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5G NSA ENDC Network Architecture And Mobility Overview

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5G NSA Mobility Guide

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NSA (ENDC) Network Overview

NSA Networking- Option 3X

EPC

eNodeB (MeNB)

Cell 1   Cell 2

Cell 3   Cell 4

gNodeB (SgNB)

NSA UE

——— User Plane

- - - - Control Plane

ENDC Accessbility & Mobility Overview

MeNB1/SgNB1   MeNB2/SgNB2

4G Initial Access   SgNB Addition   SgNB Change   MeNB HO   SgNB Release

4G Coverage   NR Coverage
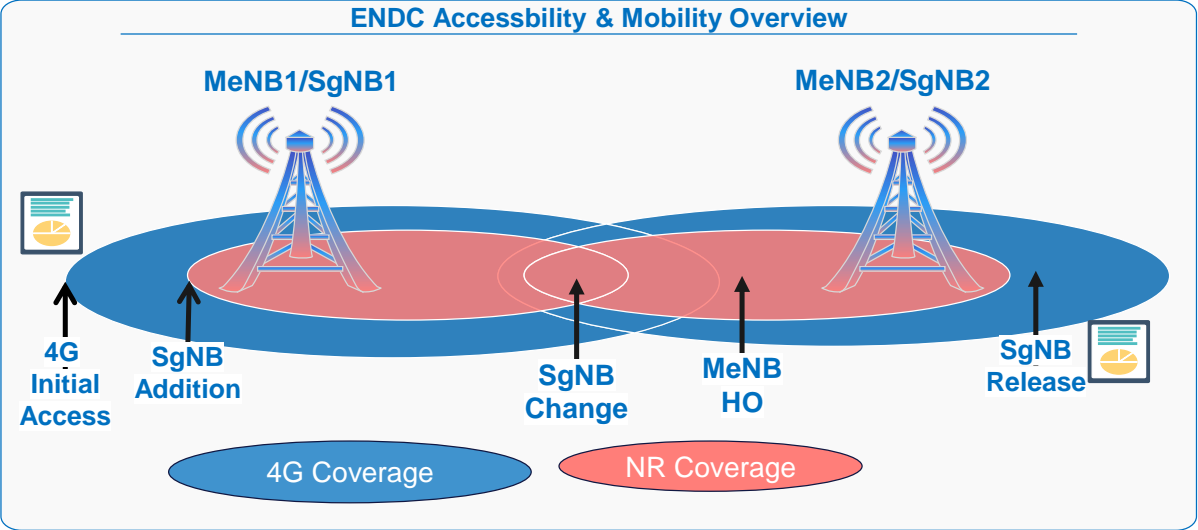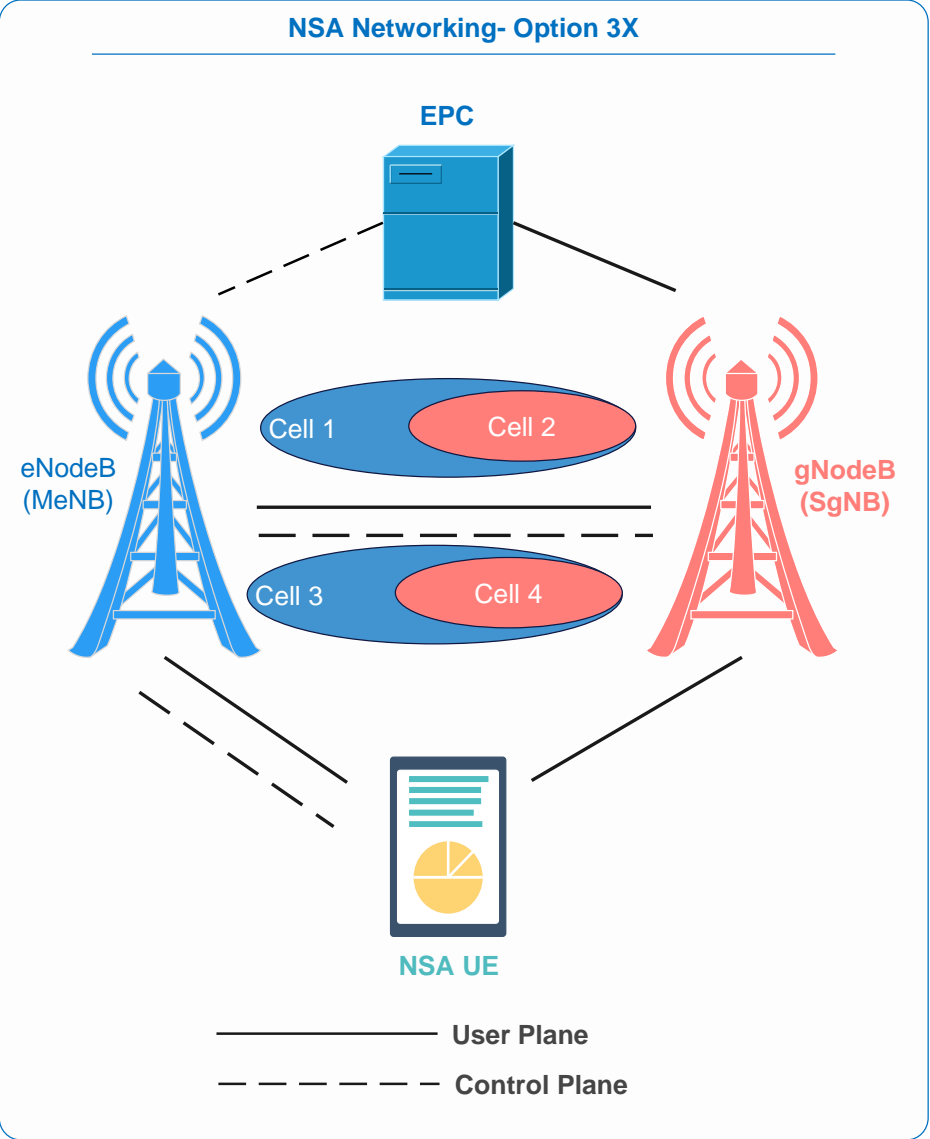
| Category	Concept	Node
Base station	MeNB	eNodeB
	SgNB	gNodeB
Cell group	MCG	Cell 1 & 3
	SCG	Cell 2 & 4
Cell	PCell	Cell 1
	SPCell	Cell 2
	SCell	Cell 3 & 4
Carrier	CC	All Cells
	PCC	Cell 1
	PSCC	Cell 2
	SCC	Cell 3 & 4

5G Non-Standalone Mobility Overview

- In 5G NSA, mobility primarily occurs in connected mode, and the following represent the most prevalent mobility scenarios in 5G Non-Standalone:

5G NSA Mobility Scenarios

1. **SgNB-SPCell Cell Change (Intra or InterFreq):**
- This scenario involves the change of the serving gNB (SgNB) and the primary cell (SPCell), either within the same frequency (IntraFreq) or across different frequencies (InterFreq).
2. **SCell Change (Only in Carrier Aggregation Scenarios):**
- This scenario specifically pertains to changes in secondary cells (SCells), and it is applicable exclusively in Carrier Aggregation scenarios.
3. **5G NSA to SA Redirection or Handovers (Only Applicable in Mixed Networks):**
- This scenario encompasses redirections or handovers from 5G NSA to 5G SA and is relevant only in mixed networks where both Non-Standalone (NSA) and Standalone (SA) architectures coexist.
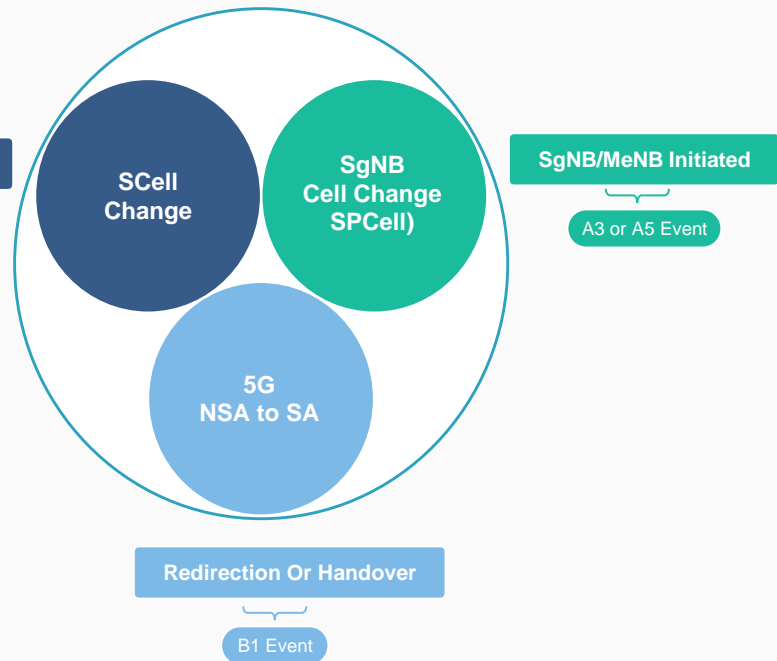
SgNB Cell Change (SPCell HO)
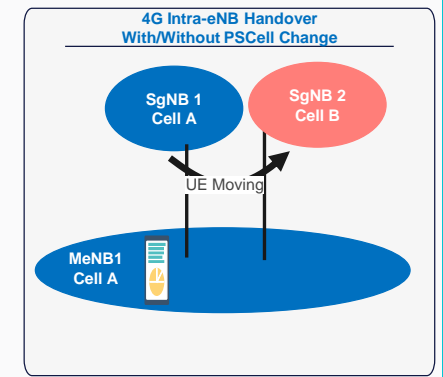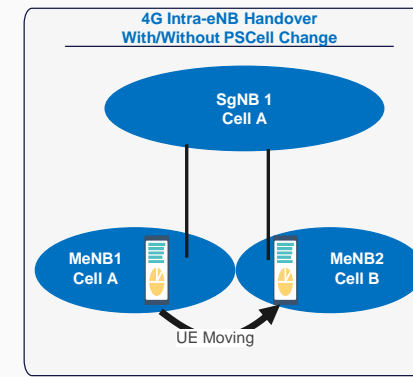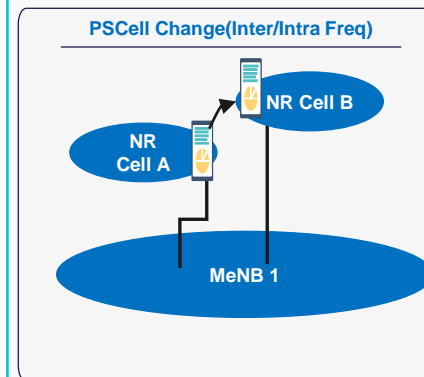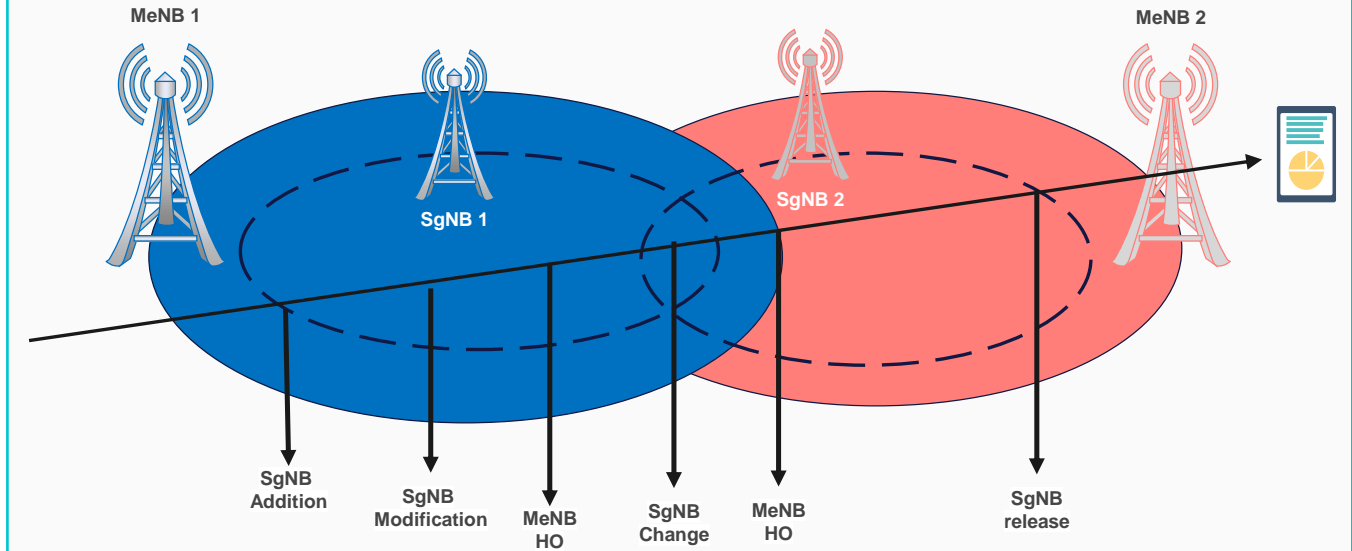
EN-DC UEs Capability Check

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For details, see section 4.2.9 "MeasAndMobParameters" in 3GPP TS 38.306.

| 3GPP TS 38.306 version 17.0.0 Release 17	125		ETSI TS 138 306 V17.0.0 (2022-05)		
Definitions for parameters		**Per**	**M**	**FDD-TDD DIFF**	**FR1-FR2 DIFF**
intraAndInterF-MeasAndReport Indicates whether the UE supports NR intra-frequency and inter-frequency measurements and at least periodical reporting. This field only applies to SN configured measurement when (NG)EN-DC is configured. For NR SA, MN and SN configured measurement when NR-DC is configured, and MN configured measurement when NE-DC is configured, this feature is mandatory supported.		UE	Yes	Yes	No

11:16:13.710	MS1	UL-C...	MS->eNodeB	RRCConnectionRequest
11:16:13.734	MS1	DL-C...	eNodeB->MS	RRCConnectionSetup
11:16:13.739	MS1	UL-D...	MS->eNodeB	RRCConnectionSetupComplete
11:16:13.802	MS1	BCCH...	eNodeB->MS	SystemInformation
11:16:13.806	MS1	BCCH...	eNodeB->MS	SystemInformationBlockType1
11:16:13.826	MS1	BCCH...	eNodeB->MS	SystemInformationBlockType1
11:16:13.841	MS1	BCCH...	eNodeB->MS	SystemInformation
11:16:13.846	MS1	BCCH...	eNodeB->MS	SystemInformationBlockType1
11:16:13.887	MS1	DL-D...	eNodeB->MS	DLInformationTransfer
11:16:13.887	MS1	NAS	eNodeB->MS	ESMInformationRequest
11:16:13.887	MS1	NAS	MS->eNodeB	ESMInformationResponse
11:16:13.888	MS1	UL-D...	MS->eNodeB	ULInformationTransfer
11:16:15.510	MS1	DL-D...	eNodeB->MS	RRCSecurityModeCommand
11:16:15.511	MS1	UL-D...	MS->eNodeB	RRCSecurityModeComplete
11:16:15.561	MS1	DL-D...	eNodeB->MS	UECapabilityEnquiry
11:16:15.564	MS1	UL-D...	MS->eNodeB	UE-EUTRA-Capability
11:16:15.564	MS1	UL-D...	MS->eNodeB	UECapabilityInformation
11:16:15.624	MS1	DL-D...	eNodeB->MS	UECapabilityEnquiry
11:16:15.625	MS1	UL-D...	MS->eNodeB	UECapabilityInformation
11:16:15.693	MS1	UL-D...	gNodeB->MS	FreqBandListNR
11:16:15.701	MS1	DL-D...	eNodeB->MS	UECapabilityEnquiry
11:16:15.702	MS1	UL-D...	MS->eNodeB	UECapabilityInformation
11:16:15.708	MS1	UL-D...	MS->gNodeB	UE-MRDC-CapabilityNR
11:16:15.711	MS1	UL-D...	MS->gNodeB	UE-NR-CapabilityNR
11:16:15.723	MS1	UL-D...	MS->eNodeB	UE-EUTRA-Capability
11:16:15.742	MS1	DL-D...	eNodeB->MS	RRCConnectionReconfiguration
11:16:15.742	MS1	DL-D...	eNodeB->MS	RadioBearerConfigNR

```
▼ measAndMobParameters

    ▼ measAndMobParametersCommon

        ssb-RLM:supported (0)

        ▼ groupExtension-r15-0

            eventB-MeasAndReport:supported (0)
            handoverFDD-TDD:supported (0)
            eutra-CGI-Reporting:supported (0)
            nr-CGI-Reporting:supported (0)

        ▼ groupExtension-r15-1

            periodicEUTRA-MeasAndReport:supported (0)

    ▼ measAndMobParametersXDD-Diff

        intraAndInterF-MeasAndReport:supported (0)
        eventA-MeasAndReport:supported (0)
```

# PSCell Change – Inter-SgNB

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If an **inter**-SgNB PSCell change is required, the target PSCell can be **an intra- or inter-frequency** cell of a neighboring base station.
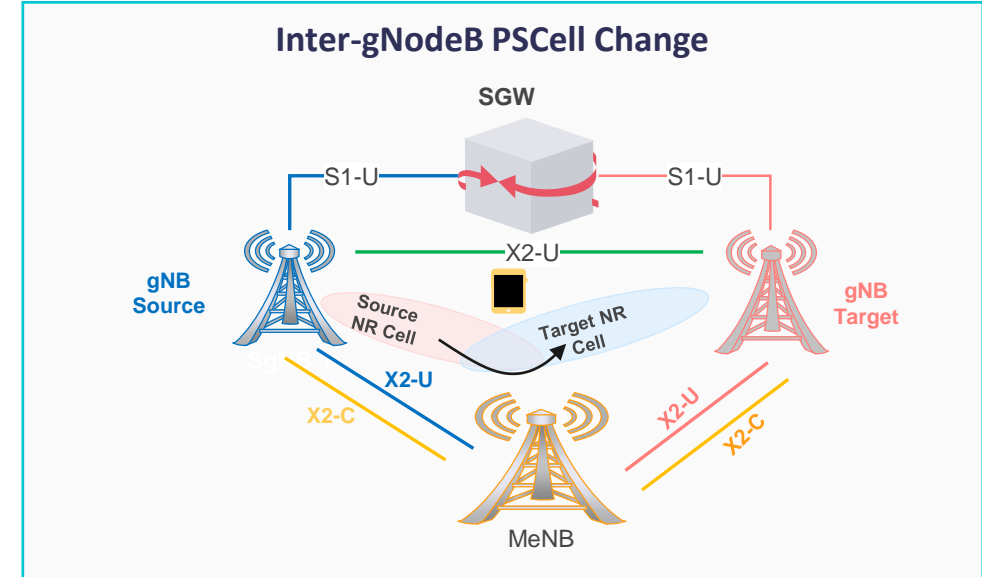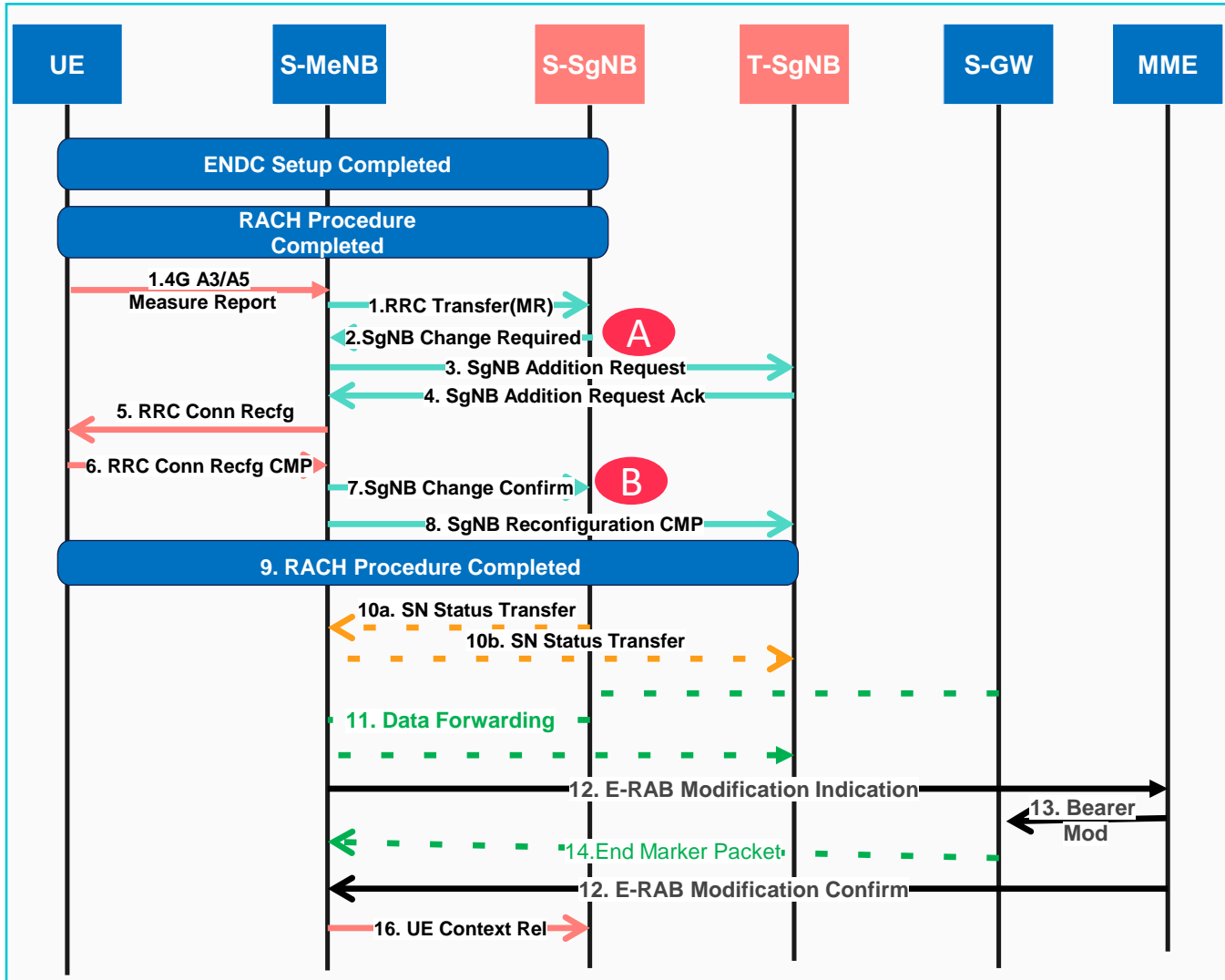
Inter-gNodeB PSCell Change

1. The UE Transfers MR Report, encompassing RSRP, RSRQ, and SINR for both Serving and Target SPCell.
2. SgNB responded with a requirement for SgNB Change, which included the current SPCell information and candidate cell information. The latter consisted of SSB Frequency, PCI for the new Pscell, and RSRP information.
3. S-MN initiated an SGNB addition request to T-SgNB. This request included Current SPCellConfig PCI, SSB, NRBand, AbsoluteFreqA, BW, and SCS. Additionally, it might incorporate SCELLTOaDDmODlIST INFO, covering the same information as SPCell. It also included other details like DRX, HO & RLF Timers, reference signal information, and candidate SPCELL Info (PCI).
4. T-SgNB responded with an SGNB Add Req Ack, including SPCell and SCELL Info, DRX, timers, etc.
5. S-MN forwarded the same information through the RRC Reconfiguration message.
6. Subsequently, S-MN sent SGNB Change Confirm to S-SgNB to remove the currently configured context. It then forwarded the confirmation to T-SgNB for the addition.
7. The RACH process was initiated.
8. SN Status transfer was sent from S-GNB to S-MN, which was then forwarded to T-SGNB. This transfer included two crucial pieces of information regarding PDCP SN & HFN to align the sequence and timing with the target nodes.
9. Afterward, the PATH SWITCH was initiated to change the path from SGW to the new Target SgNB.

Chapter 10 "Multi-Connectivity operation related aspects" in 3GPP TS 37.340.
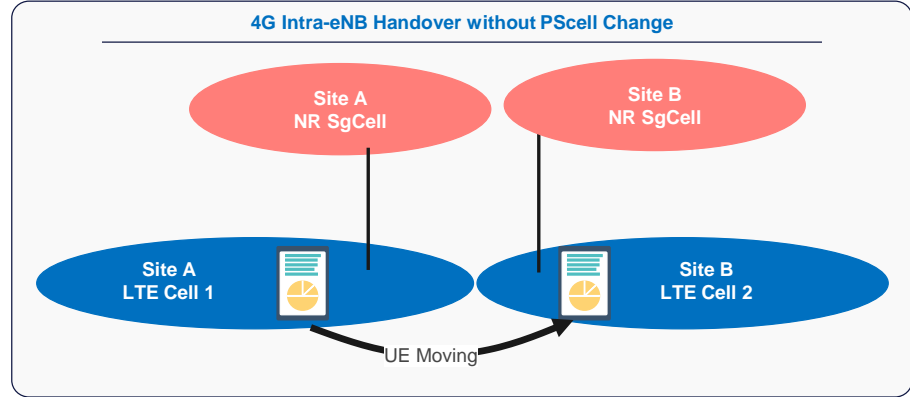**"10.3 Secondary Node Modification (MN/SN initiated) "**

PSCell Change - Intra-SgNB

- SgNB-initiated SgNB modification is mainly used for NR inter-frequency measurement gap request, intra-NR resource configuration, or intra-SgNB PSCell change.
- After receiving an intra-frequency or inter-frequency measurement report, the SgNB triggers an intra-base-station cell change procedure if the measured cell is served by the current SgNB.
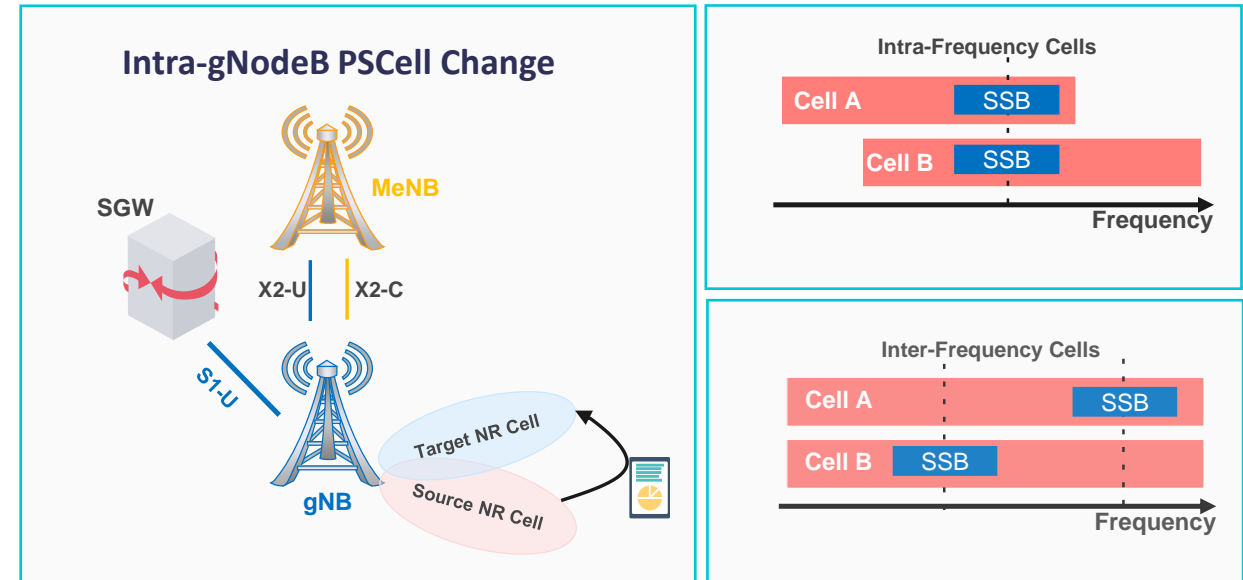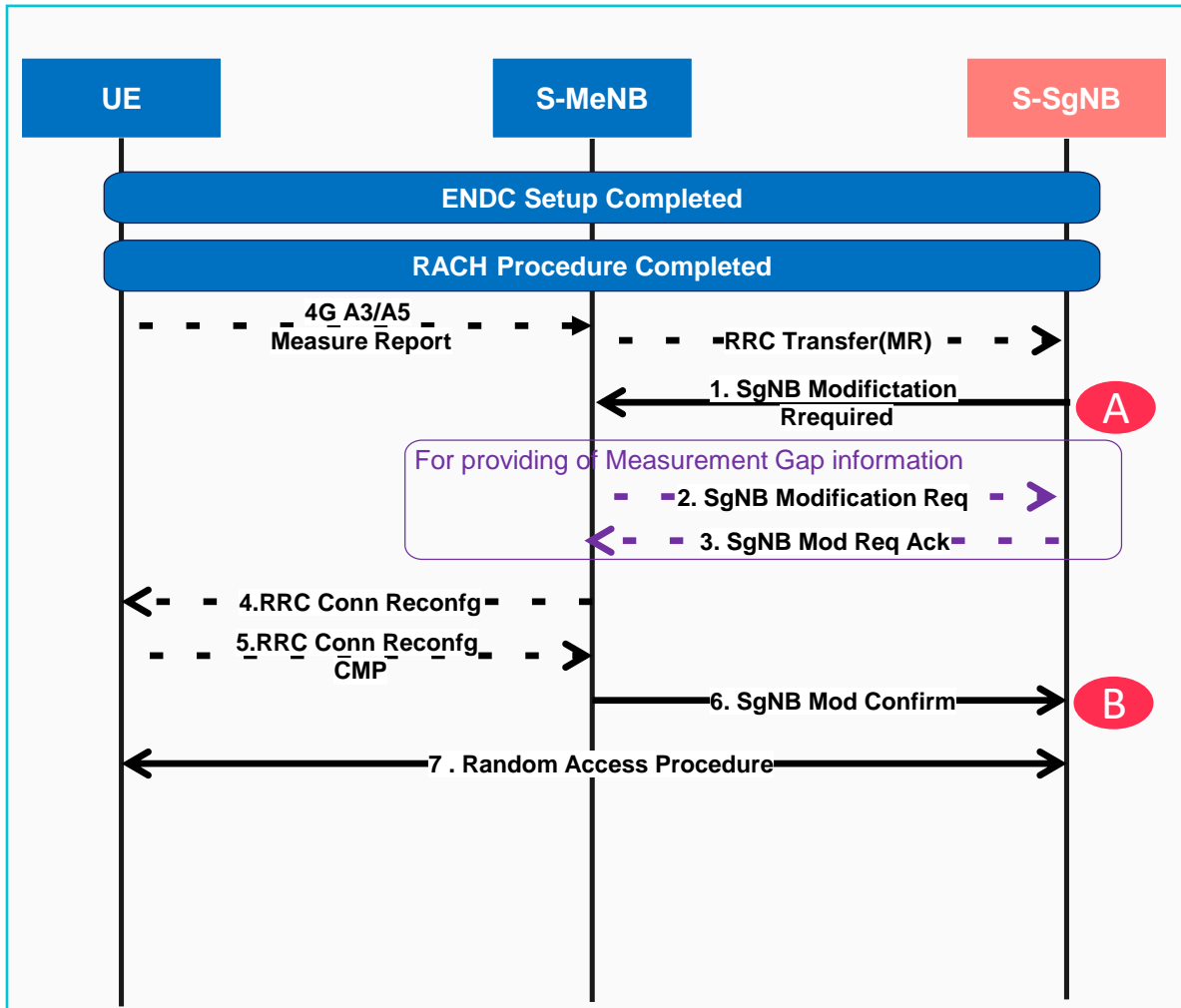
Intra-gNodeB PSCell Change

1.The UE Transfers MR Report, encompassing RSRP, RSRQ, and SINR for both Serving and Target SPCell.

2.SgNB responded with a requirement for SgNB modification required, which included the current SPCell information and candidate cell information. The latter consisted of SSB Frequency, PCI for the new Pscell, and RSRP information.

3.S-MN forwarded the same information through the RRC Reconfiguration message.

4.Subsequently, S-MN sent SgNB Modification Confirm to S-SgNB.

5.The RACH process was initiated.

Chapter 10 "Multi-Connectivity operation related aspects" in 3GPP TS 37.340.
"10.3 Secondary Node Modification (MN/SN initiated) "

4G Inter-eNB Handover with PSCell Change

UE	S-MeNB	S-SgNB	T-MeNB	T-SgNB	S-GW	MME

ENDC Setup Completed

RACH Procedure Completed

1.4G A3/A5 Measure Control

2.4G A3/A5 Measure Report

3.HO Request

4.SgNB Add Req

5.SgNB Add Req Ack

6.HO Request Ack

7.SgNB Rel Req

8.SgNB Rel Req Ack

9. RRC Conn Recfg

10. RACH Procedure Completed

11. RRC Conn Recfg Comp

11. RACH Procedure Completed

13.SgNB Recfg CMP

14. Path Switch

15. UE Context Rel

16. UE Context Rel

4G Intra-eNB Handover without PScell Change

Site A NR SgCell

Site B NR SgCell

Site A LTE Cell 1

Site B LTE Cell 2

UE Moving

4G Inter-eNB Handover without PSCell Change

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UE	S-MeNB	SgNB	T-MeNB	S-GW	MME

ENDC Setup Completed

RACH Procedure Completed

1.4G A3/A5 Measure Control

2.4G A3/A5 Measure Report

3.HO Request

4.SgNB Add Req

5.SgNB Add Req Ack

6.HO Request Ack

7.SgNB Rel Req

8.SgNB Rel Req Ack

9. RRC Conn Recfg

10. RACH Procedure Completed

11. RRC Conn Recfg Comp

11. RACH Procedure Completed

13.SgNB Recfg CMP

14. Path Switch

15. UE Context Rel

16. UE Context Rel

4G Intra-eNB Handover without PScell Change

Site A NR SgCell

Site A LTE Cell 1

Site B LTE Cell 2

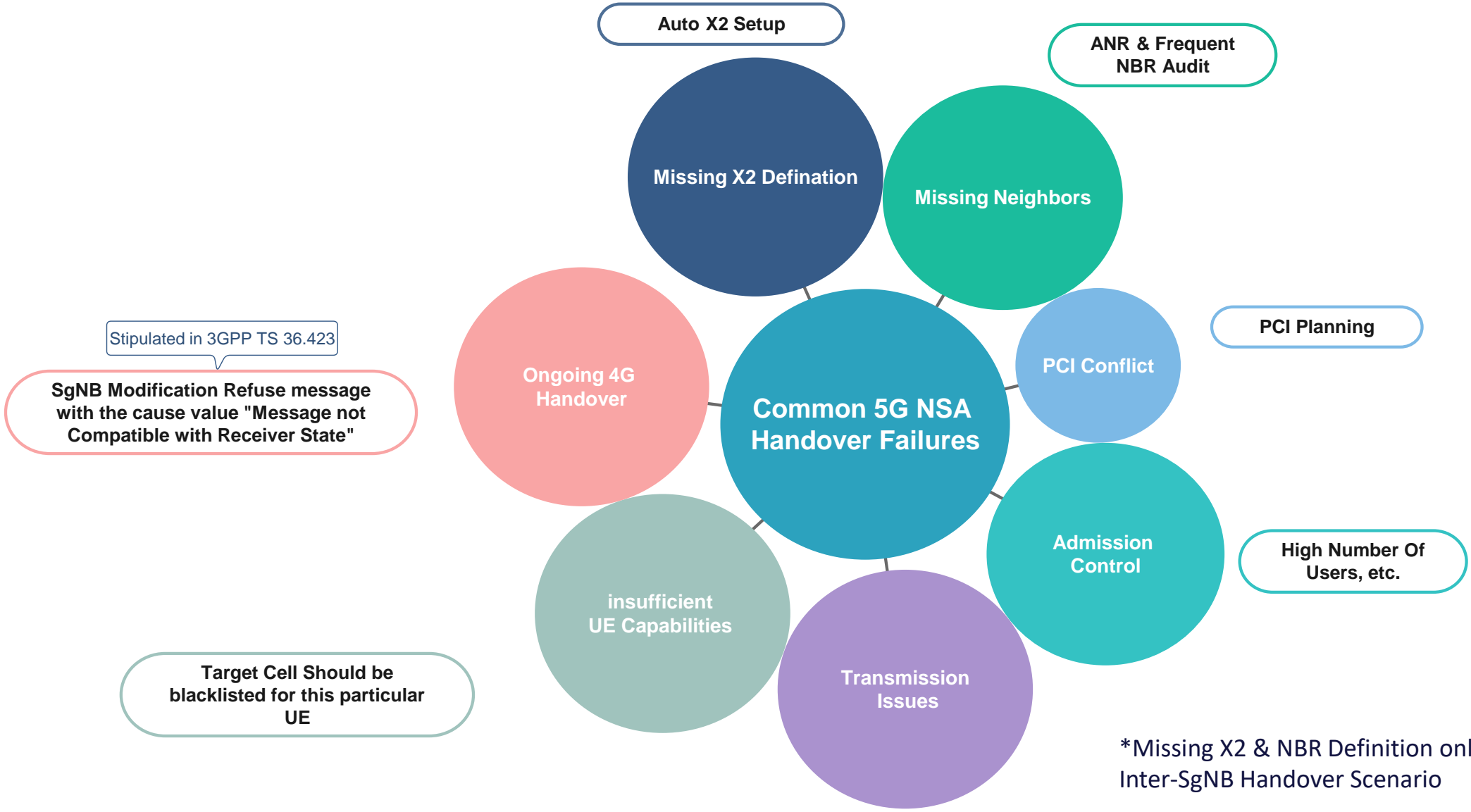UE Moving

Mobility Related Parameters

- Ms and Mn: measurement results of the serving cell and a neighboring cell, respectively
- Hys: hysteresis for an event
- TimeToTrig: duration during which a condition is met before the event can be triggered
- Thresh, Thresh1, and Thresh2: thresholds
- Ofs and Ofn: frequency-specific offsets for the serving cell and a neighboring cell, respectively
- Ocs and Ocn: cell individual offset (CIO) for the serving cell and a neighboring cell, respectively
- Off: offset for a measurement result
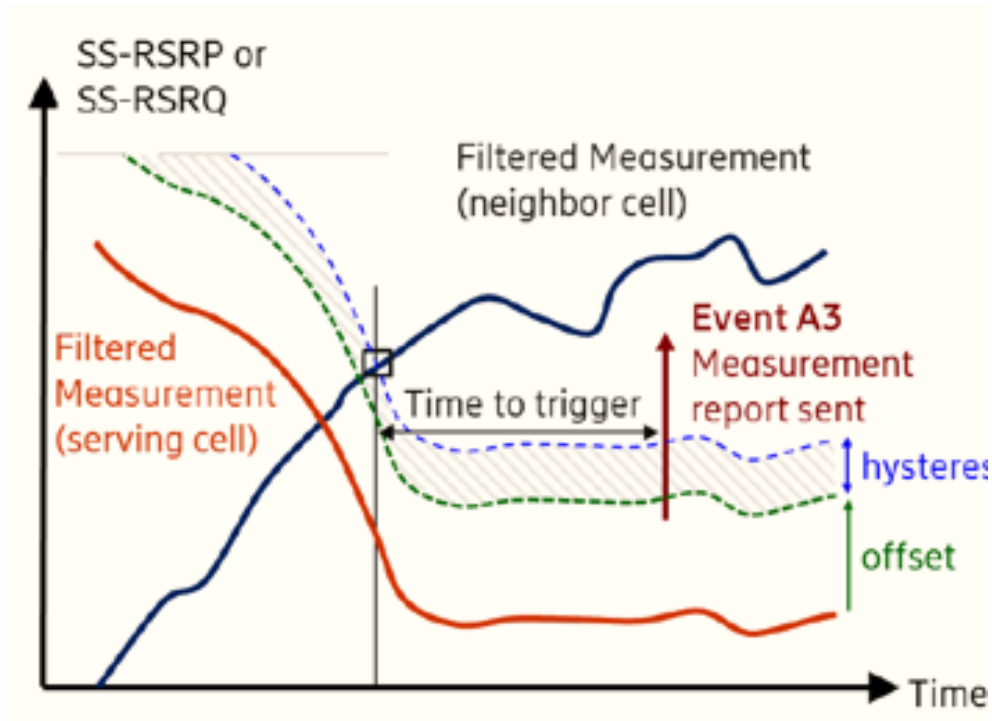
Event	Parameter ID	Description	Entering Condition
A3	a3-Offset hysteresis timeToTrigger	The signal quality of a neighboring cell is higher than that of the serving cell by a certain offset.	$(Mn + Ofn + Ocn - Hys > Ms + Ofs + Ocs + Off)$ is true during the time specified by TimeToTrig.
A2	Hys Thresh	The signal quality of the serving cell is below a specific threshold.	$(Ms + Hys < Thresh)$ is true during the time specified by TimeToTrig.
A5	Hys Thresh1 Thresh2 TimeToTrig	The signal quality of the serving cell is below threshold 1 and the signal quality of a neighboring cell exceeds threshold 2.	$(Ms + Hys < Thresh1)$ and $(Mn + Ofn + Ocn - Hys > Thresh2)$ are true during the time specified by TimeToTrig.

5G NSA Mobility Common Handover Issues

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Auto X2 Setup

ANR & Frequent NBR Audit

Missing X2 Defination

Missing Neighbors

Stipulated in 3GPP TS 36.423

PCI Planning

SgNB Modification Refuse message with the cause value "Message not Compatible with Receiver State"

Ongoing 4G Handover

Common 5G NSA Handover Failures

PCI Conflict

Admission Control

High Number Of Users, etc.

insufficient UE Capabilities

Transmission Issues

Target Cell Should be blacklisted for this particular UE

*Missing X2 & NBR Definition only applicable in Inter-SgNB Handover Scenario

9.1.1.4   SN STATUS TRANSFER

This message is sent by the source NG-RAN node to the target NG-RAN node to transfer the uplink/downlink PDCP SN and HFN status during a handover or for dual connectivity.

Direction: source NG-RAN node → target NG-RAN node(handover),
NG-RAN node from which the DRB context is transferred → NG-RAN node to which the DRB context is transferred (RRC connection re-establishment or dual connectivity).

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.2.3.1		YES	ignore
Source NG-RAN node UE XnAP ID	M		NG-RAN node UE XnAP ID 9.2.3.16	Allocated for handover at the source NG-RAN node and for dual connectivity at the NG-RAN node from which the DRB context is transferred.	YES	reject
Target NG-RAN node UE XnAP ID	M		NG-RAN node UE XnAP ID 9.2.3.16	Allocated for handover at the target NG-RAN node and for dual connectivity at the NG-RAN node to which the DRB context is transferred.	YES	reject
DRBs Subject To Status Transfer List	M		9.2.1.14		YES	ignore