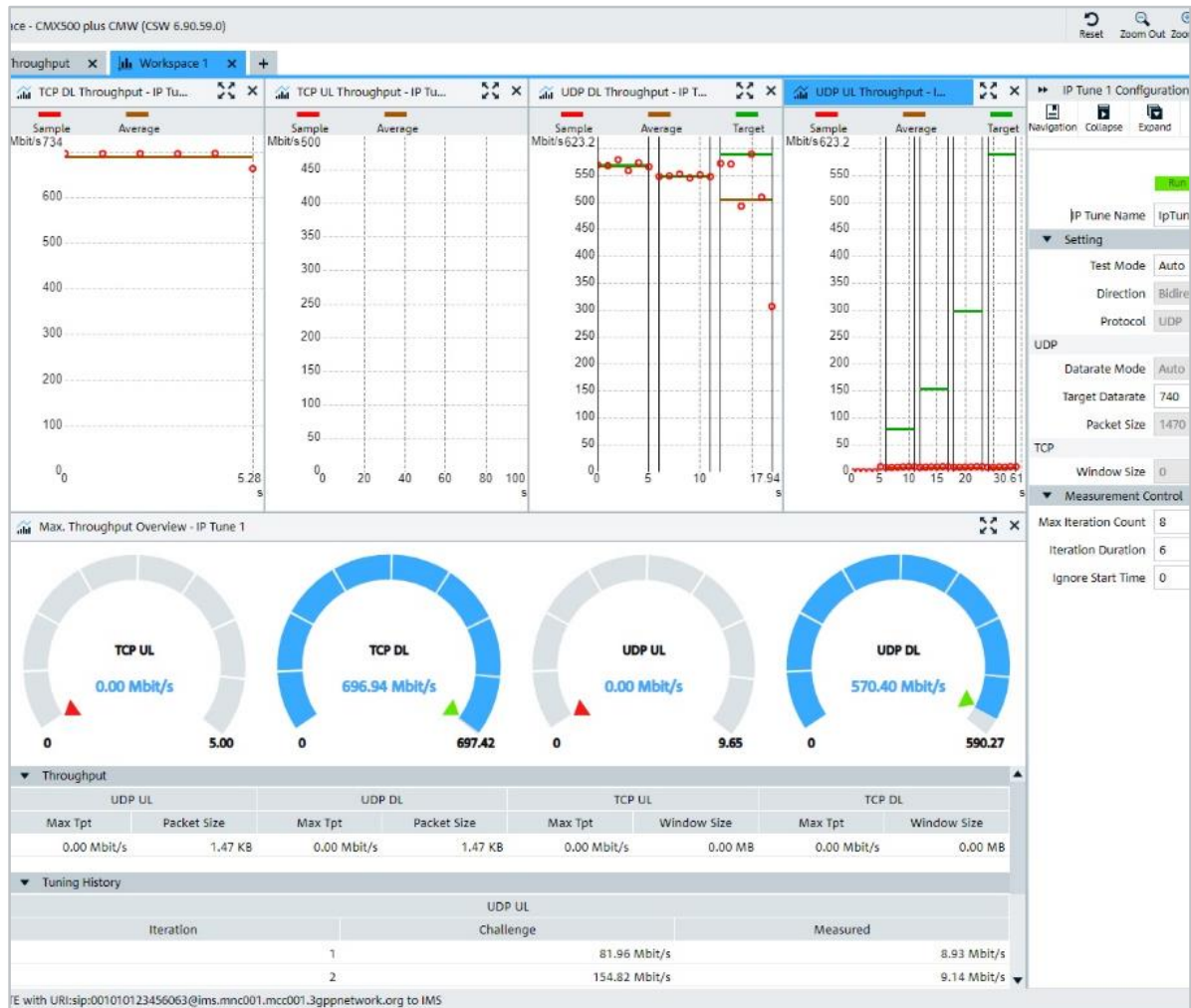
Throughput App 2

Automatic tuning of the IP throughput to the maximum

IP TUNE

► Features:

- Channel Quality overview BLER vs. MCS
- Step by step qualification of current channel UDP/TCP



USE CASE: WLAN OFFLOADING / WLAN CALLING CMX500 WITH INTEGRATED ePDG INTERFACE

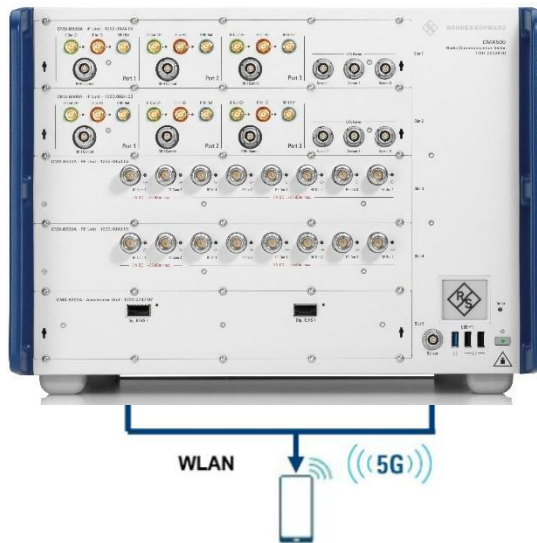
Procedure



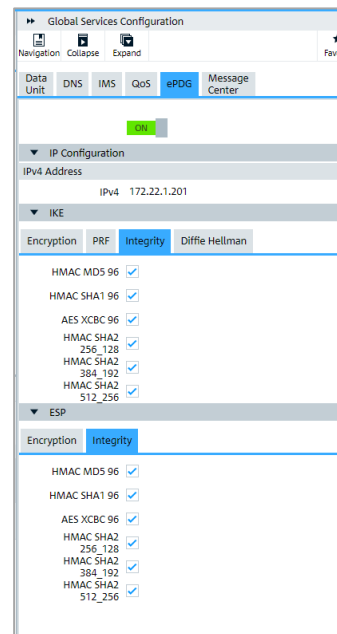
► NR <-> WLAN data offloading

► VoNR <-> WLAN calling

Test setup

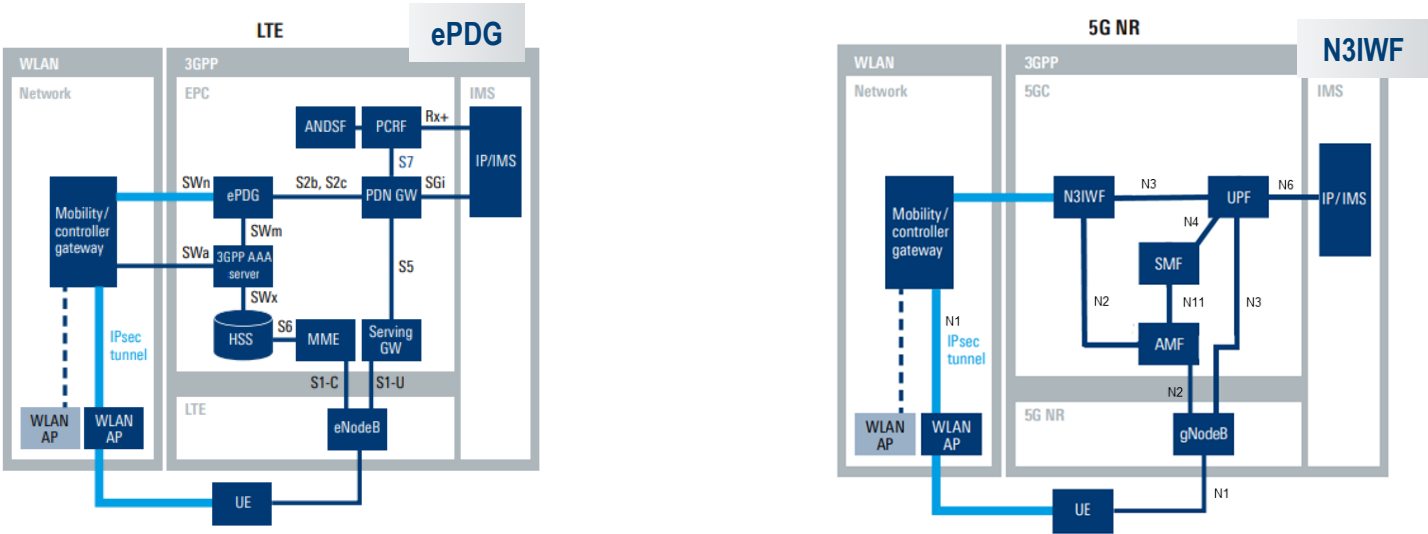


Configuration



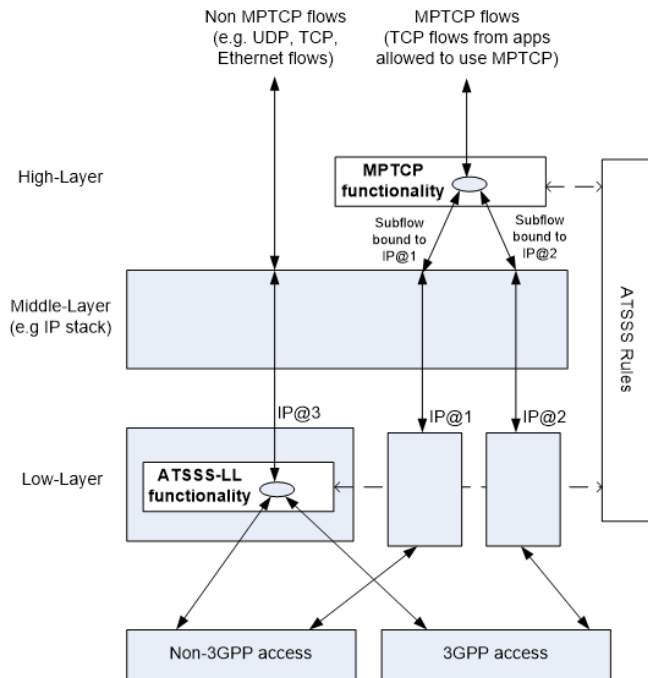
N3IWF – NON-3GPP INTER WORKING FUNCTION

The evolution from LTE based ePDG to N3IWF for 5G-NR network



ATSSS – OVERVIEW

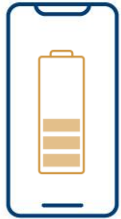
- ▶ **Access Traffic Steering, Switching and Splitting (ATSSS)**
- ▶ On top of N3IWF for 5G NR networks
- ▶ Two **steering functionalities**:
 - ATSSS-LL (operate on lower layer, e.g., IP)
 - MPTCP (use two TCP connections instead of one)
- ▶ Four **steering modes**:
 - smallest delay
 - active-standby
 - load balancing
 - priority based



UE POWER SAVING FEATURES – SUPPORTED ON CMX

Rel-15

Rel-16



DRX

BWP Switching

Wake-Up Signal

RRM measurement
Relaxation

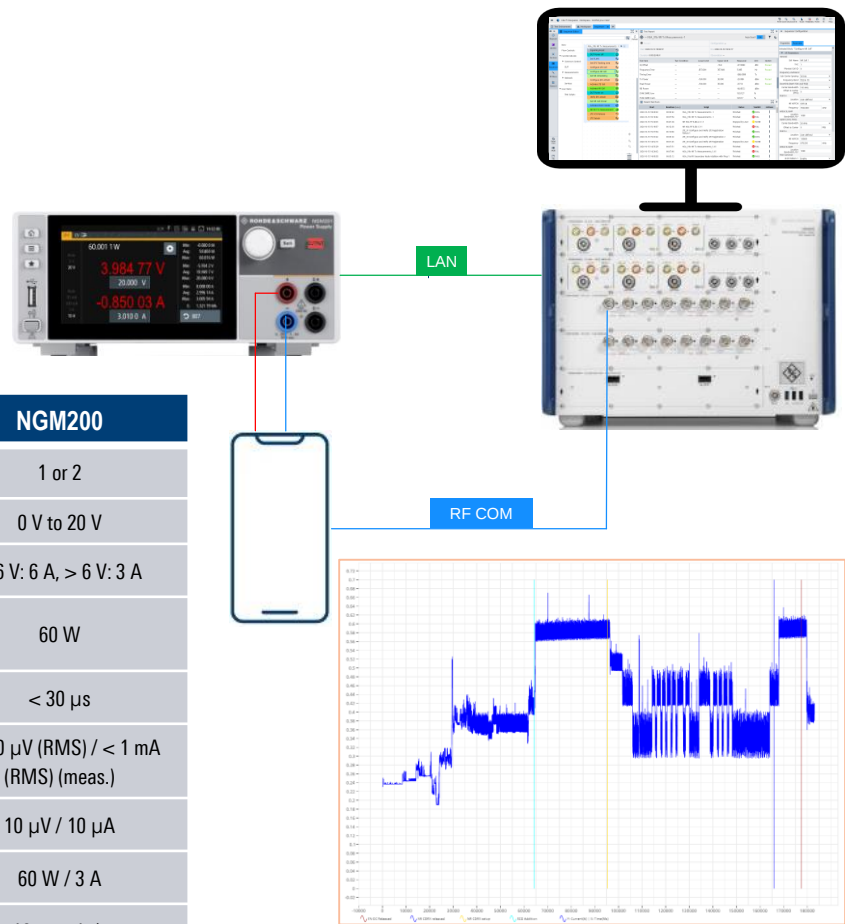
UE assistance
information



BATTERY LIFE MEASUREMENTS

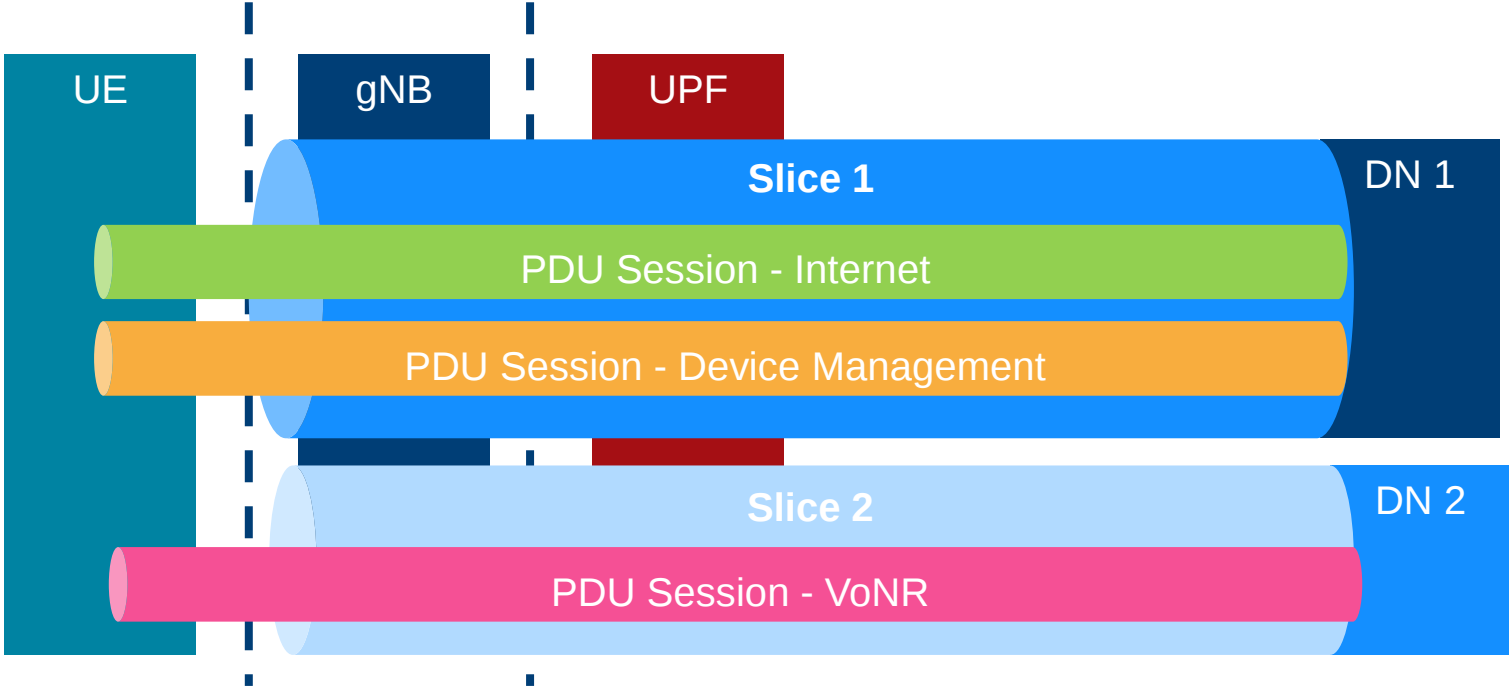
- ▶ DUT Power consumption measurements with CMX500 and NGM Power supply
- ▶ Up to 2-channel measurements of Voltage, Current and Power
- ▶ Rel.16 Power Saving features on CMX500
- ▶ CMX-KM110 option to enable measurements in Cmsquares
- ▶ Test script package for Battery life tests with CMsequencer

	NGM200
Number of channels	1 or 2
Voltage per channel	0 V to 20 V
Max. current per channel	≤ 6 V: 6 A, > 6 V: 3 A
Max. output power per channel	60 W
Load recovery time	< 30 μ s
Ripple and noise	< 500 μ V (RMS) / < 1 mA (RMS) (meas.)
Max. Readback resolution	10 μ V / 10 μ A
Electronic load	60 W / 3 A
Data Logging	10 sample/s



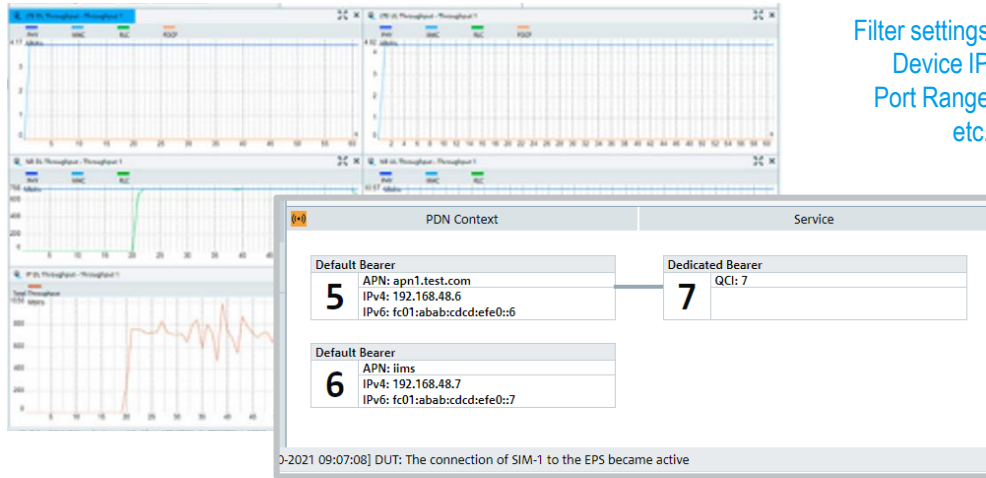
NETWORK SLICING

Example configuration



NETWORK SLICING

- ▶ Throughput per PDU session
- ▶ QoS per PDU session
- ▶ Overview of active slices and PDU sessions



Enable/Disable QoS

Enable/Disable QoS

Filter settings
Device IP
Port Range
etc.

The Services Configuration window shows the QoS tab selected. It includes settings for Profile 0 and Profile 1, with options to enable/disable QoS. The QoS Protocol is set to User_Defined, and the IP Protocol is set to All. The Source Port Range and Destination Port Range are both set to 1-65535. The Filter settings include Route Selection (IP Address) and Impairment (QoS Class). The QoS Class is set to User_Defined, and the TCP Ack Prioritization is checked. The Hop Limit is set to 255, and the Packet Loss Rate is 0.00%. The Delay and Jitter are both 0 ms. The Jitter Distribution is set to NORMAL. The Reordering Rate, Duplicates Rate, and Corruption Rate are all 0.00%. The Max Bit Rate is checked and set to 100000000 Kbit/s.

QoS Tab in Service menu

Add additional Profile settings

Protocol settings

Multiple impairment settings
Packet Loss rate
Delay
Jitter
etc.

USE CASE - INDUSTRIAL INTERNET OF THINGS

- ▶ Ethernet PDU support
- ▶ Delay & Throughput measurement



SUMMARY

- ▶ Future proof 5G NR device test platform
- ▶ Modular and scalable HW-architecture
- ▶ Super flexible software concept
- ▶ Many Use Cases supported
- ▶ There is more to come!





Thank You!