

# Redefining Drive Test for 5G

2019.11.27

Keysight Nemo Wireless Solution

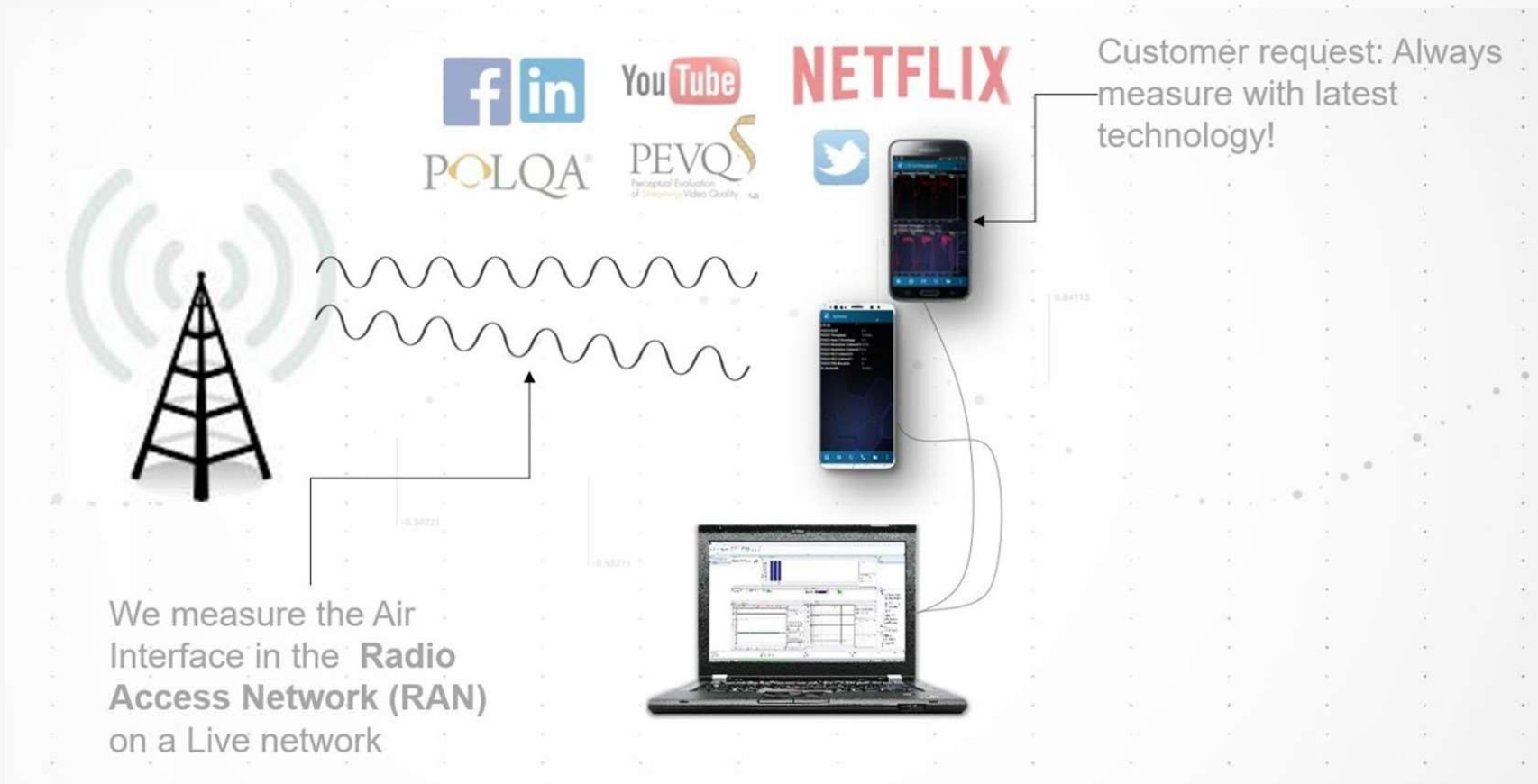


# Agenda

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

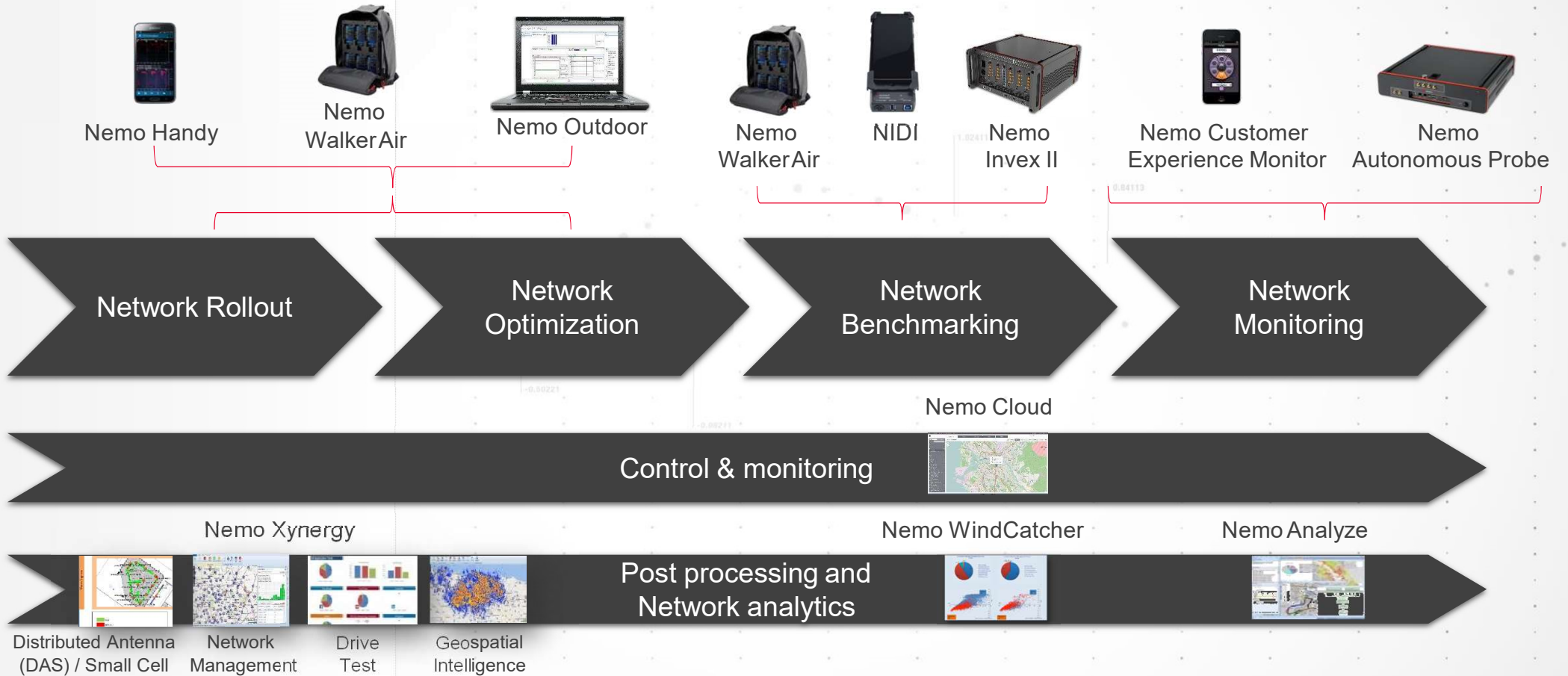


# Nemo Wireless Solutions for Live Network Testing



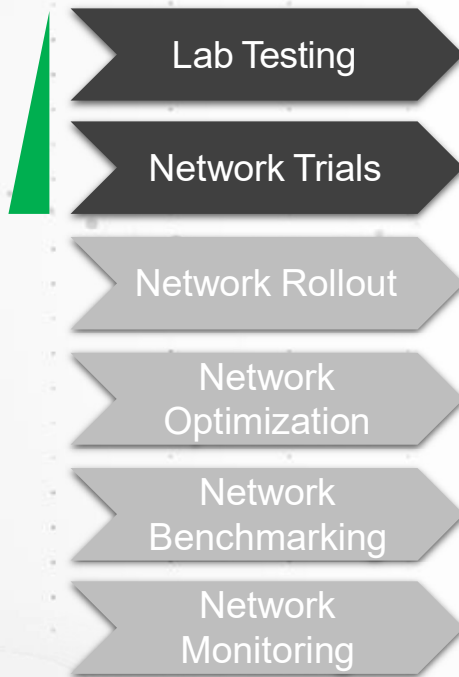
# Nemo Test & Measurement Products

## WIRELESS NETWORK LIFECYCLE SOLUTIONS

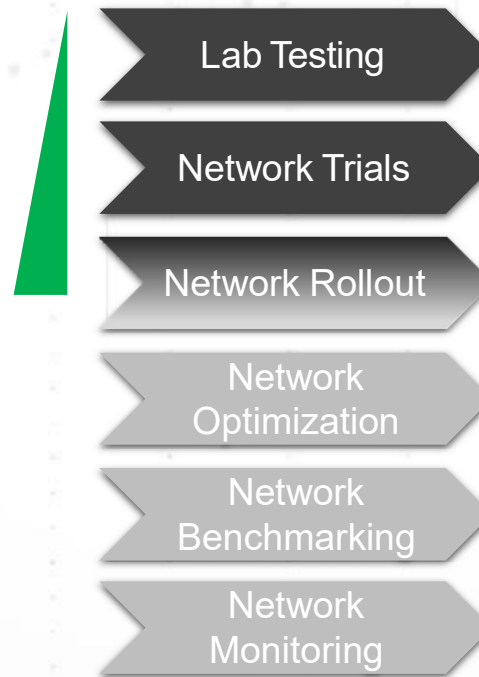
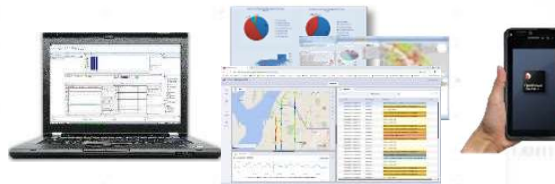


# 5G Field Measurement Evolution

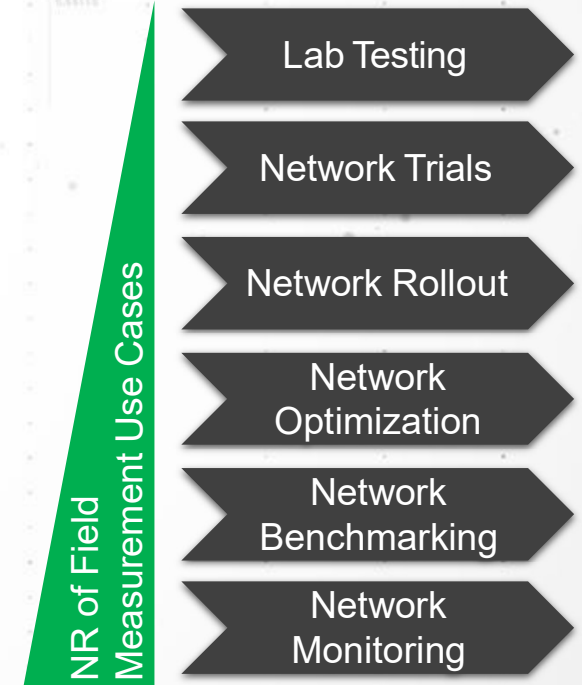
## 5G Testing Now



## 5G Testing 2020



## 5G Testing 2021+



# 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

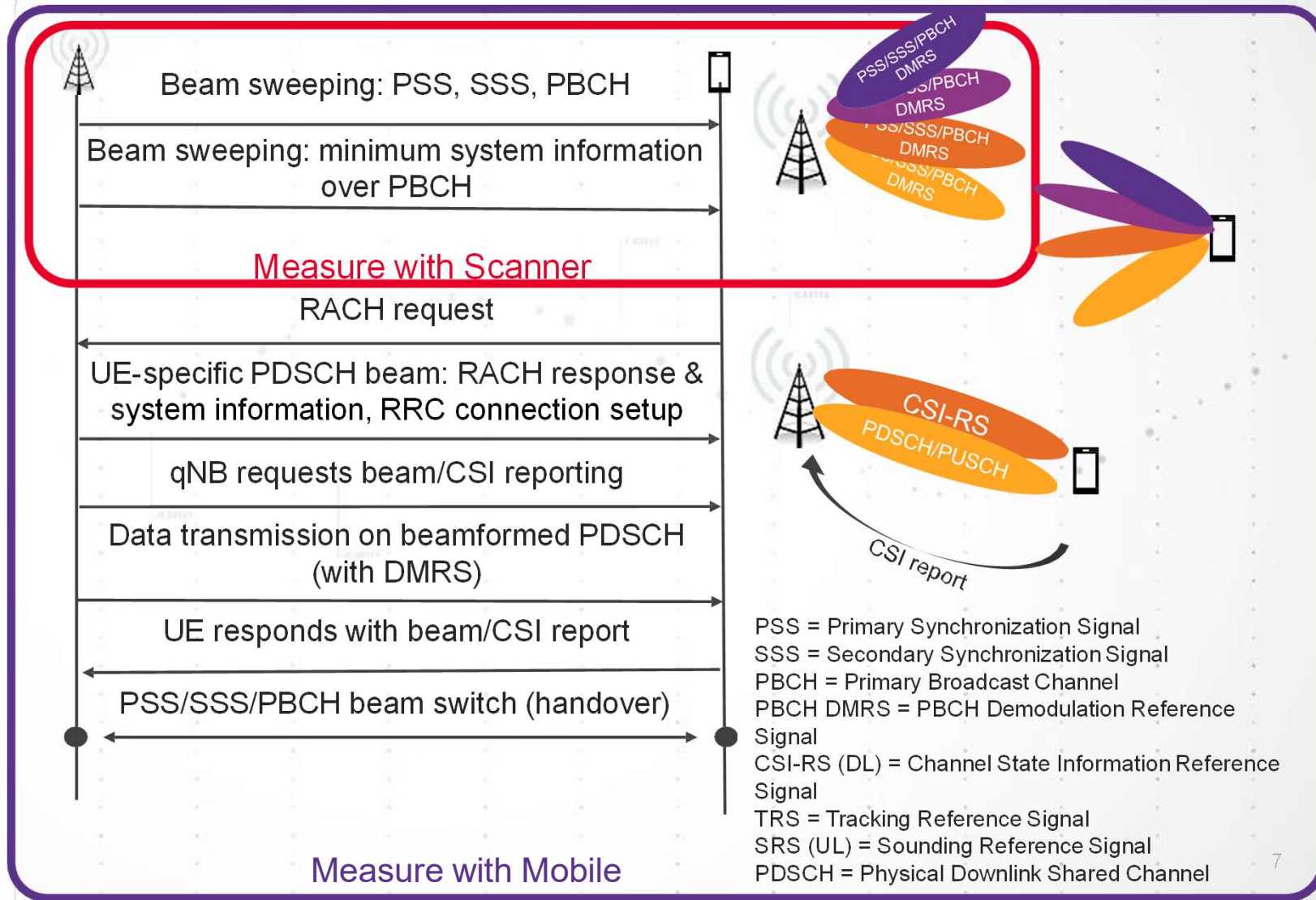




# 5G Coverage

# 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

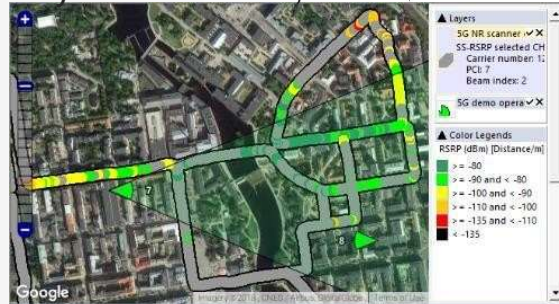
- Shift from cell-based network coverage to beam-based network coverage
- Major challenge for operators and NEMs to verify and understand the network coverage in the field

Legacy technologies, cell coverage footprint

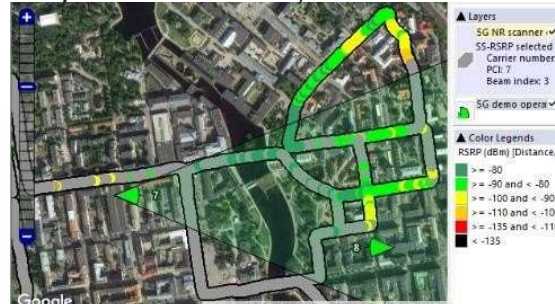


5G NR – cell coverage is split into multiple beams with non-continuous coverage footprints

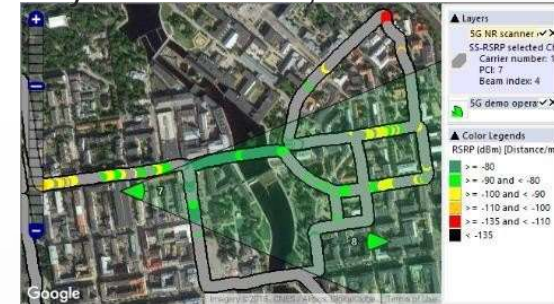
Physical Cell Id 7, beam index 2



Physical Cell Id 7, beam index 3

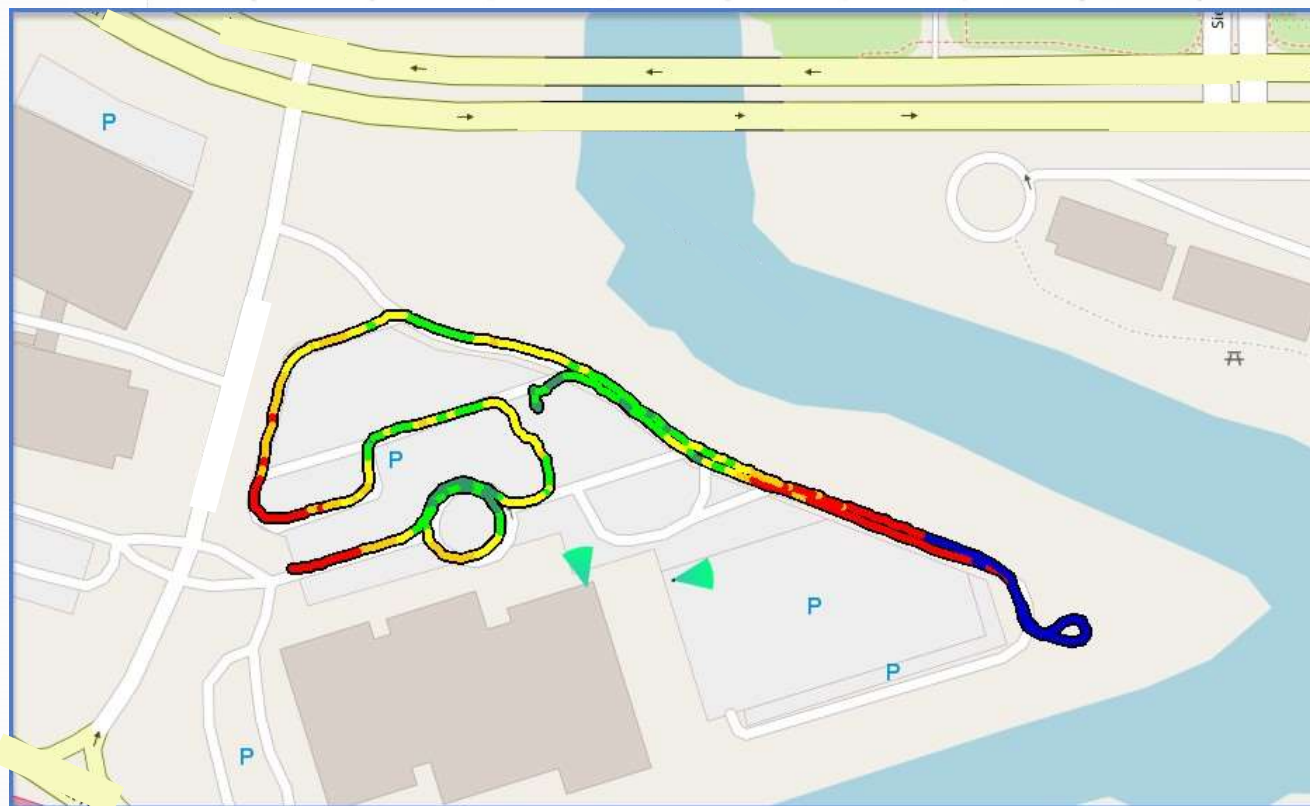


Physical Cell Id 7, beam index 4



# NR Cell Coverage - PCI

FR2/39GHZ – SCANNER MEASUREMENT

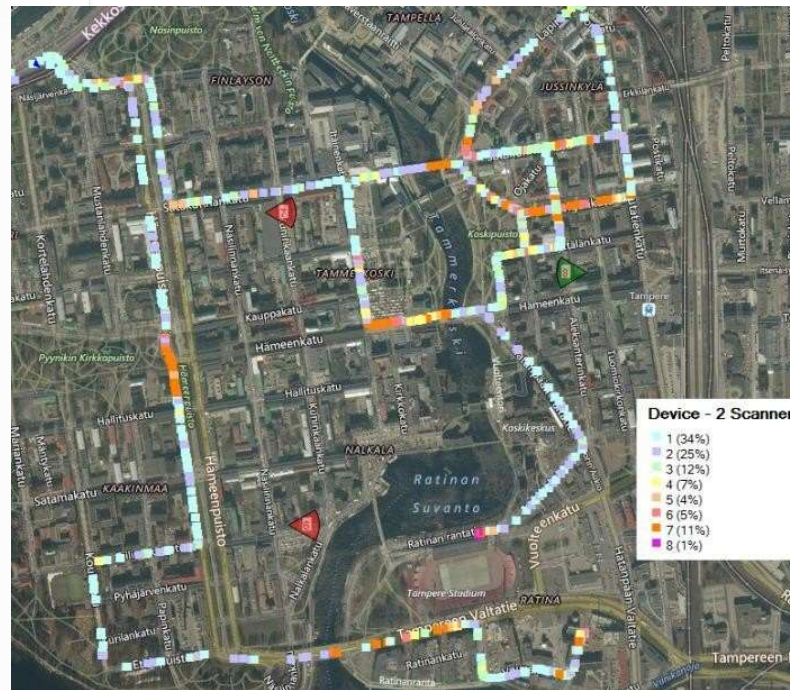


# 5G NR Scanner Analytics

## WINDCATCHER 5G SCANNER TROUBLESHOOTING

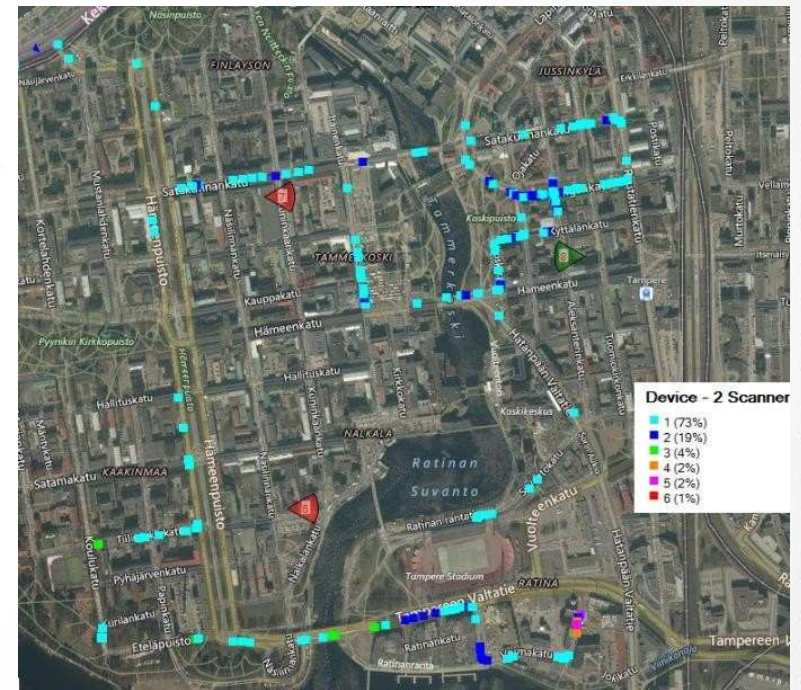
- Troubleshooting
- Poor Coverage
- Possible Interference
- Numbers of Servers
- Numbers of Beams
- Numbers of Beams for PCI
- Number of Servers Within Threshold
- Number of Beams Within Threshold
- Number of Beams for PCI Within Threshold

### 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

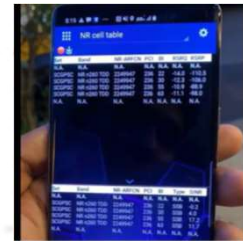
- 5G NR UE with diagnostics interface (QC/Samsung/Hisilicon device)
- Scanner
- Nemo Outdoor and Handy SW for measurement control
- Nemo Analyze/Nemo WindCatcher for post-processing

### • Use Cases

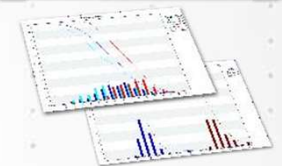
- Throughput & latency testing
- 5G <> LTE multimode connectivity analysis
- Dual connectivity
- Beam switching & HO analysis

### • 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 ARCHITECTURE

Release 15

9

3GPP TS 37.340 V15.6.0 (2019-06)

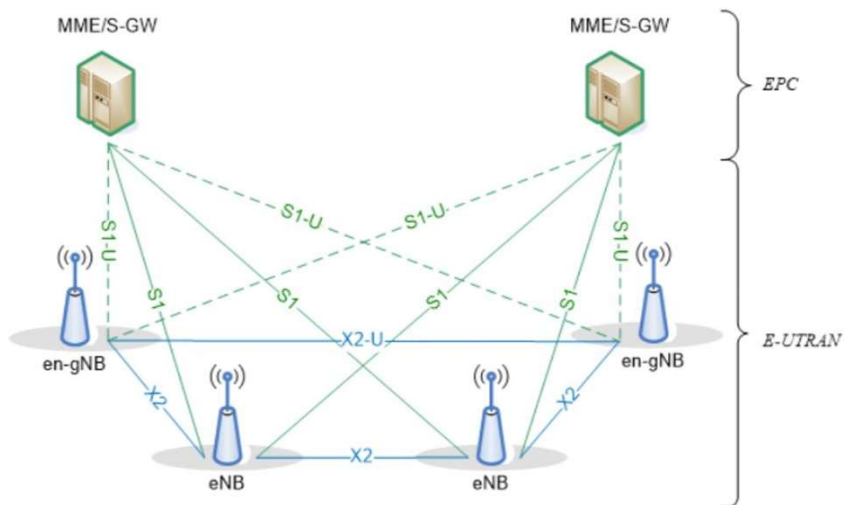
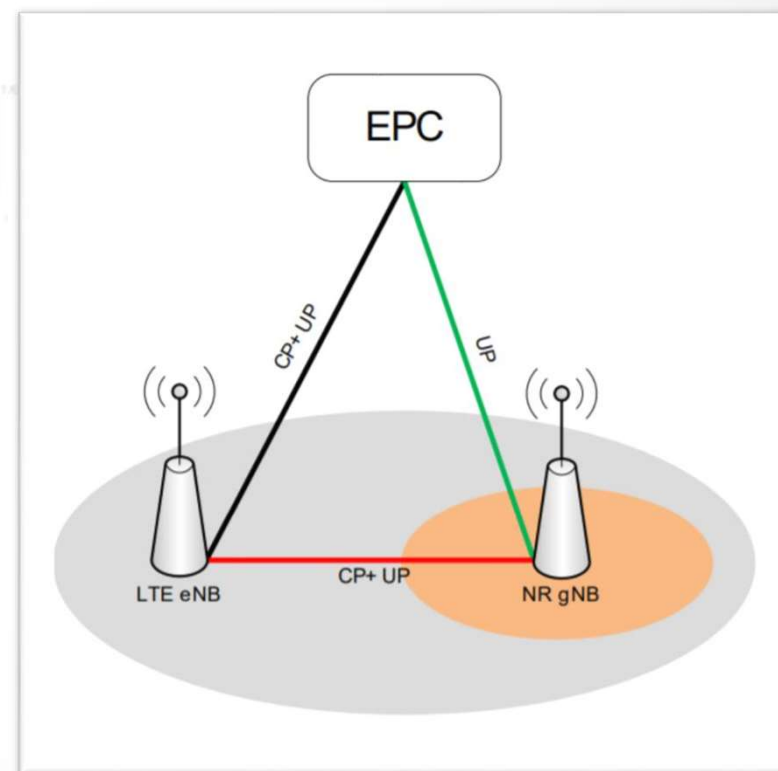


Figure 4.1.2-1: EN-DC Overall Architecture



# 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	1	Uplink	ATTACH_REQUEST	
L3SM	14:39:24.399		Uplink	PDN_CONNECTIVITY_REQUEST	
RRCSM	14:39:24.399	CCCH	Uplink	RRCCConnectionRequest	
RACHI	14:39:24.399				
RRCSM	14:39:24.399	CCCH	Downlink	RRCCConnectionSetup	
RRCSM	14:39:24.399	DCCH	Uplink	RRCCConnectionSetupComplete	
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	2	Downlink	UECapabilityEnquiry	
RRCSM	14:39:26.412	DCCH	Uplink	UECapabilityInformation	
RRCSM	14:39:26.412	3	Downlink	RRCCConnectionReconfiguration	
RRCSM	14:39:26.615	DCCH	Uplink	RRCCConnectionReconfiguration...	
L3SM	14:39:26.615		Downlink	ACTIVATE_DEFAULT_EPS_BE...	
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_BE...	
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	4	Uplink	MeasurementReport	
RRCSM	14:39:27.431	DCCH	Downlink	RRCCConnectionReconfiguration	5
RRCSM	14:39:27.431	BCCH-BCH	Downlink	MIB	6
RRCSM	14:39:27.431	DCCH	Uplink	RRCCConnectionReconfiguration...	
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				
L3SM	14:39:27.431				7 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.

The screenshot displays a network analysis tool interface with two main panes. The left pane, titled 'Layer 3/ RRC Messages - 1. Qualcomm', contains a table of RRC messages. The right pane, titled 'Layer 3 signaling message - 1. Qualcomm 11:38:23.610', shows the details of the selected message.

EventId	Time	RRC subch...	RRC dir...	RRC message name
RRCSM	11:38:23.398	BCCH-BCH	Downlink	MasterInformationBlock
RRCSM	11:38:23.418	BCCH-SCH	Downlink	SystemInformationBlockType1
RRCSM	11:38:23.433	BCCH-SCH	Downlink	SystemInformation - SIB3
RRCSM	11:38:23.539	BCCH-SCH	Downlink	SystemInformation - SIB5
RRCSM	11:38:23.574	BCCH-SCH	Downlink	SystemInformation - SIB2
L3SM	11:38:23.610	Uplink	Uplink	ATTACH_REQUEST
L3SM	11:38:23.639	Uplink	Uplink	PDN_CONNECTIVITY_REQUEST
RRCSM	11:38:23.639	CCCH	Uplink	RRCCConnectionRequest
RRCSM	11:38:23.662	CCCH	Downlink	RRCCConnectionSetup
RRCSM	11:38:23.667	DCCH	Uplink	RRCCConnectionSetupComplete
RRCSM	11:38:23.693	DCCH	Downlink	DLInformationTransfer
L3SM	11:38:23.693	Downlink	Downlink	IDENTITY_REQUEST
L3SM	11:38:23.693	Uplink	Uplink	IDENTITY_RESPONSE
RRCSM	11:38:23.693	DCCH	Uplink	ULInformationTransfer
RRCSM	11:38:23.713	DCCH	Downlink	DLInformationTransfer
L3SM	11:38:23.713	Downlink	Downlink	ATTACH_REJECT
RRCSM	11:38:23.714	DCCH	Downlink	RRCCConnectionRelease
RRCSM	11:38:23.977	BCCH-BCH	Downlink	MasterInformationBlock
RRCSM	11:38:23.998	BCCH-SCH	Downlink	SystemInformationBlockType1
RRCSM	11:38:23.998	BCCH-SCH	Downlink	SystemInformation - SIB3
RRCSM	11:38:23.998	BCCH-SCH	Downlink	SystemInformation - SIB5
RRCSM	11:38:23.998	BCCH-SCH	Downlink	SystemInformation - SIB2
RRCSM	11:38:24.168	BCCH-BCH	Downlink	MasterInformationBlock
RRCSM	11:38:24.329	BCCH-SCH	Downlink	SystemInformationBlockType1
RRCSM	11:38:24.416	BCCH-BCH	Downlink	MasterInformationBlock
RRCSM	11:38:24.487	BCCH-SCH	Downlink	SystemInformationBlockType1
RRCSM	11:38:24.597	BCCH-BCH	Downlink	MasterInformationBlock

The details pane for the 'ATTACH\_REQUEST' message shows the following supported and unsupported features:

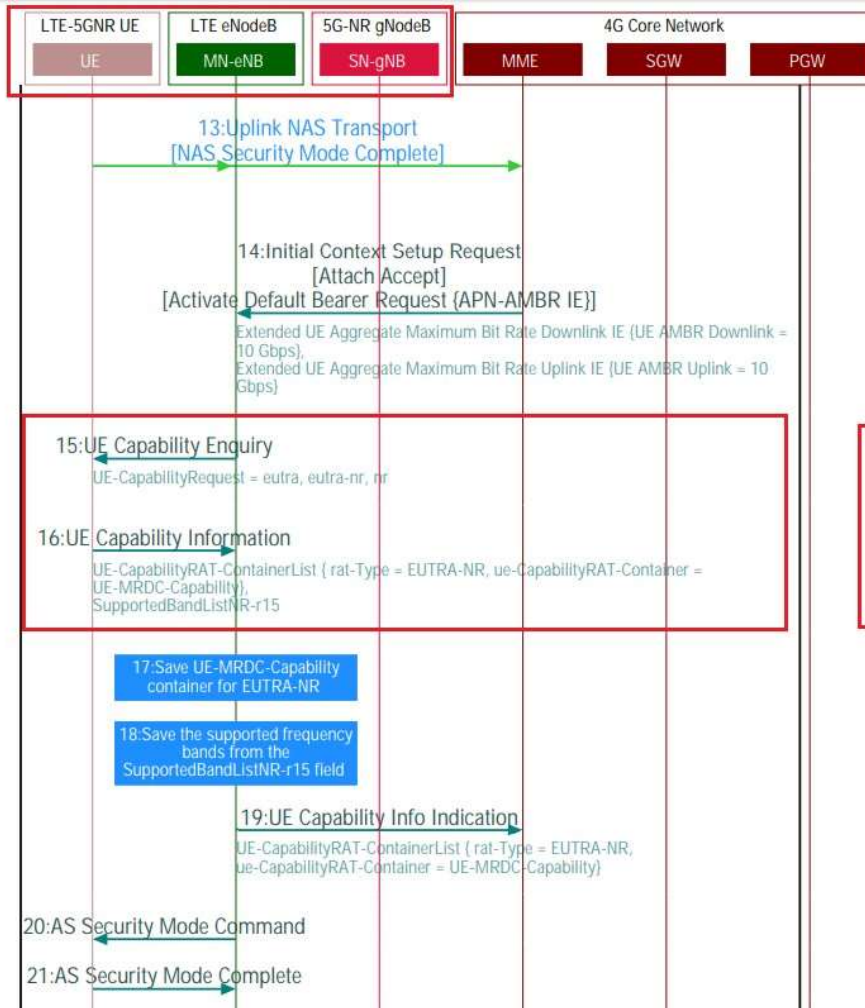
- UIA6: not supported
- UIA7: not supported
- NF: notification procedure not supported
- 1xSRVCC capability: SRVCC from E-UTRAN to cdma2000?1xCS not supported
- LCS: LCS notification mechanisms not supported
- LPP: LTE Positioning Protocol (LPP) supported
- ACC-CSFB: eNodeB-based access class control for CSFB supported
- H.245-ASH: H.245 after SRVCC handover capability not supported
- ProSe: ProSe not supported
- ProSe-dd: ProSe direct discovery not supported
- ProSe-dc: ProSe direct communication not supported
- ProSe-relay: ProSe direct communication not supported
- CP CIoT: not supported
- UP CIoT: not supported
- S1-U data: not supported
- ERw/oPDN: not supported
- HC-CP CIoT: not supported
- ePCO: not supported
- multipleDRB: not supported
- V2XPC5: not supported
- RestrictEC: not supported
- CPbackoff: not supported
- DCNR: supported**
- N1mode: supported
- SGC: supported
- 15 bearers: supported

Additional information at the bottom of the details pane:

- M ESM message container (hex data: 002a021e d011d127 23808021 10010000 10810600)
- ESM message container contents: 021ed011d12723808021100100001081060000
- 0 Last visited registered TAI (hex data: 5264f679 61ad)
- MCC: 466
- MNC: 97
- TAC: 25005 (0x61ad)



# 5G NR NSA SN Setup



NAS level security procedure is completed. From this point, all communication between MME and UE will be encrypted.

MME responds back to the eNodeB with a message containing three messages: STAP Initial Context Setup Request, NAS Attach Accept and Activate Default Bearer Request. 5G downlink and uplink data rates are signaled via Extended UE-AMBR Downlink and Uplink Information Elements.

MME has not sent UE capabilities so the eNodeB asks the UE for "UE Capabilities". UE capabilities are requested for 4G-LTE (utra), EN-DC (eutra-nr) and 5G (nr).

UE reports that it supports the EUTRA-NR radio access technology. EUTRA-NR specific capabilities are specified in the UE-MRDC-Capability container. The message also contains information about the supported 5G frequency bands.

Extract the dual connectivity capabilities from the UE Capability Info message.

Extract information about the UE supported frequency bands.

UE capabilities are also passed to the MME.

Setup security between the eNodeB and the UE

Ciphering is enabled in both directions.

# 5G NR NSA SN Setup

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

The screenshot shows a network protocol analyzer interface. The main window, titled 'Layer 3/ RRC Messages - 1. Qualcomm', displays a list of RRC messages. The message at 11:38:29.463 is highlighted with a red dashed box. The detailed view of this message, titled 'RRC signaling message - 1. Qualcomm 11:38:29.463', shows the following structure:

```
Time: 11:38:29.463
UECapabilityEnquiry (3GPP TS 36.331 ver 15.5.1 Rel 15)
DL-DCCH-Message
message
c1
  ueCapabilityEnquiry
    rrc-TransactionIdentifier : 2
    criticalExtensions
      c1
        ueCapabilityEnquiry-r8
          ue-CapabilityRequest
            ue-CapabilityRequest value : nr, eutra-nr
          nonCriticalExtension
            nonCriticalExtension
            nonCriticalExtension
            nonCriticalExtension
            requestedFreqBandsNR-MRDC-r15
              FreqBandList
                FreqBandList value 1
                  bandInformationEUTRA
                    bandEUTRA : 3
                FreqBandList value 2
                  bandInformationNR
                    bandNR : 78
            nonCriticalExtension
              eutra-nr-only-r15 : true
```

# 5G NR NSA SN Setup

- UE reports that it supports b3-n78 combination.

The image shows two screenshots from a network analysis tool. The left screenshot is a table of Layer 3/ RRC Messages. The right screenshot is a detailed view of an RRC signaling message.

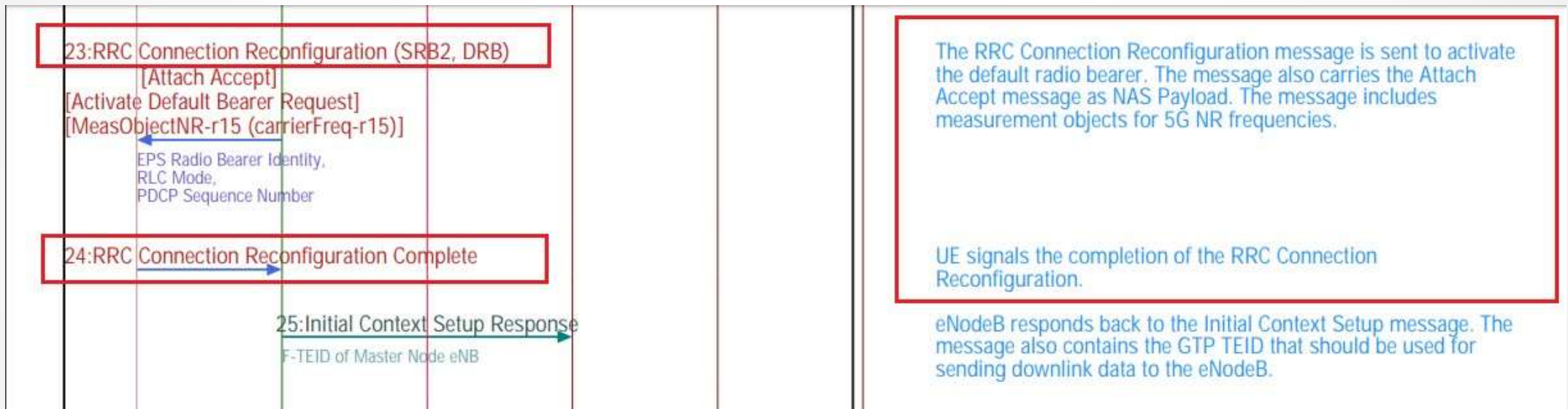
EventId	Time	RRC subch...	RRC dir...	RRC message name
RRCSM	11:38:28.863	DCCH	Downlink	DLInformationTransfer
L3SM	11:38:28.863		Downlink	ESM_INFORMATION_REQUEST
L3SM	11:38:28.863		Uplink	ESM_INFORMATION_RESPONSE
RRCSM	11:38:28.864	DCCH	Uplink	ULInformationTransfer
RRCSM	11:38:28.990	DCCH	Downlink	SecurityModeCommand
RRCSM	11:38:28.992	DCCH	Uplink	SecurityModeComplete
RRCSM	11:38:28.992	DCCH	Downlink	UECapabilityEnquiry
RRCSM	11:38:28.992	DCCH	Uplink	UECapabilityInformation
RRCSM	11:38:29.010	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:38:29.058	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMPLETE
L3SM	11:38:29.060		Downlink	ATTACH_ACCEPT
L3SM	11:38:29.060		Downlink	ACTIVATE_DEFAULT_EPS_BEARER_CONTEXT_REQUEST
L3SM	11:38:29.069		Uplink	ATTACH_COMPLETE
L3SM	11:38:29.069		Uplink	ACTIVATE_DEFAULT_EPS_BEARER_CONTEXT_ACCEPT
RRCSM	11:38:29.070	DCCH	Uplink	ULInformationTransfer
RRCSM	11:38:29.098	DCCH	Downlink	DLInformationTransfer
L3SM	11:38:29.099		Downlink	EMM_INFORMATION
RRCSM	11:38:29.447	DCCH	Uplink	MEASUREMENTREPORT
RRCSM	11:38:29.463	DCCH	Downlink	UECapabilityEnquiry
RRCSM	11:38:29.511	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:38:29.516	BCCH-BCH	Downlink	MIB
RRCSM	11:38:29.567	DCCH	Uplink	MEASUREMENTREPORT
RRCSM	11:38:29.572	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMPLETE
RRCSM	11:38:29.654	BCCH-BCH	Downlink	MIB
RRCSM	11:38:29.880	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:38:29.881	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMPLETE

The right screenshot shows the details of the RRC signaling message received at 11:38:29.463. The message is an RRCConnectionReconfigurationComplete. The UE reports that it supports the b3-n78 combination. The supportedBandCombinationList value 1 is highlighted with a red dashed box, showing the following details:

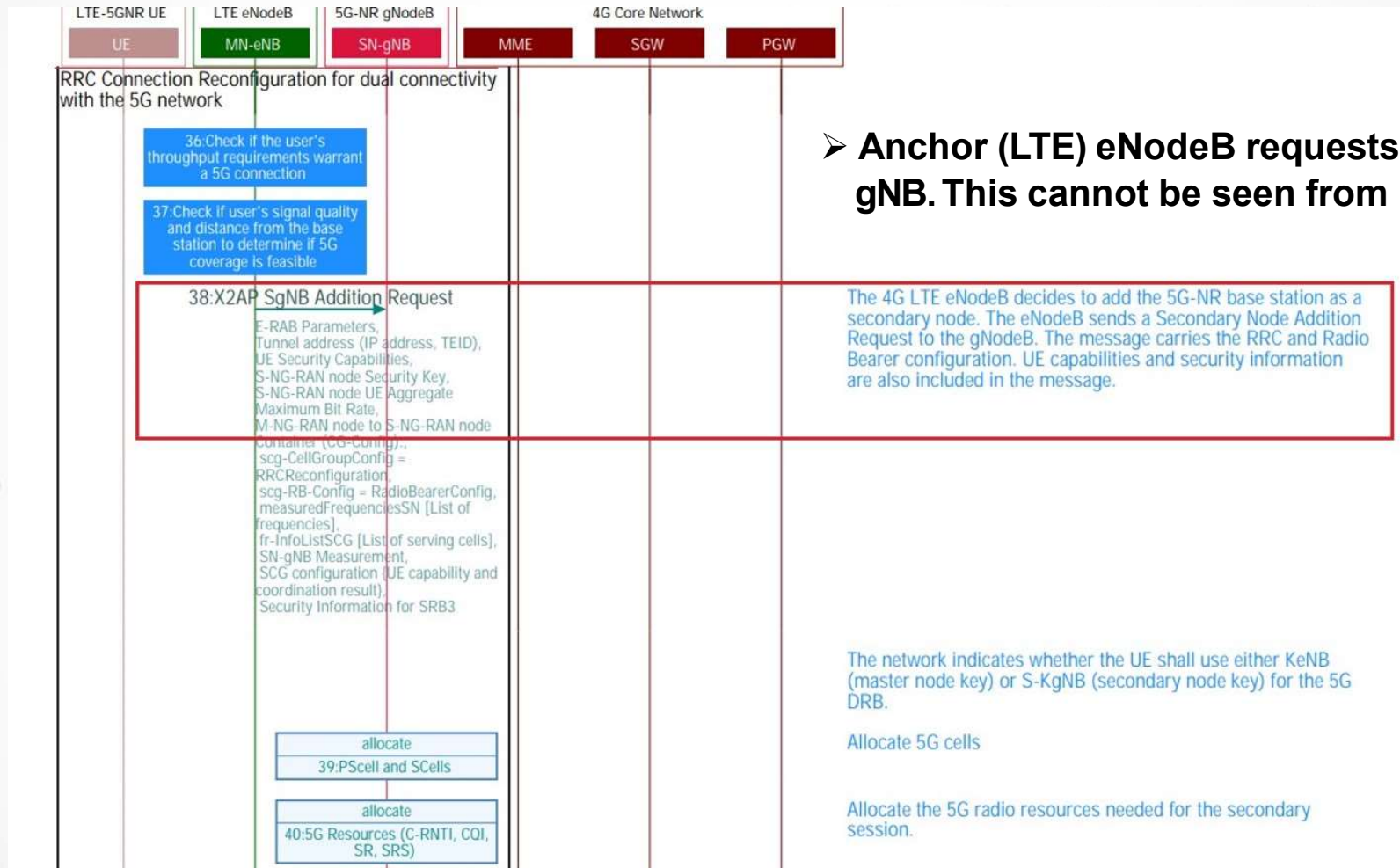
- bandList value 1
  - eutra
    - bandEUTRA : 3
    - ca-BandwidthClassDL-EUTRA : a
    - ca-BandwidthClassUL-EUTRA : a
  - nr
    - bandNR : 78
    - ca-BandwidthClassDL-NR : a
    - ca-BandwidthClassUL-NR : a

# 5G NR NSA SN Setup

- Network should send RRC Connection Reconfiguration to UE.

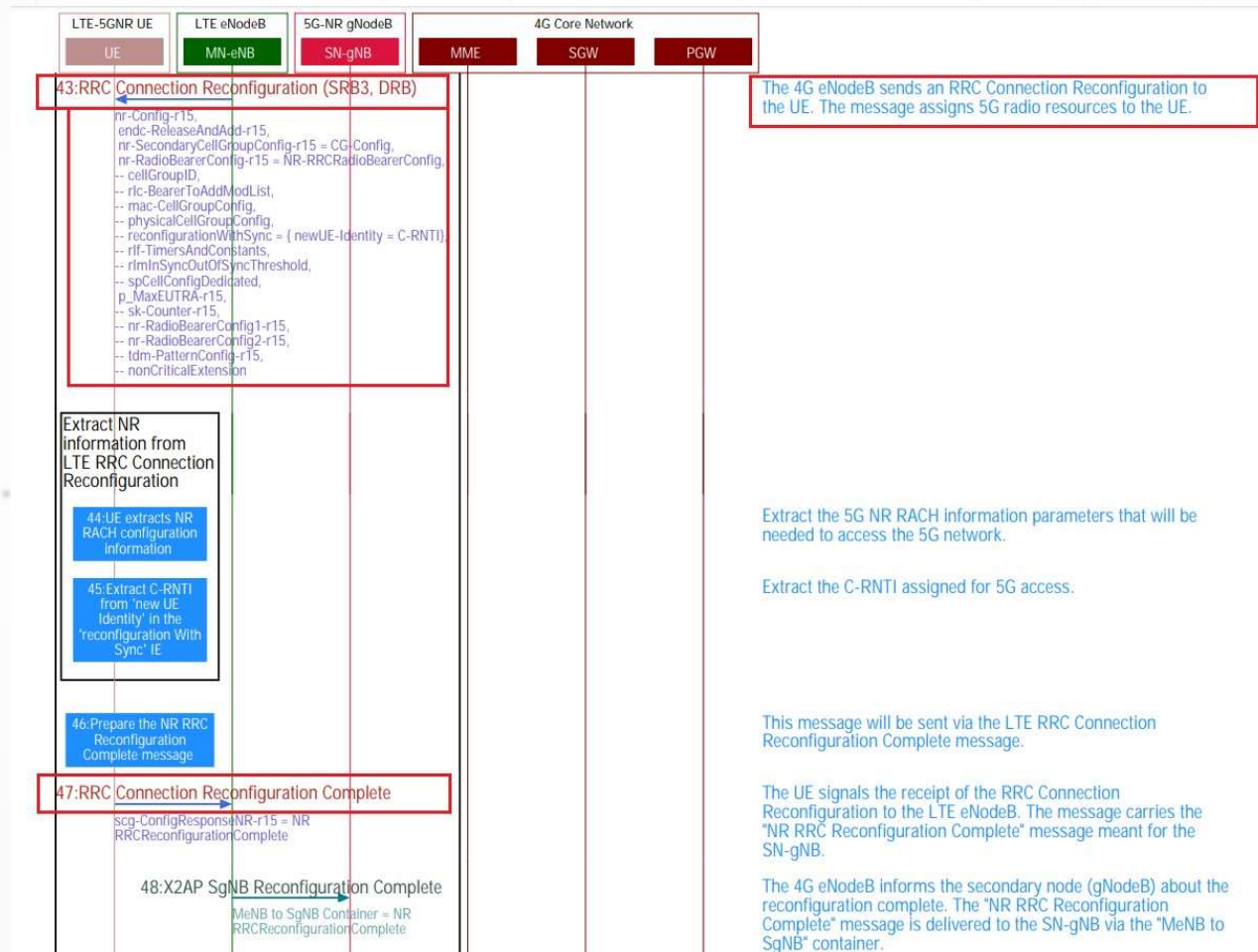


# 5G NR NSA SN Setup



# 5G NR NSA SN Setup

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



# 5G NR NSA SN Setup

## ➤ NR Configuration – adding SCG.

Layer 3/ RRC Messages - 1. Qualcomm

EventId	Time	RRC subch...	RRC dir...	RRC message name
RRCSCM	11:38:28.863	DCCH	Downlink	DLInformationTransfer
L3SM	11:38:28.863		Downlink	ESM_INFORMATION_REQUEST
L3SM	11:38:28.863		Uplink	ESM_INFORMATION_RESPONSE
RRCSCM	11:38:28.864	DCCH	Uplink	ULInformationTransfer
RRCSCM	11:38:28.990	DCCH	Downlink	SecurityModeCommand
RRCSCM	11:38:28.992	DCCH	Uplink	SecurityModeComplete
RRCSCM	11:38:28.992	DCCH	Downlink	UECapabilityEnquiry
RRCSCM	11:38:28.992	DCCH	Uplink	UECapabilityInformation
RRCSCM	11:38:29.010	DCCH	Downlink	RRCConnectionReconfiguration
RRCSCM	11:38:29.058	DCCH	Uplink	RRCConnectionReconfigurationComplete
L3SM	11:38:29.060		Downlink	ATTACH_ACCEPT
L3SM	11:38:29.060		Downlink	ACTIVATE_DEFAULT_EPS_BEARER_CONTEXT_REQUEST
L3SM	11:38:29.069		Uplink	ATTACH_COMPLETE
L3SM	11:38:29.069		Uplink	ACTIVATE_DEFAULT_EPS_BEARER_CONTEXT_ACCEPT
RRCSCM	11:38:29.070	DCCH	Uplink	ULInformationTransfer
RRCSCM	11:38:29.098	DCCH	Downlink	DLInformationTransfer
L3SM	11:38:29.099		Downlink	EMM_INFORMATION
RRCSCM	11:38:29.447	DCCH	Uplink	MeasurementReport
RRCSCM	11:38:29.463	DCCH	Downlink	UECapabilityEnquiry
RRCSCM	11:38:29.463	DCCH	Uplink	UECapabilityInformation
RRCSCM	11:38:29.511	DCCH	Downlink	RRCConnectionReconfiguration
RRCSCM	11:38:29.516	BCCH-BCH	Downlink	MIB
RRCSCM	11:38:29.567	DCCH	Uplink	MeasurementReport
RRCSCM	11:38:29.572	DCCH	Uplink	RRCConnectionReconfigurationComplete
RRCSCM	11:38:29.654	BCCH-BCH	Downlink	MIB
RRCSCM	11:38:29.880	DCCH	Downlink	RRCConnectionReconfiguration
RRCSCM	11:38:29.881	DCCH	Uplink	RRCConnectionReconfigurationComplete

RRC signaling message - 1. Qualcomm 11:38:29.511

```

nr-config
  periodicPHR-Timer : sf100
  prohibitPHR-Timer : sf0
  dl-PathlossChange : dB3
  dualConnectivityPHR
  setup
    phr-ModeOtherCG-r12 : virtual
  nonCriticalExtension
  nonCriticalExtension
  nonCriticalExtension
  nonCriticalExtension
  nonCriticalExtension
  nonCriticalExtension
  nonCriticalExtension
  nonCriticalExtension
  nonCriticalExtension
  nonCriticalExtension
  nr-Config-r15
  setup
    endc-ReleaseAndAdd-r15 : fal
  nr-SecondaryCellGroupConfig-r15
  RRCReconfiguration
    rrc-TransactionIdentifier : 0
  criticalExtensions
  rrcReconfiguration
  secondaryCellGroup
  CellGroupConfig
    cellGroupId : 1
    rlc-BearerToAddModList
    rlc-BearerToAddModList
    logicalChannelIdent
    servedRadioBearer
    drb-Identity
    reestablishRLC
    rlc-Config
  
```

# 5G NR NSA SN Setup

## ➤ Completion of adding SCG.

The screenshot displays a software interface for analyzing RRC signaling messages. On the left, a table lists various messages, with the entry at 11:38:29.572 highlighted in blue and a red dashed box around it. On the right, a detailed view of this message is shown, including its ASN.1 structure and hex data.

EventId	Time	RRC subch...	RRC dir...	RRC message name
RRCSM	11:38:29.098	DCCH	Downlink	DLInformationTransfer
L3SM	11:38:29.099		Downlink	EMM_INFORMATION
RRCSM	11:38:29.447	DCCH	Uplink	MeasurementReport
RRCSM	11:38:29.463	DCCH	Downlink	UECapabilityEnquiry
RRCSM	11:38:29.463	DCCH	Uplink	UECapabilityInformation
RRCSM	11:38:29.511	DCCH	Downlink	RRCCConnectionReconfiguration
RRCSM	11:38:29.516	BCCH-BCH	Downlink	MIB
RRCSM	11:38:29.567	DCCH	Uplink	MeasurementReport
RRCSM	11:38:29.572	DCCH	Uplink	RRCCConnectionReconfigurationComplete
RRCSM	11:38:29.654	BCCH-BCH	Downlink	MIB
RRCSM	11:38:29.880	DCCH	Downlink	RRCCConnectionReconfiguration
RRCSM	11:38:29.881	DCCH	Uplink	RRCCConnectionReconfigurationComplete
RRCSM	11:38:31.088	DCCH	Uplink	ULInformationTransferMRDC
L3SM	11:38:31.119		Uplink	PDN_CONNECTIVITY_REQUEST
RRCSM	11:38:31.119	DCCH	Downlink	RRCCConnectionReconfiguration
RRCSM	11:38:31.121	DCCH	Uplink	ULInformationTransfer
RRCSM	11:38:31.164	DCCH	Uplink	RRCCConnectionReconfigurationComplete
RRCSM	11:38:31.168	DCCH	Downlink	DLInformationTransfer
L3SM	11:38:31.168		Downlink	PDN_CONNECTIVITY_REJECT
RRCSM	11:38:31.567	DCCH	Uplink	MeasurementReport
RRCSM	11:38:31.613	DCCH	Downlink	RRCCConnectionReconfiguration
RRCSM	11:38:31.668	DCCH	Uplink	RRCCConnectionReconfigurationComplete
RRCSM	11:38:31.672	BCCH-BCH	Downlink	MIB
RRCSM	11:38:31.766	BCCH-BCH	Downlink	MIB
RRCSM	11:38:39.247	DCCH	Uplink	ULInformationTransferMRDC
RRCSM	11:38:39.278	DCCH	Downlink	RRCCConnectionReconfiguration
RRCSM	11:38:39.320	DCCH	Uplink	RRCCConnectionReconfigurationComplete
RRCSM	11:38:39.700	DCCH	Uplink	MeasurementReport

**RRC signaling message - 1. Qualcomm 11:38:29.572**

RRC SIGNALING MESSAGE  
Time: 11:38:29.572

RRCCConnectionReconfigurationComplete (3GPP TS 36.331 ver 15.5.1)

UL-DCCH-Message  
message  
c1  
rrcConnectionReconfigurationComplete  
rrc-TransactionIdentifier : 1  
criticalExtensions  
rrcConnectionReconfigurationComplete-r8  
nonCriticalExtension  
nonCriticalExtension  
nonCriticalExtension  
nonCriticalExtension  
nonCriticalExtension  
nonCriticalExtension  
scg-ConfigResponseNR-r15  
RRCCReconfigurationComplete  
rrc-TransactionIdentifier: 0  
criticalExtensions  
rrcReconfigurationComplete

Data (hex):  
12 A5 46 01 00



# 5G NR NSA SN Setup

## ➤ nr-Config1-r15 NR Radio Bearer configuration

Layer 3/ RRC Messages - 1. Qualcomm (Filtered)

EventId	Time	RRC subch...	RRC dir...	RRC message name
RRCSM	11:38:29.567	DCCH	Uplink	MeasurementReport
RRCSM	11:38:29.572	DCCH	Uplink	RRCConnectionReconfigurationComplete
RRCSM	11:38:29.654	BCCH-BCH	Downlink	MIB
RRCSM	11:38:29.880	DCCH	Downlink	RRCConnectionReconfiguration
RRCSM	11:38:29.881	DCCH	Uplink	RRCConnectionReconfigurationComplete
RRCSM	11:38:31.088	DCCH	Uplink	ULInformationTransferMRDC
L3SM	11:38:31.119		Uplink	PDN_CONNECTIVITY_REQUEST
<b>RRCSM</b>	<b>11:38:31.119</b>	<b>DCCH</b>	<b>Downlink</b>	<b>RRCConnectionReconfiguration</b>
RRCSM	11:38:31.121	DCCH	Uplink	ULInformationTransfer
RRCSM	11:38:31.164	DCCH	Uplink	RRCConnectionReconfigurationComplete
RRCSM	11:38:31.168	DCCH	Downlink	DLInformationTransfer
RRCSM	11:38:31.567	DCCH	Uplink	MeasurementReport
RRCSM	11:38:31.613	DCCH	Downlink	RRCConnectionReconfiguration
RRCSM	11:38:31.668	DCCH	Uplink	RRCConnectionReconfigurationComplete
RRCSM	11:38:31.672	BCCH-BCH	Downlink	MIB
RRCSM	11:38:31.766	BCCH-BCH	Downlink	MIB
RRCSM	11:38:39.247	DCCH	Uplink	ULInformationTransferMRDC
RRCSM	11:38:39.278	DCCH	Downlink	RRCConnectionReconfiguration
RRCSM	11:38:39.320	DCCH	Uplink	RRCConnectionReconfigurationComplete
RRCSM	11:38:39.726	DCCH	Uplink	MeasurementReport
RRCSM	11:38:39.772	DCCH	Downlink	RRCConnectionReconfiguration
RRCSM	11:38:39.825	DCCH	Uplink	RRCConnectionReconfigurationComplete
RRCSM	11:38:39.830	BCCH-BCH	Downlink	MIB
RRCSM	11:38:39.915	BCCH-BCH	Downlink	MIB
RRCSM	11:38:49.947	DCCH	Uplink	ULInformationTransferMRDC
RRCSM	11:38:49.980	DCCH	Downlink	RRCConnectionReconfiguration
RRCSM	11:38:50.015	DCCH	Uplink	RRCConnectionReconfigurationComplete

RRC signaling message - 1. Qualcomm 11:38:31.119

```
nonCriticalExtension
nonCriticalExtension
nonCriticalExtension
nonCriticalExtension
nonCriticalExtension
nr-Config-r15
nr-Config-r15 : release
nr-RadioBearerConfig1-r15
RadioBearerConfig
drb-ToAddModList
drb-ToAddModList value 1
cnAssociation
eps-BearerIdentity : 5
drb-Identity : 6
pdcp-Config
drb
discardTimer : ms300
pdcp-SN-SizeUL : len18bits
pdcp-SN-SizeDL : len18bits
headerCompression
headerCompression : notUsed
t-Reordering : ms0
drb-ToReleaseList
drb-ToReleaseList value : 5
securityConfig
securityAlgorithmConfig
cipheringAlgorithm : nea2
keyToUse : master
```

(hex):  
22 12 81 C0 20 11 C0 18 81 48



**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

The screenshot displays a network protocol analyzer interface. On the left, a table titled 'Layer 3/ RRC Messages - 1. Qualcomm' lists various RRC messages. The message at 14:33:47.188, 'RRCConnectionReconfiguration', is highlighted in blue. A black arrow points from this message to a detailed view on the right. The detailed view, titled 'RRC signaling message - 1. Qualcomm 14:33:47.188', shows the configuration parameters for the measurement object. A blue box highlights the 'measObject' configuration for 'measObjectNR-r15'.

Event	Time	RRC sub...	RRC dir...	RRC message name	Physical cell identity (pcell)	Physical cell identity (pcell)
CELL...	14:33:45.196					
CELL...	14:33:46.157					
CELL...	14:33:46.157				401	
L3SM	14:33:46.975		Uplink	SERVICE_REQUEST		
RRC...	14:33:46.975	CCCH	Uplink	RRCCConnectionRequest		
RRC...	14:33:47.046	CCCH	Downlink	RRCCConnectionSetup		
RRC...	14:33:47.049	DCCH	Uplink	RRCCConnectionSetupComplete		
RRC...	14:33:47.150	DCCH	Downlink	SecurityModeCommand		
RRC...	14:33:47.151	DCCH	Uplink	SecurityModeComplete		
RRC...	14:33:47.188	DCCH	Downlink	RRCCConnectionReconfiguration		
RRC...	14:33:47.206	DCCH	Uplink	RRCCConnectionReconfigurationComplete		
RRC...	14:33:47.327	DCCH	Uplink	MeasurementReport		
RRC...	14:33:47.349	DCCH	Downlink	RRCCConnectionReconfiguration		
RRC...	14:33:47.370	DCCH	Uplink	RRCCConnectionReconfigurationComplete		
CELL...	14:33:47.388				401	
RRC...	14:33:47.451	DCCH	Uplink	MeasurementReport		

```
physcellid : 401
cellIndividualOffset : dB-1
measObjectToAddModList value 2
measObjectId : 2
measObject
  measObjectNR-r15
    carrierFreq-r15 : 522078
    rs-ConfigSSB-r15
      measTimingConfig-r15
        periodicityAndOffset-r15
          sf20-r15 : 14
          ssb-Duration-r15 : sf5
        subcarrierSpacingSSB-r15 : kHz30
      quantityConfigSet-r15 : 1
      bandNR-r15
        setup : 41
measObjectToAddModList value 3
measObjectId : 3
measObject
```

NR measurement object configuration

# NR SN CHANGE

## NR REPORT CONFIG

The screenshot displays a network protocol analyzer interface. The main window shows a list of RRC messages in Layer 3. The 'NR' tab is selected, and a specific RRC signaling message is expanded to show its details. The message is an RRCConnectionReconfigurationComplete, which includes a list of measurement configurations. The configuration for MeasID 3 is highlighted, showing it is triggered by event B1-NR-r15. The configuration parameters for MeasID 3 are as follows:

```
reportQuantity : both
maxReportCells : 1
reportInterval : ms5120
reportAmount : infinity
reportConfigToAddModList value 3
reportConfigId : 3
reportConfig
reportConfigInterRAT
triggerType
event
eventId
eventB1-NR-r15
b1-ThresholdNR-r15
nr-RSRP-r15 : 41
reportOnLeave-r15 : false
hysteresis : 2 (= 1.0 dB)
timeToTrigger : ms100
maxReportCells : 4
reportInterval : ms120
reportAmount : infinity
reportQuantityCellNR-r15
ss-rsrp : true
ss-rsrq : true
ss-sinr : false
```

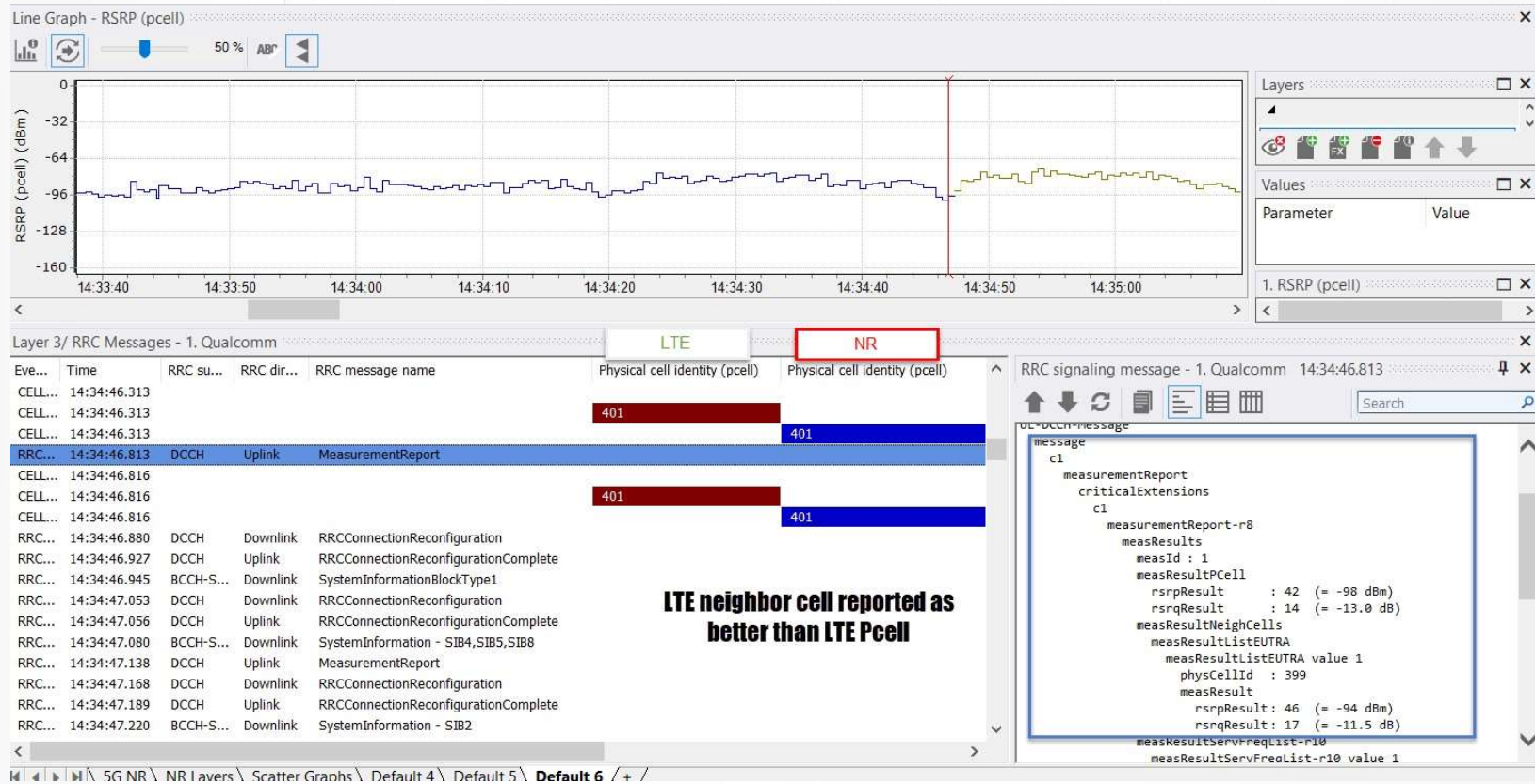
The detailed view also shows other measurement configurations:

```
measIdToAddModList value 1
measId : 1
measObjectId : 1
reportConfigId : 1
measIdToAddModList value 2
measId : 2
measObjectId : 1
reportConfigId : 2
measIdToAddModList value 3
measId : 3
measObjectId : 2
reportConfigId : 3
measIdToAddModList value 4
measId : 4
measObjectId : 3
reportConfigId : 4
measIdToAddModList value 5
measId : 5
measObjectId : 3
```

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

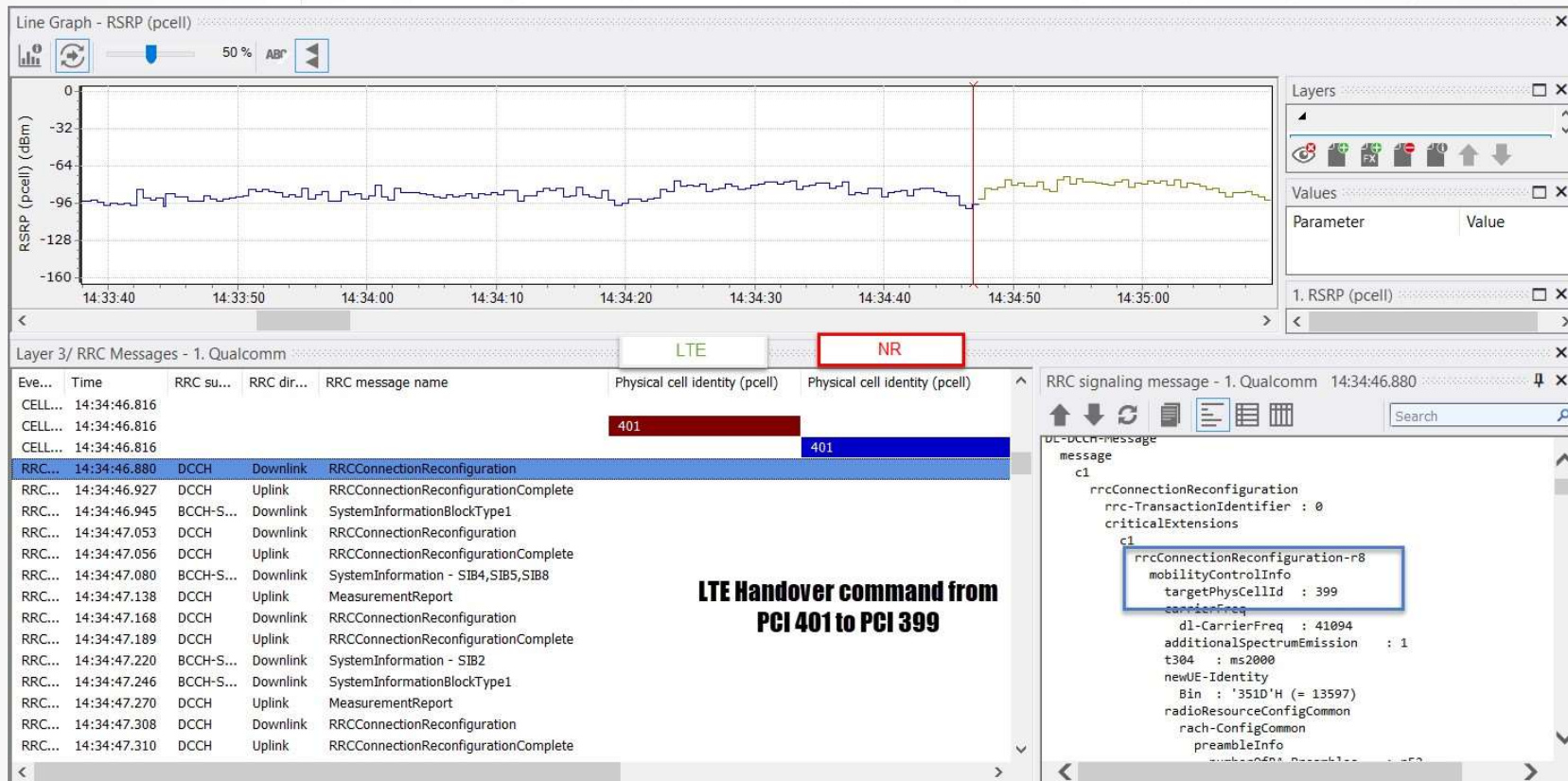
# NR SN CHANGE

## LTE HANDOVER INITIATION



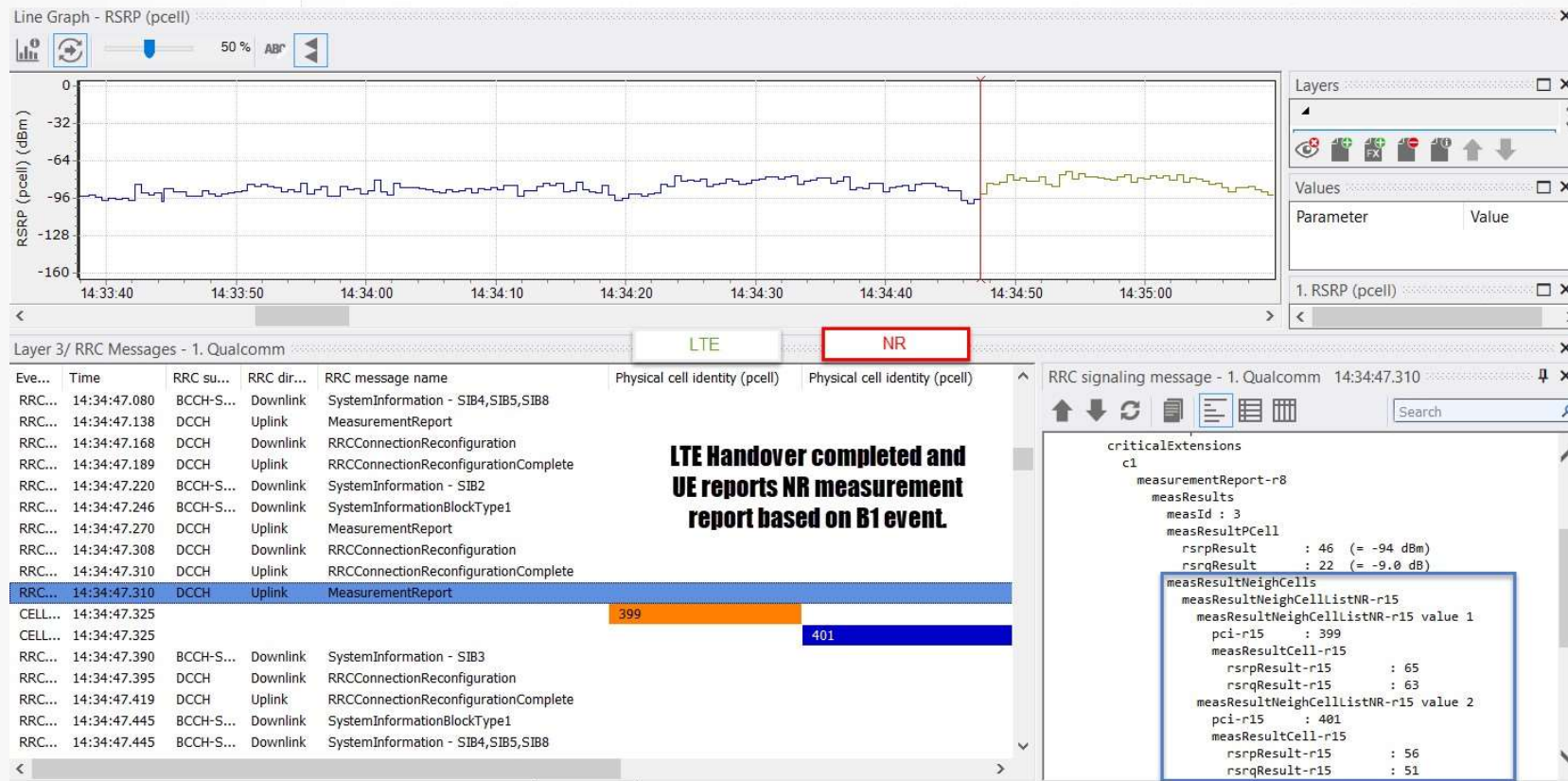
# NR SN CHANGE

## LTE HANDOVER COMMAND



# NR SN CHANGE

## COMPLETION OF LTE HO AND MRSENTWITHNRCELLINFO





# NR SN CHANGE

NR NEW SN ADDITION. NR INTERRUPTION

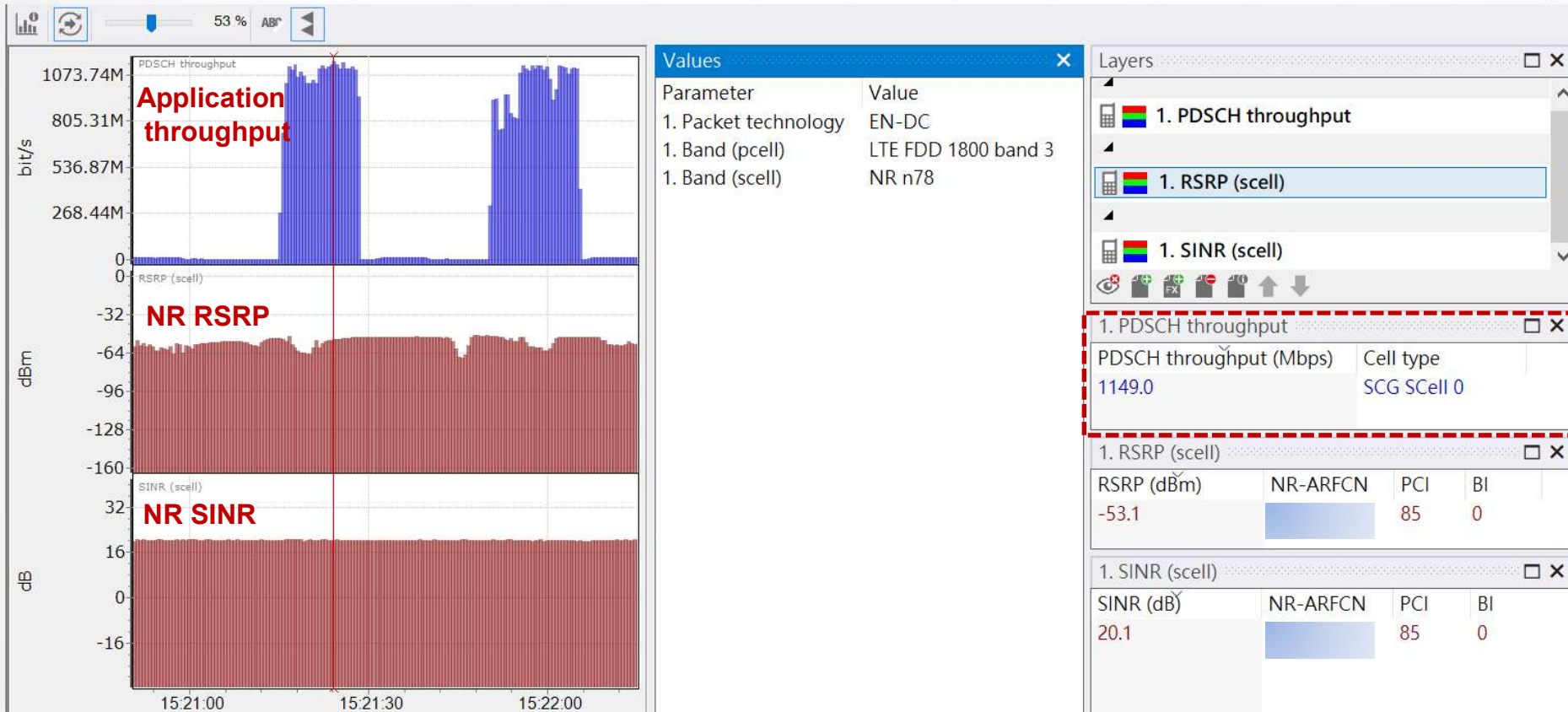




## 5G NR – Field testing observations

# 5G NR downlink speed

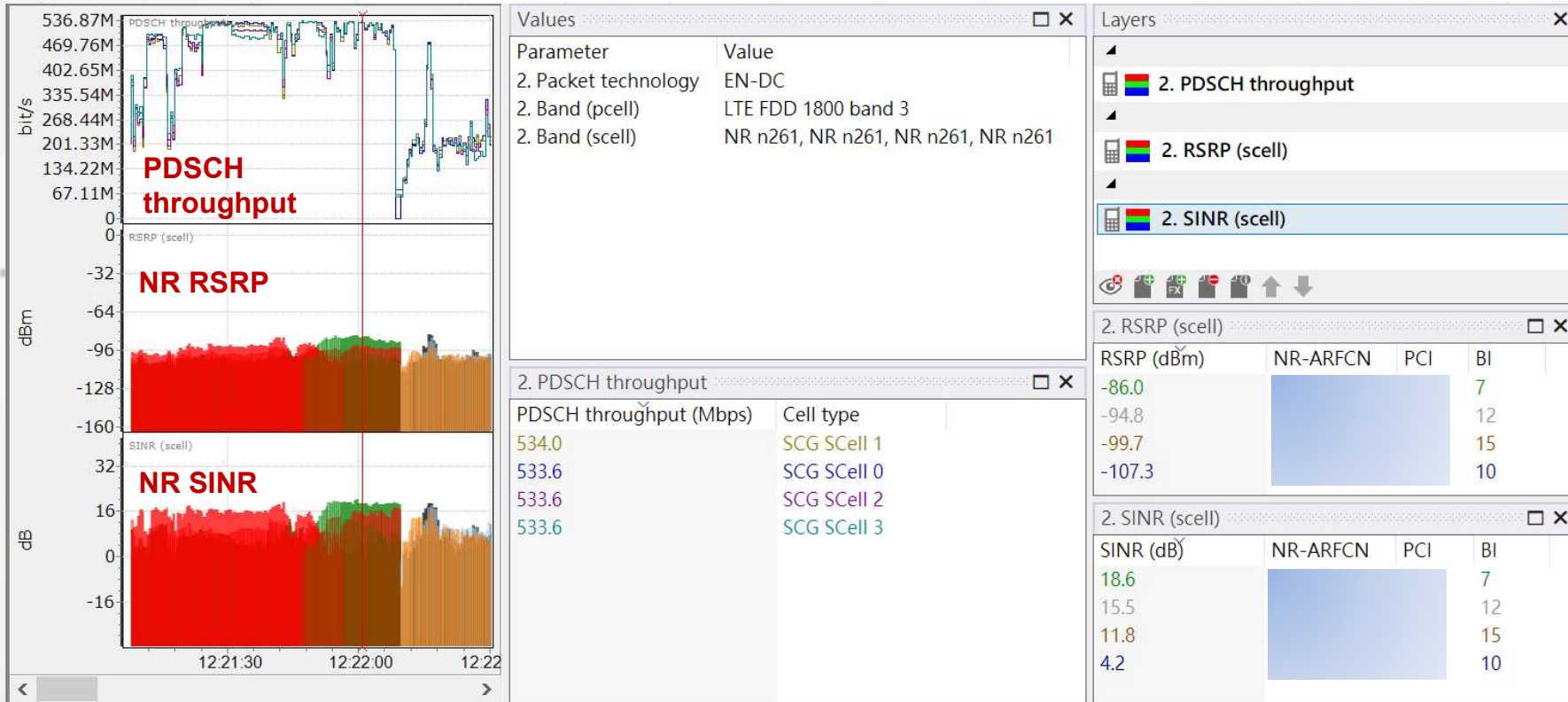
FR1 - N78



Max. downlink speed ~ 1Gbps

# 5G NR downlink speed

FR2 – N261



Max. downlink speed ~ 2Gbps

# 5G NR RACH Issue

## SCG FAILURE WITH RACH – SCGFailureInformationNR

**Line Graph - RSRP (scell)**

Application throughput downloadlink (bit/s): 0 to 268.44M

NR RSRP (dBm): -128 to -64

Time: 11:59:45 to 12:00:30

**1. Application throughput downloadlink**

App. rate DL (Mbps)	Data transfer context ID
0.2	32

**1. RSRP (scell)**

RSRP (dBm)	NR-ARFCN	PCI	BI
-122.7		5	2
-123.5		5	1
-128.6		5	4

**Layer 3/ RRC Messages - 1. Qualcomm**

EventId	Time	RRC subch...	RRC dir...	RRC message name
RRCSM	11:59:55.378	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:59:55.381	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMP
RRCSM	11:59:58.334	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:59:58.374	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMP
RRCSM	11:59:58.793	DCCH	Uplink	MEASUREMENTREPORT
RRCSM	11:59:58.812	BCCH-BCH	Downlink	MIB
RRCSM	11:59:58.835	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:59:58.923	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMP
RRCSM	11:59:58.977	BCCH-BCH	Downlink	MIB
RRCSM	11:59:59.771	DCCH	Uplink	SCGFAILUREINFORMATIONNR
RRCSM	12:00:00.529	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	12:00:00.375	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMP
RRCSM	12:00:00.794	DCCH	Uplink	MEASUREMENTREPORT
RRCSM	12:00:00.853	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION

**RRC signaling message - 1. Qualcomm 11:59:59.771**

```
SCGFailureInformationNR (3GPP TS 36.331 ver 15.5.1 Rel 15)
UL-DCCH-Message
message
messageClassExtension
c2
scgFailureInformationNR-r15
criticalExtensions
c1
scgFailureInformationNR-r15
failureType-r15 : randomAccessProblem
measResultSCG-r15
MeasResultSCG-Failure
```

# 5G NR Sync Reconfiguration Issue

## SCG FAILURE WITH Sync Reconfig – SCGFailureInformationNR

The screenshot displays the Keysight Wireshark interface with several panels:

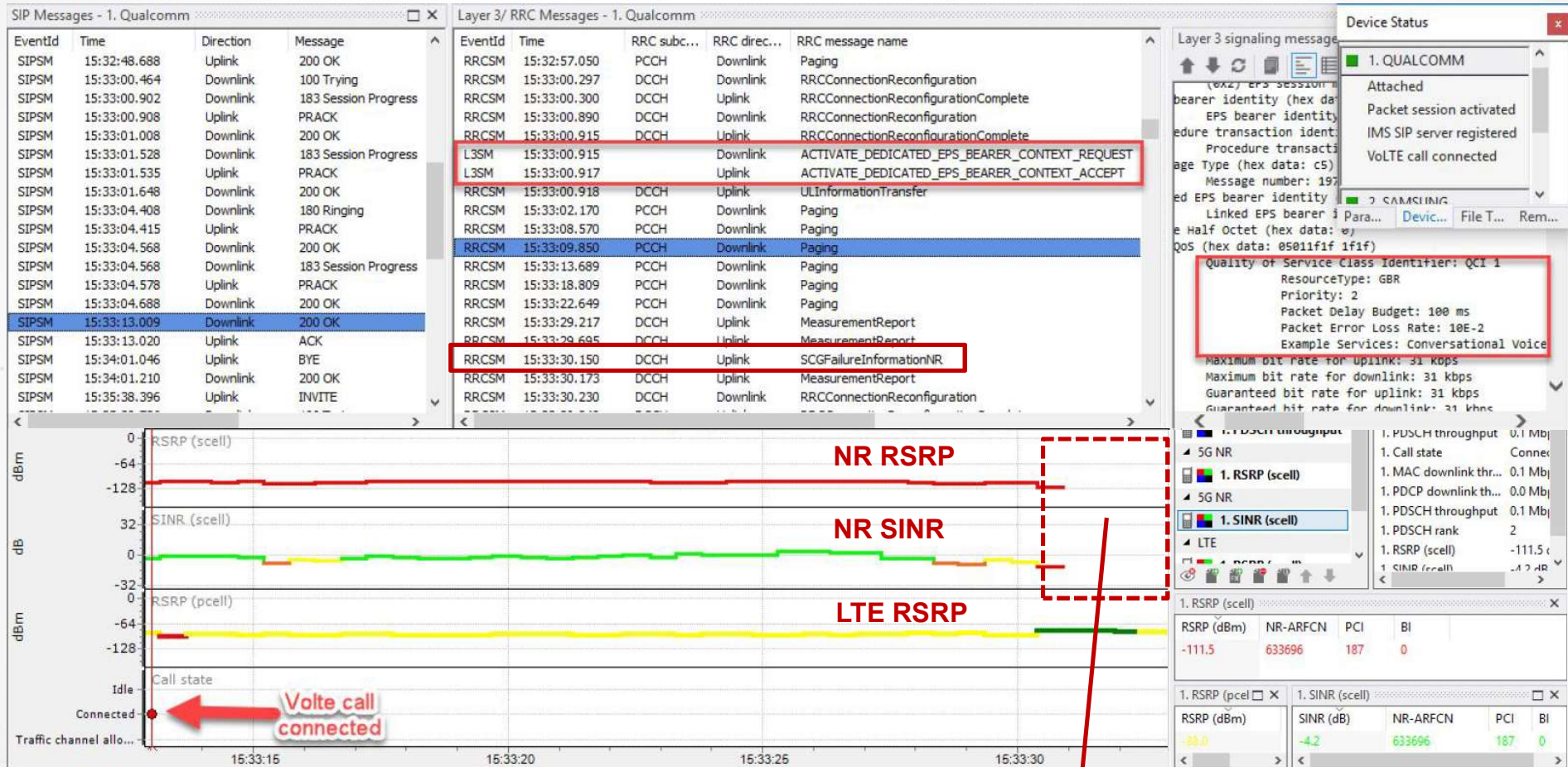
- Line Graph - RSRP (scell):** Shows Application throughput (red) and NR RSRP (yellow) over time. A vertical red line marks a sync reconfiguration event at 11:55:00.
- 1. Application throughput downlink:** Shows App. rate DL (Mbps) as 0.8 and Data transfer context ID as 26.
- 1. RSRP (scell):** Shows RSRP (dBm) values for NR-ARFCN, PCI, and BI.
- Layer 3/ RRC Messages - 1. Qualcomm:** A table of RRC messages with the following data:

EventId	Time	RRC subch...	RRC dir...	RRC message name
RRCSM	11:55:03.652	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:55:03.691	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMP
RRCSM	11:55:04.077	DCCH	Uplink	MEASUREMENTREPORT
RRCSM	11:55:04.120	BCCH-BCH	Downlink	MIB
RRCSM	11:55:04.123	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:55:04.177	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMP
RRCSM	11:55:04.257	DCCH	Uplink	SCGFAILUREINFORMATIONNR
RRCSM	11:55:04.532	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:55:04.570	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMP
RRCSM	11:55:04.957	DCCH	Uplink	MEASUREMENTREPORT
RRCSM	11:55:04.967	BCCH-BCH	Downlink	MIB
RRCSM	11:55:05.000	DCCH	Downlink	RRCCONNECTIONRECONFIGURATION
RRCSM	11:55:05.055	DCCH	Uplink	RRCCONNECTIONRECONFIGURATIONCOMP
RRCSM	11:55:05.129	BCCH-BCH	Downlink	MIB
RRCSM	11:55:07.415	DCCH	Uplink	MEASUREMENTREPORT
- RRC signaling message - 1. Qualcomm 11:55:04.257:** Shows the SCGFailureInformationNR message structure:

```
RRC SIGNALING MESSAGE
Time: 11:55:04.257
SCGFailureInformationNR (3GPP TS 36.331 ver 15.5.1 Rel 15)
UL-DCCH-Message
  message
  messageClassExtension
    c2
      scgFailureInformationNR-r15
        criticalExtensions
          c1
            scgFailureInformationNR-r15
              failureReportSCG-NR-r15
                failureType-r15 : synchReconfigFailureSCG
```
- Device Status:** Shows the device is attached and has packet session activated (HTTP #26: DL: 43%).

# 5G NR Volte call

## Lost of NR during Volte call





**QUESTIONS?**



# Resources

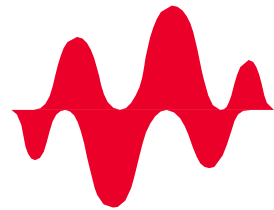
## FOR MORE INFORMATION

- [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 – 5<sup>th</sup> Generation NewRadio
- 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

-4.80221



**KEYSIGHT**  
TECHNOLOGIES