Redefining Drive Test for 5G

2019.11.27

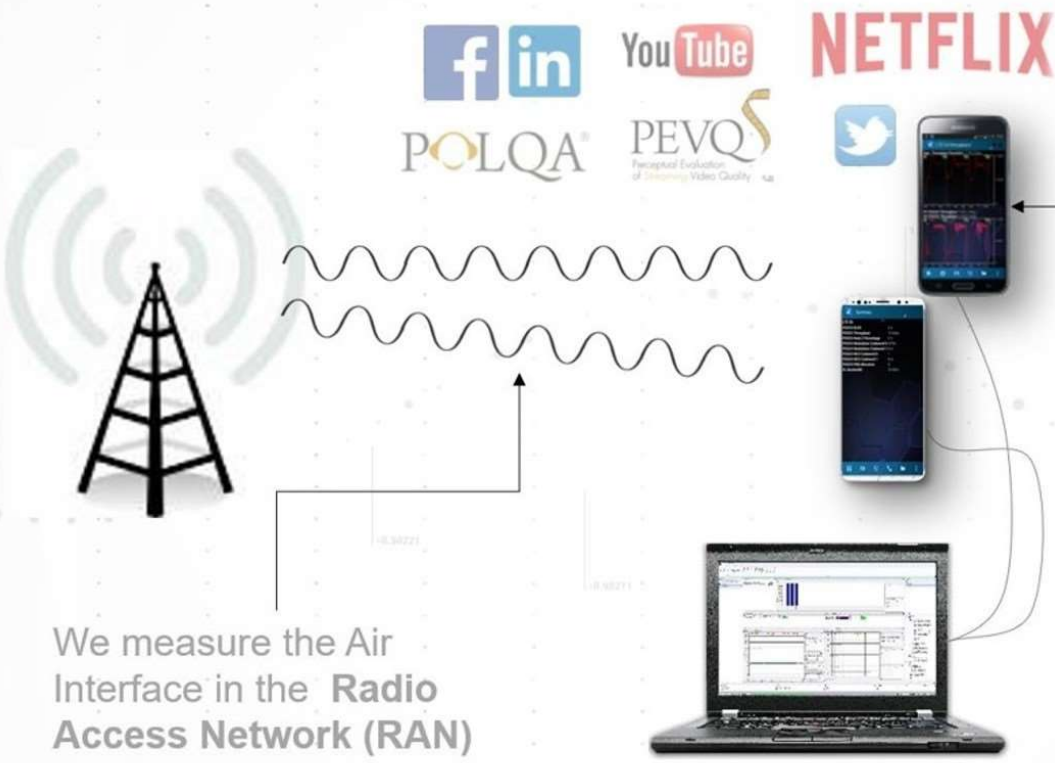
Keysight Nemo Wireless Solution

Agenda

- Introduction
- Nemo portfolio
- Beam-based coverage
- UE & scanner field measurements
- NSA call flow
- Summary & Q&A

KEYSIGHT TECHNOLOGIES

Nemo Wireless Solutions for Live Network Testing



Nemo Test & Measurement Products

WIRELESS NETWORK LIFECYCLE SOLUTIONS

Nemo Handy

Nemo WalkerAir

Nemo Outdoor

Nemo WalkerAir

NIDI

Nemo Invex II

Nemo Customer Experience Monitor

Nemo Autonomous Probe

Network Rollout

Network Optimization

Network Benchmarking

Network Monitoring

Nemo Cloud

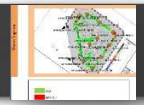
Control & monitoring

Nemo Xynergy

Nemo WindCatcher

Nemo Analyze

Post processing and Network analytics



Distributed Antenna (DAS) / Small Cell

Network Management

Drive Test

Geospatial Intelligence

5G Field Measurement Evolution

5G Testing Now

- Lab Testing
- Network Trials
- Network Rollout
- Network Optimization
- Network Benchmarking
- Network Monitoring

5G Testing 2020

- Lab Testing
- Network Trials
- Network Rollout
- Network Optimization
- Network Benchmarking
- Network Monitoring

5G Testing 2021+

NR of Field Measurement Use Cases

- Lab Testing
- Network Trials
- Network Rollout
- Network Optimization
- Network Benchmarking
- Network Monitoring

Supported 5G Test Devices

- All devices listed here are supported in Nemo Outdoor and have been used on the field by Keysight customers
- Devices in both mmWave and sub6GHz are supported
- Nemo Handy supports both QC X50 and Samsung Exynos 5100 chipsets

Samsung S10 5G
(Both Qualcomm X50 based, and Samsung Exynos 5100 based)

Huawei Mate 20X 5G
(HiSi Chipset based, beta, demo and trial capability)

Qualcomm X50 based devices

LG V50 ThinQ

Xiaomi Mi Mix 3 5G

HTC 5G Hub

OnePlus 5G

ZTE Axon 10 Pro 5G

Oppo Reno 5G

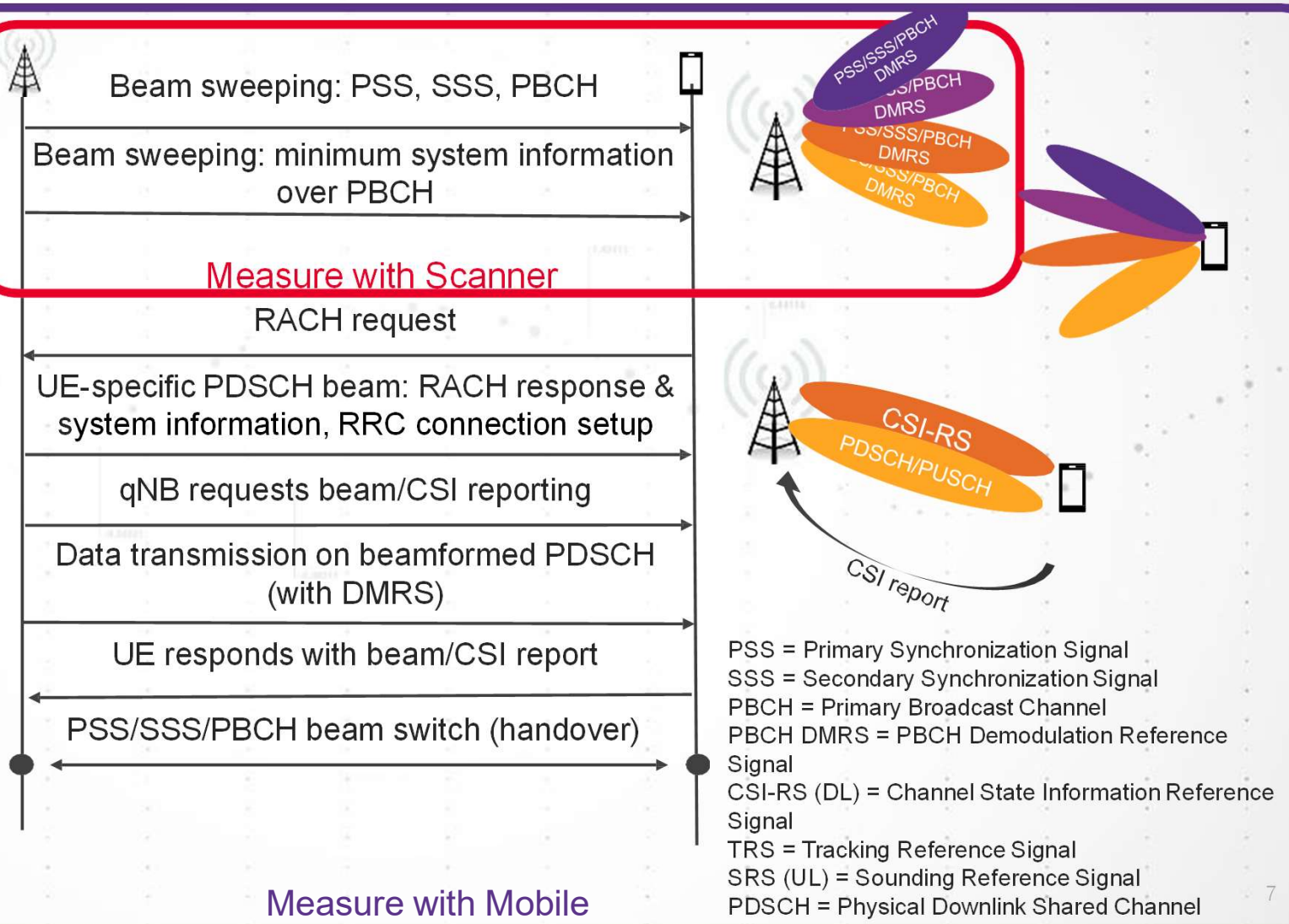
Netgear Nighthawk

WNC 5G hotspot

5G Coverage

Beam Based Network Coverage

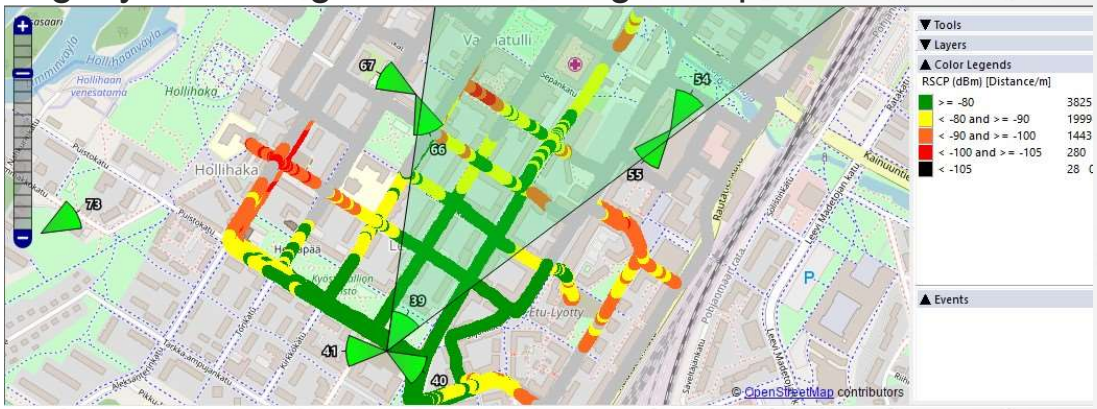
- Paradigm shift from cell coverage to beam coverage
- Many kinds of beams, static and dynamic, mobile, and network side
  - DL reference beams
  - UL beams (UE/CPE-specific)
  - DL/UL traffic beams
  - Vendor-specific



5G NR – Beam-based Network Coverage

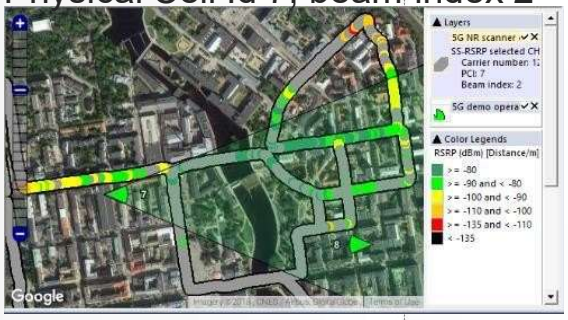
- Shift from cell-based network coverage to beam-based network coverage
- Major challenge for operators and NEMs to verify and understand the network coverage in the field

Legacy technologies, cell coverage footprint



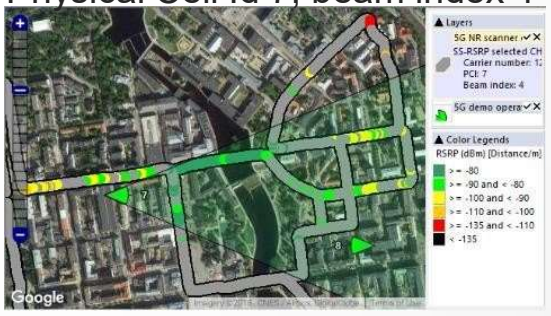
5G NR – cell coverage is split into multiple beams with non-continuous coverage footprints

Physical Cell Id 7, beam index 2



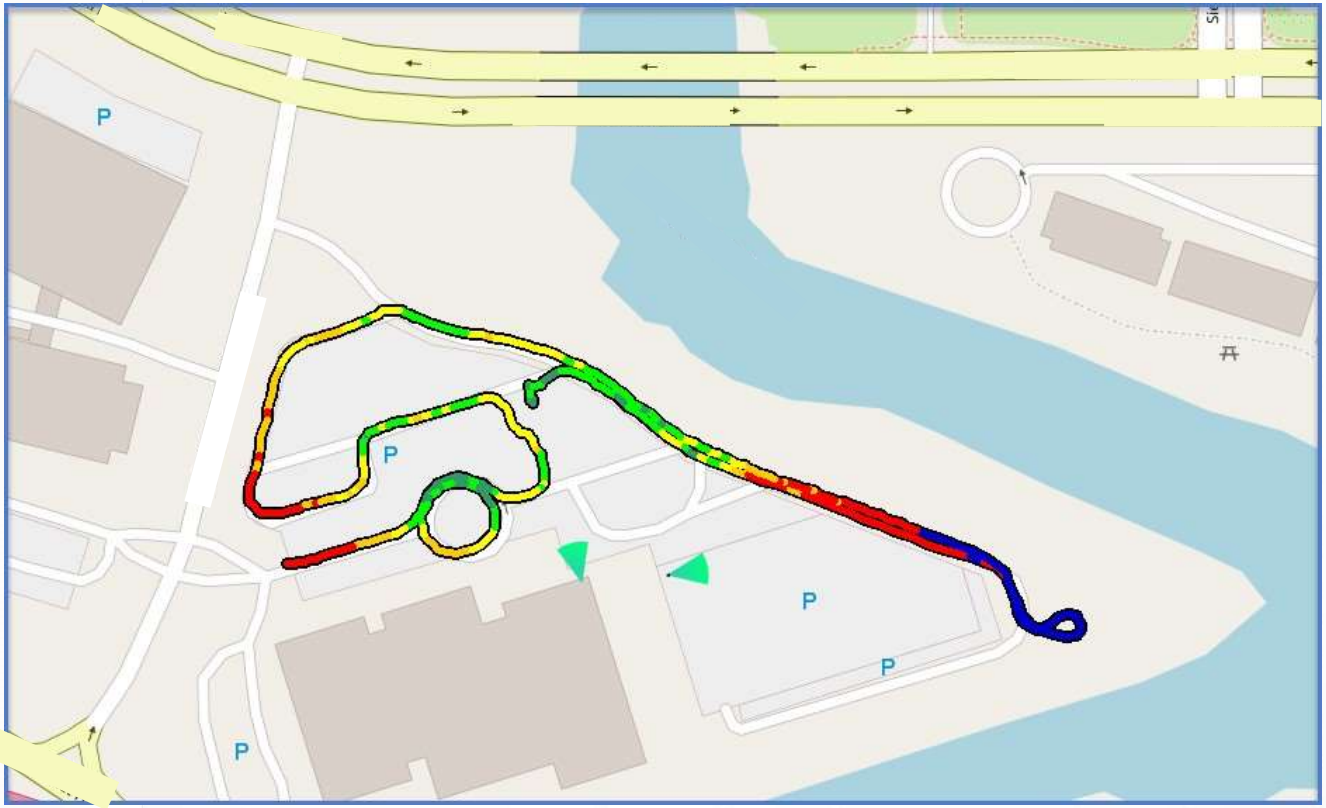
Physical Cell Id 7, beam index 3

Physical Cell Id 7, beam index 4



NR Cell Coverage - PCI

FR2/39GHZ – SCANNER MEASUREMENT

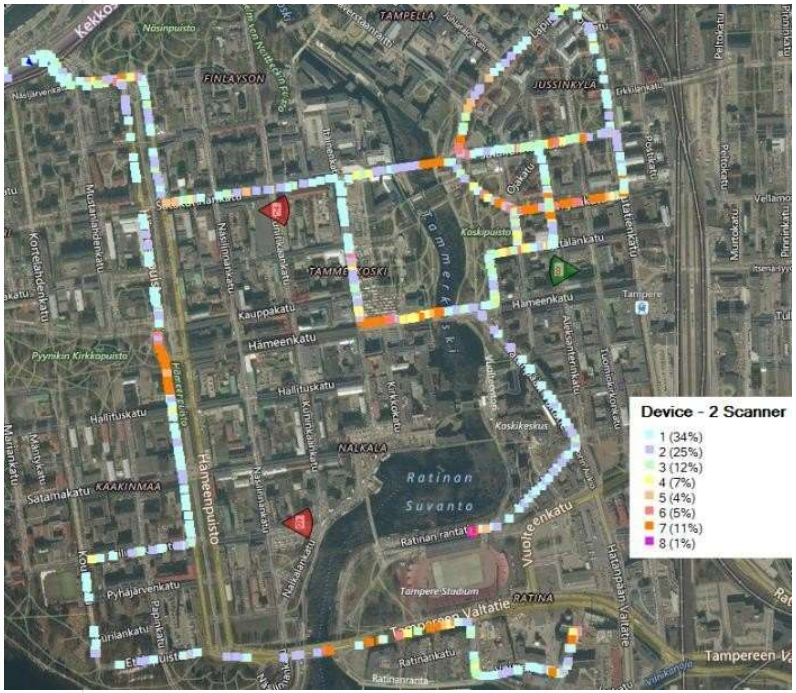


5G NR Scanner Analytics

WINDCATCHER 5G SCANNER TROUBLESHOOTING

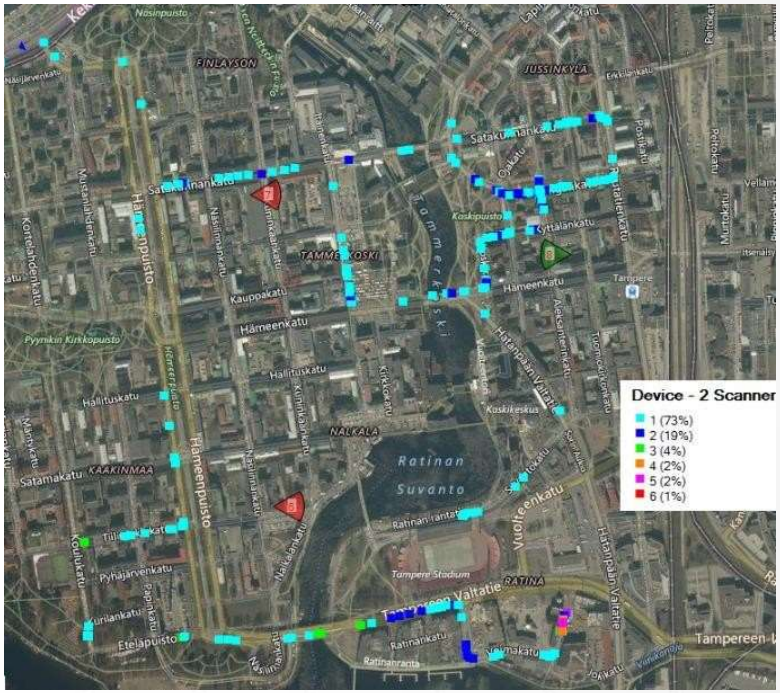
- Troubleshooting
  - Poor Coverage
  - Possible Interference
  - Numbers of Servers
  - Numbers of Beams
  - Numbers of Beams for PCI
  - Number of Servers Within Threshold
  - Number of Beams Within Threshold
  - Number of Beams for PCI Within Threshold

Number of Beams



Number of beams above coverage threshold

Number of Strong Beams

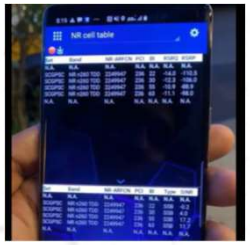


Number of beams above coverage threshold and within 5 dB of best server

UE-based Field Measurements

X50 CHIPSET

- **Solution**
  - 5G NR UE with diagnostics interface (QC/Samsung/Hisilicon device)
  - Scanner
  - Nemo Outdoor and Handy SW for measurement control
  - Nemo Analyze/Nemo WindCatcher for post-processing
- **Use Cases**
  - Throughput & latency testing
  - 5G <> LTE multimode connectivity analysis
  - Dual connectivity
  - Beam switching & HO analysis
- **UE-based KPIs**
  - Cell measurements: SS-RSRP, -RSRQ, -SINR
  - RACH related KPIs
  - RRC/L3 signaling
  - L1 and MAC throughput, BLER/retransmission rate
  - Link adaptation metrics, MCS, TB size, PRB allocation, modulation, etc.
  - Application QoS KPIs, throughput, latency



Nemo post-processing

Nemo Outdoor

5G NR NSA Network Attach & SN Addition

5G NR – NSA Secondary node setup

EN-DC ARCHITECHTURE

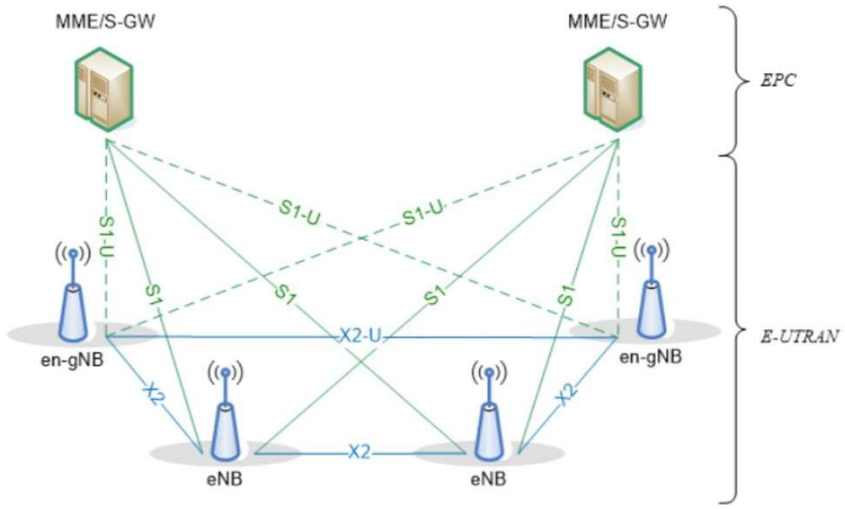
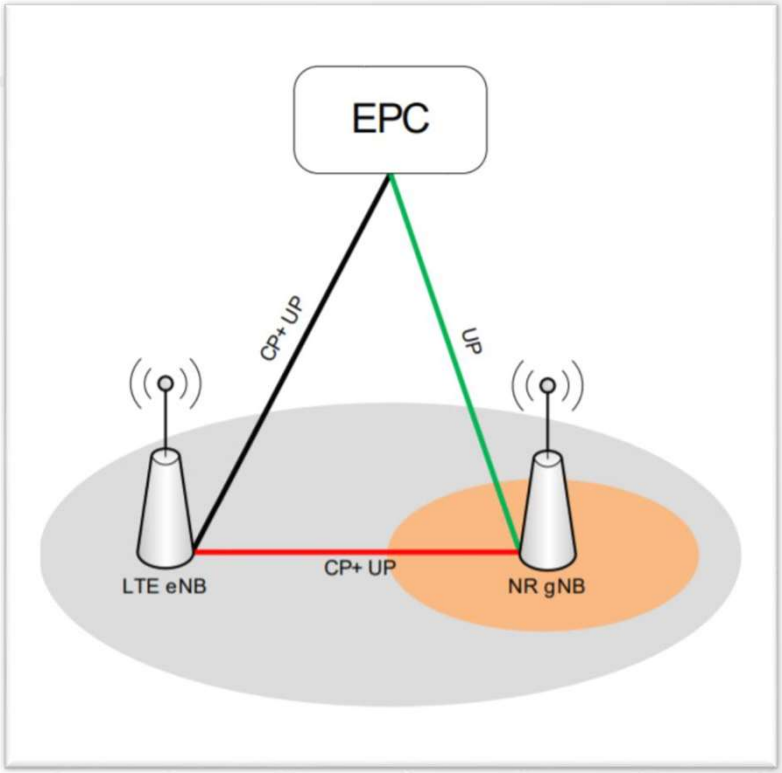


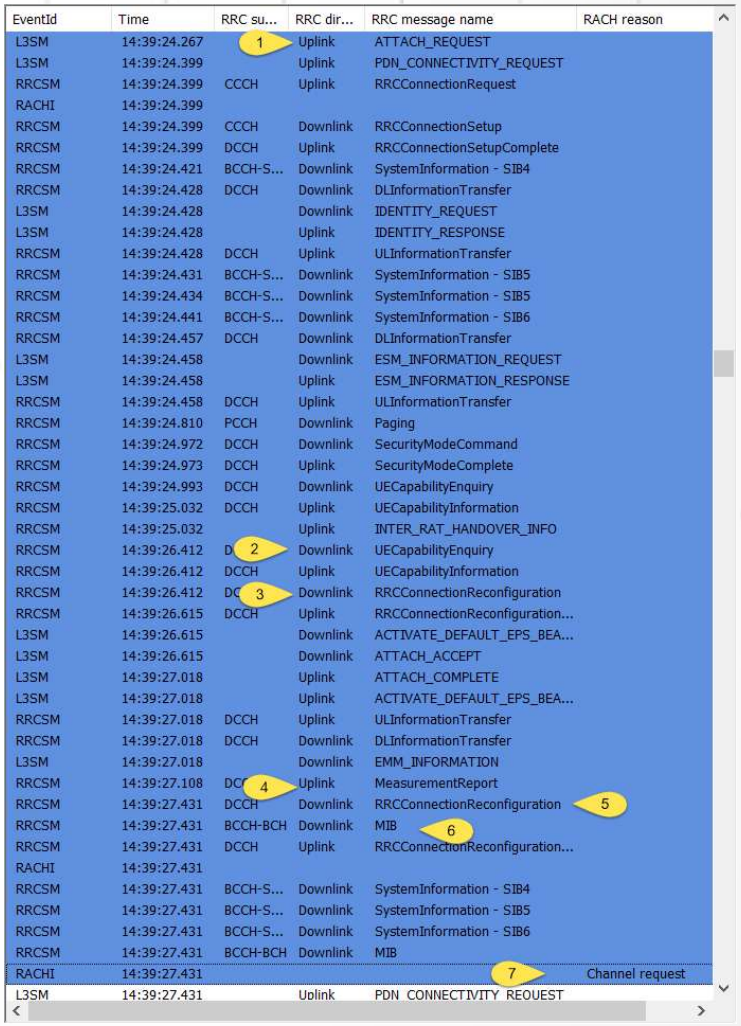
Figure 4.1.2-1: EN-DC Overall Architecture



5G NR NSA SN setup

NSA SECONDARY NODE SETUP

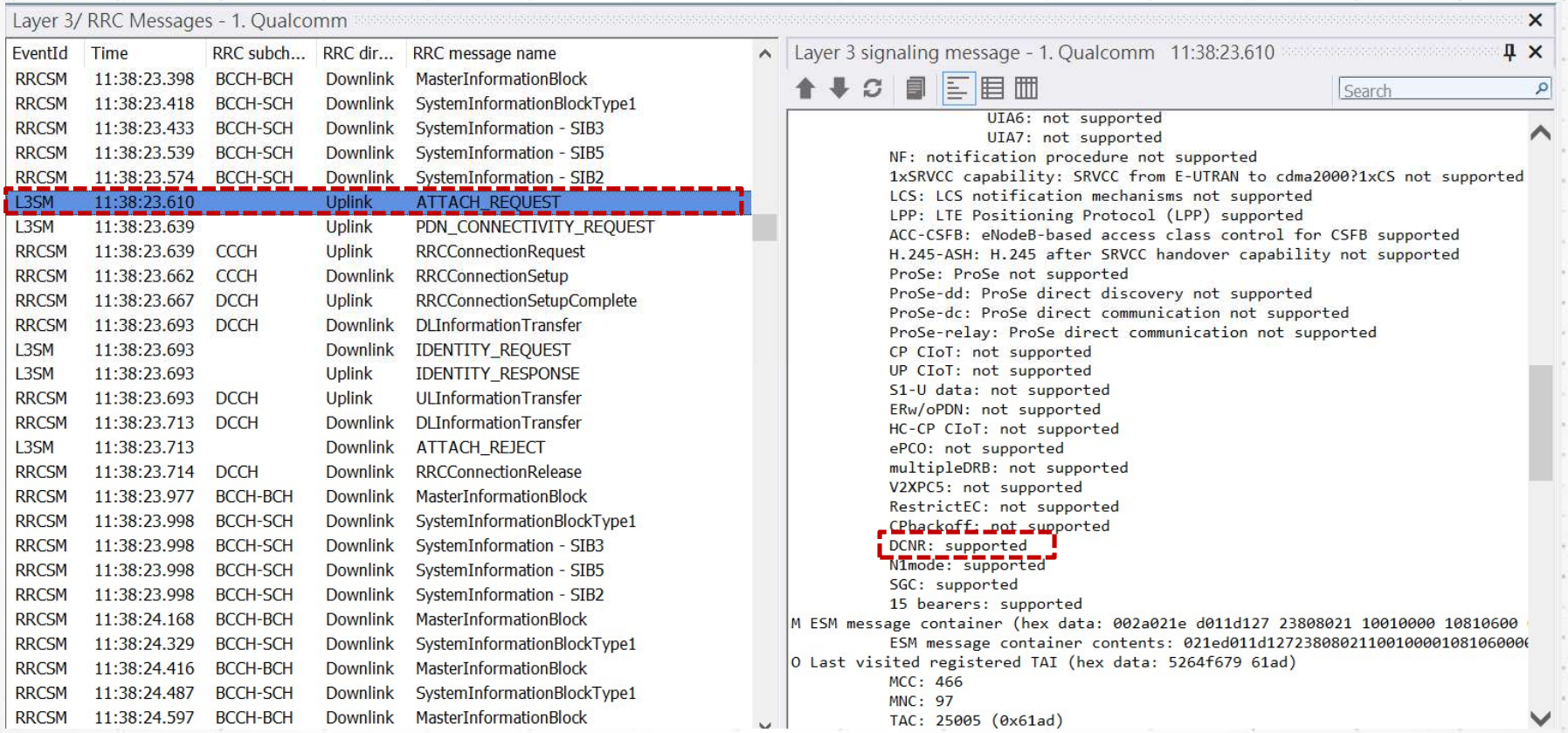
1. Attach Request: UE indicates support for MR-DC.
2. UE capability enquiry: gNB -> eNB -> UE. Request for NR – eUTRA UE capabilities
3. UE NR measurement event configuration
4. UE measurement report for NR
5. gNB -> eNB -> UE. Secondary node setup
6. UE NR DL synchronization
7. NR RACH



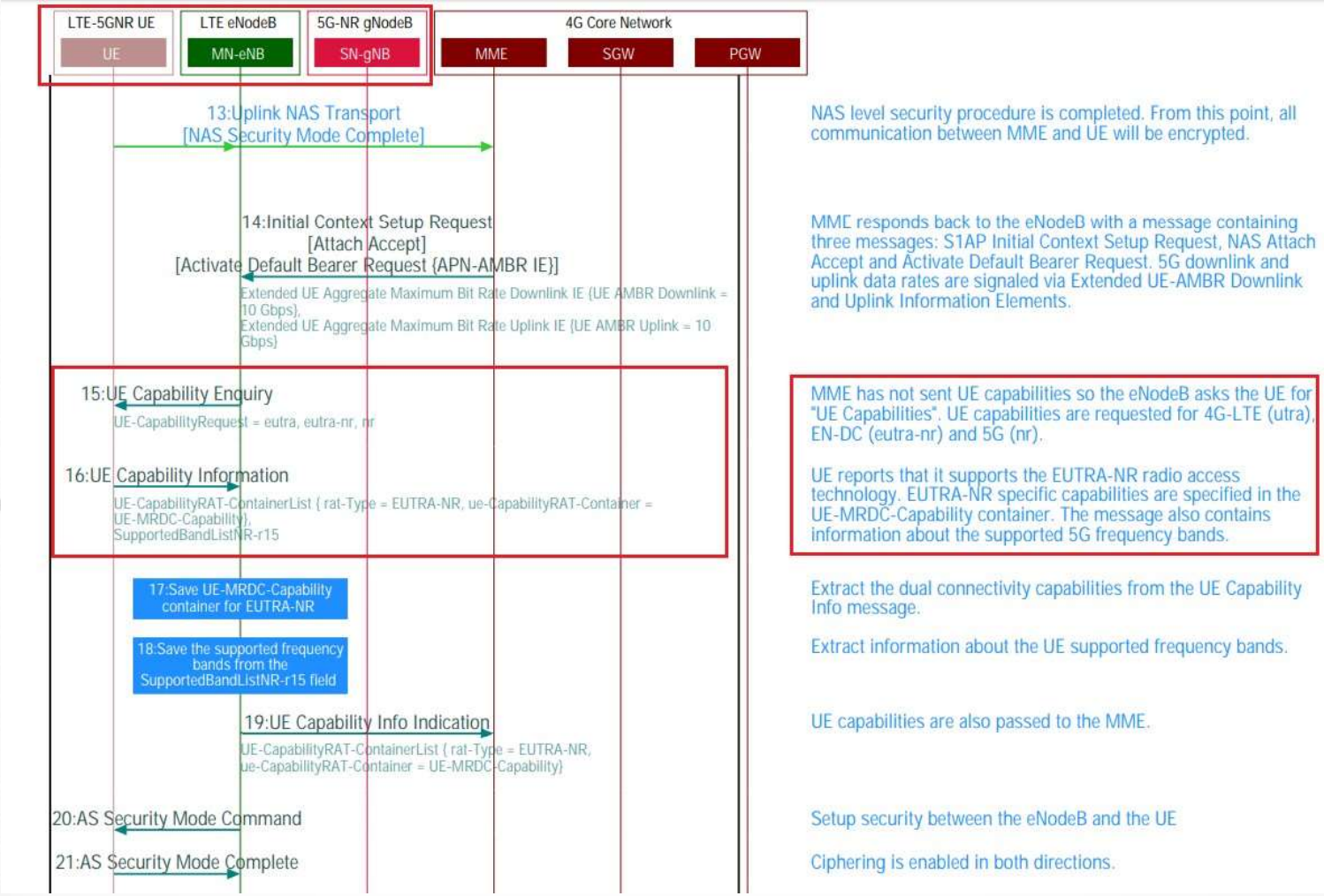
EventId	Time	RRC su...	RRC dir...	RRC message name	RACH reason
L3SM	14:39:24.267		Uplink	ATTACH_REQUEST	
L3SM	14:39:24.399		Uplink	PDN_CONNECTIVITY_REQUEST	
RRCSM	14:39:24.399	CCCH	Uplink	RRCConnectionRequest	
RACHI	14:39:24.399				
RRCSM	14:39:24.399	CCCH	Downlink	RRCConnectionSetup	
RRCSM	14:39:24.399	DCCH	Uplink	RRCConnectionSetupComplete	
RRCSM	14:39:24.421	BCCH-S...	Downlink	SystemInformation - SIB4	
RRCSM	14:39:24.428	DCCH	Downlink	DLInformationTransfer	
L3SM	14:39:24.428		Downlink	IDENTITY_REQUEST	
L3SM	14:39:24.428		Uplink	IDENTITY_RESPONSE	
RRCSM	14:39:24.428	DCCH	Uplink	ULInformationTransfer	
RRCSM	14:39:24.431	BCCH-S...	Downlink	SystemInformation - SIB5	
RRCSM	14:39:24.434	BCCH-S...	Downlink	SystemInformation - SIB5	
RRCSM	14:39:24.441	BCCH-S...	Downlink	SystemInformation - SIB6	
RRCSM	14:39:24.457	DCCH	Downlink	DLInformationTransfer	
L3SM	14:39:24.458		Downlink	ESM_INFORMATION_REQUEST	
L3SM	14:39:24.458		Uplink	ESM_INFORMATION_RESPONSE	
RRCSM	14:39:24.458	DCCH	Uplink	ULInformationTransfer	
RRCSM	14:39:24.810	PCCH	Downlink	Paging	
RRCSM	14:39:24.972	DCCH	Downlink	SecurityModeCommand	
RRCSM	14:39:24.973	DCCH	Uplink	SecurityModeComplete	
RRCSM	14:39:24.993	DCCH	Downlink	UECapabilityEnquiry	
RRCSM	14:39:25.032	DCCH	Uplink	UECapabilityInformation	
RRCSM	14:39:25.032		Uplink	INTER_RAT_HANDOVER_INFO	
RRCSM	14:39:26.412	D	Downlink	UECapabilityEnquiry	
RRCSM	14:39:26.412	DCCH	Uplink	UECapabilityInformation	
RRCSM	14:39:26.412	DC	Downlink	RRCConnectionReconfiguration	
RRCSM	14:39:26.615	DCCH	Uplink	RRCConnectionReconfiguration...	
L3SM	14:39:26.615		Downlink	ACTIVATE_DEFAULT_EPS_BEA...	
L3SM	14:39:26.615		Downlink	ATTACH_ACCEPT	
L3SM	14:39:27.018		Uplink	ATTACH_COMPLETE	
L3SM	14:39:27.018		Uplink	ACTIVATE_DEFAULT_EPS_BEA...	
RRCSM	14:39:27.018	DCCH	Uplink	ULInformationTransfer	
RRCSM	14:39:27.018	DCCH	Downlink	DLInformationTransfer	
L3SM	14:39:27.018		Downlink	EMM_INFORMATION	
RRCSM	14:39:27.108	DC	Uplink	MeasurementReport	
RRCSM	14:39:27.431	DCCH	Downlink	RRCConnectionReconfiguration	
RRCSM	14:39:27.431	BCCH-BCH	Downlink	MIB	
RRCSM	14:39:27.431	DCCH	Uplink	RRCConnectionReconfiguration...	
RACHI	14:39:27.431				
RRCSM	14:39:27.431	BCCH-S...	Downlink	SystemInformation - SIB4	
RRCSM	14:39:27.431	BCCH-S...	Downlink	SystemInformation - SIB5	
RRCSM	14:39:27.431	BCCH-S...	Downlink	SystemInformation - SIB6	
RRCSM	14:39:27.431	BCCH-BCH	Downlink	MIB	
RACHI	14:39:27.431				Channel request
L3SM	14:39:27.431		Uplink	PDN_CONNECTIVITY_REQUEST	

5G NR NSA SN Setup

- **During ATTACH Request, UE reports to Network that it supports DCNR.**

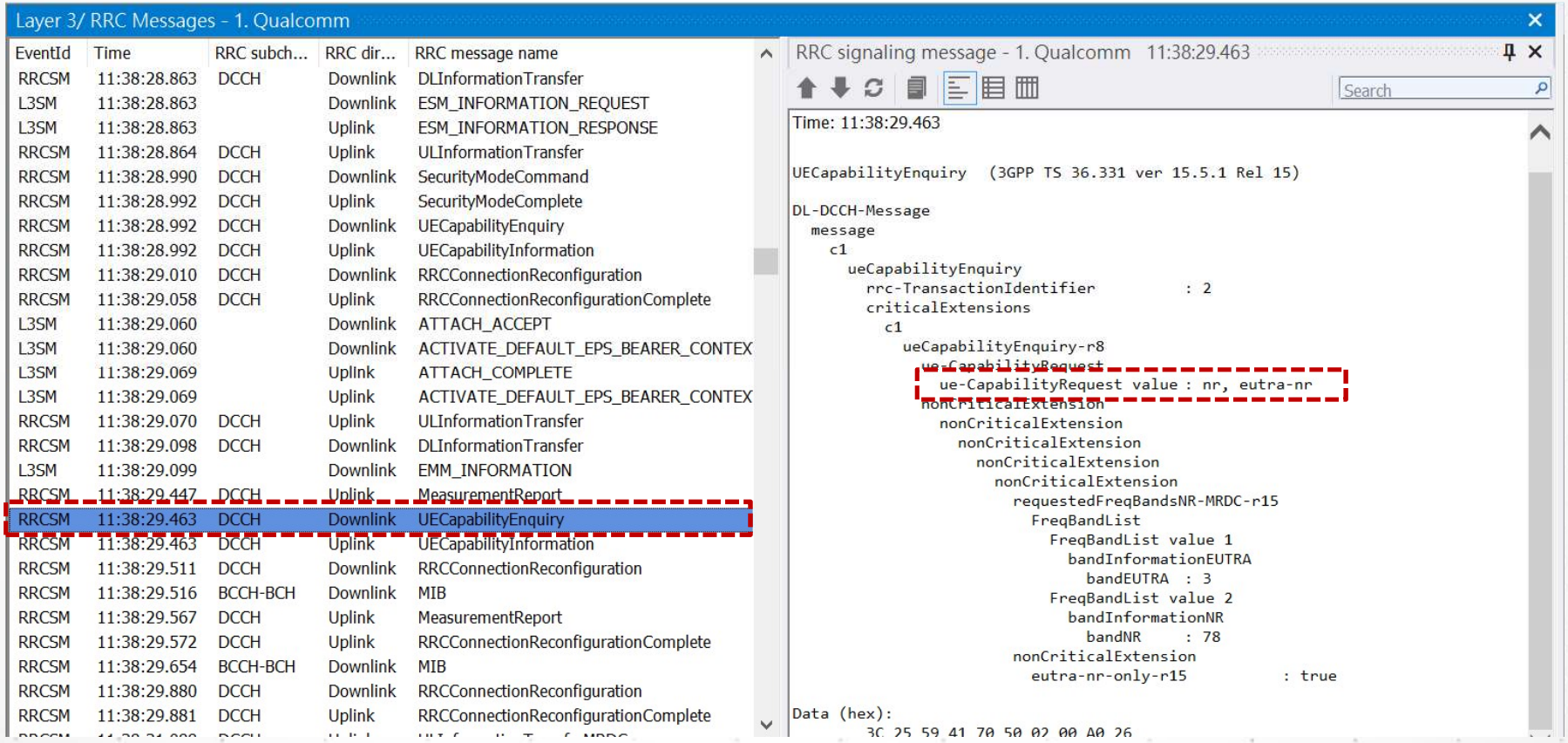


5G NR NSA SN Setup



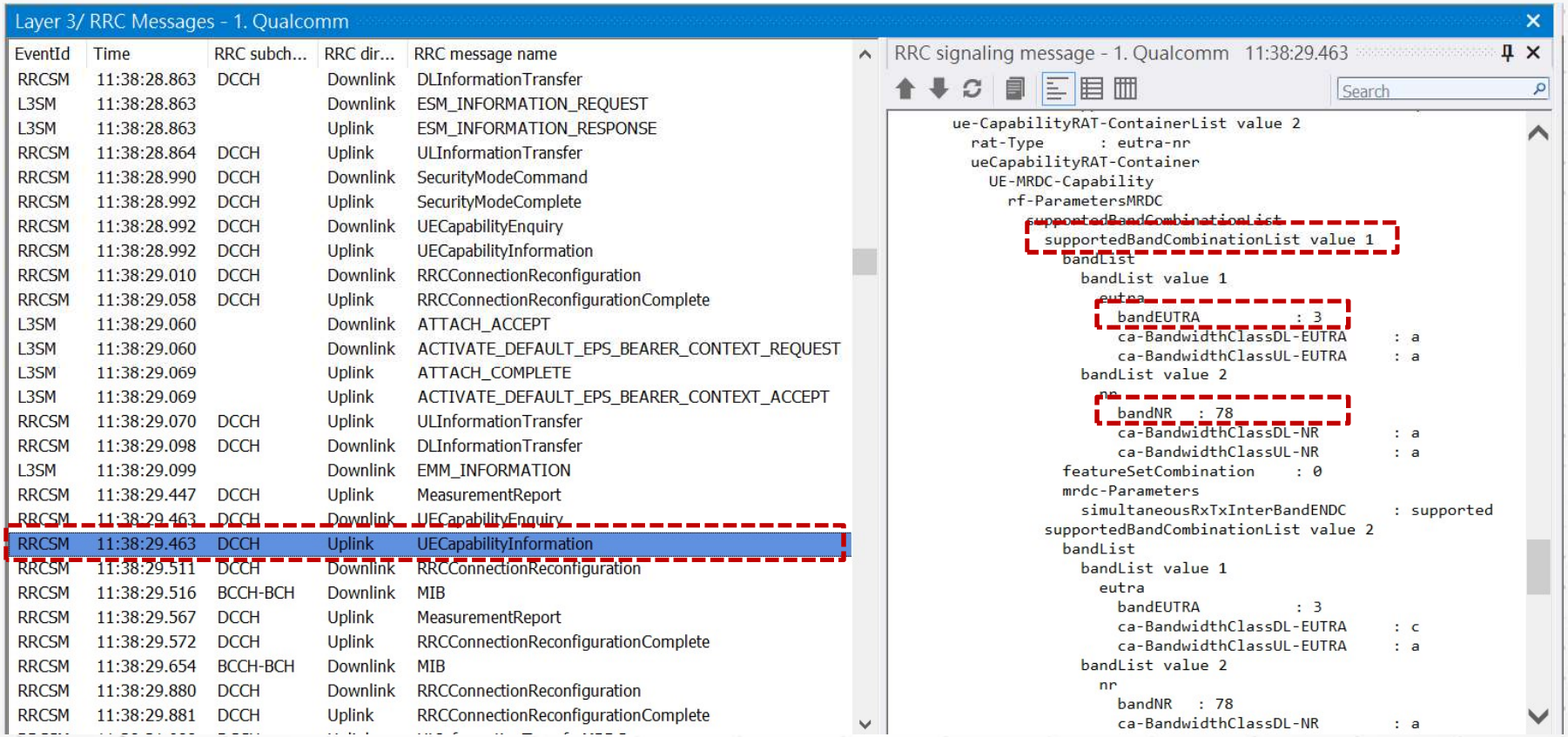
5G NR NSA SN Setup

- **Network requests UE to report supported LTE and NR capabilities.**



5G NR NSA SN Setup

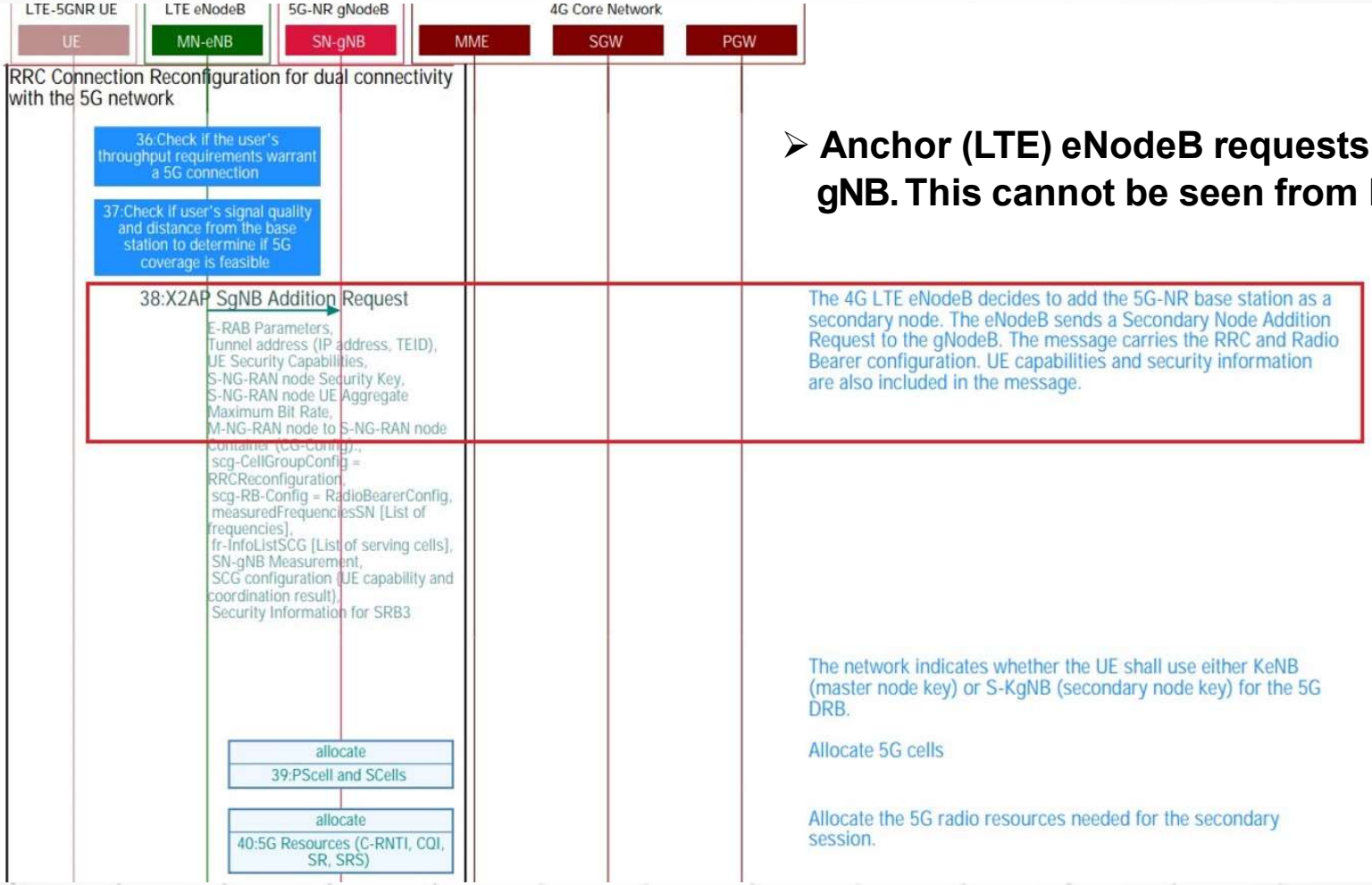
- **UE reports that it supports b3-n78 combination.**



5G NR NSA SN Setup

- **Network should send RRC Connection Reconfiguration to UE.**

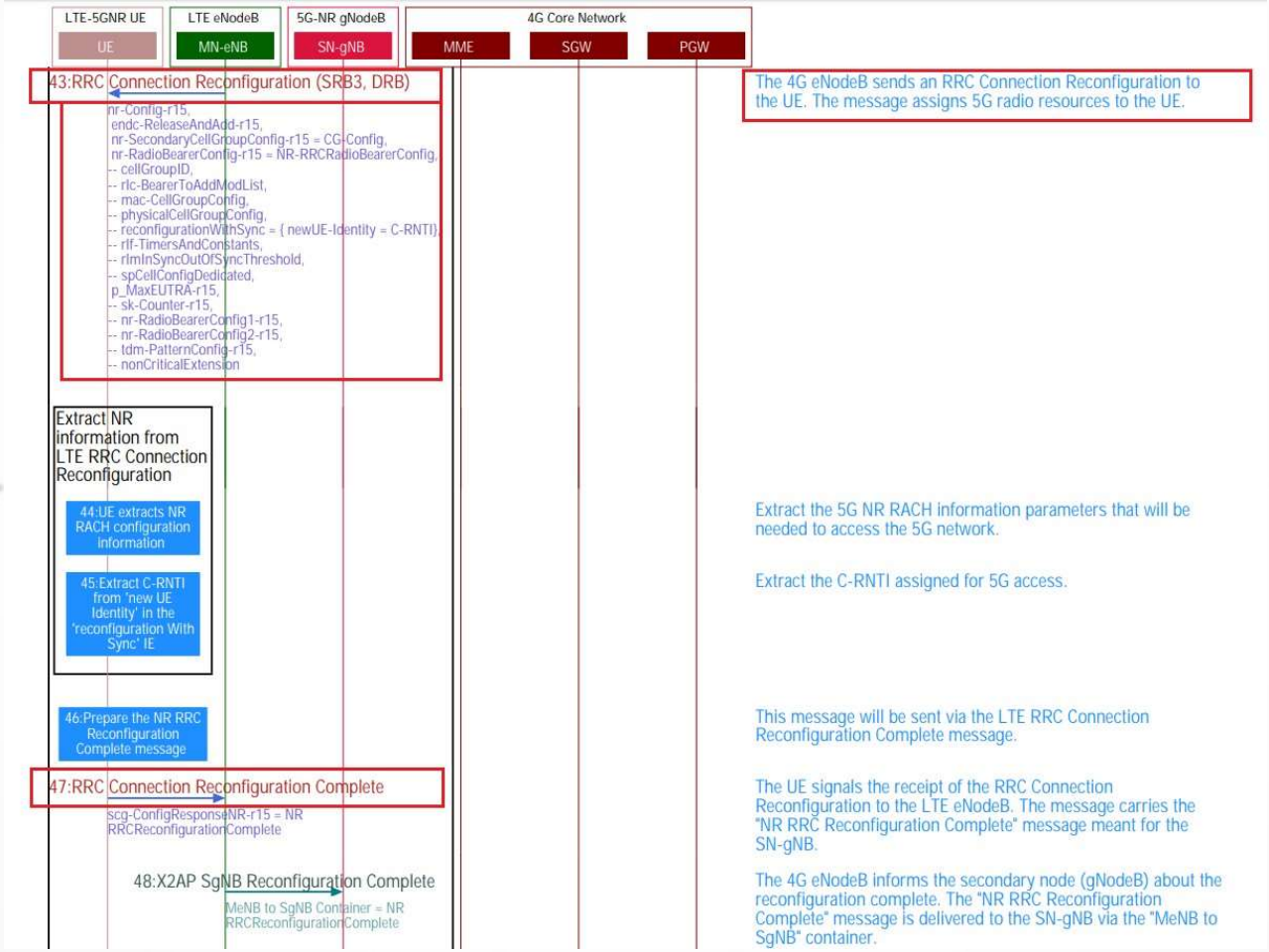
5G NR NSA SN Setup



- **Anchor (LTE) eNodeB requests SN addition to gNB. This cannot be seen from DT tool side.**

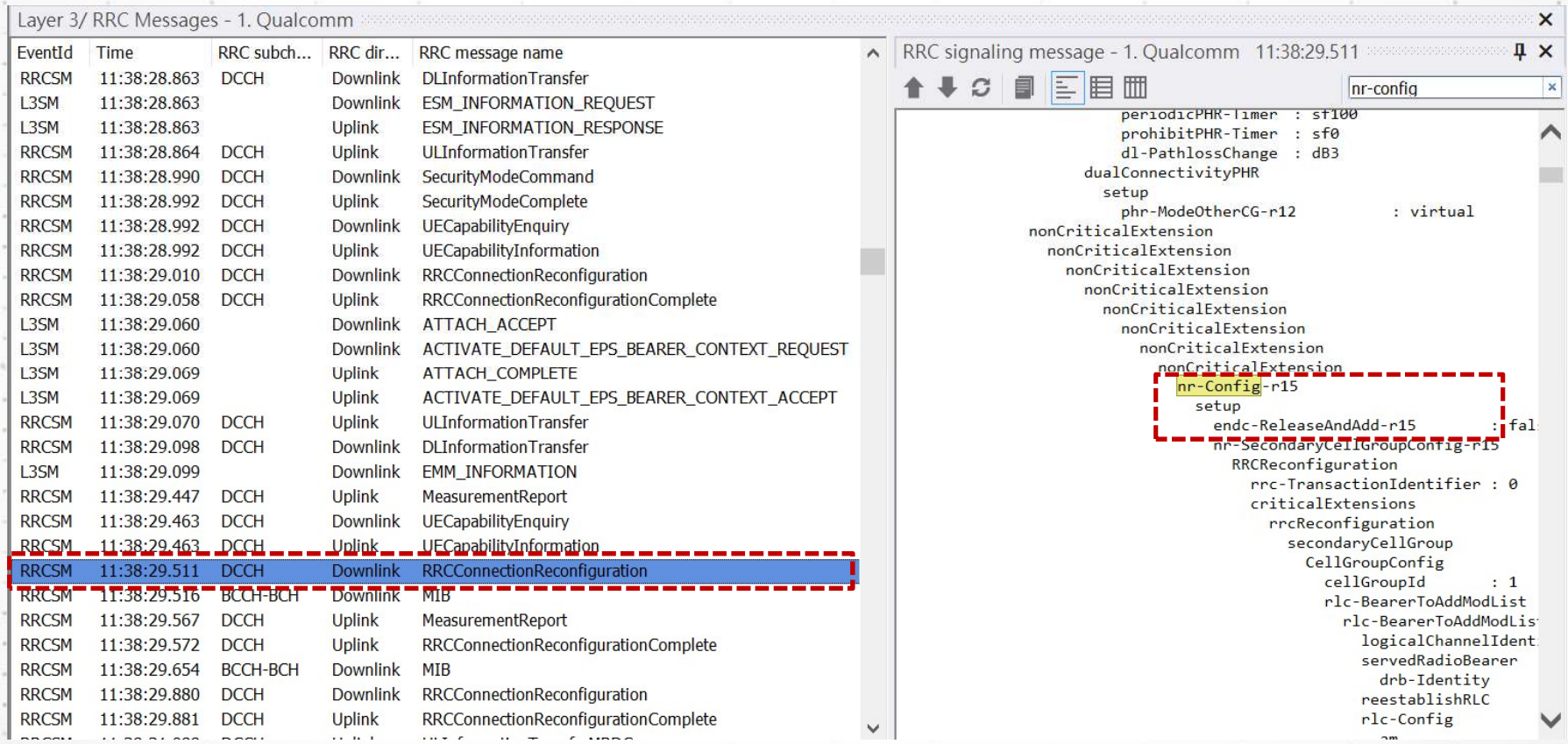
5G NR NSA SN Setup

- **UE should receive RRC Connection Reconfiguration for SCG (node) addition.**



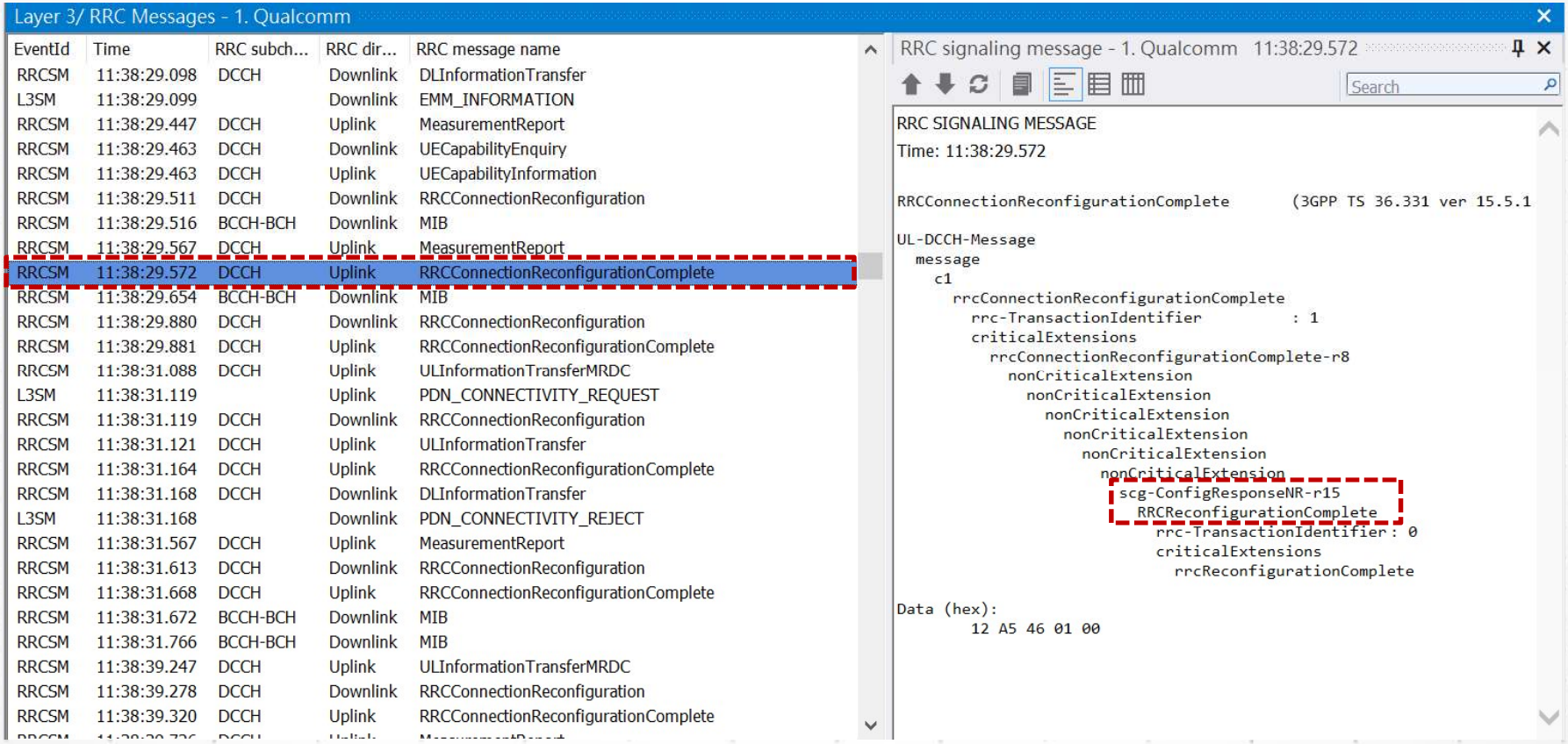
5G NR NSA SN Setup

- **NR Configuration – adding SCG.**



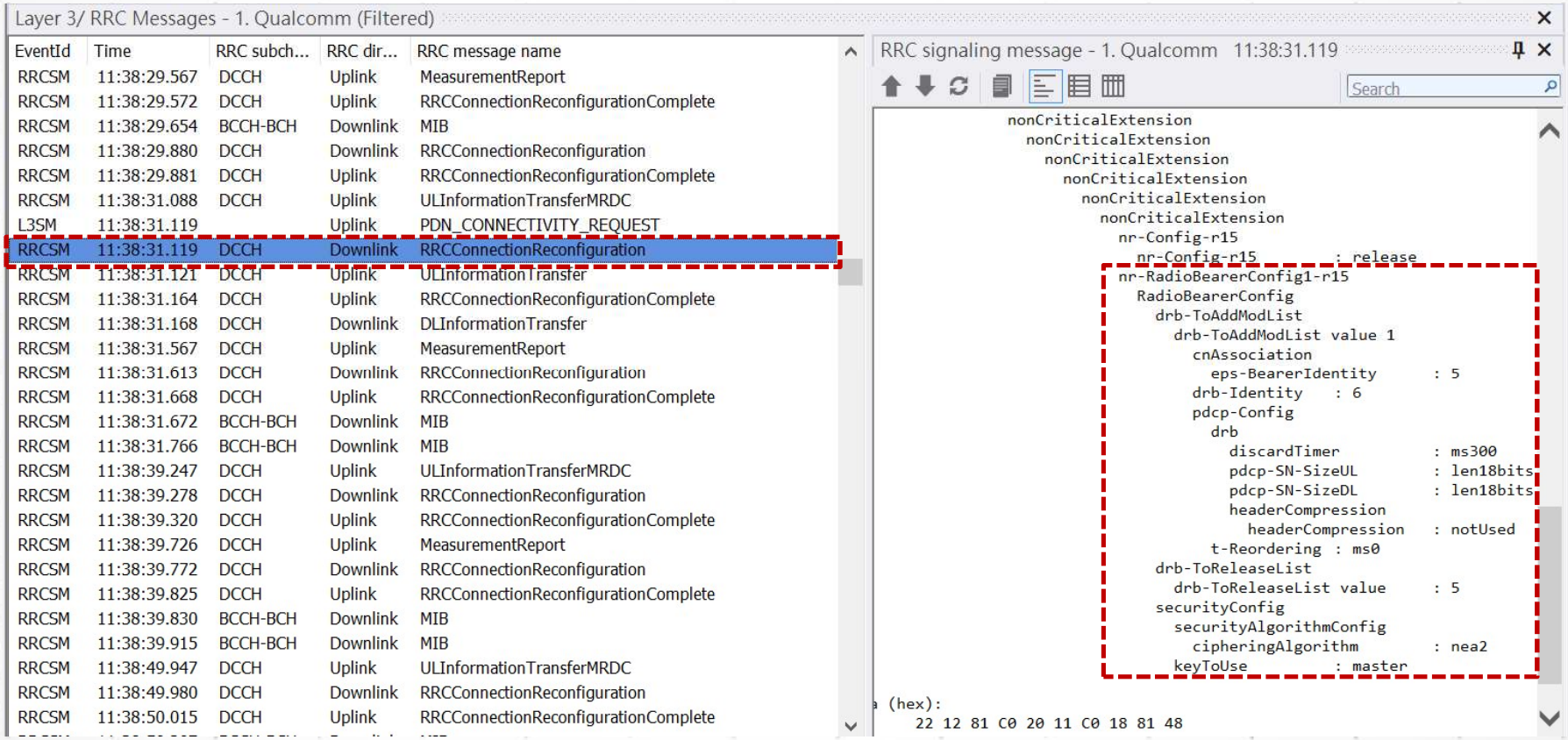
5G NR NSA SN Setup

- **Completion of adding SCG.**



5G NR NSA SN Setup

- **nr-Config1-r15 NR Radio Bearer configuration**



5G NR – SN Change

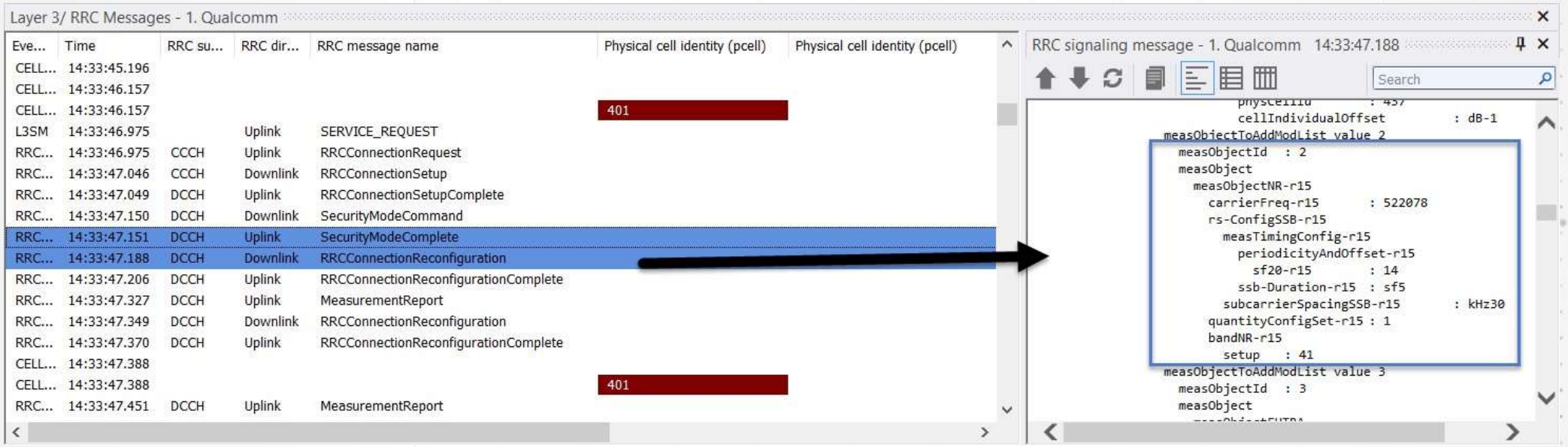
NR SECONDARY NODE CHANGE

SUMMARY

- Slide set shows NR secondary node change as UE moves.
- Sequence of events:
  - LTE HO to new cell
  - Loss of NR
  - UE receives NR measurement config on new LTE cell
  - UE sends MR based on B1 event
  - New LTE cell provides new SN information
  - UE performs DL synchronization on NR and then performs RACH
  - NR is now active on new LTE cell
- Due to the break and make process, discrimination needs to be made between Handover and Secondary node change.

NR SN CHANGE

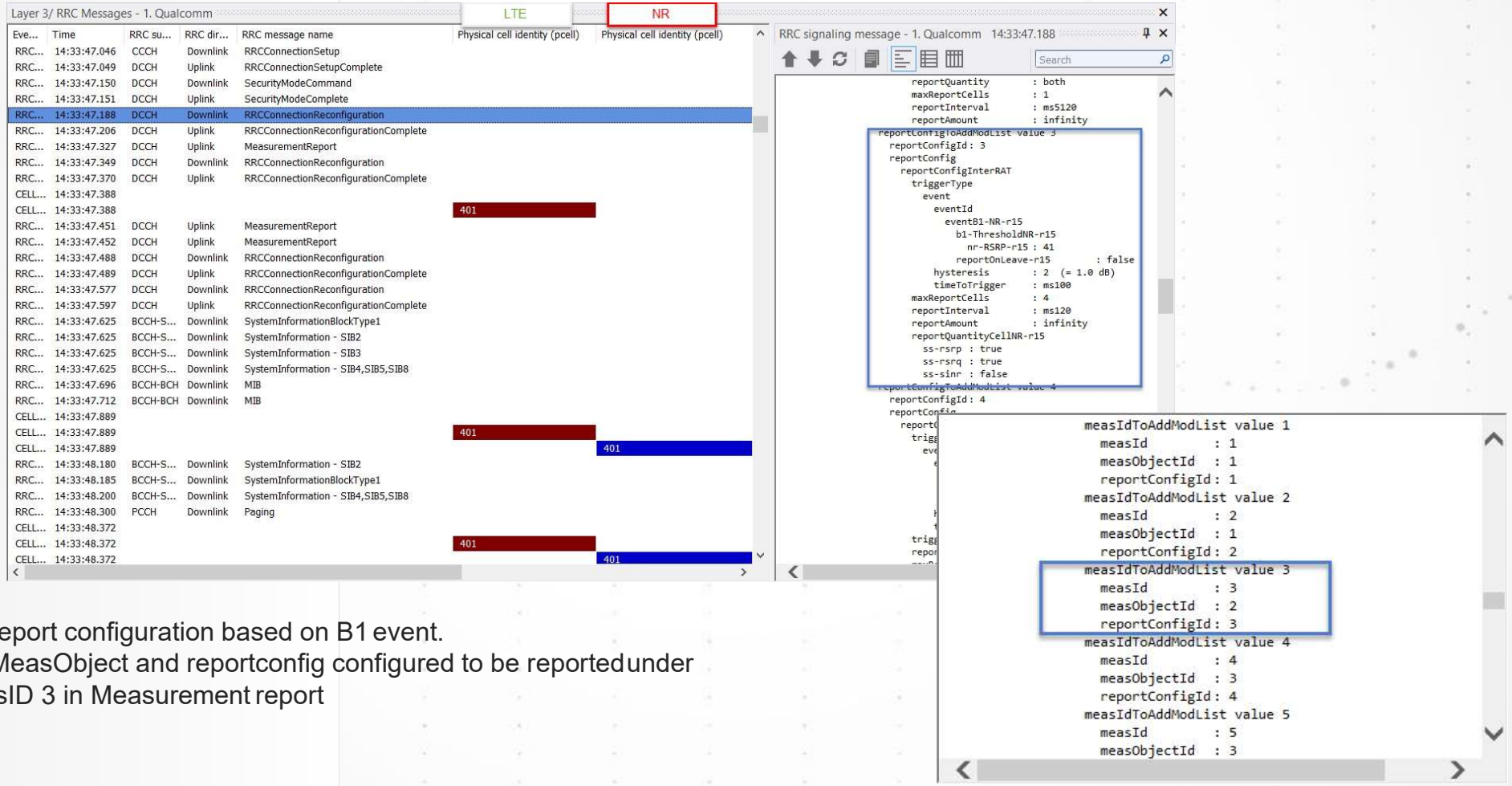
NR MEASUREMENT OBJECT



NR measurement object configuration

NR SN CHANGE

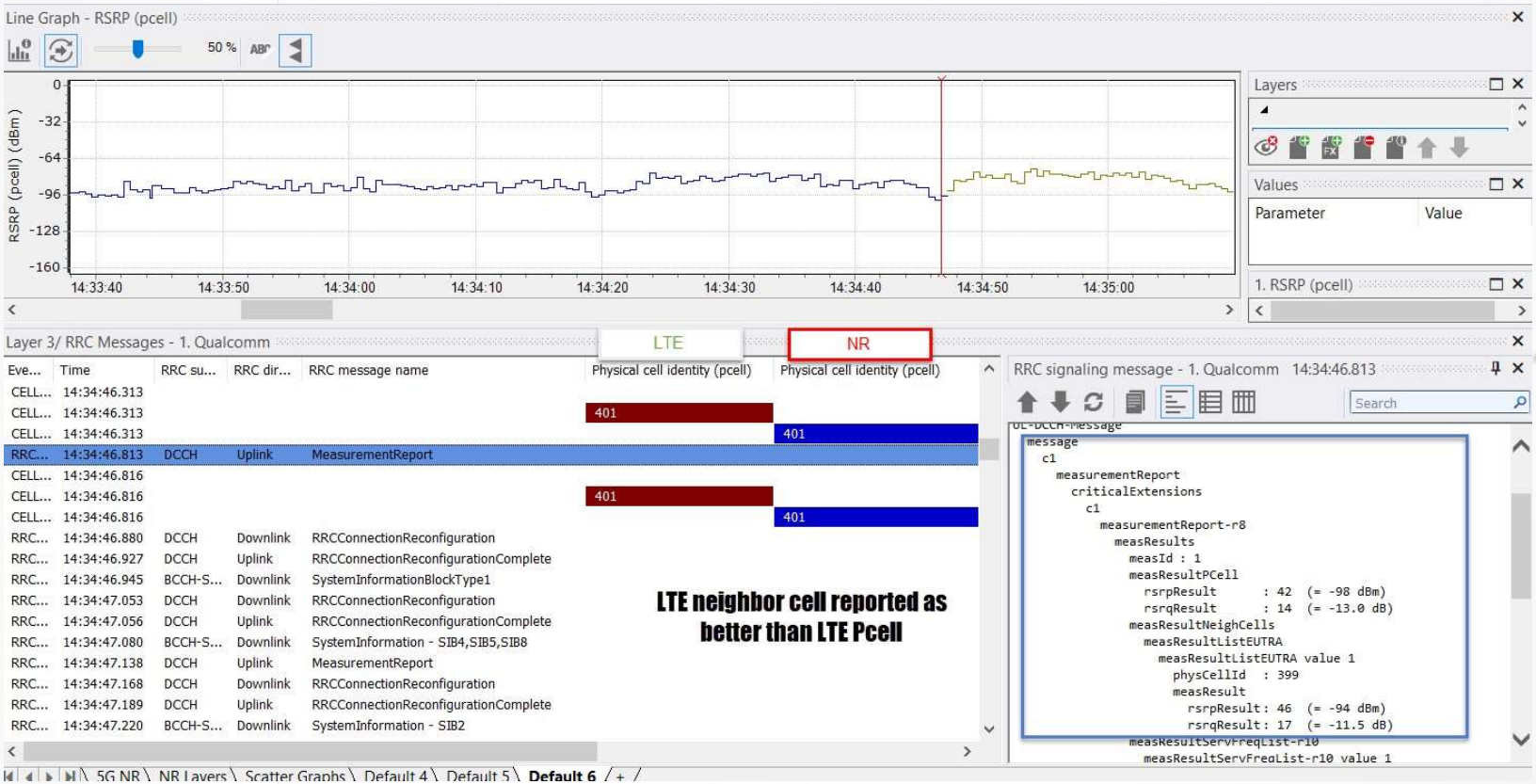
NR REPORT CONFIG



NR report configuration based on B1 event.
NR MeasObject and reportconfig configured to be reportedunder MeasID 3 in Measurement report

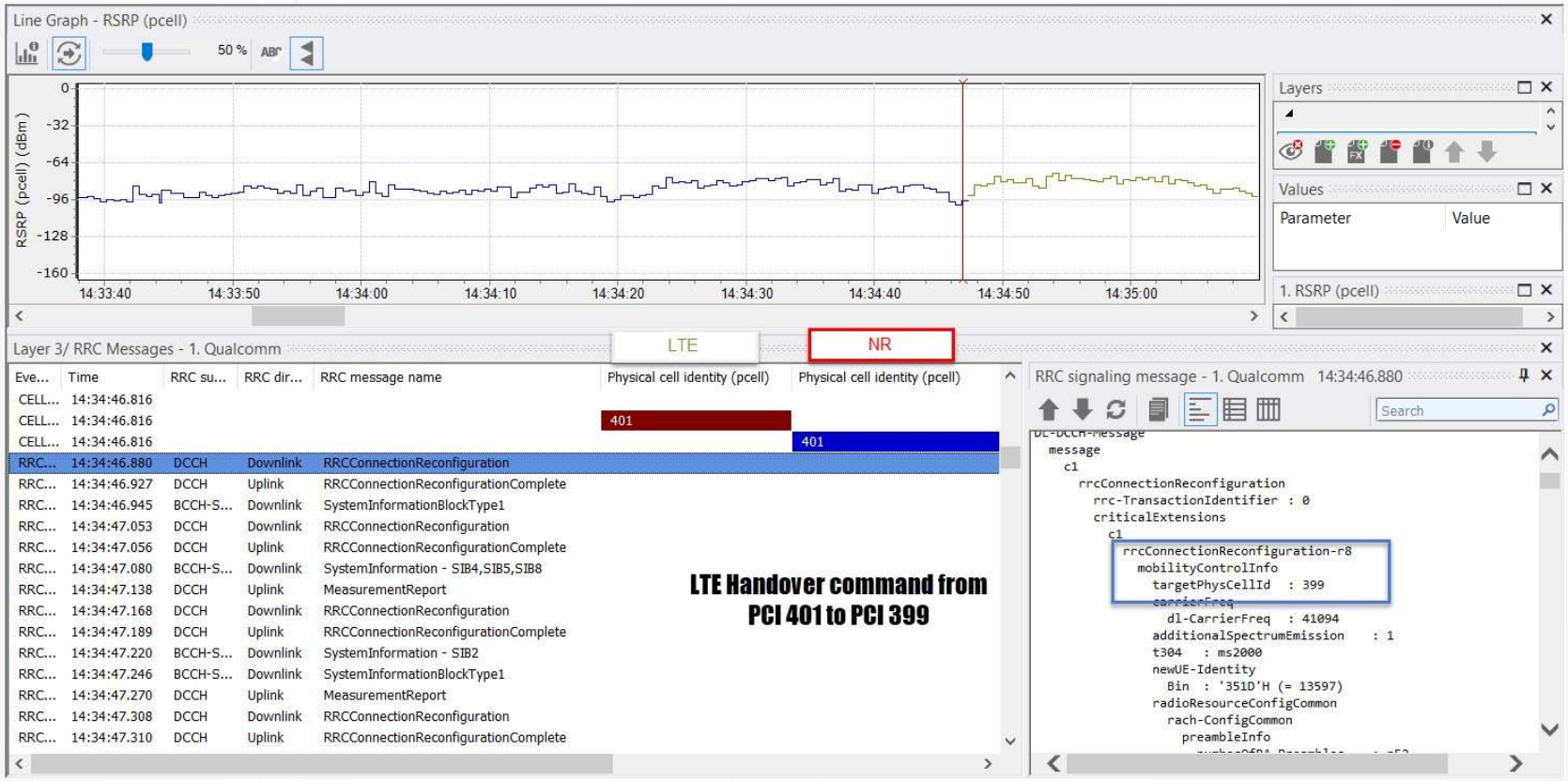
NR SN CHANGE

LTE HANDOVER INITIATION



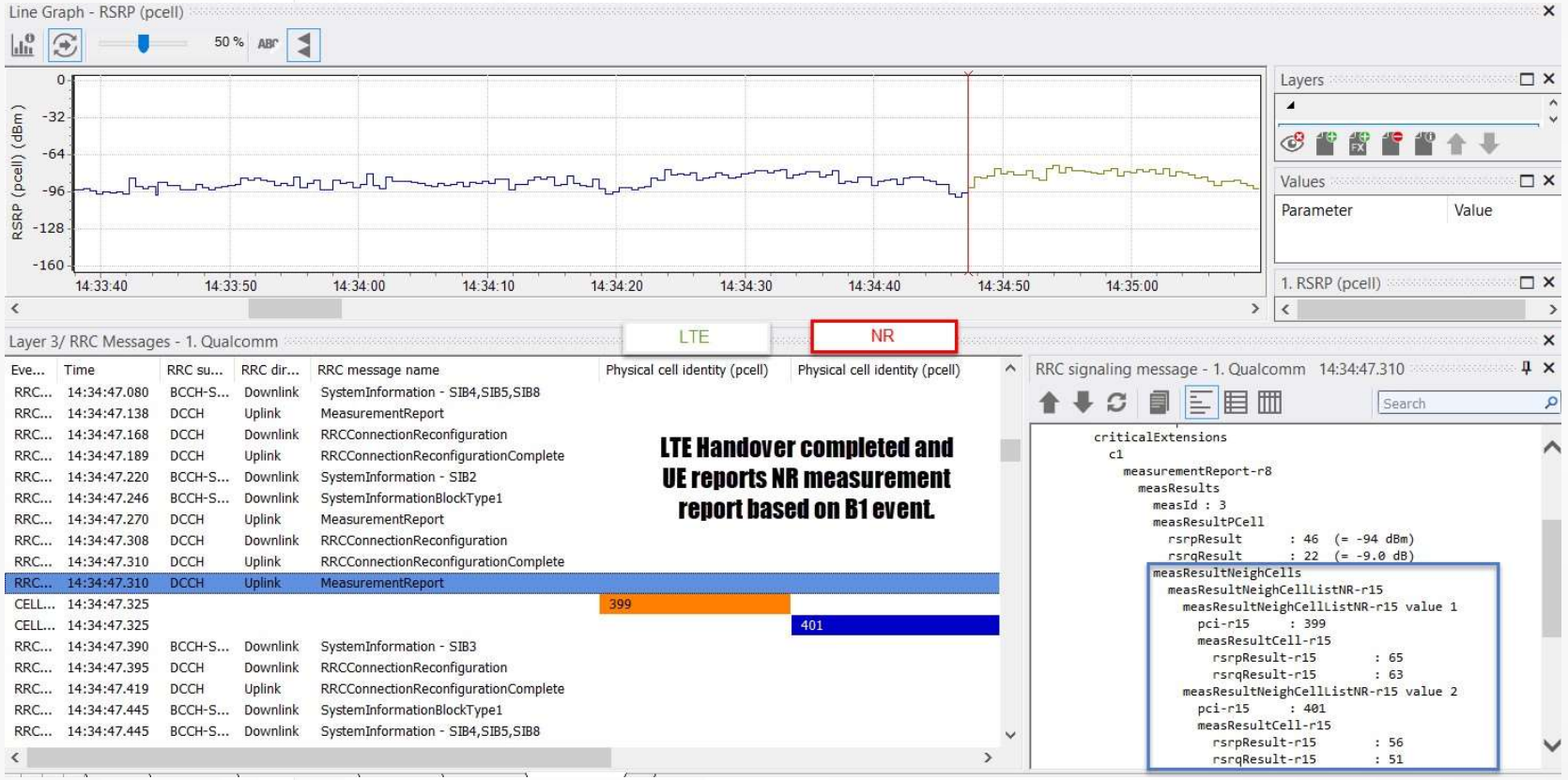
NR SN CHANGE

LTE HANDOVER COMMAND



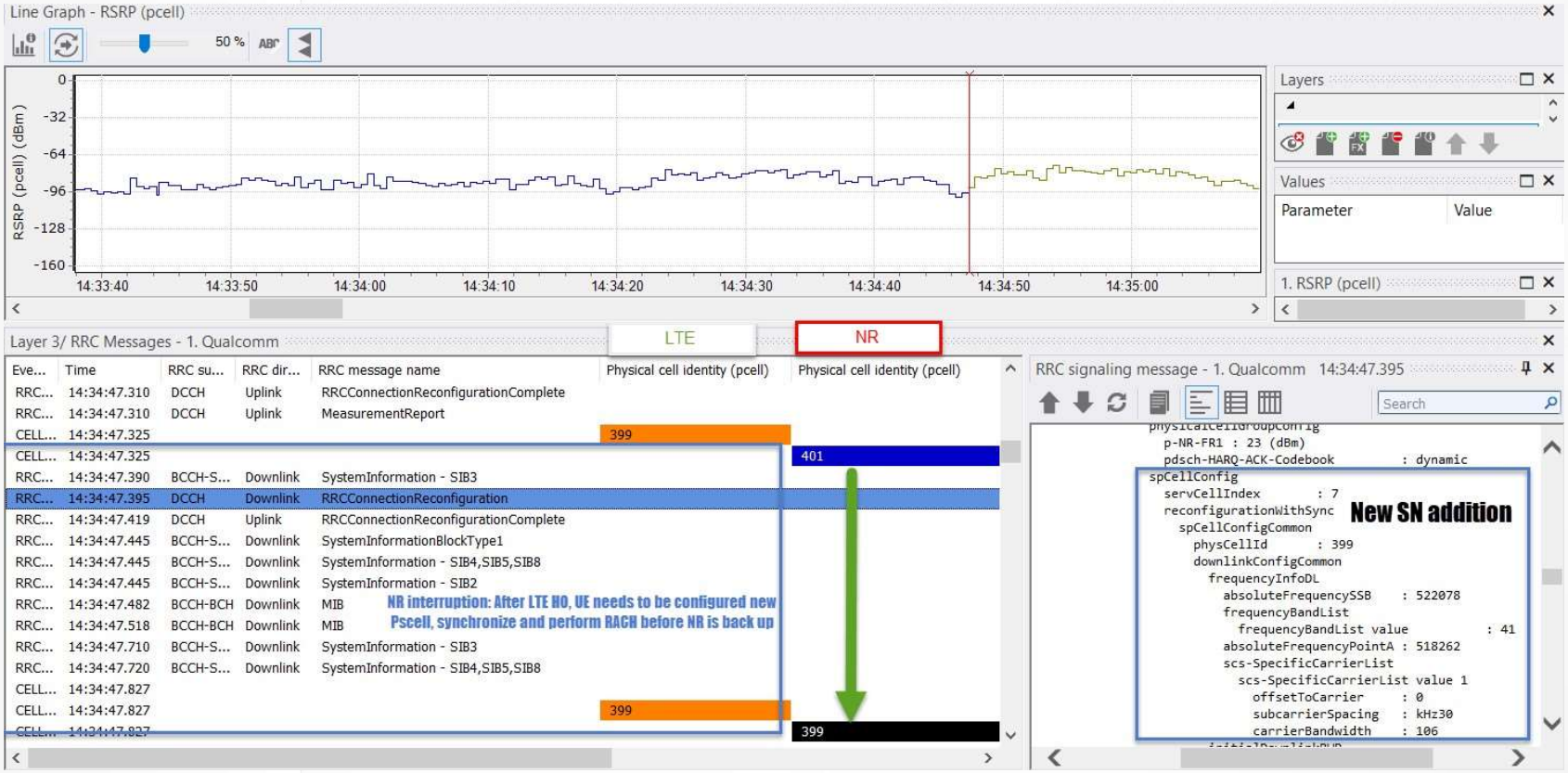
NR SN CHANGE

COMPLETION OF LTE HO AND MRSENTWITHNRCELLINFO



NR SN CHANGE

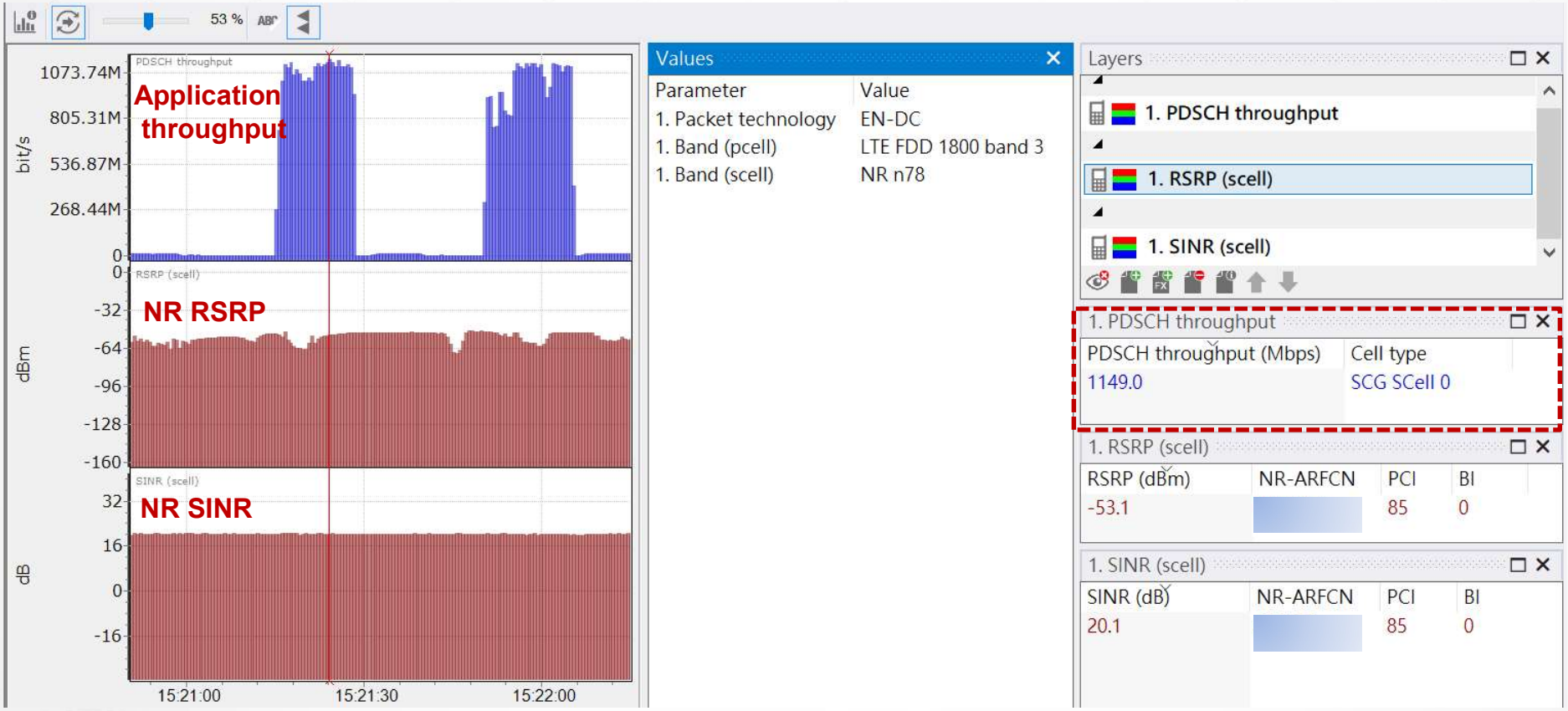
NR NEW SN ADDITION. NR INTERRUPTION



5G NR – Field testing observations

5G NR downlink speed

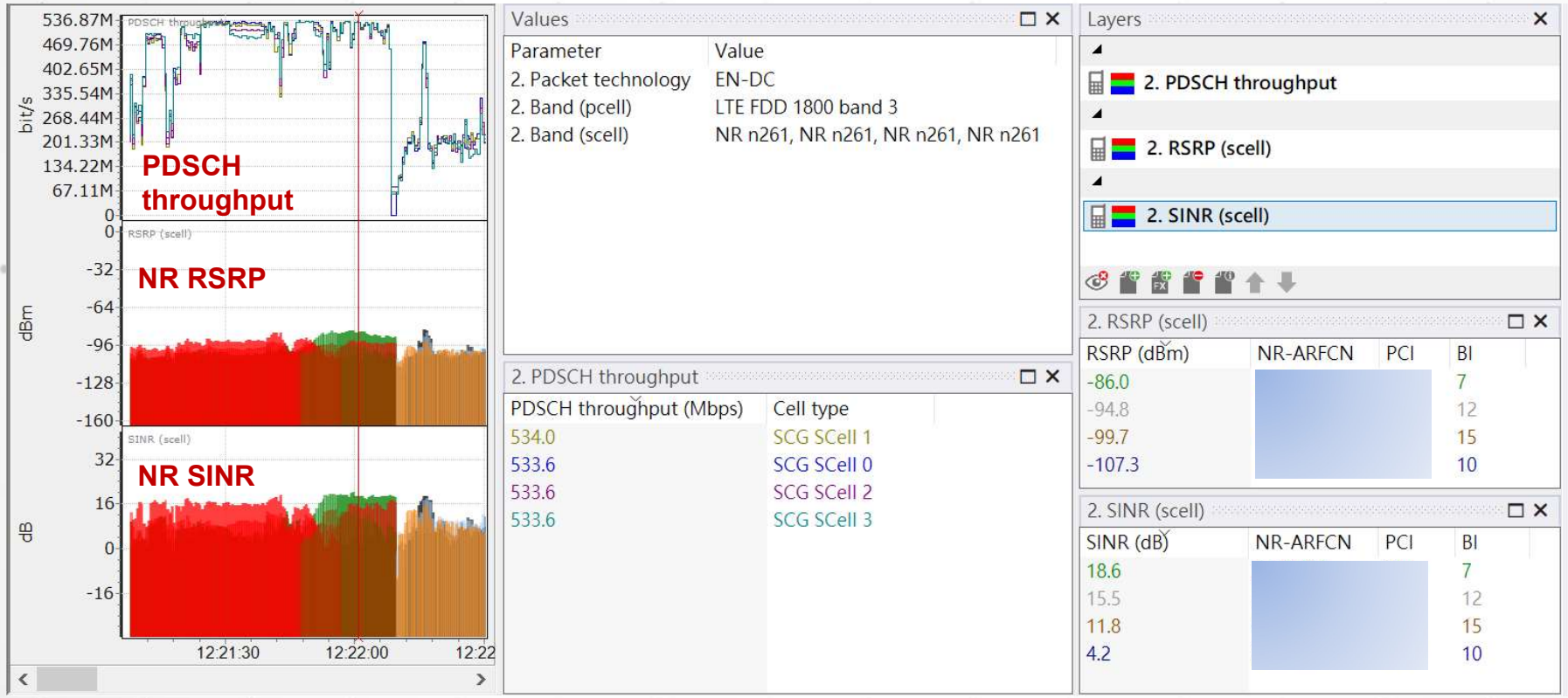
FR1 - N78



Max. downlink speed ~ 1Gbps

5G NR downlink speed

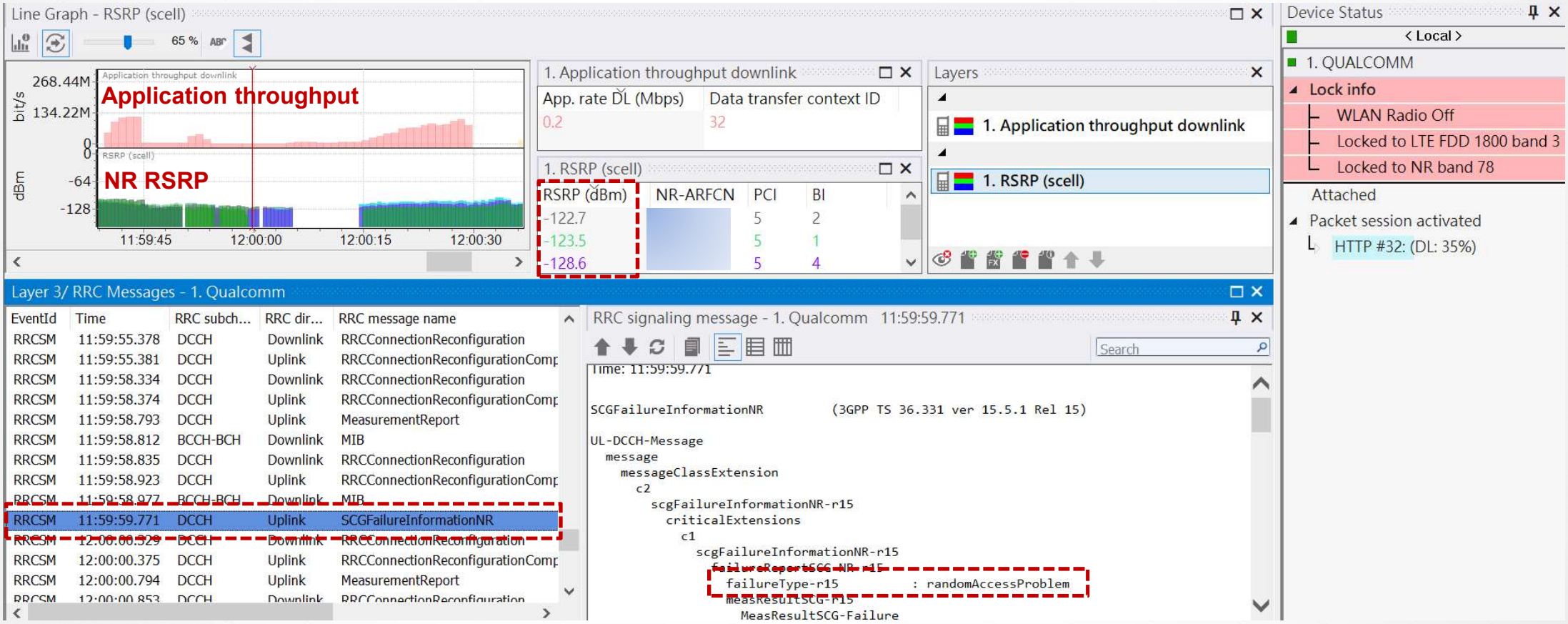
FR2 – N261



Max. downlink speed ~ 2Gbps

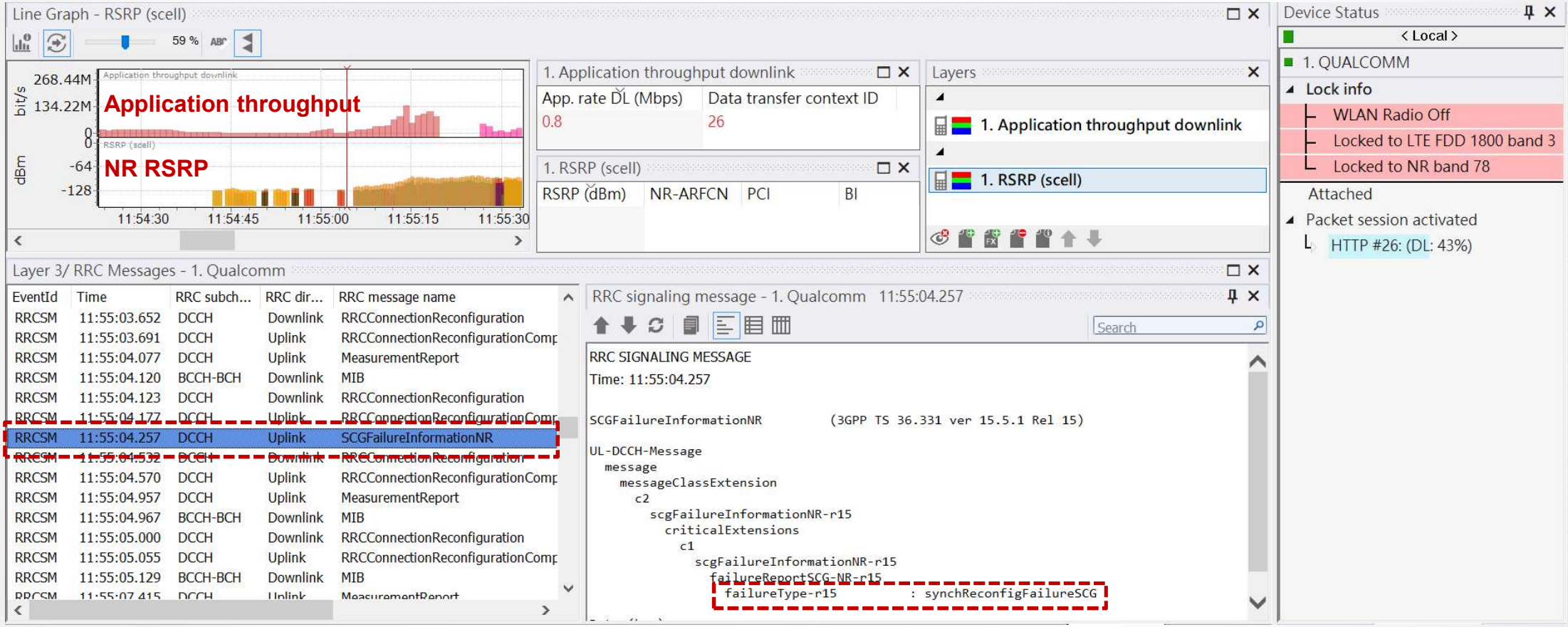
5G NR RACH Issue

SCG FAILURE WITH RACH – SCGFailureInformationNR



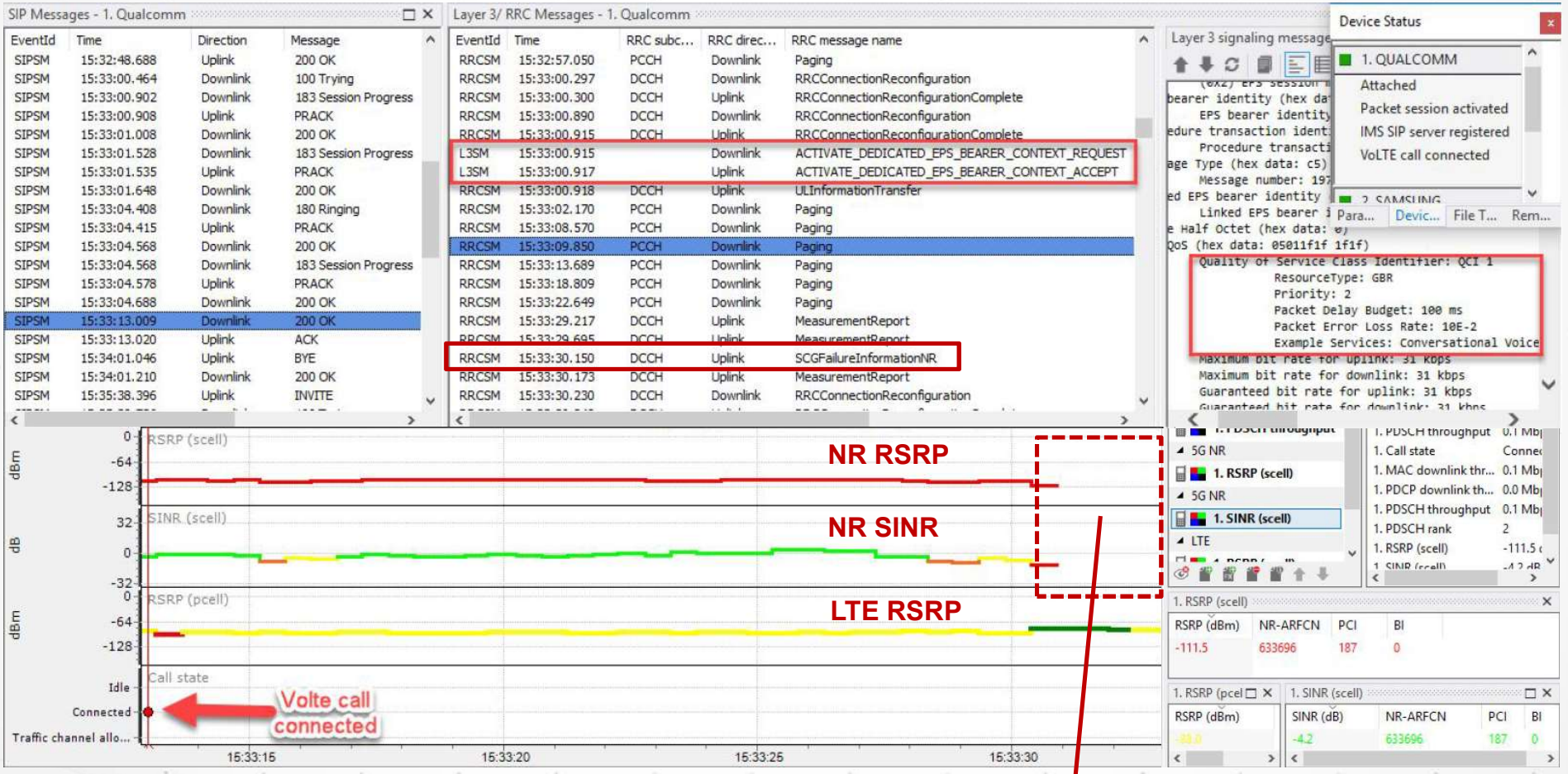
5G NR Sync Reconfiguration Issue

SCG FAILURE WITH Sync Recofig – SCGFailureInformationNR



5G NR Volte call

Lost of NR during Volte call



QUESTIONS?

Resources

FOR MORE INFORMATION

- Redefining 5G New Radio Drive Testing
- 5G NR drive testing and benchmarking with Nemo Intelligent Device Interface
- Nemo Outdoor 5G NR Drive Test Solution

- Related Products:
  - Nemo Handy
  - Nemo FSR1
  - Nemo Walker Air
  - Nemo Invex II
  - Nemo Customer Experience Monitor
  - Nemo Autonomous Probe
  - Nemo Cloud
  - Nemo Xynergy
  - Nemo WindCatcher
  - Nemo Analyze

Acronym Decoder

- 3GPP – Third Generation Partnership Project
- 5G NR – 5th Generation New Radio
- BI – Beam Index
- BLER – Block Error Rate
- CPE – Customer Premise Equipment
- CSI-RS (DL) = Channel State Information Reference Signal
- DL – Downlink
- FCC – Federal Communications Commission
- KPI – Key Performance Indicator
- MAC – Media Access Control
- MCS – Mobile Crowd Sourcing
- MIMO – Multiple Input Multiple Output
- mmWave – Millimeter-wave
- NEM – Network Equipment Manufacturer
- PBCH – Primary Broadcast Channel
- PBCH DMRS – PBCH Demodulation Reference Signal
- PDSCH – Physical Downlink Shared Channel
- PRB – Physical Resource Block
- PSS – Primary Synchronization Signal
- QoE – Quality of Experience
- QoS – Quality of Service
- RACH – Random Access Channel
- RAN – Radio Access Network
- RAT – Radio Access Technology
- RRC – Radio Resource Control
- SRS (UL) - Sounding Reference Signal
- SSB – Synchronization Signal Block
- SS-RSRP – SS Reference Signal Received Power
- SS-RSRQ – SS Reference Signal Received Quality
- SS-SINR – SS Signal-to-Noise and Interference Ratio
- SSS – Secondary Synchronization Signal
- TRS – Tracking Reference Signal
- TX – Transmitter
- UE – User Equipment
- UL – Uplink


KEYSIGHT
TECHNOLOGIES