Application Note

VOICE CALL ASPECTS IN 5G NEW RADIO NETWORKS

Functional testing

Products:

R&S®CMW500

R&S®CMX500

Christian Wicke, Fabian Bette | 1SL364 | Version 0e | 10.2021

https://www.rohde-schwarz.com/appnote/1SL364

Contents

1 Overview

Although data services in the context of eMBB, URLLC and mMTC are the pivotal drivers behind the 5G evolution, legacy services like voice and video communications still represent important services that operators want to offer to their subscribers. As part of the technology evolution, we have seen a major change from circuit-switched 2G networks with an initial focus on telephony to fully packet-switched 4G networks focused on internet data communications.

This application note focuses on different details of voice services in 5G networks. Besides some theoretical background this document describes the procedure to setup a 5G network with R&S®CMW500 and R&S®CMX500 radio communication testers and how to carry out different functional voice call tests for 5G networks.

Moreover, this application note includes a 'Tips & Tricks' chapter which gives some hands-on advises for debugging and troubleshooting.

The audio quality tests are not explained in more detail in this document. However, the CMX500 offers maximum flexibility to connect different audio analyzers via IP Forward mode or the External Media Endpoint. Tests can be carried out with T&M devices from Rohde & Schwarz or other equipment. For more information please see section for further reading.

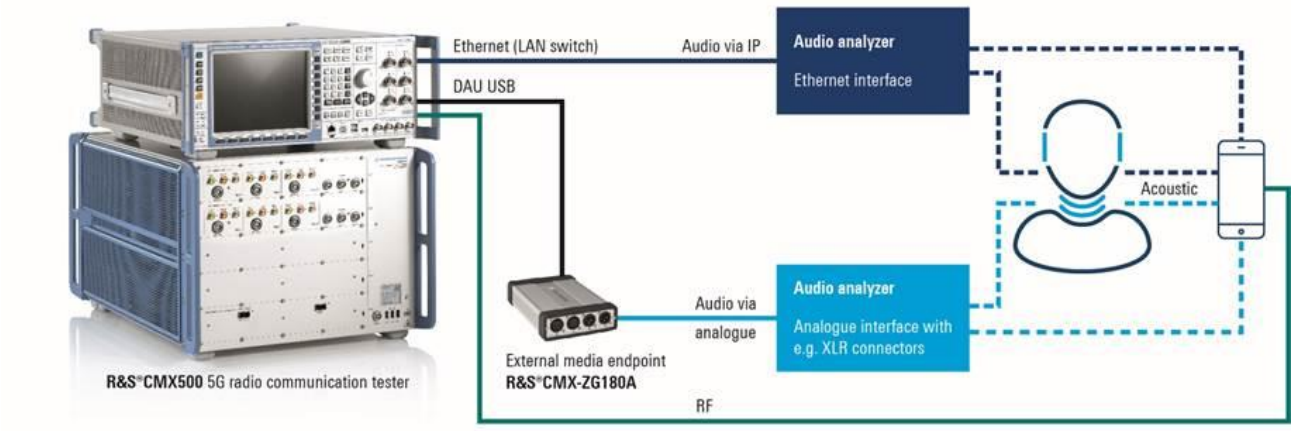


Figure 1: Flexibility of test setup for audio quality testing

2 General voice call aspects in 5G NR networks

When talking about voice in 5G networks this is not limited to VoNR. However, depending on the deployment scenario, several additional ways to handle voice in 5G networks are possible (e.g. VoLTE, EPS/RAT fallback, etc.).

Like the predecessor technology VoLTE, VoNR bases on the IP multimedia subsystem (IMS) architecture. 5G voice calls are implemented as end-to-end voice over IP (VoIP) connections and are managed by the IMS core which acts as a service enabler for voice, video and text services. Unlike voice services provided by external applications, voice over IMS supports quality of service (QoS) management across the entire 5G system.

As mentioned in the beginning, voice aspects in 5G networks show that there is no single implementation of voice. Instead, various different deployment scenarios are supported. Which scenario is used depends i.a. on the Radio Access Technology (RAT) and what Core Network is available. More information about the different deployment scenarios can be found in the following paragraph.

2.1 Deployment scenarios

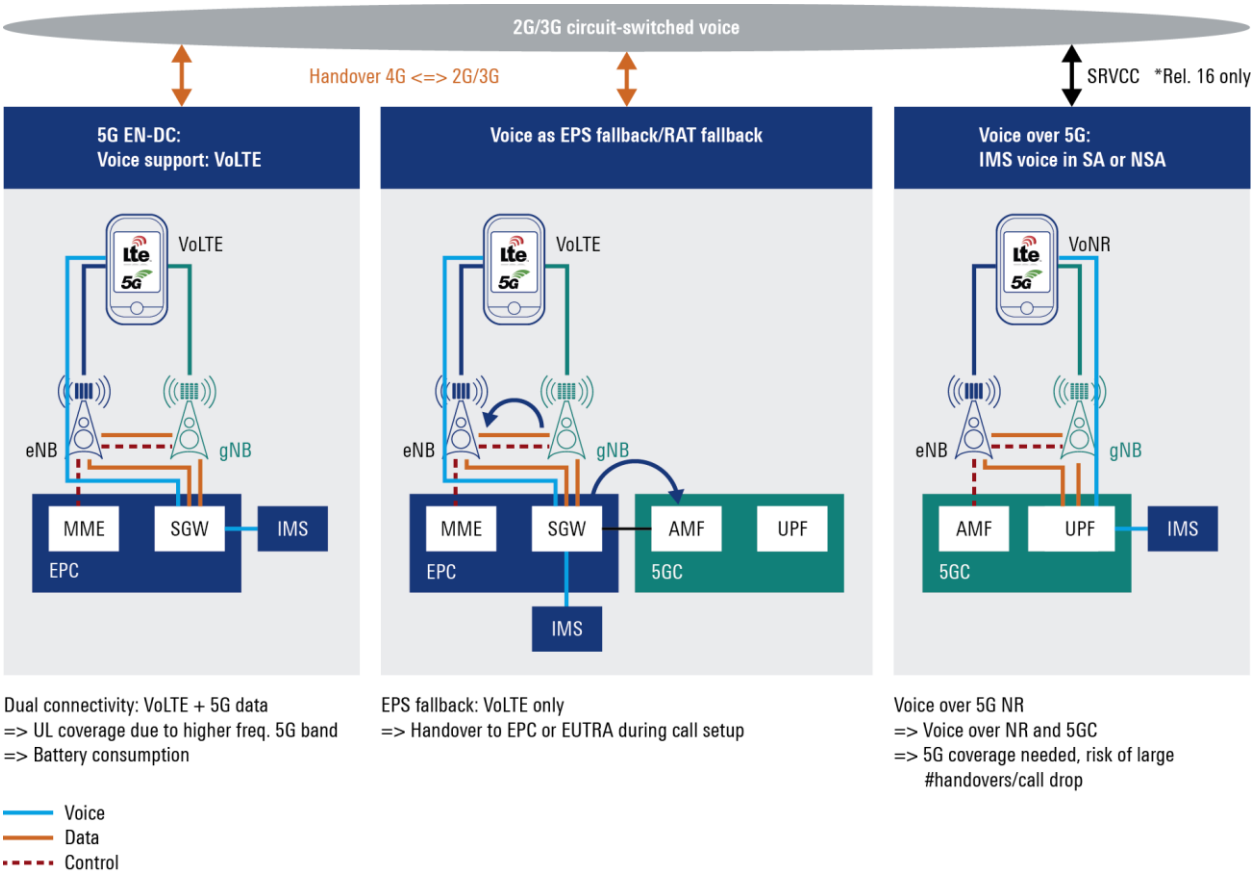


Figure 2: Deployment scenarios supporting voice in 5G

2.2 Audio codec aspects

A test system for voice in 5G networks must support the legacy AMR-NB, AMR-WB and the EVS codecs. The EVS speech codec was introduced with LTE in several networks already, but 5G voice services rely on this advanced speech coding algorithm more extensively. This codec uses Fullband spectrum and allows to handle high-end audio (also called as Full-HD-Voice). Figure 3 visualizes the different bandwidths used by the audio codecs.

- 300 Hz to 3400 Hz: narrowband (NB)
- 50 Hz to 7000 Hz: wideband (WB)
- 50 Hz to 14000 Hz: super wideband (SWB)
- 20 Hz to 20000 Hz: fullband (FB)

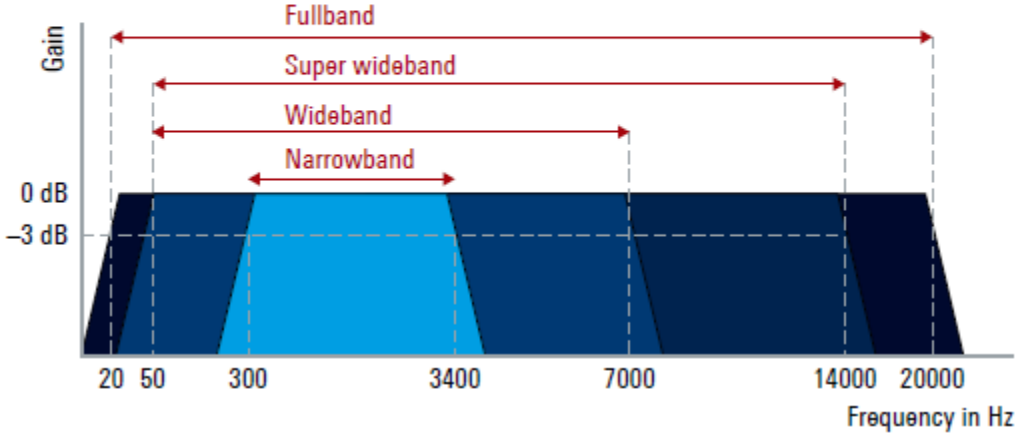
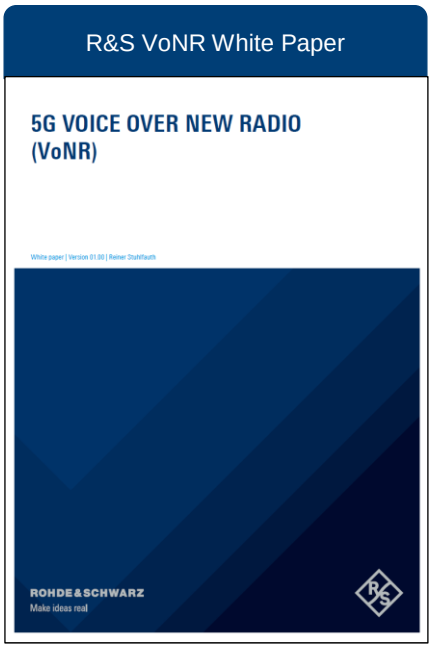


Figure 3: Audio bandwidth

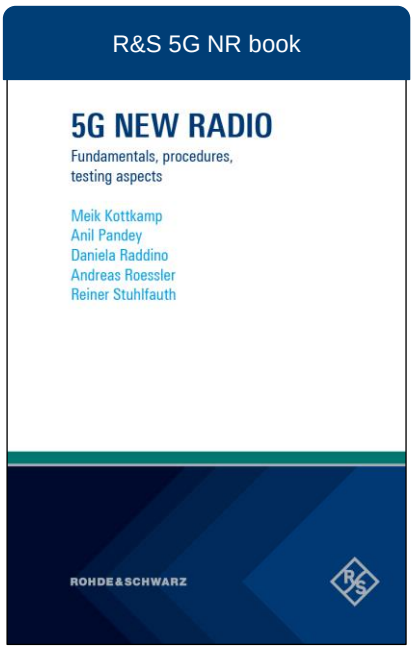
- AMR NB
  - Adaptive Multi-Rate Narrowband
- AMR WB
  - Adaptive Multi-Rate Wideband
- Enhanced Voice Service (EVS)
  - Fullband → covers 20 Hz – 20 kHz (complete audible frequency range of a typical human)

Further reading

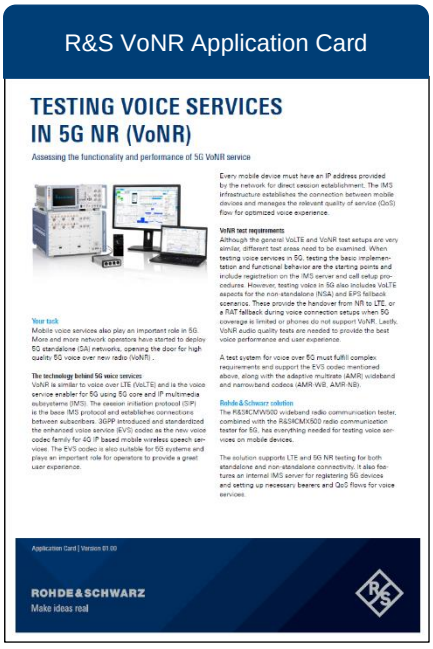
R&S VoNR White Paper



R&S 5G NR book



R&S VoNR Application Card



HEADacoustics Aplication Note

► https://www.rohde-schwarz.com/5G

3 R&S T&M equipment

3.1 Needed equipment and options

Please see chapter Ordering information for detailed information.

3.2 Different interfaces for CMX500

The CMX500 can be controlled via four different interfaces. Figure 4 summarizes them.

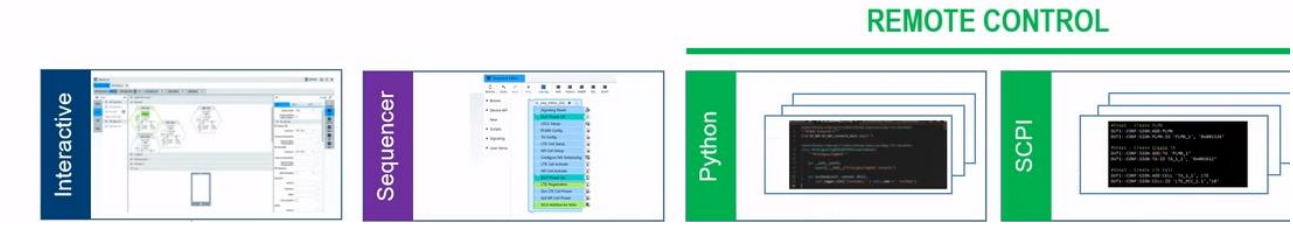


Figure 4: Four different interfaces for controlling the CMX500

- CMsquares: Interactive test mode (GUI)
- CMsequencer: Test campaign-based solution
- XLAPI: Python-based protocol test solution
- SCPI: Remote control via CMX SCPI commands

4 Performing functional tests

4.1 Overview

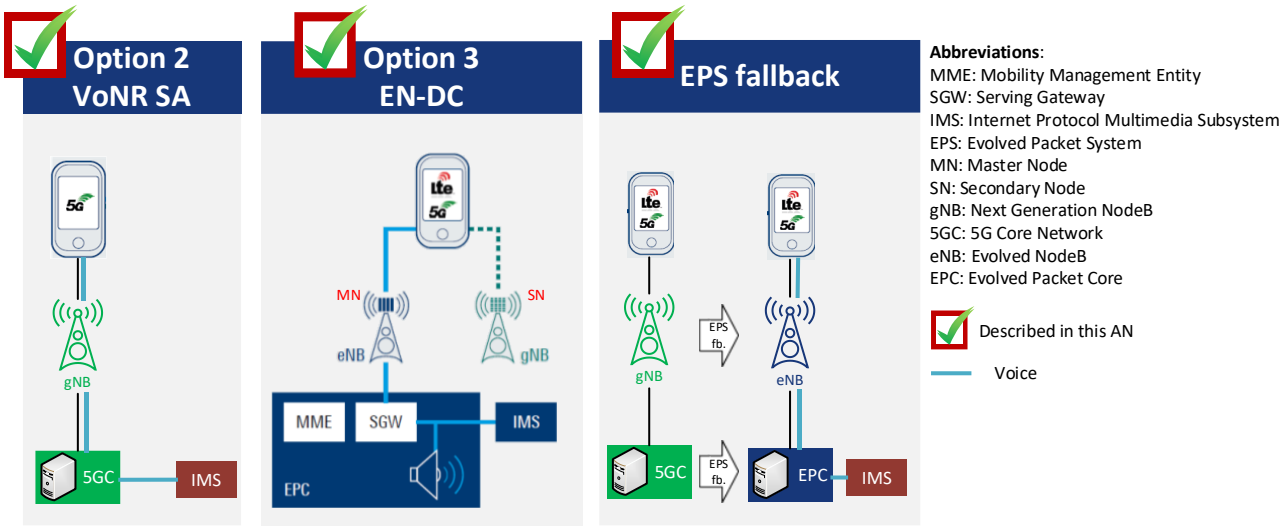


Figure 5: Deployment scenarios described in this application note

4.2 General setup routine before performing the different functional tests

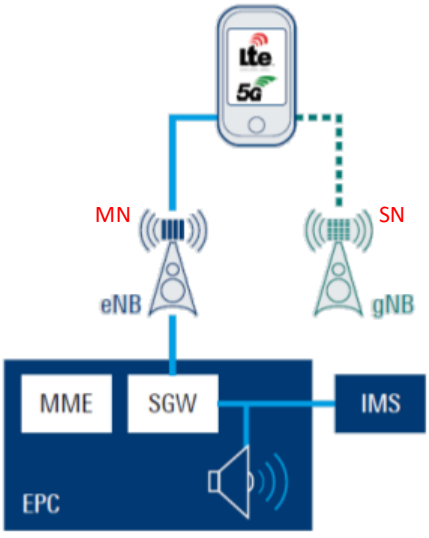
1. Insert the R&S SIM card into the UE
2. Connect the UE to the CMX → Two possible ways
    1. Wired connection
    2. OTA connection via shielded box
3. Not required but highly recommended: Test connection
    1. Ping DUT
    2. Perform some fundamental e.g. NR Tx measurements

Further reading:

► R&S Application Note 1SL368 **5G NR FR1 Non-Standalone UE RF Conformance Testing**: https://www.rohde-schwarz.com/appnote/1SL368

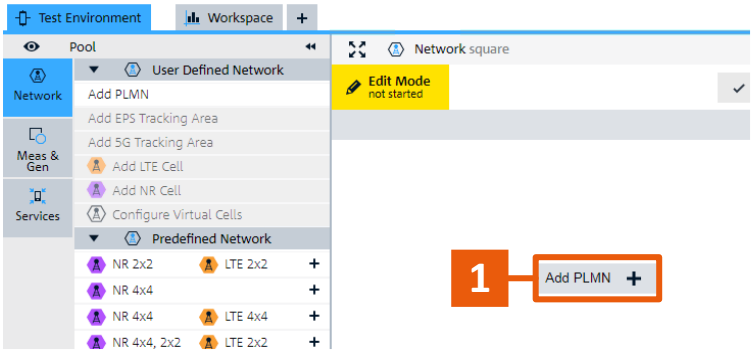
4.3 Network option 3 for NSA (EN-DC)

This section describes the testing procedure for the deployment scenario “Network option 3 in non-standalone mode”.

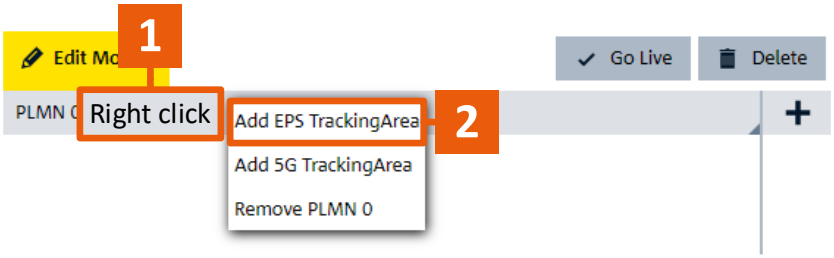


Setup procedure in CMsquares:

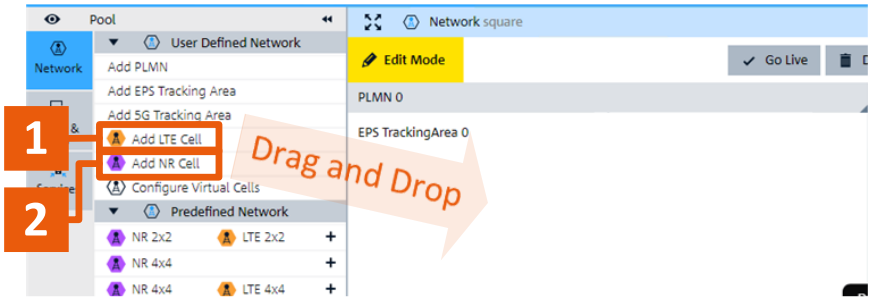
1. Add a **PLMN** to the network square



2. Add an **EPS TrackingArea**



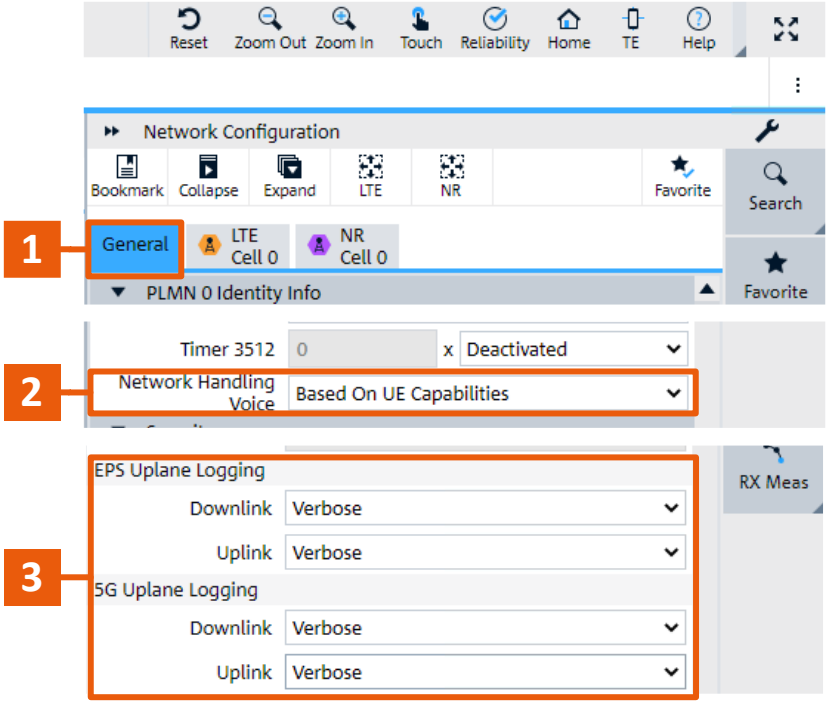
3. Add a **LTE cell** and a **NR cell** to the **EPS TrackingArea**



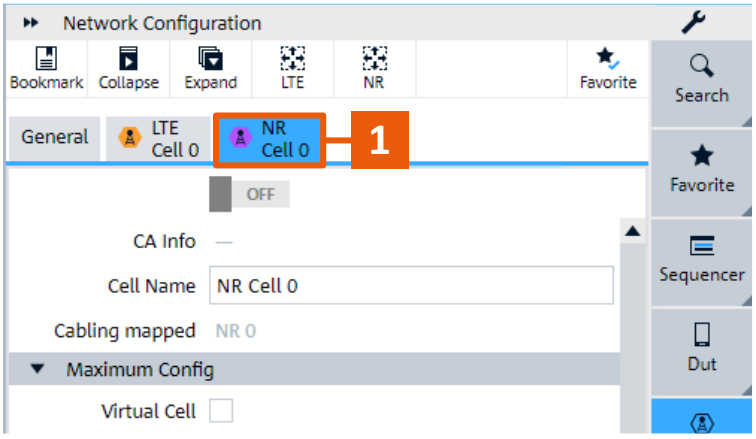
4. Adapt the General settings (sidebar)

   – Select ② **EPS Fallback Redirection** as Network Handling Voice mode

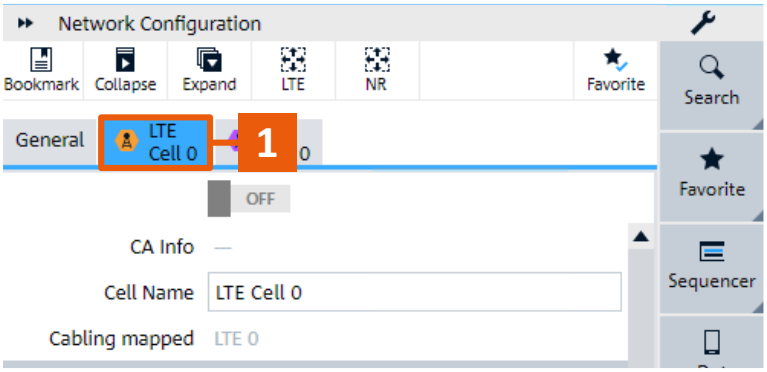
   – Set the Uplane logging to ③ **Verbose** (for Uplink and Downlink)
   → This makes debugging and troubleshooting easier



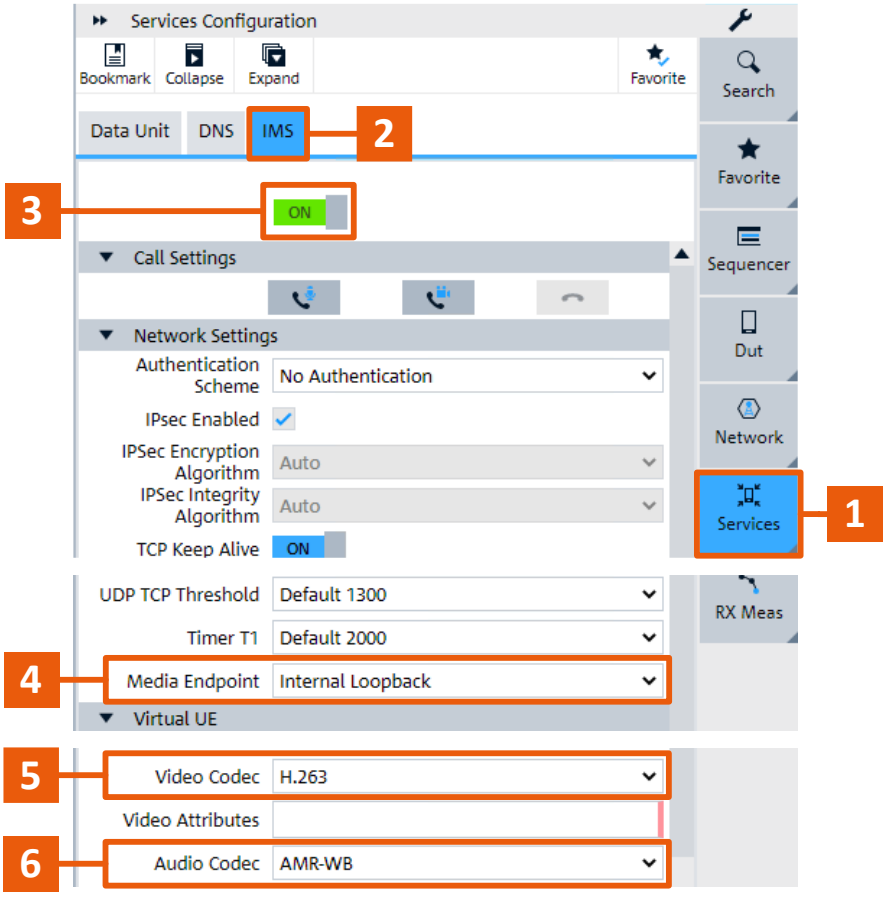
5. Adapt the **5G NR cell specific settings**



6. Adapt the **LTE cell specific settings**



7. Adapt the IMS settings
   - Set Media Endpoint to ④ **Internal Loopback**
   - Select ⑤ **Video Codec** (only required for video calls)
   - Select ⑥ **Audio Codec**



8. Go live with this configuration

9. Setup/Accept a call
   - Setup from UE side
     - Dial any number on the UE
     - Accept the call in DUT control tab
   - Setup a call in CMsquares
     - Establish a call

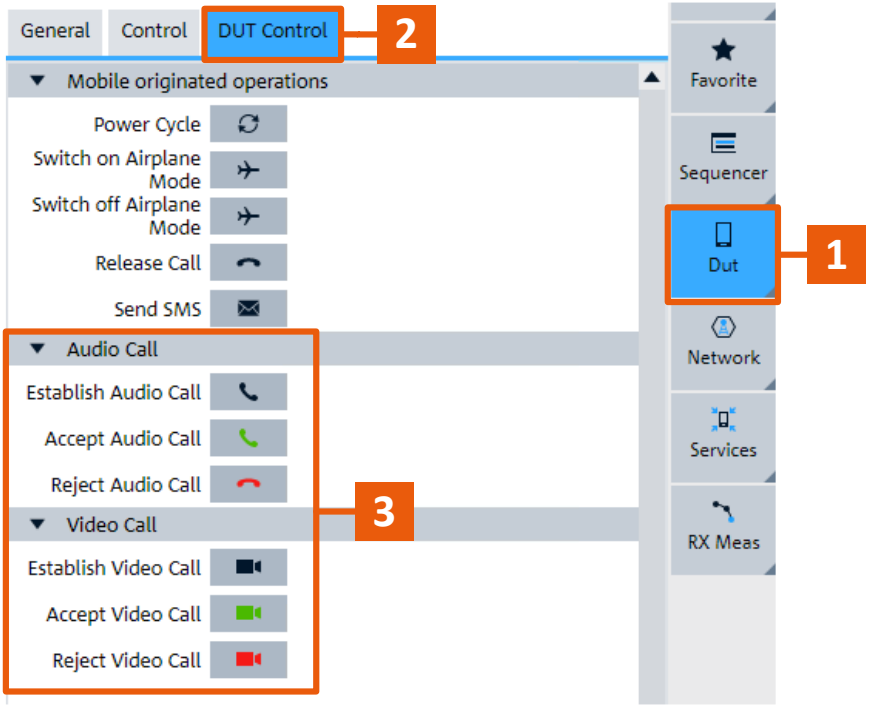
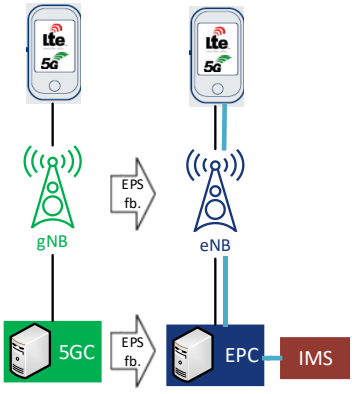


Figure 6: Network option 3 for NSA (EN-DC) scenario

4.4 EPS Fallback Redirection

This section describes the testing procedure for the EPS fallback redirection scenario. In this scenario all voice calls are redirected to LTE.

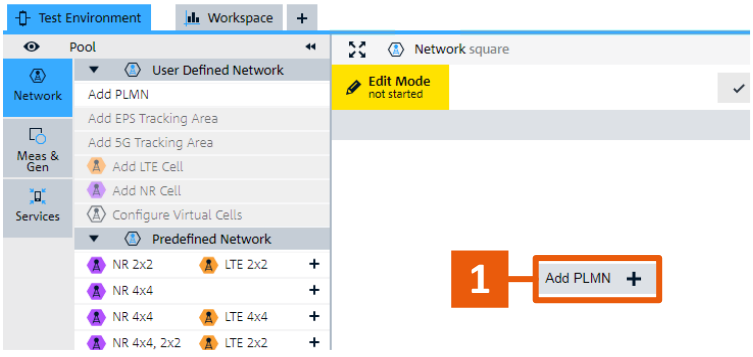


Kind of double handover:

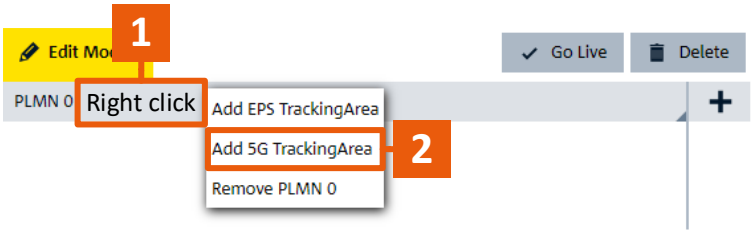
- RAT change from NR to LTE
- Core network handover from 5GC to EPC

Setup procedure in CMsquares:

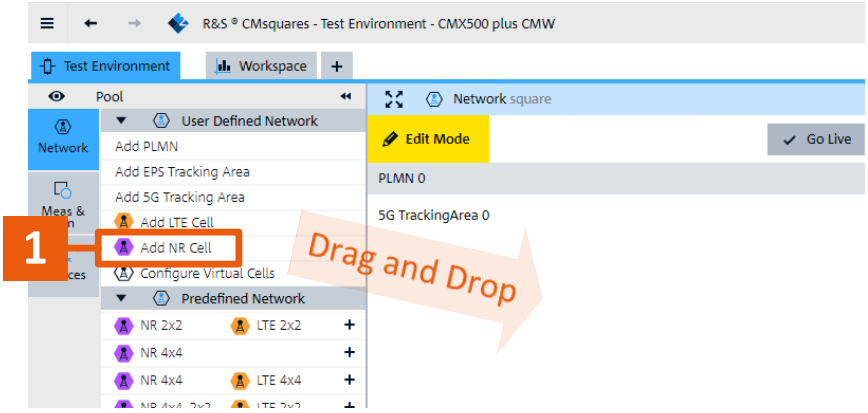
1. Add a **PLMN** to the network square



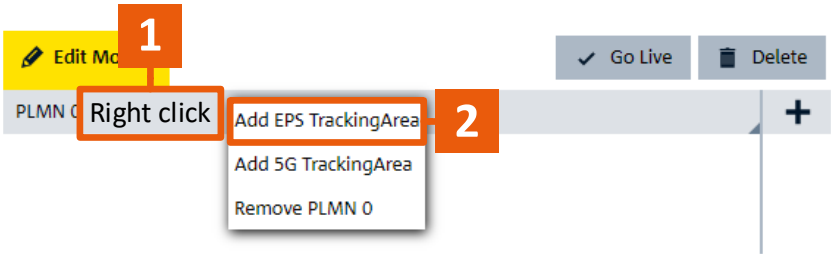
2. Add a **5G TrackingArea** to the PLMN



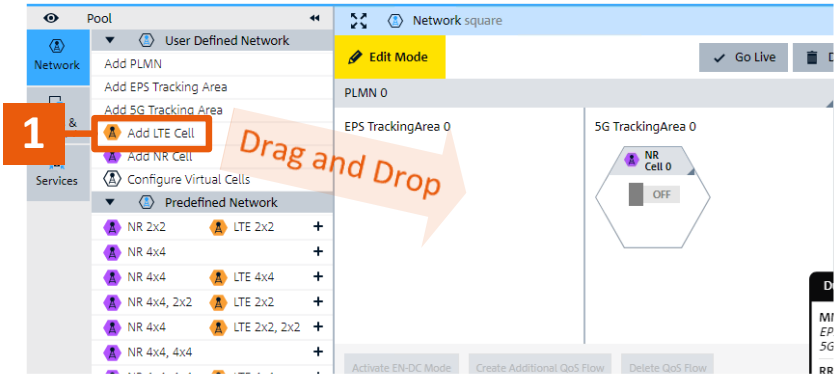
3. Create a **NR cell** in this 5G tracking area



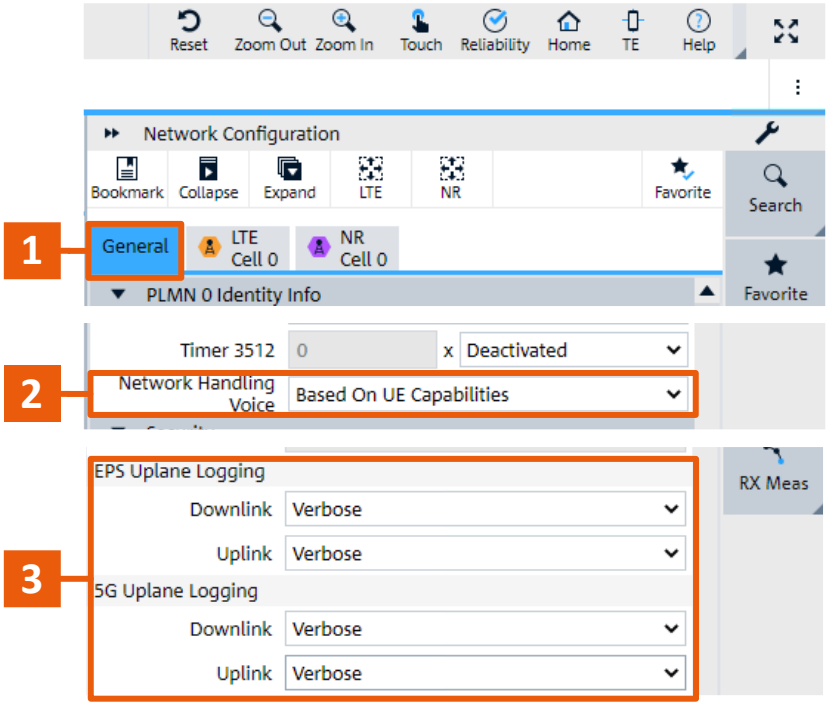
4. Add an **EPS TrackingArea**



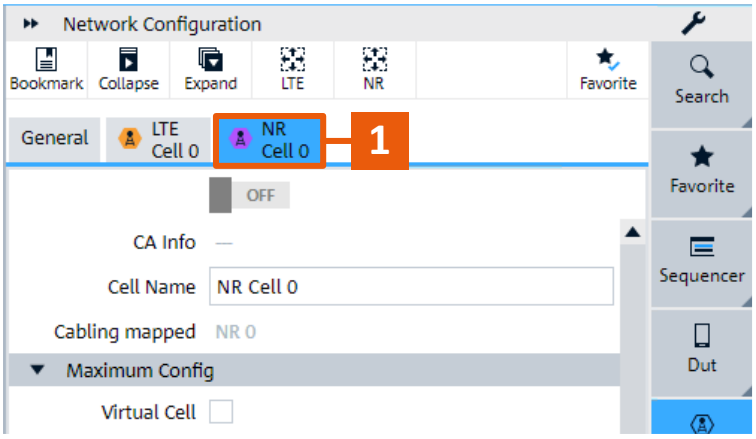
5. Create one or more **LTE cell(s)** in the EPS tracking area



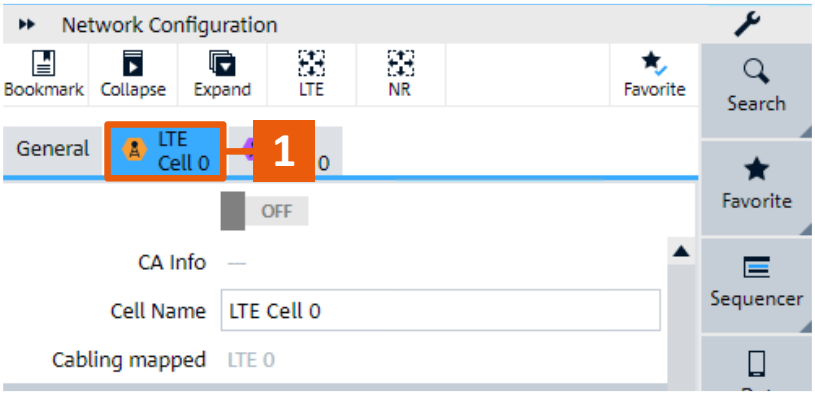
6. Adapt the General settings (sidebar)
   - Select ② **EPS Fallback Redirection** as Network Handling Voice mode
   - Set the Uplane logging to ③ **Verbose** (for Uplink and Downlink)
     → This makes debugging and troubleshooting easier



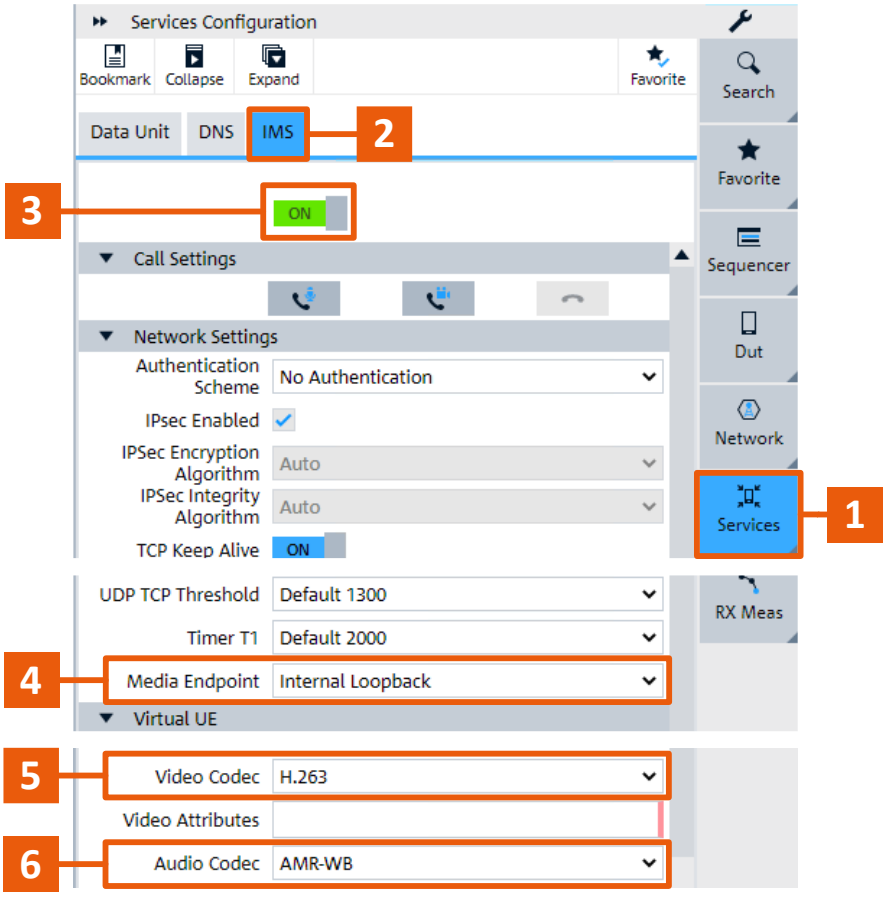
7. Adapt the 5G NR cell specific settings



8. Adapt the LTE cell specific settings



9. Adapt the IMS settings
   - Set Media Endpoint to ④ **Internal Loopback**
   - Select ⑤ **Video Codec** (only required for video calls)
   - Select ⑥ **Audio Codec**



10. Go live with this configuration

11. Setup/Accept a call
    - Setup from UE side
        - Dial any number on the UE
        - Accept the call in DUT control tab
    - Setup a call in CMsquares
        - Establish a call

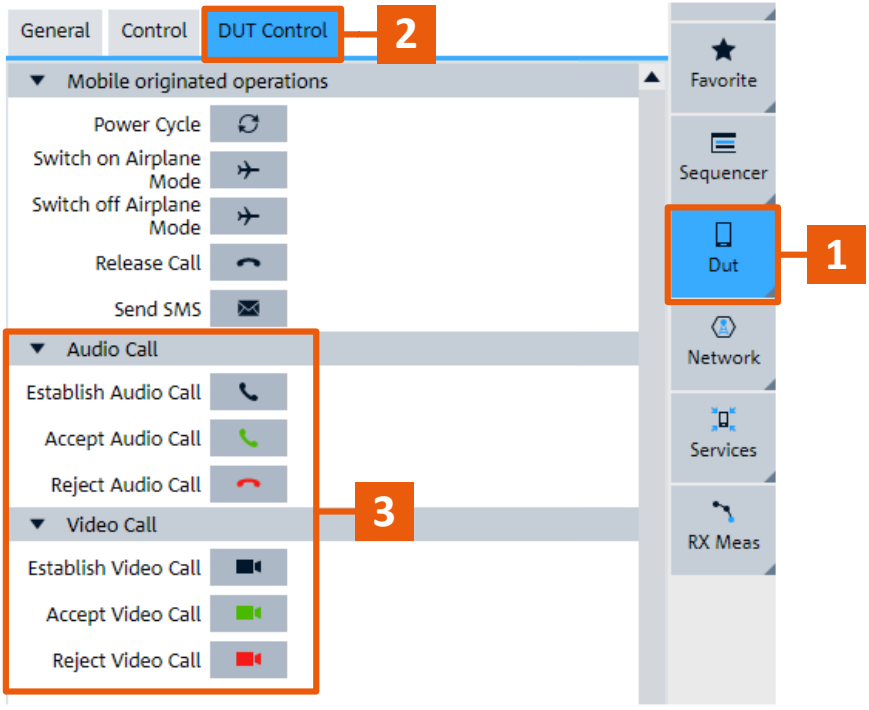


Figure 7: EPS fallback scenario

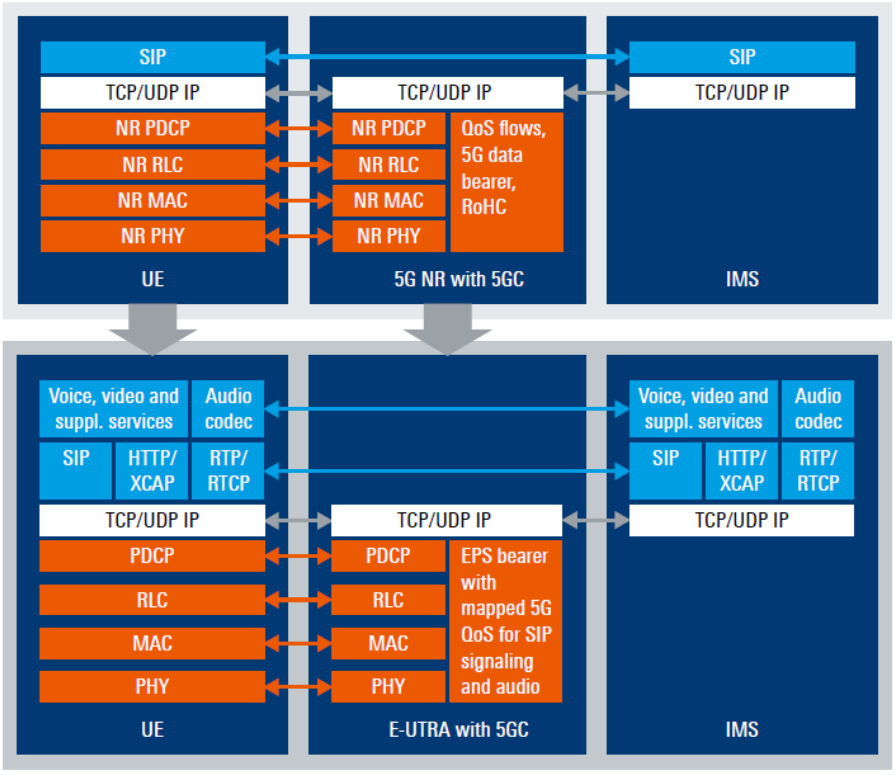


Figure 7: EPS fallback scenario

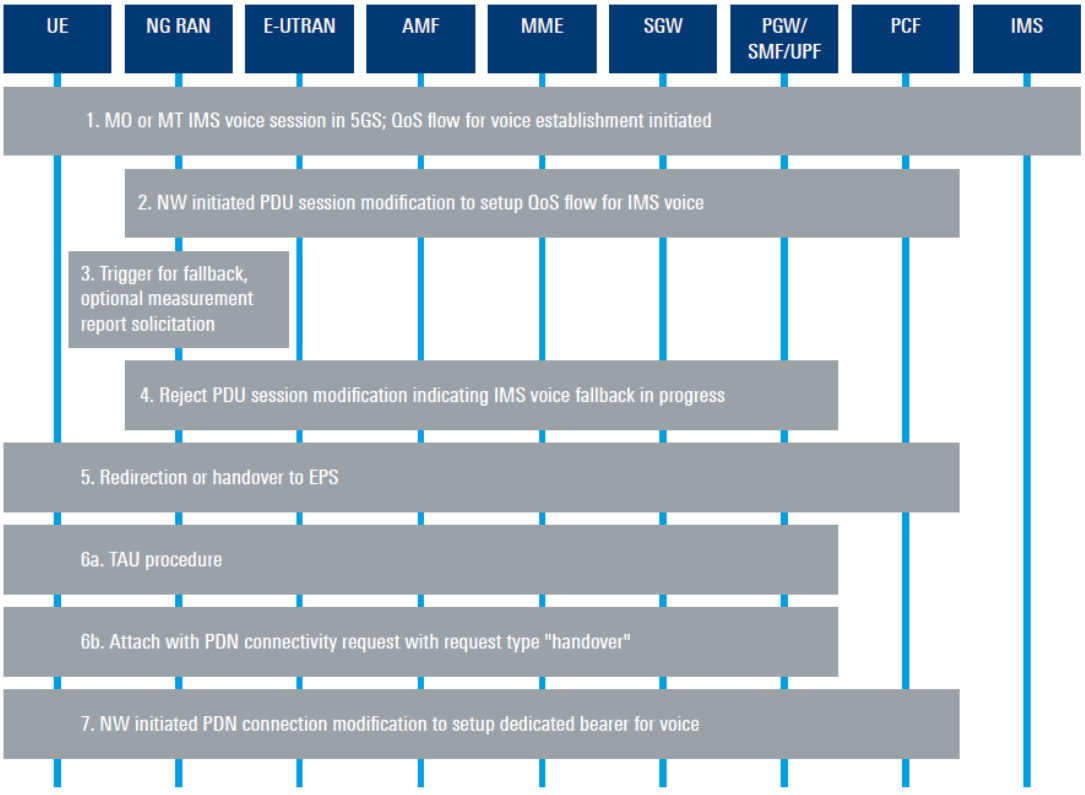


Figure 8: EPS fallback message flow

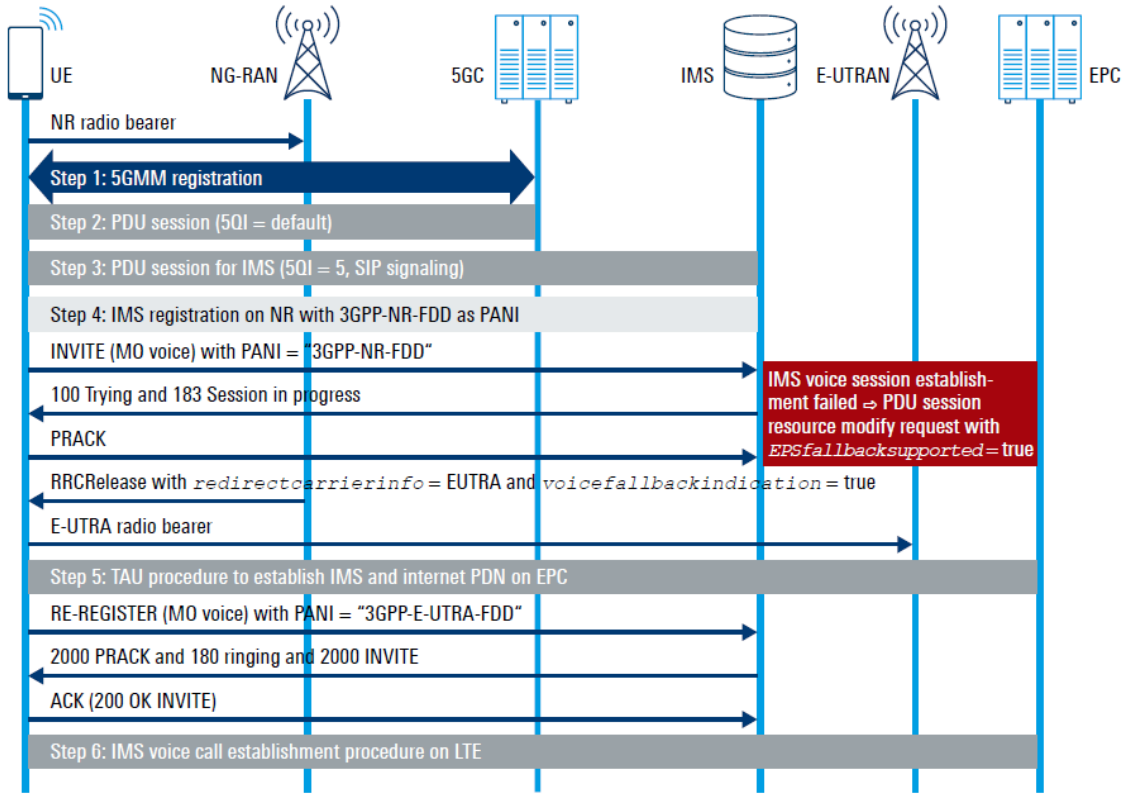


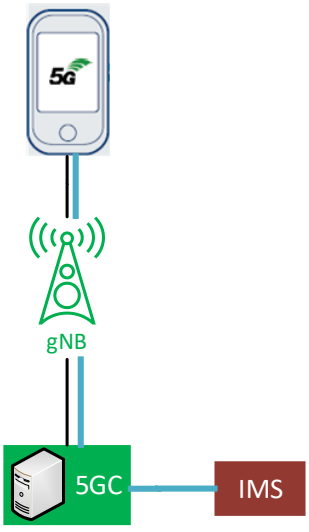
Figure 9: EPS fallback signaling procedure

4.5 EPS Fallback Handover

In the EPS Fallback Handover scenario are all voice calls handovered to LTE. However, this scenario is not described in the current version of application note.

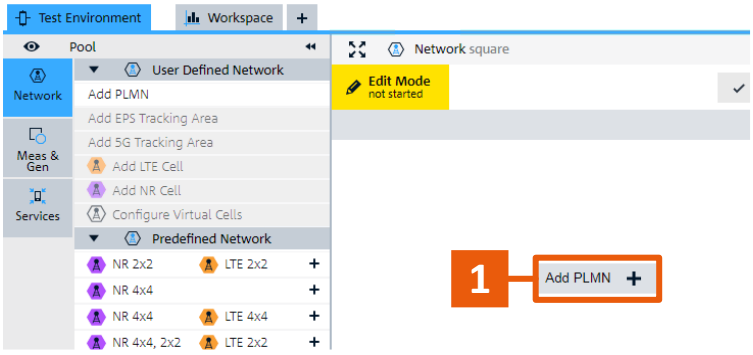
4.6 Voice over NR (SA)

This section describes the testing procedure for the Voice over New Radio standalone scenario.

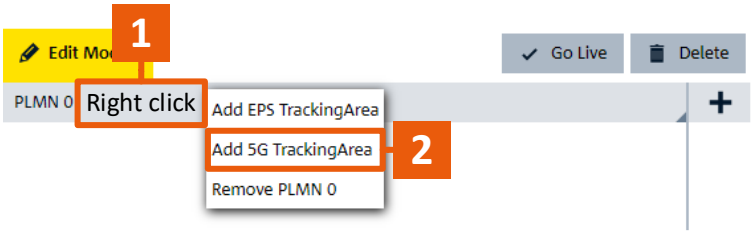


Setup procedure in CMsquares:

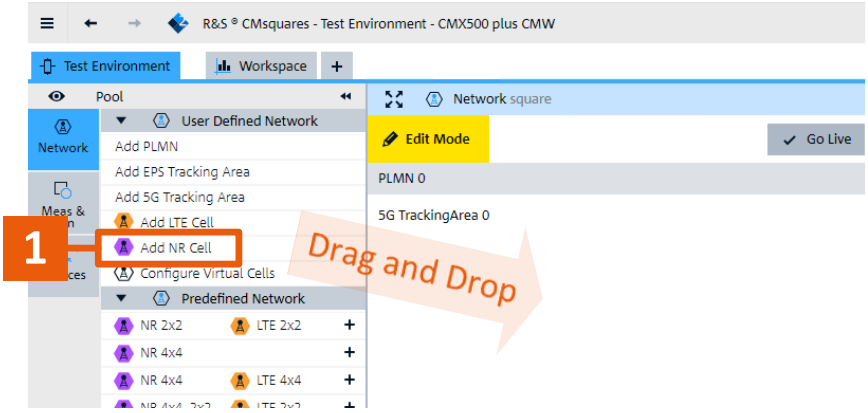
1. Add a **PLMN** to the network square



2. Add a **5G TrackingArea** to the PLMN



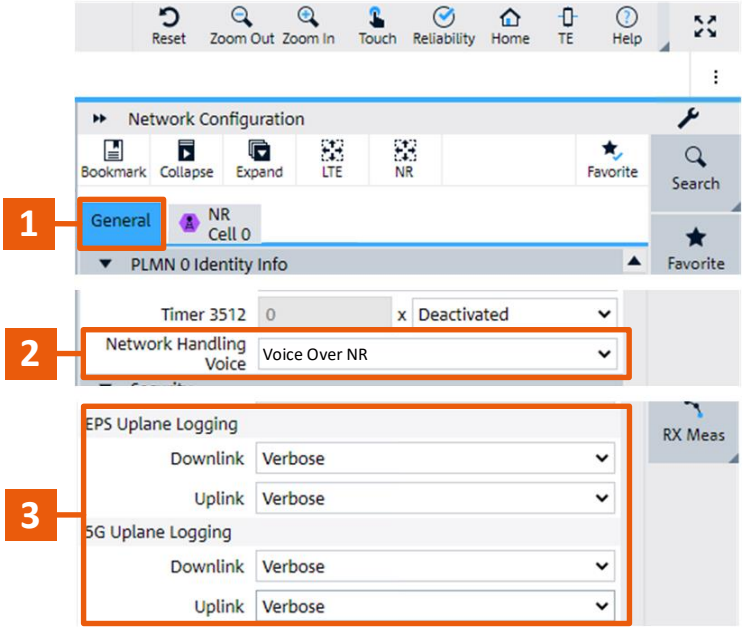
3. Create a NR cell in this 5G tracking area



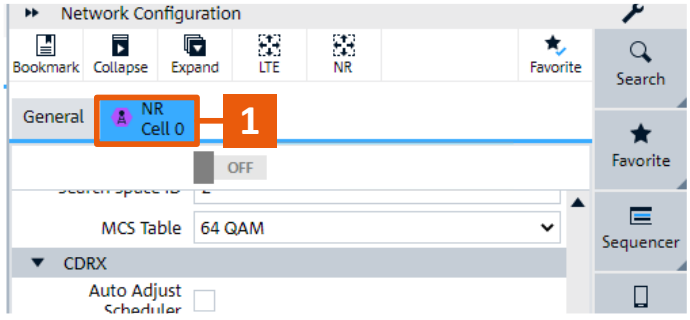
4. Adapt the General settings (sidebar)

   1. Select ② **Voice Over NR** as Network Handling Voice mode

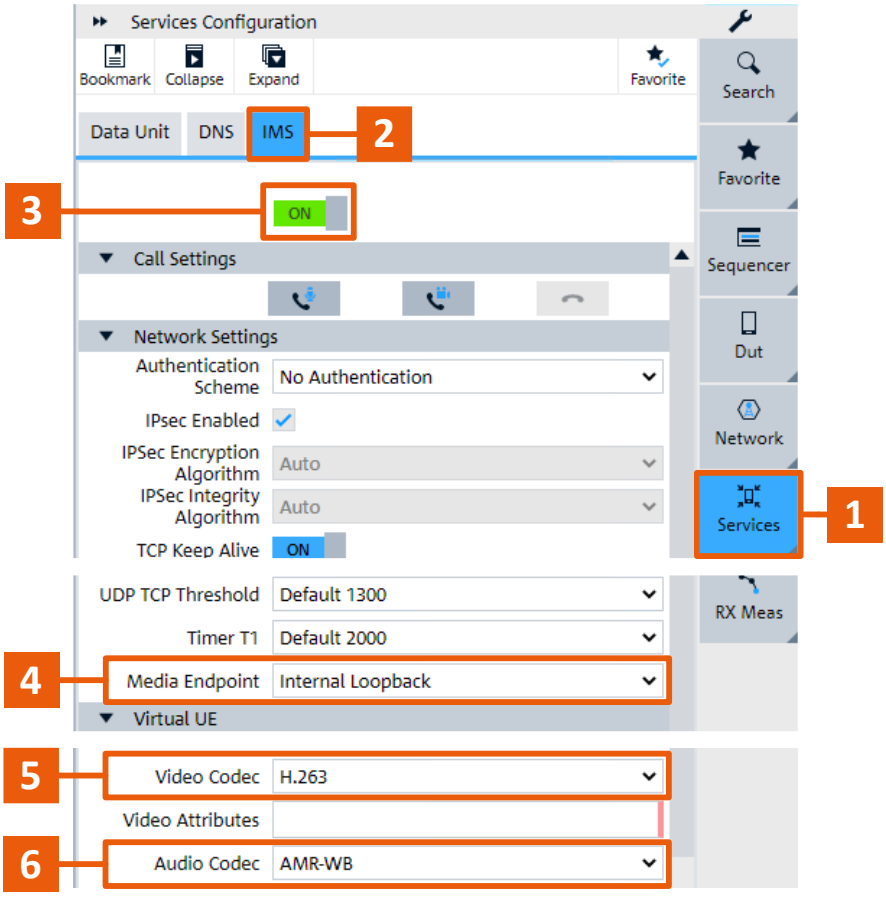
   2. Set the Uplane logging to ③ **Verbose** (for Uplink and Downlink)
      → This makes debugging and troubleshooting easier



5. Adapt the cell specific settings

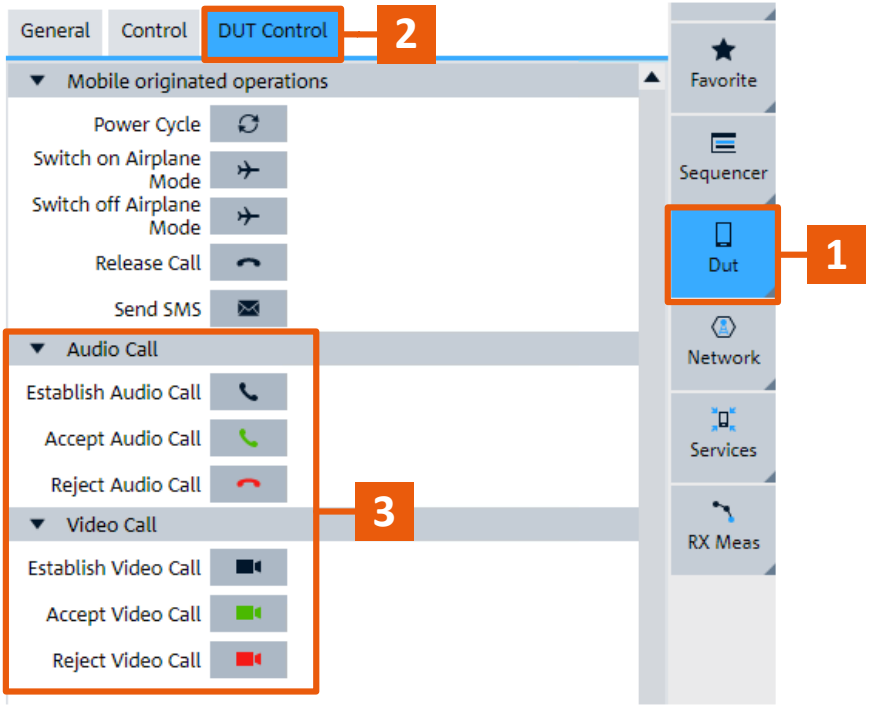


6. Adapt the IMS settings
   - Set Media Endpoint to ④ **Internal Loopback**
   - Select ⑤ **Video Codec** (only required for video calls)
   - Select ⑥ **Audio Codec**



7. Go live with this configuration

8. Setup/Accept a call
   - Setup from UE side
     - Dial any number on the UE
     - Accept the call in DUT control tab
   - Setup a call in CMsquares
     - Establish a call



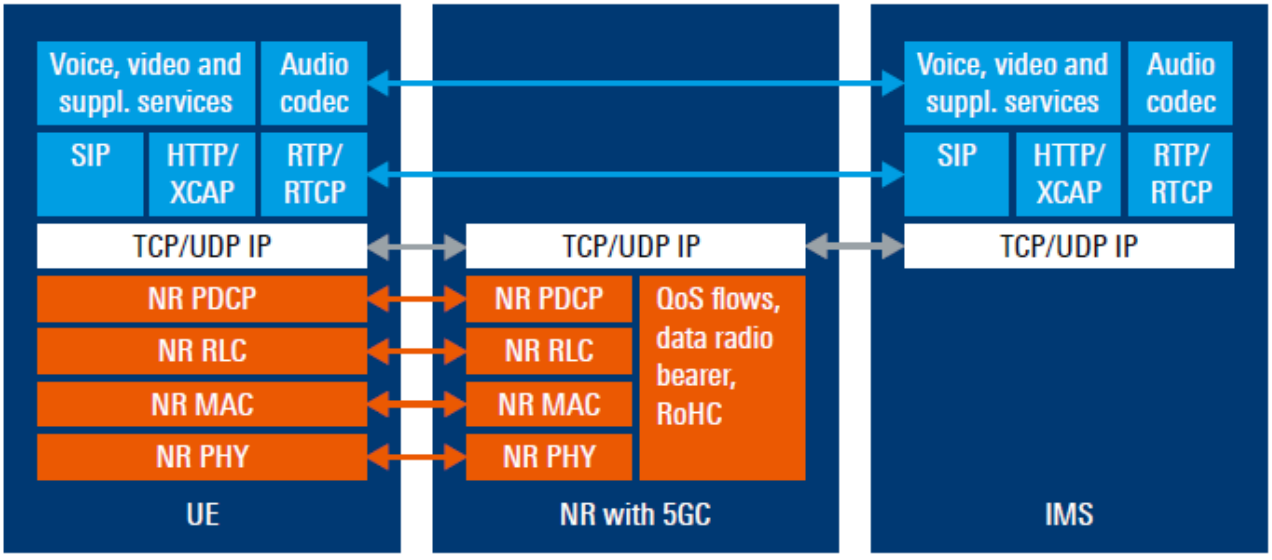


Figure 10: Voice over NR (VoNR) standalone scenario

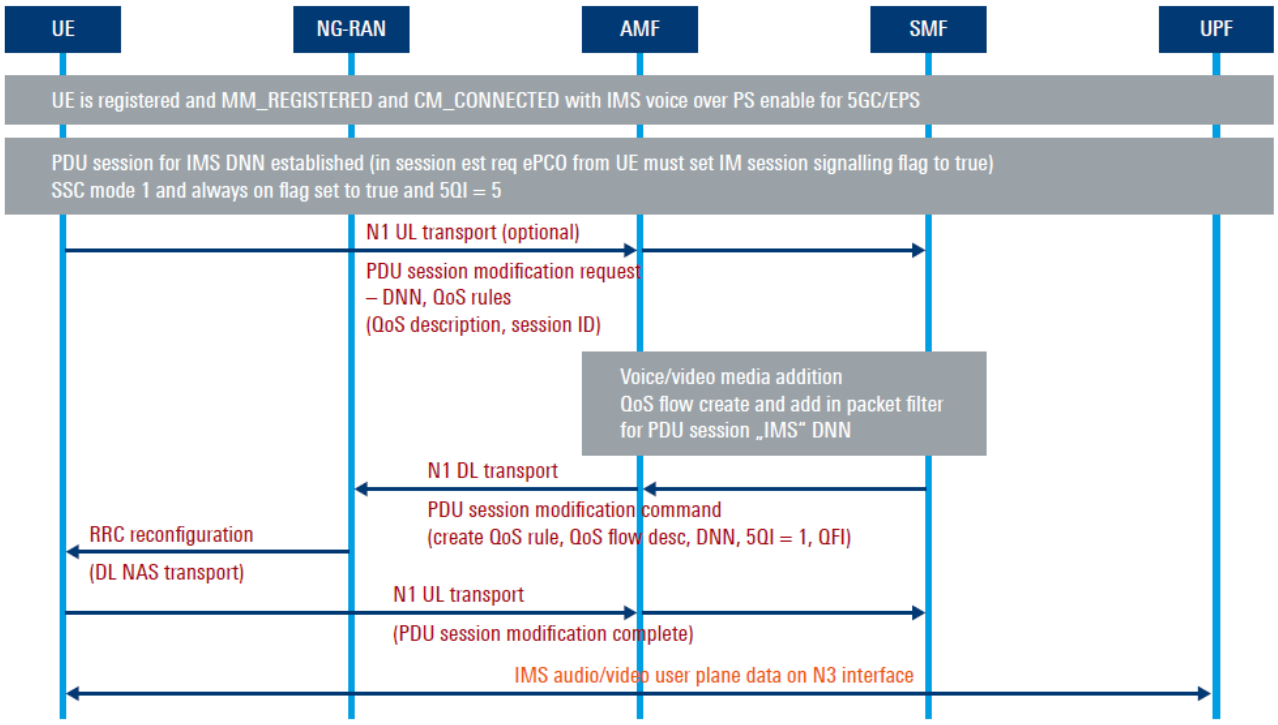


Figure 11: Voice over NR message flow

5 Tips and Tricks

5.1 Debugging with CMXmars

R&S®CMXmars provides a huge feature set for analysis and debugging. Simplified views of the message sequencer chart, user equipment capability views and detailed views of message content trees help to monitor the test execution in real time. Of course, the same message log is available offline and can be downloaded along with the measurement report.

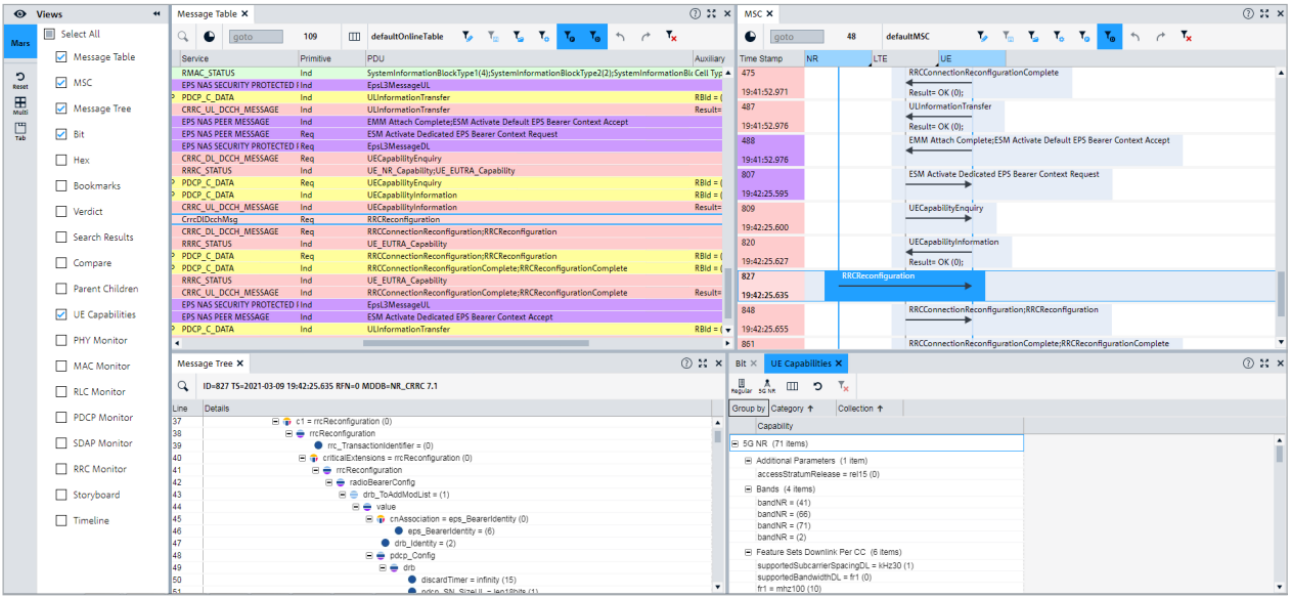


Figure 12: Screenshot of R&S®CMXmars

CMXmars can be accessed via the browser-based GUI of CMX.

5.2 Packet capture feature

The CMsquares allows to download the detailed packet capture logs. This functionality allows to export the packet capture session (.pcapng file) and analyze them with the open source packet analyzer Wireshark

The packet capture feature can be accessed via the Home screen → Data Services → Packet capture.

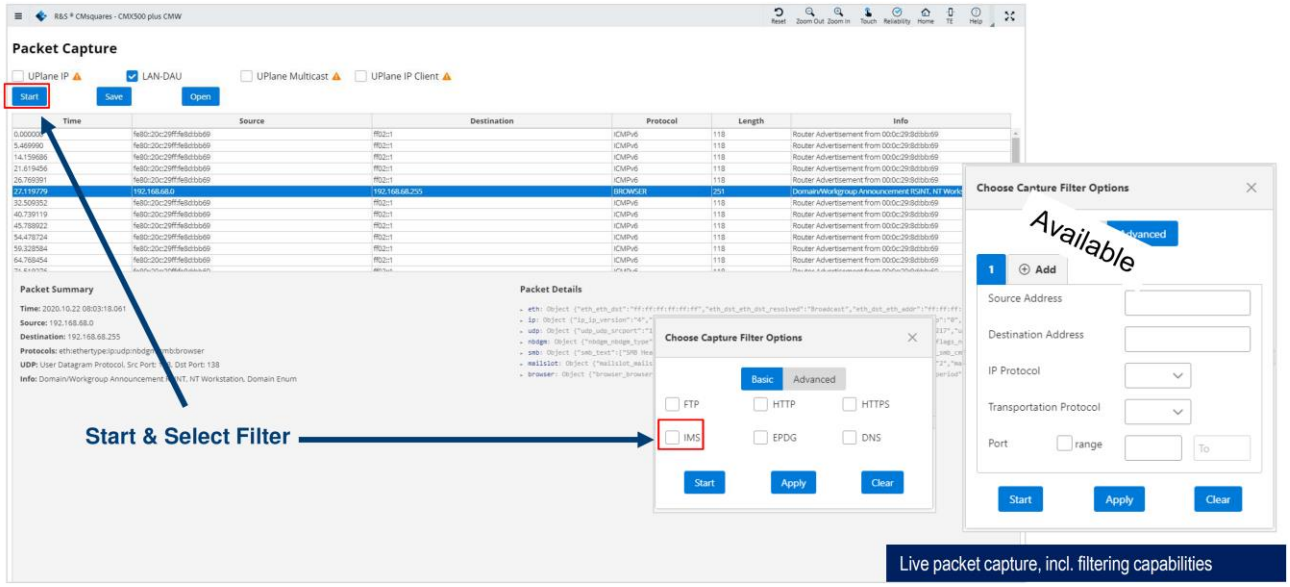


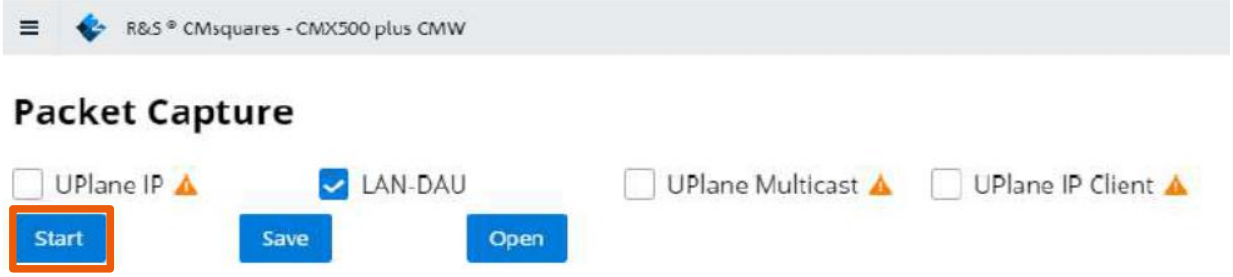
Figure 13: Screenshot of Packet Capture feature

5.2.1 Export packet capture to Wireshark

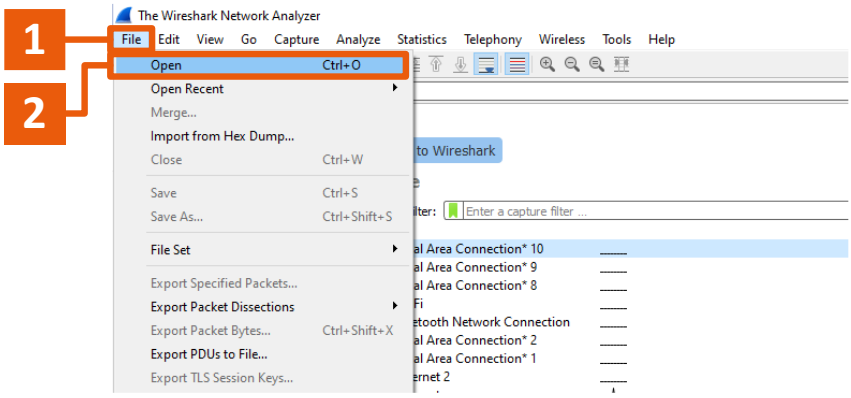
Note: For full functionality "Verbose Uplane logging" is required

Wireshark is an open source packet analyzer which provides various functions for network troubleshooting, analysis, software and communications protocol development. It enables a detailed analysis of RTP streams (timing, packet loss, packet ordering, etc.).

Export .pcapng file from CMsquares



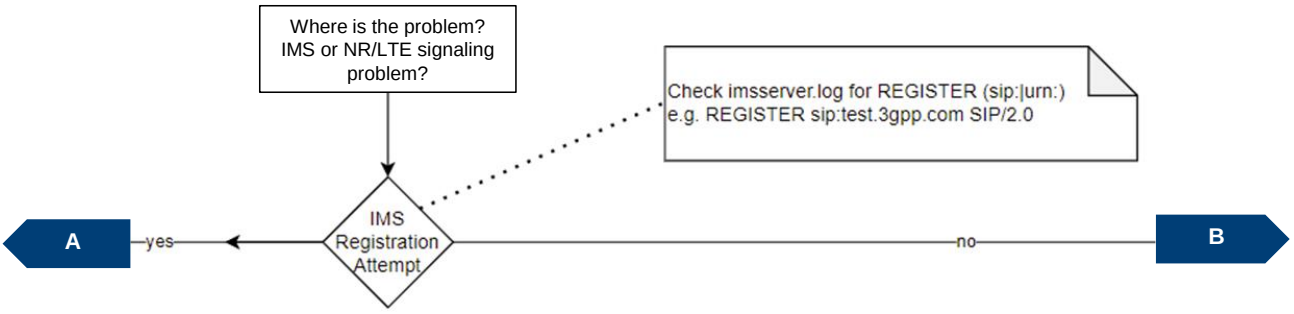
Open .pcapng file in Wireshark

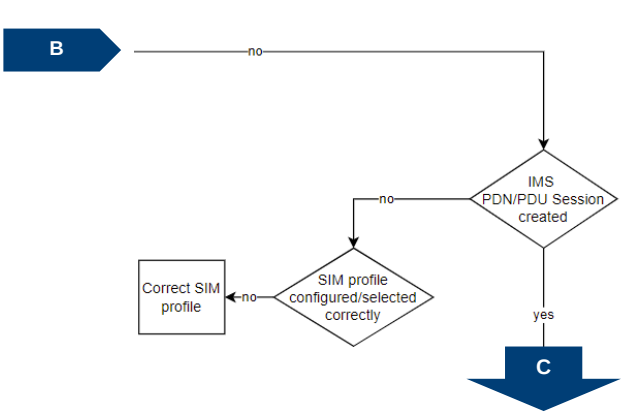


Further reading

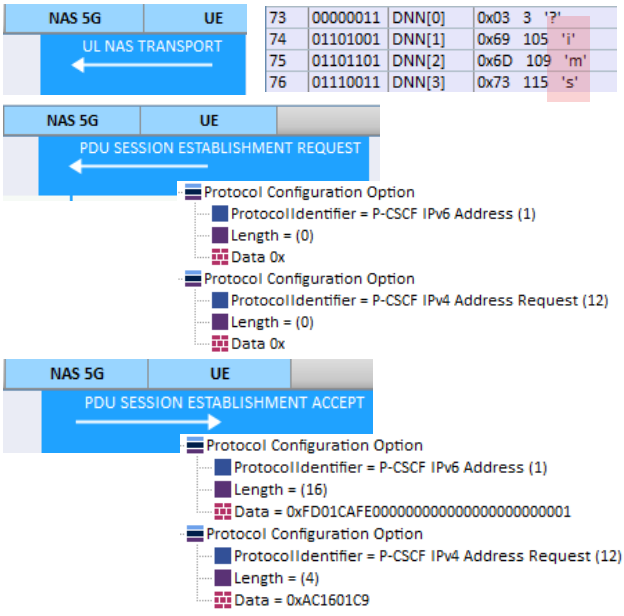
► https://www.wireshark.org/

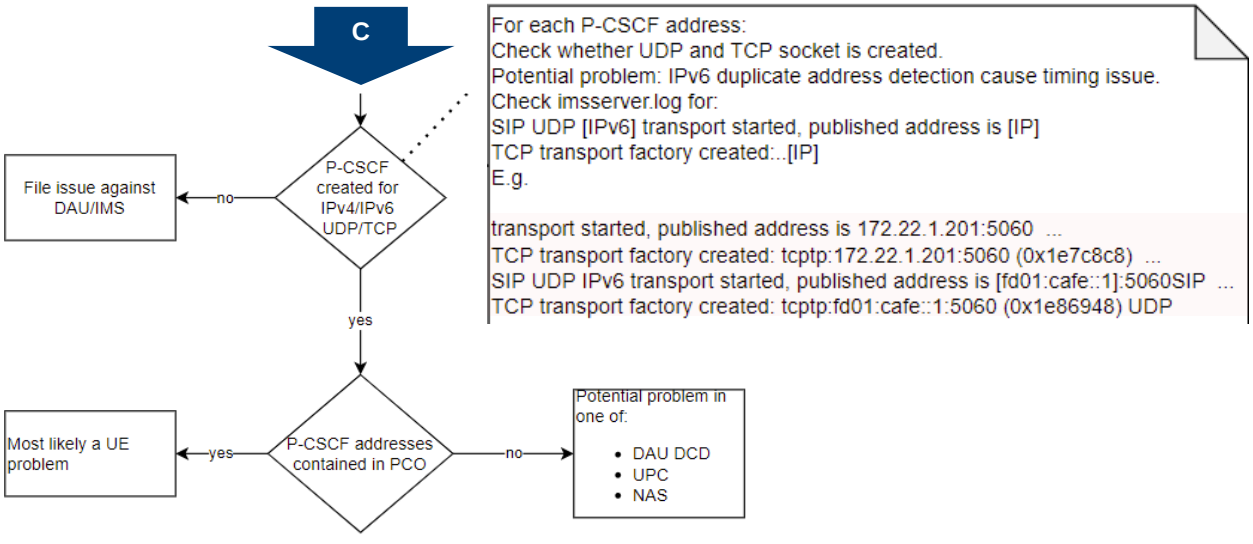
5.3 Troubleshooting

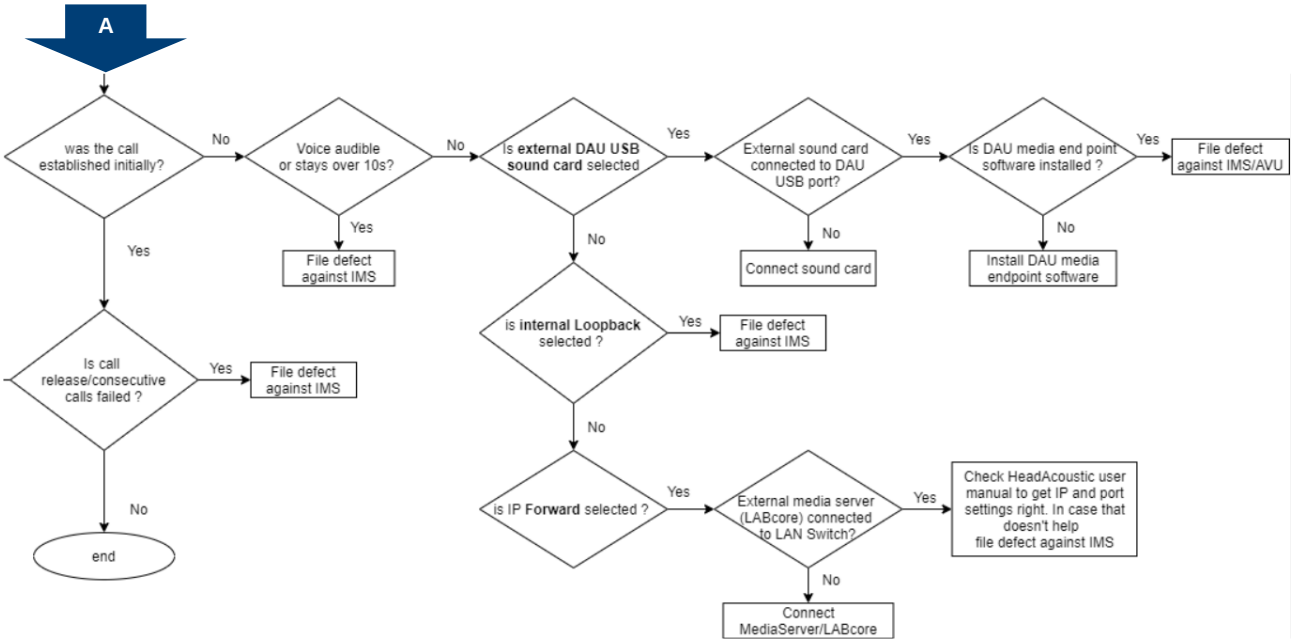




NR	LTE
DNN	APN
PDU Session Establishment Request	ESM PDN Connectivity Request






A
was the call established initially?
No
Voice audible or stays over 10s?
No
Is external DAU USB sound card selected
Yes
External sound card connected to DAU USB port?
Yes
Is DAU media end point software installed ?
Yes
File defect against IMS/AVU
Yes
File defect against IMS
No
Connect sound card
No
Install DAU media endpoint software
Yes
Is call release/consecutive calls failed ?
Yes
File defect against IMS
No
is internal Loopback selected ?
Yes
File defect against IMS
No
is IP Forward selected ?
Yes
External media server (LABcore) connected to LAN Switch?
Yes
Check HeadAcoustic user manual to get IP and port settings right. In case that doesn't help file defect against IMS
No
Connect MediaServer/LABcore
No
end

6 Abbreviations

Abbreviation	Designation
5GC	5G core
5GS	5G system
5QI	5G QoS indicator
AMF	Access and mobility management function
AMR	Adaptive multi-rate
AMR-WB	AMR wideband
AS	Access stratum
CSFB	Circuit-switched fallback
DNN	Data network name
DRB	Data radio bearer
DRVCC	Dual radio voice call continuity
EPC	Evolved packet core (LTE core)
E-UTRAN	Evolved UMTS terrestrial radio network
EVS	Enhanced voice services
GBR	Guaranteed bit rate
GSM	Global system for mobile communications
GSMA	GSM association
GUI	Graphical user interface
HOS	Home operator services
IETF	Internet Engineering Task Force
IMS	IP multimedia subsystem
IP-CAN	IP connectivity access network
IVS	In-vehicle system
KPI	Key performance indicator
LRF	Location resource function
LTE	Long term evolution
MAC	Medium access control
MM	Mobility management
MME	Mobility management entity
MTSI	Multimedia telephony services for IMS
NAS	Non-access stratum
NSA	Non-standalone
PLMN	Public Land Mobile Network
QoE	Quality of experience
QoS	Quality of service

Abbreviation	Designation
RAN	Radio access network
RAT	Radio access technology
RLC	Radio link control
RTP	Real-time protocol
SA	Standalone
SIP	Session initiation protocol
SRB	Signaling radio bearer
SRVCC	Single radio voice call continuity
UE	User equipment
ViNR	Video over New Radio
VoLTE	Voice over LTE
VoNR	Voice over New Radio

7 Literature

[1] Rohde & Schwarz, 5G New Radio - Fundamentals, procedures, testing aspects.

[2] Rohde & Schwarz, White Paper - 5G Voice over New Radio (VoNR).

8 Ordering information

Designation	Type	Order number	No.
CMW Wideband Radio Communication Tester			
Wideband Radio Communication Tester	**CMW500**	**1201.0002K50**	**1**
R&S®CMW500 Basic Assembly(mainframe), 70MHz to 3.3GHz (sel.)	CMW-PS505	1208.8921.06	1
Measurement Unit Advanced (MUA), H100H (sel.)	CMW-S100H	1202.4701.09	1
Baseband interconnection, flexible link H550N (sel.)	CMW-S550N	1202.4801.15	1
RF Converter (TRX), BW 160 MHz, H570H (sel.)	CMW-S570H	1202.5008.09	1
RF Frontend, advanced functionality, H590D (sel.)	CMW-S590D	1202.5108.03	1
CMW500 Frontpanel With Display/Keypad, H600B (sel.)	CMW-S600B	1201.0102.03	1
Solid State Drive (SSD), H052S (sel.)	CMW-S052S	1202.4201.20	1
Signaling Unit Advanced (SUA), H500I (HW opt.)	CMW-B500I	1208.7954.10	2
Data Application Unit, H450I (HW opt.)	CMW-B450I	1202.8759.10	1
Digital IQ Interface QUAD, H540I (HW opt.)	CMW-B540I	1211.2514.10	1
Multi-CMW PCIe enabler, H554N (HW opt.)	CMW-B554N	1208.8950.15	1

Extra RF Converter (TRX), BW 160 MHz, H570H (HW opt.)	CMW-B570H	1202.8659.09	3
Extra RF Frontend, advanced functionality, H590D (hw opt.)	CMW-B590D	1202.8707.03	1
Option Carrier, H660H (hw opt.)	CMW-B660H	1202.7000.09	1
Ethernet Switch, H661H (hw opt.)	CMW-B661H	1202.7100.09	1
OCXO, high stability, H690B (hw opt.)	CMW-B690B	1202.6004.02	1
6GHz Flat Rate, for up to 4 RF converters (TRXs) (SL)	CMW-PK364	1208.7319.02	1
LTE Rel.15 FDD Basic Signaling (SL)	CMW-KS505	1211.3862.02	1
LTE Rel.15 TDD Basic Signaling (SL)	CMW-KS555	1211.3885.02	1
10 GBPS Ethernet Switch	CMWC-Z70A	3628.1135K00	1
10 GBPS Ethernet Switch	CMWC-Z70A	3628.1135.00	1
Rohde & Schwarz Service Options			
CW2CMW500 WARR EXT+CAL 2Y, 2 CAL, 12M CAL INT, #4CH 3.3/6GHZ	CW2CMW500	3595.5796S07	1

CMX 5G Audio Configuration:

Designation	Type	Order number	No.
CMX Radio Communication Tester			
Radio Communication Tester	**CMX500**	**1201.0002K70**	**1**
CMX500 Basic Assembly	CMX-PB70B	1222.0676.03	1
Accelerator Unit	CMX-B200A	1222.0747.02	2
Processing Unit	CMX-B300A	1222.0801.02	1
CMX Application test feature set 1 (SL) (IMS, IPv4/6, Ping ...)	CMX-KA100	1222.1595.02	1
1NR Signaling, NSA Mode Enabler Basic Level (SL)	CMX-KS600B	1222.1672.02	1
NR Signaling, SA Mode Enabler Basic Level (SL)	CMX-KS601B	1222.2327.02	1
Optional (required for audio quality tests)			
CMX Audio Enabler Basic (SL)	CMX-KA180	1222.4165.02	1
CMX external Media Endpoint	CMX-ZG180A	1222.4313.02	1
HEADSET CABLE SET	CM-Z91	1212.3050.02	1