TS 5G.331 v1.0 (2016-08)

Technical Specification

KT PyeongChang 5G Special Interest Group (KT 5G-SIG); KT 5th Generation Radio Access; Radio Resource Control (RRC); Protocol specification (Release 1)

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Document History

Version	Date	Change
0.1.0	2016-04-06	First Draft Version
0.1.1	2016-05-08	Updated version
0.1.2	2016-05-20	Updated after 1st Teleconference
0.1.3	2016-06-01	Updated after 2nd Teleconference
0.1.4	2016-06-14	Include IWK part
0.1.5	2016-06-30	Add RRC operation for SA mode Apply CRs on beam management, Security, UE Capability, and IEs
0.1.6	2016-08-05	Apply CRs on RRC IEs, Security, Measurement
0.1.7	2016-08-23	Apply CRs on details for SA-related operation and ASN.1
1.0.0	2016-08-30	1st Release Version

Contents

Foreword

This Technical Specification has been produced by the KT PyeongChang 5G Special Interest Group (KT 5G-SIG)

1 Scope

The present document specifies the Radio Resource Control protocol for the PyeongChang 5G trial.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.

For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document, a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] TS 5G.211: "5G Radio Access (5G RA); Physical channels and modulation".

[2] TS 5G.212: "5G Radio Access (5G RA); Multiplexing and channel coding".

[3] TS 5G.213: "5G Radio Access (5G RA); Physical layer procedures".

[4] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); UE Procedures in Idle Mode".

[6] TS 5G.321: "5G Radio Access (5G RA); Medium Access Control (MAC) protocol specification".

[7] TS 5G.322:" 5G Radio Access (5G RA); Radio Link Control (RLC) protocol specification".

[8] TS 5G.323: "5G Radio Access (5G RA); Packet Data Convergence Protocol (PDCP) Specification".

[9] TS 5G.300: "5G Radio Access (5G RA); Overall description; Stage 2".

[10] 3GPP TS 23.122: "Non-Access-Stratum (NAS) functions related to Mobile Station (MS) in idle mode".

[11] 3GPP TS 33.401: "3GPP System Architecture Evolution (SAE); Security architecture".

[12] 3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3".

[13] 3GPP TS 36.323: "Evolved Universal Terrestrial Radio Access (E-UTRA); Packet Data Convergence Protocol (PDCP) specification".

[14] 3GPP TS 36.322: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Link Control (RLC) protocol specification".

[15] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

[16] 3GPP TS 36.302: "Evolved Universal Terrestrial Radio Access (E-UTRA); Services provided by the physical layer".

3 Definitions, symbols and abbreviations

3.1 Definitions

Definition format

<defined term>*: <definition>.*

example: text used to clarify abstract rules by applying them literally.

3.2 Abbreviations

5G-RAN	5G-RAN
LTE	Long Term Evolution
MAC	Medium Access Control
P5G	PyeongChang 5G
RLC	Radio Link Control
RRC	Radio Resource Control
PDCP	Packet Data Convergence Protocol
UE	User Equipment
5G-UTRA	5th Generation Universal Terrestrial Radio Access for P5G trial
5G-RAN	5th Generation Universal Terrestrial Radio Access Network for P5G trial

4 General

4.1 Introduction

This specification is organised as follows:

- sub-clause 4.2 describes the RRC protocol model;

- sub-clause 4.3 specifies the services provided to upper layers as well as the services expected from lower layers;

- sub-clause 4.4 lists the RRC functions;

- clause 5 specifies RRC procedures, including UE state transitions;

- clause 6 specifies the RRC message in a mixed format (i.e. tabular & ASN.1 together);

- clause 7 specifies the variables (including protocol timers and constants) and counters to be used by the UE;

- clause 8 specifies the encoding of the RRC messages;

- clause 9 specifies the specified and default radio configurations;

- clause 11 specifies the UE capability related constraints and performance requirements.

4.2 Architecture

4.2.1 UE states and state transitions

A UE is in 5G RRC_CONNECTED when an 5G RRC connection has been established. If this is not the case, i.e. no RRC connection is established, the UE is in 5G RRC_IDLE state. The 5G RRC states can further be characterised as follows:

- **5G RRC_IDLE in non-standalone mode:**
  - No PDN connection established (LTE side) for 5G RRC;
  - The UE does not perform any 5G related actions.
- **5G RRC_IDLE in standalone mode**:
  - PLMN selection;
  - Broadcast of system information;

- Cell selection mobility;

- **5G RRC_CONNECTED:**
  - In non-standalone mode there is a PDN connection (LTE side) for 5G RRC;
  - Transfer of unicast data to/from UE;
  - The UEs supporting CA, use of one or more SCells, aggregated with the PCell, for increased bandwidth;
  - Network controlled mobility, i.e. 5G cell addition, 5G cell change, 5G cell release, 5G-RAN-B handover.
  - The UE:
    - Monitors control channels associated with the shared data channel to determine if data is scheduled for it;
    - Provides channel quality and feedback information;
    - Perform beam management;
    - Performs neighbouring cell measurements and measurement reporting;
    - Acquires system information.

The following figure provides an overview of the RRC states.

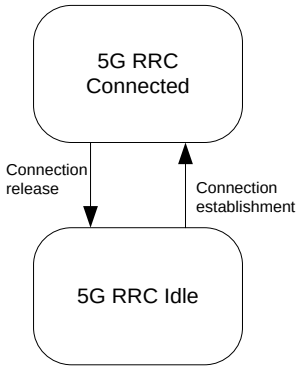

Figure 4.2.1-1: 5G-RRC states

4.2.2 Signalling radio bearers

"Signalling Radio Bearers" (SRBs) are defined as Radio Bearers (RB) that are used only for the transmission of RRC and NAS messages. More specifically, the following three SRBs are defined:

- SRB0 is for RRC messages using the CCCH logical channel;
- SRB1 is for RRC messages (which may include a piggybacked NAS message) as well as for NAS messages prior to the establishment of SRB2, all using DCCH logical channel;
- SRB2 is for NAS messages, using DCCH logical channel. SRB2 has a lower-priority than SRB1 and is always configured by 5G-RAN after security activation.

In downlink piggybacking of NAS messages is used only for one dependant (i.e. with joint success/ failure) procedure: bearer establishment/ modification/ release. In uplink NAS message piggybacking is used only for transferring the initial NAS message during connection setup.

NOTE The NAS messages transferred via SRB2 are also contained in RRC messages, which however do not include any RRC protocol control information.

Once security is activated, all RRC messages on SRB1 and SRB2, including those containing a NAS or a non-3GPP message, are integrity protected and ciphered by PDCP. NAS independently applies integrity protection and ciphering to the NAS messages.

4.3 Services

4.3.1 Services provided to upper layers

The RRC protocol offers the following services to upper layers:

- Broadcast of general control information;
- Transfer of dedicated control information, i.e. information for one specific UE.

4.3.2 Services expected from lower layers

In brief, the following are the main services that 5G RRC expects from lower layers:if operating in non-standalone mode:

- LTE PDCP: ciphering;
- LTE RLC: reliable and in-sequence transfer of information, without introducing duplicates and with support for segmentation and concatenation;
- Routing of 5G RRC messages to 5G RRC entity.

Further details about the services provided by LTE Packet Data Convergence Protocol layer (e.g. integrity and ciphering) are provided in 3GPP TS 36.323 [13]. The services provided by LTE Radio Link Control layer (e.g. the RLC modes) are specified in 3GPP TS 36.322 [14]. Further details about the services provided by LTE Medium Access Control layer (e.g. the logical channels) are provided in 3GPP TS 36.321 [15]. The services provided by LTE physical layer (e.g. the transport channels) are specified in 3GPP TS 36.302 [16].

If operating in standalone mode:

- PDCP: integrity protection and ciphering;
- RLC: reliable and in-sequence transfer of information, without introducing duplicates.

Further details about the services provided by Packet Data Convergence Protocol layer (e.g. integrity and ciphering) are provided in TS 5G.323 [8]. The services provided by Radio Link Control layer (e.g. the RLC modes) are specified in TS 5G.322 [7]. Further details about the services provided by Medium Access Control layer (e.g. the logical channels) are provided in TS 5G.321 [6].

4.4 Functions

The 5G RRC protocol includes the following main functions:

- Broadcast of system information:
    - Master information block;
    - XSystem information block (if operating in standalone mode)
- 5G RRC connection control:
    - Establishment/modification/release of 5G RRC connection, including e.g. assignment / modification of UE identity (C-RNTI), and in standalone mode establishment/ modification/ release of SRB1 and SRB2;
    - In standalone mode, initial security activation, i.e. initial configuration of AS integrity protection (CP) and AS ciphering (CP, UP);
    - Security activation for AS ciphering for DRBs in non-standalone mode;
    - 5G RRC connection mobility including e.g. intra-frequency handover, associated security handling, i.e. key/ algorithm change;

  - Establishment/ modification/ release of RBs carrying user data (DRBs);
  - Radio configuration control including e.g. assignment/ modification of ARQ configuration, and HARQ configuration, DRX configuration;
  - In case of CA, cell management including e.g. change of PCell, and addition/ modification/ release of SCell(s);
  - QoS control including assignment/ modification of parameters for UL rate control in the UE, i.e. allocation of a priority for each RB;
  - Recovery from 5G radio link failure;
- Measurement configuration and reporting:
  - Establishment/ modification/ release of measurements (e.g. intra-frequency);
  - Measurement reporting;
- Transfer of UE radio access capability information;
- Transfer of dedicated NAS information (if operating in standalone mode);
- Generic protocol error handling.

NOTE: Random access is specified entirely in the MAC including initial transmission power estimation.

5 Procedures

5.1 General

5.1.1 Introduction

The procedural requirements are structured according to the main functional areas: system information (5.2), connection control (5.3) and measurements (5.5). In addition sub-clause 5.6 covers UE capability transfer, sub-clause 5.7 specifies the generic error handling.

5.1.2 General Requirements

The UE shall:

1> process the received messages in order of reception by 5G RRC, i.e. the processing of a message shall be completed before starting the processing of a subsequent message;

NOTE 1: 5G-RAN may initiate a subsequent procedure prior to receiving the UE's response of a previously initiated procedure.

1> within a sub-clause execute the steps according to the order specified in the procedural description;

1> consider the term 'radio bearer' (RB) to cover DRBs and in standalone mode SRBs;

1> set the rrc-TransactionIdentifier in the response message, if included, to the same value as included in the message received from 5G-RAN that triggered the response message;

1> upon receiving a choice value set to setup:

2> apply the corresponding received configuration and start using the associated resources, unless explicitly specified otherwise;

1> upon receiving a choice value set to release:

2> clear the corresponding configuration and stop using the associated resources;

1> upon receiving an RRCConnectionReconfiguration message including the fullConfig:

2> apply the Conditions in the ASN.1 for inclusion of the fields for the DRB/PDCP/RLC setup during the reconfiguration of the DRBs included in the drb-ToAddModList;

NOTE 2: At each point in time, the UE keeps a single value for each field except for during handover when the UE temporarily stores the previous configuration so it can revert back upon handover failure. In other words: when the UE reconfigures a field, the existing value is released except for during handover.

NOTE 3: Although not explicitly stated, the UE initially considers all functionality to be deactivated/ released until it is explicitly stated that the functionality is setup/ activated. Correspondingly, the UE initially considers lists to be empty e.g. the list of radio bearers, the list of measurements.

5.2 System Information

5.2.1 Introduction

5.2.1.1 General

System information includes the *MasterInformationBlock* (MIB) and the *XSystemInformationBlock* (xSIB). The MIB includes a limited number of most essential and frequently transmitted parameters that are needed to acquire other information from the cell, and is transmitted on BCH. xSIB contains information needed to access the system for standalone operation. All other information is transmitted using dedicated messages.

The UE applies the system information acquisition procedures for the PCell. For a SCell, 5G-RAN provides, via dedicated signalling, all system information relevant for operation in RRC_CONNECTED when adding the SCell.

5.2.1.2 Scheduling

The MIB uses a fixed schedule with a periodicity of 40 ms and repetitions made within 40 ms. The first transmission of the MIB is scheduled in a subframe #0 of radio frames for which the SFN mod 4 = 0, and repetitions are scheduled in subframe #0 of all radio frames except for which the SFN mod 4 = 0, and subframe #25 of all radio frames.

5.2.1.3 System information validity and notification of changes

When the network changes (some of the) system information except MIB/xSIB content, it provides (at least) the updated system information to the UE via dedicated signalling within an *RRCConnectionReconfiguration* message. Otherwise, the UE applies the previously provided system information.

5.2.2 System information acquisition

5.2.2.1 General

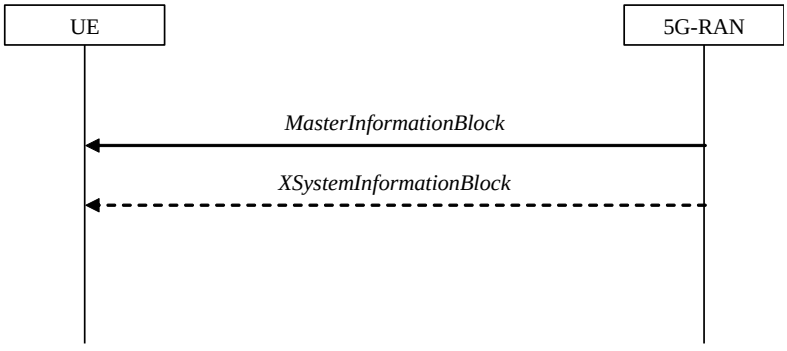

Figure 5.2.2.1-1: System information acquisition, standalone

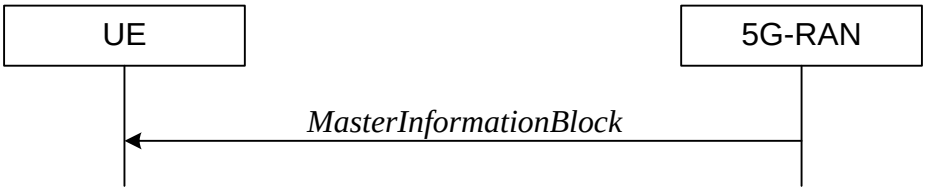

Figure 5.2.2.1-1a: System information acquisition, non-standalone

The UE applies the system information acquisition procedure to acquire the AS- system information that is broadcasted by the 5G-RAN. The procedure applies to UEs in RRC_IDLE and in 5G RRC_CONNECTED.

5.2.2.2 Initiation

In standalone operation the UE shall apply the system information acquisition procedure upon selecting (e.g. upon power on) and upon re-selecting a cell, after handover completion, upon return from out of coverage, upon receiving a notification that the system information has changed (FFS).

In non-standalone operation the UE shall apply the system information acquisition procedure upon completion of cell addition/ change.

Unless explicitly stated otherwise in the procedural specification, the system information acquisition procedure overwrites any stored system information, i.e. delta configuration is not applicable for system information and the UE discontinues using a field if it is absent in system information unless explicitly specified otherwise.

5.2.2.3 System information required by the UE

The UE shall:

1> in non-standalone operation the UE ensure having valid version of *MasterInformationBlock* according to clause 5.2.1.3.

1> in standalone operation the UE ensure having valid version of MasterInformationBlock and XSystemInformationBlock according to clause 5.2.1.3.

5.2.2.4 System information acquisition by the UE

The UE shall:

1> apply the specified BCCH configuration defined in 9.1.1.1;

1> in standalone mode, acquire the system information required, as defined in 5.2.2.3:

2> neither initiate the RRC connection establishment procedure nor initiate transmission of the RRCConnectionReestablishmentRequest message until the UE has the valid system information;

1> in non-standalone mode, following successful addition/ change of a 5G Cell for which the UE does not have stored a valid version of the system information required in 5G RRC_CONNECTED, as defined in 5.2.2.3:

2> acquire, using the system information acquisition procedure as defined in 5.2.3, the system information required in 5G RRC_CONNECTED, as defined in 5.2.2.3;

5.2.2.5 Essential system information missing

The UE shall:

1> if in RRC_IDLE or in 5G RRC_CONNECTED while T311 is running:

2> if the UE is unable to acquire the *MasterInformationBlock* or in standalone mode the *XSystemInformationBlock*:

3> consider the cell as barred with TS36.304 [4];

5.2.2.6 Actions upon reception of the *MasterInformationBlock* message

Upon receiving the *MasterInformationBlock* message the UE shall:

1> apply the configuration included in brsTransmisionPeriod and ePBCHConfiguration.

5.2.2.7 Actions upon reception of the XSystemInformationBlock message

Upon receiving the XSystemInformationBlock message the UE shall:

1> forward the cellidentity to upper layers;

1> apply the default configuration as defined in 9.2.5.

5.3 Connection Control

5.3.1 Introduction

5.3.1.1 RRC connection control in standalone mode

RRC connection establishment involves the establishment of SRB1. 5G-RAN completes RRC connection establishment prior to completing the establishment of the S1 connection, i.e. prior to receiving the UE context information from the EPC. Consequently, AS security is not activated during the initial phase of the RRC connection. During this initial phase of the RRC connection, the 5G-RAN may configure the UE to perform measurement reporting, but the UE only sends the corresponding measurement reports after successful security activation. However, the UE only accepts a handover message when security has been activated.

Upon receiving the UE context from the EPC, 5G-RAN activates security (both ciphering and integrity protection) using the initial security activation procedure. The RRC messages to activate security (command and successful response) are integrity protected, while ciphering is started only after completion of the procedure. That is, the response to the message used to activate security is not ciphered, while the subsequent messages (e.g. used to establish SRB2 and DRBs) are both integrity protected and ciphered.

After having initiated the initial security activation procedure, 5G-RAN initiates the establishment of SRB2 and DRBs, i.e. 5G-RAN may do this prior to receiving the confirmation of the initial security activation from the UE. In any case, 5G-RAN will apply both ciphering and integrity protection for the RRC connection reconfiguration messages used to establish SRB2 and DRBs. E-UTRAN should release the RRC connection if the initial security activation and/ or the radio bearer establishment fails (i.e. security activation and DRB establishment are triggered by a joint S1-procedure, which does not support partial success).

For SRB2 and DRBs, security is always activated from the start, i.e. the 5G-RAN does not establish these bearers prior to activating security.

After having initiated the initial security activation procedure, 5G-RAN may configure a UE that supports CA, with one or more SCells in addition to the PCell that was initially configured during connection establishment. The PCell is used to provide the security inputs and upper layer system information. SCells are used to provide additional downlink and uplink radio resources.

For some radio configuration fields, a critical extension has been defined. A switch from the original version of the field to the critically extended version is allowed using any connection reconfiguration. The UE reverts to the original version of some critically extended fields upon handover and re-establishment as specified elsewhere in this specification. Otherwise, switching a field from the critically extended version to the original version is only possible using the handover or re-establishment procedure with the full configuration option. This also applies for fields that are critically extended within a release (i.e. original and extended version defined in same release).

5.3.1.1a RRC connection control in non-standalone mode

5G RRC connection establishment involves the establishment of LTE DRB. All 5G RRC messages are ciphered by LTE PDCP of the given DRB. 5G ciphering is not activated during the initial phase of the RRC connection. During this initial phase of the RRC connection, the 5G-RAN may configure the UE to perform measurement reporting.

For 5G DRBs, ciphering is always activated from the start, i.e. the 5G-RAN does not establish these bearers prior to activating security.

NOTE1: The ciphering may be activated in the same RRC message the 5G DRBs are established.

5G RRC connection may only be released by releasing the corresponding DRB by E-UTRAN.

5.3.1.2 Security in standalone mode

AS security comprises of the integrity protection of RRC signalling (SRBs) as well as the ciphering of RRC signalling (SRBs) and user data (DRBs).

RRC handles the configuration of the security parameters which are part of the AS configuration: the integrity protection algorithm, the ciphering algorithm and two parameters, namely the *keyChangeIndicator* and the *nextHopChainingCount*, which are used by the UE to determine the AS security keys upon handover and/ or connection re-establishment.

NOTE : Only AES shall be mandatory, other algorithms could be considered for subsequent phases.The integrity protection algorithm is common for signalling radio bearers SRB1 and SRB2. The ciphering algorithm is common for all radio bearers (i.e. SRB1, SRB2 and DRBs). Neither integrity protection nor ciphering applies for SRB0.

RRC integrity and ciphering are always activated together, i.e. in one message/ procedure. RRC integrity and ciphering are never de-activated. However, it is possible to switch to a 'NULL' ciphering algorithm (eea0).

The 'NULL' integrity protection algorithm (eia0) is used only for the UE in limited service mode [TS33.401]. In case the 'NULL' integrity protection algorithm is used, 'NULL' ciphering algorithm is also used.

NOTE 1: Lower layers discard RRC messages for which the integrity check has failed and indicate the integrity verification check failure to RRC.

The AS applies three different security keys: one for the integrity protection of RRC signalling (K_{RRCint}), one for the ciphering of RRC signalling (K_{RRCenc}) and one for the ciphering of user data (K_{UPenc}). All three AS keys are derived from the 5G K_{eNB} key. The 5G K_{eNB} is based on the K_{ASME} key, which is handled by upper layers.

Upon connection establishment new AS keys are derived. No AS-parameters are exchanged to serve as inputs for the derivation of the new AS keys at connection establishment.

The integrity and ciphering of the RRC message used to perform handover is based on the security configuration used prior to the handover and is performed by the source5G-RAN.

The integrity and ciphering algorithms can only be changed upon handover. The four AS keys (5G $K_{eNB,}$ K_{RRCint}, K_{RRCenc} and K_{UPenc}) change upon every handover and connection re-establishment. The *keyChangeIndicator* is used upon handover and indicates whether the UE should use the keys associated with the K_{ASME} key taken into use with the latest successful NAS SMC procedure. The *nextHopChainingCount* parameter is used upon handover and connection re-establishment by the UE when deriving the new 5G K_{eNB} that is used to generate K_{RRCint}, K_{RRCenc} and K_{UPenc} (see TS 33.401 [11]). An intra cell handover procedure may be used to change the keys in RRC_CONNECTED.

For each radio bearer an independent counter (COUNT, as specified in 5G.323 [8]) is maintained for each direction. For each DRB, the COUNT is used as input for ciphering. For each SRB, the COUNT is used as input for both ciphering and integrity protection. It is not allowed to use the same COUNT value more than once for a given security key. In order to limit the signalling overhead, individual messages/ packets include a short sequence number (PDCP SN, as specified in 5G.323 [8]). In addition, an overflow counter mechanism is used: the hyper frame number (TX_HFN and RX_HFN, as specified in 5G.323 [8]). The HFN needs to be synchronized between the UE and the 5G-RAN. The 5G-RAN is responsible for avoiding reuse of the COUNT with the same RB identity and with the same 5G K_{eNB}, e.g. due to the transfer of large volumes of data, release and establishment of new RBs. In order to avoid such re-use, the 5G-RAN may e.g. use different RB identities for successive RB establishments, trigger an intra cell handover or an RRC_CONNECTED to RRC_IDLE to RRC_CONNECTED transition.

For each SRB, the value provided by RRC to lower layers to derive the 5-bit BEARER parameter used as input for ciphering and for integrity protection is the value of the corresponding *srb-Identity* with the MSBs padded with zeroes.

5.3.1.2a Security in non-standalone mode

AS security in 5G comprises the ciphering of user data (DRBs).

5G RRC handles the configuration of the security parameters which are part of the AS configuration: the ciphering algorithm and the 5G K_{eNB}. The ciphering algorithm is common for all radio bearers (DRBs). The ciphering is never de-activated. However, it is possible to switch to a 'NULL' ciphering algorithm (eea0).

The UE and 5G-RAN applies one K_{UPenc} for the ciphering of user data. This K_{UPenc} is derived from the 5G K_{eNB}.by UE and 5G-RAN as defined in [9]. The 5G K_{eNB} is derived at the 5G cell by using 5G-RAND, which is a basic random value used as input into 5G K_{eNB} derivations. The 5G-RAN, delivers the 5G K_{eNB} and selected ciphering algorithm to the UE only via encrypted link 4G DRB for 5G RRC signalling.

Whenever a 5G cell change takes place, 5G K_{eNB} is derived at the target 5G cell and delivered to the UE.

The 5G-C value is used as freshness input into the 5G K_{eNB} derivations. The 5G-C value is increased by 1 whenever generating a 5G K_{eNB} for any UE within the 5G cell. 5G AS security keys are refreshed when PDCP COUNTs are about to wrap around. 5G K_{eNB*} is newly derived by 5G-RAN from the current "5G- C value" and delivered to UE via 5G RRC signalling. 5G K_{eNB*} is then used as new 5G K_{eNB} for 5G user data. When the UE goes into 5G RRC-IDLE all keys are deleted from the 5G-RAN. AS key is updated at 5G cell change by indicating in 5G RRC signalling to the UE the value of the new 5G K_{eNB} generated at new 5G cell.

5.3.1.3 Connected mode mobility

In 5G RRC_CONNECTED, the network controls UE mobility, i.e. the network decides when the UE shall connect to which 5G cell. For network controlled mobility in 5G RRC_CONNECTED, the 5G cell can be changed using an *RRCConnectionReconfiguration* message including the *mobilityControlInfo*. The network triggers the handover procedure e.g. based on radio conditions, load. To facilitate this, the network may configure the UE to perform measurement reporting. The network may also initiate handover blindly, i.e. without having received measurement reports from the UE.

Before sending the handover message to the UE, the source 5G-RAN prepares one or more target cells. The source 5G-RAN selects the target 5G cell. The target 5G cell decides which SCells are configured for use after handover.

The target 5G Node generates the message used to perform the handover, i.e. the message including the AS-configuration to be used in the target cell(s). The source 5G Node transparently (i.e. does not alter values/ content) forwards the handover message/ information received from the target to the UE. When appropriate, the source 5GNode may initiate data forwarding for (a subset of) the DRBs.

After receiving the handover message, the UE attempts to access the target 5G cell at the first available RACH occasion according to Random Access resource selection defined in TS 5G.321 [6], i.e. the handover is asynchronous. Consequently, when allocating a dedicated preamble for the random access in the target 5G cell, 5G-RAN shall ensure it is available from the first RACH occasion the UE may use. Upon successful completion of the handover, the UE sends a message used to confirm the handover.

In RRC_CONNECTED, the network may initiate UE-based mobility, i.e., the 5GNB configures measurement events for detection of candidate cells and triggering of handover execution in UE-based handover. The 5GNB transmits an RRCConnectionReconfiguration message including the mobilityControlInfo (list of candidate cells for UE-based handover). The 5GNB configures a dedicated measurement event for handover execution in UE-based handover procedure. Upon triggering the measurement event the UE attempts to perform a RRC Connection Reestablishment procedure in the best candidate cell.

If the target 5GNB does not support the release of RRC protocol which the source 5GNB used to configure the UE, the target 5GNB may be unable to comprehend the UE configuration provided by the source 5GNB. In this case, the target 5GNB should use the full configuration option to reconfigure the UE for Handover and Re-establishment. Full configuration option includes an initialization of the radio configuration, which makes the procedure independent of the configuration used in the source cell(s) with the exception that the security algorithms are continued for the RRC re-establishment.

After the successful completion of handover, PDCP SDUs may be re-transmitted in the target cell(s). This only applies for DRBs using RLC-AM mode and for handovers not involving full configuration option. The further details are specified in TS 5G.323 [8]. After the successful completion of handover not involving full configuration option, the SN

and the HFN are reset except for the DRBs using RLC-AM mode (for which both SN and HFN continue). For reconfigurations involving the full configuration option, the PDCP entities are newly established (SN and HFN do not continue) for all DRBs irrespective of the RLC mode. The further details are specified in TS 5G.323 [8].One UE behaviour to be performed upon handover is specified, i.e. this is regardless of the handover procedures used within the network (e.g. whether the handover includes X2 or S1 signalling procedures).

The source 5G cell should, for some time, maintain a context to enable the UE to return in case of handover failure. After having detected handover failure, the UE attempts to resume the RRC connection either in the source 5G Cell or in another cell using the RRC re-establishment procedure. This connection resumption succeeds only if the accessed cell is prepared, i.e. concerns a cell of the source 5G cell or of another 5G cell towards which handover preparation has been performed. The cell in which the re-establishment procedure succeeds becomes the PCell while SCells, if configured, are released.

5.3.2 Void

Editors note: This section covers paging in LTE. It is FFS if paging is introduced in standalone operation.

5.3.3 RRC connection establishment in standalone operation

Editors note: This section is to cover RRC connection establishment in stand-alone operation.

5.3.3.1 General

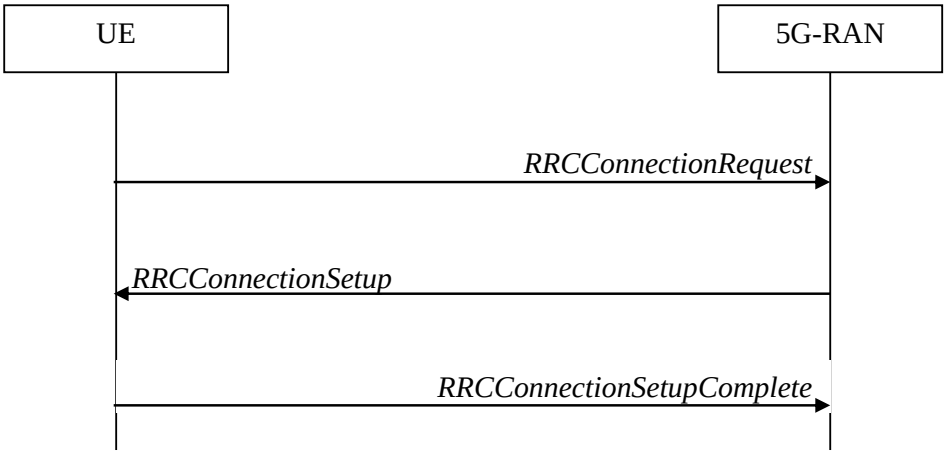

Figure 5.3.3.1-1: RRC connection establishment, successful

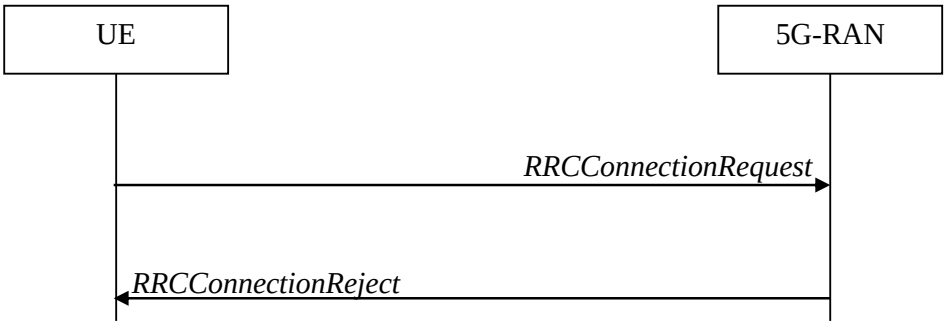

Figure 5.3.3.1-2: RRC connection establishment, network reject

The purpose of this procedure is to establish an RRC connection in standalone operation. RRC connection establishment involves SRB1 establishment. The procedure is also used to transfer the initial NAS dedicated information/ message from the UE to 5G-RAN.

5GRAN applies the procedure as follows:

- to establish SRB1 only.

5.3.3.2 Initiation

The UE initiates the procedure when upper layers request establishment of an RRC connection while the UE is in RRC_IDLE.

Upon initiation of the procedure, the UE shall:

1> apply the default physical channel configuration as specified in 9.2.4;

1> apply the default MAC main configuration as specified in 9.2.2;

1> apply the CCCH configuration as specified in 9.1.1.2;

1> start timer T300;

1> initiate transmission of the RRCConnectionRequest message in accordance with 5.3.3.3;

5.3.3.3 Actions related to transmission of *RRCConnectionRequest* message

The UE shall set the contents of *RRCConnectionRequest* message as follows:

1> set the *ue-Identity* as follows:

2> if upper layers provide an S-TMSI:

3> set the *ue-Identity* to the value received from upper layers;

2> else:

3> draw a random value in the range 0 .. 2^{40}-1 and set the *ue-Identity* to this value;

NOTE 1: Upper layers provide the S-TMSI if the UE is registered in the TA of the current cell.

The UE shall submit the *RRCConnectionRequest* message to lower layers for transmission.

5.3.3.4 Reception of the *RRCConnectionSetup* by the UE

NOTE: Prior to this, lower layer signalling is used to allocate a C-RNTI. For further details see TS 5G.321 [6];

The UE shall:

1> perform the radio resource configuration procedure in accordance with the received *radioResourceConfigDedicated* and as specified in 5.3.10;

1> stop timer T300;

1> stop timer T302, if running;

1> perform the actions as specified in 5.3.3.7;

1> enter RRC_CONNECTED;

1> consider the current cell to be the PCell;

1> set the content of *RRCConnectionSetupComplete* message as follows:

2> set the *selectedPLMN-Identity* to the PLMN selected by upper layers (see TS 23.122 [10], TS 24.301 [12]) from the PLMN(s) included in the *plmn-IdentityList* in x*SystemInformationBlock*;

2> if upper layers provide the 'Registered MME', include and set the *registeredMME* as follows:

3> if the PLMN identity of the 'Registered MME' is different from the PLMN selected by the upper layers:

4> include the *plmnIdentity* in the *registeredMME* and set it to the value of the PLMN identity in the 'Registered MME' received from upper layers;

3> set the *mmegi* and the *mmec* to the value received from upper layers;

2> if upper layers provided the 'Registered MME':

3> include and set the *gummei-Type* to the value provided by the upper layers;

2> set the *dedicatedInfoNAS* to include the information received from upper layers;

2> submit the *RRCConnectionSetupComplete* message to lower layers for transmission, upon which the procedure ends;

5.3.3.5 Cell selection while T300, T302 is running

The UE shall:

1> if cell selection occurs while T300, T302:

2> if timer T302:

3> stop timer;

3> perform the actions as specified in 5.3.3.7;

2> if timer T300 is running:

3> stop timer T300;

3> reset MAC, release the MAC configuration and re-establish RLC for all RBs that are established;

3> inform upper layers about the failure to establish the RRC connection

5.3.3.6 T300 expiry

The UE shall:

1> if timer T300 expires:

2> reset MAC, release the MAC configuration and re-establish RLC for all RBs that are established;

2> inform upper layers about the failure to establish the RRC connection, upon which the procedure ends;

5.3.3.7 T302 expiry or stop

The UE shall:

1> if timer T302 expires or is stopped:

2> inform upper layers about barring alleviation for mobile terminating access;

5.3.3.8 Reception of the *RRCConnectionReject* by the UE

The UE shall:

1> stop timer T300;

1> reset MAC and release the MAC configuration;

1> start timer T302, with the timer value set to the *waitTime*;

1> inform upper layers about the failure to establish the RRC connection, upon which the procedure ends;

5.3.3a 5G RRC connection establishment via E-UTRAN

5.3.3a.1 General

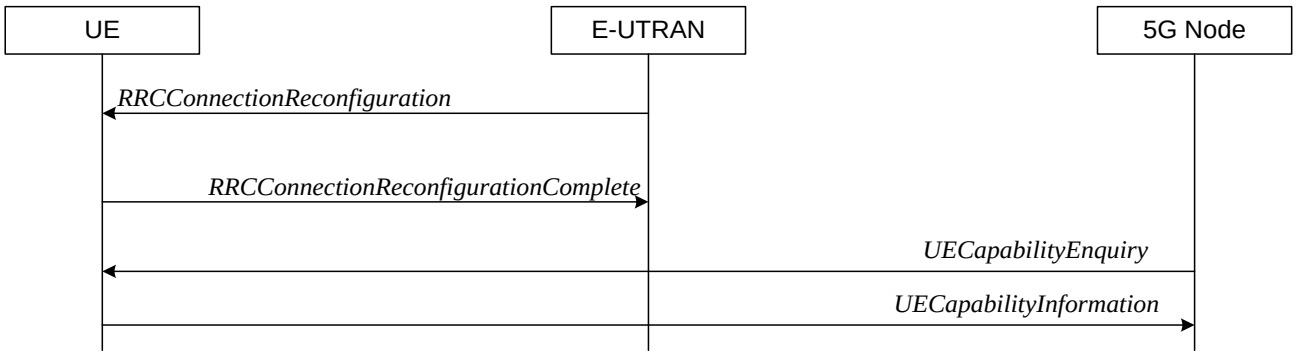

Figure 5.3.3a.1-1: 5G RRC Connection establishment

The purpose of this procedure is to establish a 5G RRC connection via E-UTRAN. 5G RRC connection establishment involves DRB establishment in LTE and 5G-RAN sending *UECapabilityEnquiry message* and UE responding 5G *UECapabilityInformation* message to 5G-RAN by using established DRB via E-UTRAN.

5.3.3a.2 Initiation

The E-UTRAN initiates the procedure upon Bearer Setup Request by MME for the 5G RRC.

Upon initiation of the procedure, the UE shall:

1> after receiving *RRCConnectionReconfiguration* message, act as defined in 36.331;

1> upon completion of the procedure, send *RRCConnectionReconfigurationComplete* as defined in 36.331;

1> upon indication by lower layers of successful delivery of *RRCConnectionReconfigurationComplete* message, able to receive 5G *UECapabilityEnquiry* message as define in 5.6.3;

1> consider to be in 5G RRC_CONNECTED state upon indication by lower layers of successful delivery of 5G *UECapabilityInformation* message.

5.3.4 Initial Security Activation

Editor's note: This procedure is for standalone operation.

5.3.4.1 General

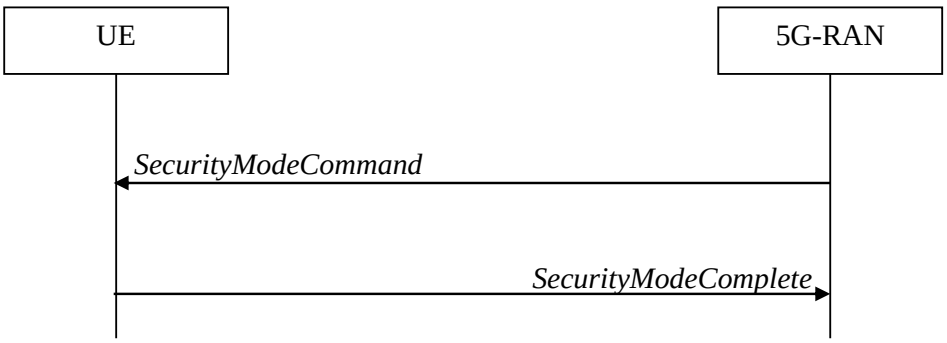

Figure 5.3.4.1-1: Security mode command, successful

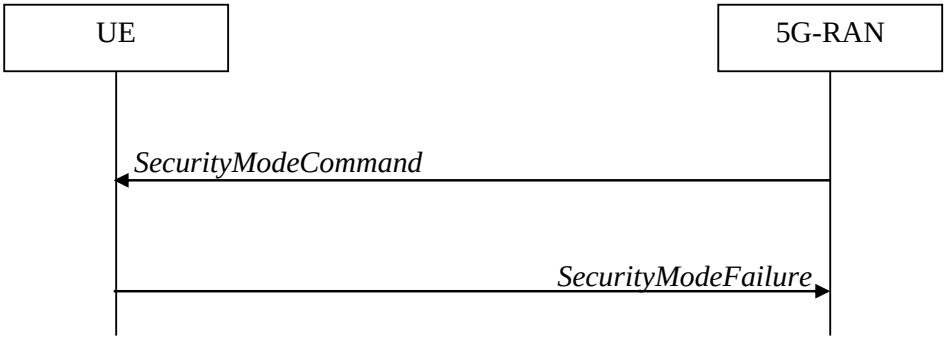

Figure 5.3.4.1-2: Security mode command, failure

The purpose of this procedure is to activate AS security upon RRC connection establishment in standalone operation.

5.3.4.2 Initiation

5G-RAN initiates the security mode command procedure to a UE in RRC_CONNECTED. Moreover, 5G-RAN applies the procedure as follows:

- when only SRB1 is established, i.e. prior to establishment of SRB2 and/ or DRBs.

5.3.4.3 Reception of the *SecurityModeCommand* by the UE

The UE shall:

1> derive the 5G K_{eNB} key, as specified in TS 33.401 [11];

1> derive the K_{RRCint} key associated with the *integrityProtAlgorithm* indicated in the *SecurityModeCommand* message, as specified in TS 33.401 [11];

1> request lower layers to verify the integrity protection of the *SecurityModeCommand* message, using the algorithm indicated by the *integrityProtAlgorithm* as included in the *SecurityModeCommand* message and the K_{RRCint} key;

1> if the *SecurityModeCommand* message passes the integrity protection check:

2> derive the K_{RRCenc} key and the K_{UPenc} key associated with the *cipheringAlgorithm* indicated in the *SecurityModeCommand* message, as specified in TS 33.401 [11];

2> configure lower layers to apply integrity protection using the indicated algorithm and the K_{RRCint} key immediately, i.e. integrity protection shall be applied to all subsequent messages received and sent by the UE, including the *SecurityModeComplete* message;

2> configure lower layers to apply ciphering using the indicated algorithm, the K_{RRCenc} key and the K_{UPenc} key after completing the procedure, i.e. ciphering shall be applied to all subsequent messages received and sent by the UE, except for the *SecurityModeComplete* message which is sent unciphered;

2> consider AS security to be activated;

2> submit the *SecurityModeComplete* message to lower layers for transmission, upon which the procedure ends;

1> else:

2> continue using the configuration used prior to the reception of the *SecurityModeCommand* message, i.e. neither apply integrity protection nor ciphering.

2> submit the *SecurityModeFailure* message to lower layers for transmission, upon which the procedure ends;

5.3.5 RRC connection reconfiguration

5.3.5.1 General

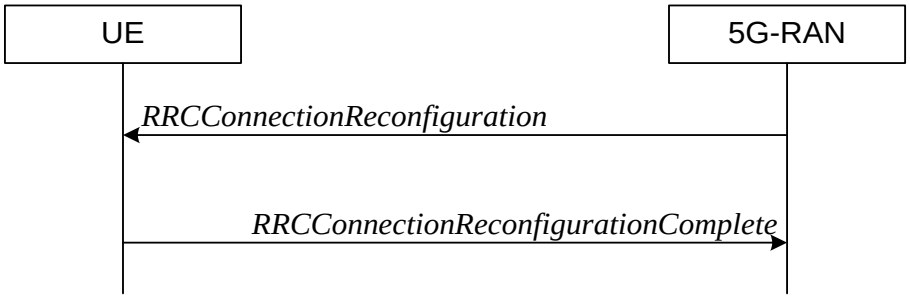

Figure 5.3.4.1-1: 5G RRC Connection reconfiguration

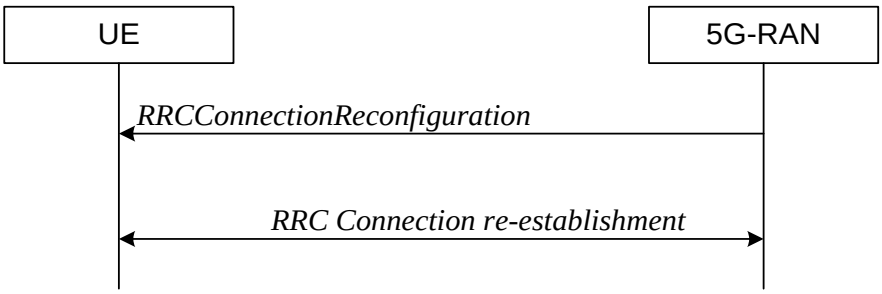

Figure 5.3.4.1-2: 5G RRC Connection reconfiguration, failure

The purpose of this procedure is to modify a 5G RRC connection, e.g. to establish/ modify/ release RBs, to perform cell change, to setup/ modify/ release measurements, to activate 5G ciphering, provide system information. As part of the procedure, NAS dedicated information may be transferred from 5G-RAN to the UE.

5.3.5.2 Initiation

5G-RAN may initiate the 5G RRC connection reconfiguration procedure to a UE in 5G RRC_CONNECTED. 5G-RAN applies the procedure as follows:

- the mobilityControlInfo is included only when AS-security has been activated, and SRB2 with at least one DRB are setup and not suspended;
- 'the establishment of RBs is included only when 5G ciphering has been activated;
- the addition of SCells is performed only when AS security has been activated;

5.3.5.3 Reception of an *RRCConnectionReconfiguration* not including the *mobilityControlInfo* by the UE

If the *RRCConnectionReconfiguration* message does not include the *mobilityControlInfo* and the UE is able to comply with the configuration included in this message, the UE shall:

1> if operating in non-standalone mode and the *RRCConnectionReconfiguration* message includes the *configRelease*:

2> perform the radio configuration procedure as specified in section 5.3.5.9;

1> if this is the first RRCConnectionReconfiguration message after successful completion of the RRC Connection Re-establishment procedure:

2> re-establish PDCP for SRB2 and for all DRBs that are established, if any;

2> re-establish RLC for SRB2 and for all DRBs that are established, if any

2> if the *RRCConnectionReconfiguration* message includes the *fullConfig*:

3> perform the radio configuration procedure as specified in section 5.3.5.8;

2> if the RRCConnectionReconfiguration message includes the radioResourceConfigDedicated:

3> perform the radio resource configuration procedure as specified in 5.3.10;

2> resume SRB2 and all DRBs that are suspended, if any;

NOTE 1: The handling of the radio bearers after the successful completion of the PDCP re-establishment, e.g. the re-transmission of unacknowledged PDCP SDUs (as well as the associated status reporting), the handling of the SN and the HFN, is specified in TS 5G.323.

NOTE 2: The UE may discard SRB2 messages and data that it receives prior to completing the reconfiguration used to resume these bearers.

1> else:

2> if the RRCConnectionReconfiguration message includes the radioResourceConfigDedicated:

3> perform the radio resource configuration procedure as specified in 5.3.10;

NOTE 3: If the RRCConnectionReconfiguration message includes the establishment of radio bearers other than SRB1, the UE may start using these radio bearers immediately, i.e. there is no need to wait for an outstanding acknowledgment of the SecurityModeComplete message.

1> if the received *RRCConnectionReconfiguration* includes the *sCellToReleaseList*:

2> perform SCell release as specified in 5.3.10.3a;

1> if the received *RRCConnectionReconfiguration* includes the *sCellToAddModList*:

2> perform SCell addition or modification as specified in 5.3.10.3b;

1> if the *RRCConnectionReconfiguration* message includes the *measConfig*:

2> perform the measurement configuration procedure as specified in 5.5.2;

1> perform the measurement identity autonomous removal as specified in 5.5.2.2a;

1> submit the *RRCConnectionReconfigurationComplete* message to lower layers for transmission using the new configuration, upon which the procedure ends;

5.3.5.4 Reception of an *RRCConnectionReconfiguration* including the *mobilityControlInfo* by the UE (handover)

If the *RRCConnectionReconfiguration* message includes the *mobilityControlInfo* and the UE is able to comply with the configuration included in this message, the UE shall:

1> if the targetPhysCellId is included:

2> stop timer T310, if running;

2> stop timer T312, if running;

2> start timer T304 with the timer value set to *t304*, as included in the *mobilityControlInfo*;

2> if the *carrierFreq* is included:

3> consider the target 5G Cell to be one on the frequency indicated by the *carrierFreq* with a physical cell identity indicated by the *targetPhysCellId*;

2> else:

3> consider the target 5G Cell to be one on the frequency of the source 5G Cell with a physical cell identity indicated by the *targetPhysCellId*;

2> start synchronising to the DL of the target 5G Cell;

NOTE 1: The UE should perform the handover as soon as possible following the reception of the RRC message triggering the handover, which could be before confirming successful reception (HARQ and ARQ) of this message.

2> reset MAC;

2> re-establish PDCP for all RBs that are established;

NOTE 2: The handling of the radio bearers after the successful completion of the PDCP re-establishment, e.g. the re-transmission of unacknowledged PDCP SDUs (as well as the associated status reporting), the handling of the SN and the HFN, is specified in 5G.323 [8].

2> re-establish RLC for all RBs that are established;

2> apply the value of the newUE-Identity as the C-RNTI;

2> if the RRCConnectionReconfiguration message includes the fullConfig:

3> perform the radio configuration procedure as specified in section 5.3.5.8;

2> configure lower layers in accordance with the received *radioResourceConfigCommon*;

2> configure lower layers in accordance with any additional fields, not covered in the previous, if included in the received *mobilityControlInfo*;

2> if the RRCConnectionReconfiguration message includes the radioResourceConfigDedicated:

3> perform the radio resource configuration procedure as specified in 5.3.10;

2> if operating in non-Standalone mode:

3> if the RRCConnectionReconfiguration message includes the securityConfig*IWK*:

3> update the 5G K_{eNB} key based on the new 5G K_{eNB}* received in the *securityConfigIWK*;

3> If the *securityConfigIWK* also includes new ciphering algorithm

4> Update ciphering algorithm based on the new ciphering algorithm received in the *securityConfigIWK*;

2> else

3> if the *keyChangeIndicator* received in the *securityConfigHO* is set to *TRUE*:

4> update the 5G K_{eNB} key based on the K_{ASME} key taken into use with the latest successful NAS SMC procedure, as specified in TS 33.401 [11];

3> else:

4> update the 5G K_{eNB} key based on the current 5G K_{eNB} or the NH, using the *nextHopChainingCount* value indicated in the *securityConfigHO*, as specified in TS 33.401 [11];

3> store the *nextHopChainingCount* value;

2> if the securityAlgorithmConfig is included in the securityConfigHO:

3> derive the KRRCint key associated with the integrityProtAlgorithm, as specified in TS 33.401 [11];

3> derive the KRRCenc key and the KUPenc key associated with the cipheringAlgorithm, as specified in TS 33.401 [11];

2> else:

3> derive the KRRCint key associated with the current integrity algorithm, as specified in TS 33.401 [11];

3> derive the KRRCenc key and the KUPenc key associated with the current ciphering algorithm, as specified in TS 33.401 [11];

2> configure lower layers to apply the integrity protection algorithm and the KRRCint key, i.e. the integrity protection configuration shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

2> configure lower layers to apply the ciphering algorithm, the KRRCenc key and the KUPenc key, i.e. the ciphering configuration shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

2> if the received RRCConnectionReconfiguration includes the sCellToReleaseList:

3> perform SCell release as specified in 5.3.10.3a;

2> if the received RRCConnectionReconfiguration includes the sCellToAddModList:

3> perform SCell addition or modification as specified in 5.3.10.3b;

2> perform the measurement related actions as specified in 5.5.6.1;

2> if the RRCConnectionReconfiguration message includes the measConfig:

3> perform the measurement configuration procedure as specified in 5.5.2;

2> perform the measurement identity autonomous removal as specified in 5.5.2.2a;

2> submit the *RRCConnectionReconfigurationComplete* message to lower layers for transmission;

2> if MAC successfully completes the random access procedure:

3> stop timer T304;

3> consider the 5G-cell as the Pcell for 5G connection

3> apply the parts of the CQI reporting configuration, the scheduling request configuration and the sounding RS configuration that do not require the UE to know the SFN of the target 5G Cell, if any;

3> apply the parts of the measurement and the radio resource configuration that require the UE to know the SFN of the target 5G Cell (e.g., periodic CQI reporting, scheduling request configuration, sounding RS configuration), if any, upon acquiring the SFN of the target 5G Cell;

NOTE 3: Whenever the UE shall setup or reconfigure a configuration in accordance with a field that is received it applies the new configuration, except for the cases addressed by the above statements.

2> the procedure ends;

NOTE 4: The UE is not required to determine the SFN of the target 5G Cell by acquiring system information from that cell before performing RACH access in the target 5G Cell.

1> else (i.e., the candidateCellInfoList is included):

2> apply the measurement configuration for UE based handover execution;

2> if an event for UE based handover execution is triggered, the UE shall perform RRC Connection Reestablishment procedure with one of the candidate cells with the highest RSRP as specified in 5.3.7.

5.3.5.5 Reconfiguration failure

The UE shall:

1> if the UE is unable to comply with (part of) the configuration included in the *RRCConnectionReconfiguration* message:

2> continue using the configuration used prior to the reception of *RRCConnectionReconfiguration* message;

2> if security has not been activated (operating in standalone mode or non-standalone mode):

4> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause other;

2> else:

4> initiate the connection re-establishment procedure as specified in 5.3.7, upon which the connection reconfiguration procedure ends;

NOTE 1: The UE may apply above failure handling also in case the *RRCConnectionReconfiguration* message causes a protocol error for which the generic error handling as defined in 5.7 specifies that the UE shall ignore the message.

NOTE 2: If the UE is unable to comply with part of the configuration, it does not apply any part of the configuration, i.e. there is no partial success/ failure.

5.3.5.6 T304 expiry (handover failure)

If operating in standalone mode the UE shall:

1> if T304 expires (handover failure):

NOTE 1: Following T304 expiry any dedicated preamble, if provided within the *rach-ConfigDedicated*, is not available for use by the UE anymore.

2> revert back to the configuration used in the source PCell, excluding the configuration configured by the *physicalConfigDedicated* and *the mac-MainConfig;*;

2> initiate the connection re-establishment procedure as specified in 5.3.7, upon which the RRC connection reconfiguration procedure ends;

Editor's note: Handover failure in non-standalone operation is FFS.

5.3.5.8 Radio Configuration involving full configuration option

The UE shall:

1> release/ clear all current dedicated radio configurations except the C-RNTI, the security configuration and the PDCP, RLC, logical channel configurations for the RBs;

NOTE 1: Radio configuration is not just the resource configuration but includes other configurations like *MeasConfig* and *OtherConfig*.

1> if the *RRCConnectionReconfiguration* message includes the *mobilityControlInfo*:

2> release/ clear all current dedicated radio configurations;

1> if operating in standalone mode:

2> use the default values specified in 9.2.5 for timer T310, T311 and constant N310, N311;

2> apply the default physical channel configuration as specified in 9.2.4;

2> apply the default MAC main configuration as specified in 9.2.2;

1> for each srb-Identity value included in the srb-ToAddModList (SRB reconfiguration):

2> apply the specified configuration defined in 9.1.2 for the corresponding SRB;

2> apply the corresponding default RLC configuration for the SRB specified in 9.2.1.1 for SRB1 or in 9.2.1.2 for SRB2;

2> apply the corresponding default logical channel configuration for the SRB as specified in 9.2.1.1 for SRB1 or in 9.2.1.2 for SRB2;

NOTE 2: This is to get the SRBs (SRB1 and SRB2 for handover and SRB2 for reconfiguration after reestablishment) to a known state from which the reconfiguration message can do further configuration

1> for each *eps-BearerIdentity* value included in the *drb-ToAddModList* that is part of the current UE configuration:

2> release the PDCP entity;

2> release the RLC entity or entities;

2> release the DTCH logical channel;

2> release the *drb-identity*;

NOTE 3: This will retain the *eps-bearerIdentity* but remove the DRBs including *drb-identity* of these bearers from the current UE configuration and trigger the setup of the DRBs within the AS in Section 5.3.10.3 using the new configuration. The *eps-bearerIdentity* acts as the anchor for associating the released and re-setup DRB.

1> for each *eps-BearerIdentity* value that is part of the current UE configuration but not part of the *drb-ToAddModList:*

2> perform DRB release as specified in 5.3.10.2;

5.3.5.9 Radio Configuration involving configuration release option

The UE shall:

1> release/ clear all current dedicated radio configurations including the C-RNTI, the security configuration and the PDCP, RLC, logical channel configurations for the RBs;

1> stop all action related to 5G.

NOTE 1: Radio configuration is not just the resource configuration but includes other configurations like *MeasConfig* and *OtherConfig*.

5.3.6 Counter Check

5.3.6.1 General

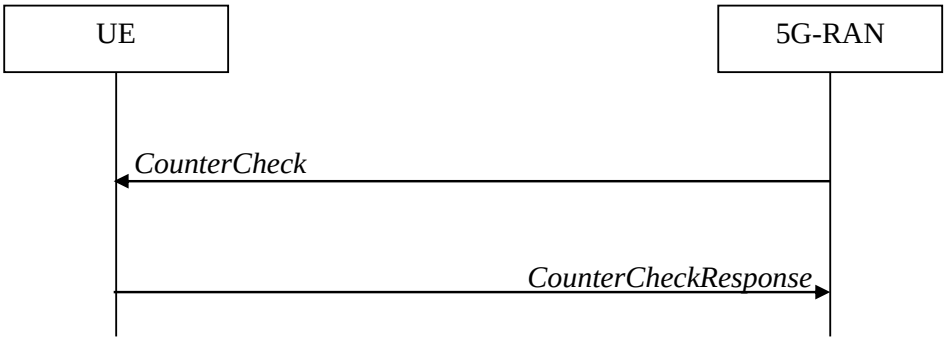

Figure 5.3.6.1-1: Counter check procedure

The counter check procedure is used by 5G-RAN to request the UE to verify the amount of data sent/ received on each DRB. More specifically, the UE is requested to check if, for each DRB, the most significant bits of the COUNT match with the values indicated by 5G-RAN.

NOTE: The procedure enables 5G-RAN to detect packet insertion by an intruder (a 'man in the middle').

5.3.6.2 Initiation

5G-RAN initiates the procedure by sending a *CounterCheck* message.

NOTE: 5G-RAN may initiate the procedure when any of the COUNT values reaches a specific value.

5.3.6.3 Reception of the *CounterCheck* message by the UE

Upon receiving the *CounterCheck* message, the UE shall:

1> for each DRB that is established:

2> if no COUNT exists for a given direction (uplink or downlink) because it is a uni-directional bearer configured only for the other direction:

3> assume the COUNT value to be '0' for the unused direction;

2> if the *drb-Identity* is not included in the *drb-CountMSB-InfoList*:

3> include the DRB in the *drb-CountInfoList* in the *CounterCheckResponse* message by including the *drb-Identity*, the *count-Uplink* and the *count-Downlink* set to the value of the corresponding COUNT;

2> else if, for at least one direction, the most significant bits of the COUNT are different from the value indicated in the *drb-CountMSB-InfoList*:

3> include the DRB in the *drb-CountInfoList* in the *CounterCheckResponse* message by including the *drb-Identity*, the *count-Uplink* and the *count-Downlink* set to the value of the corresponding COUNT;

1>for each DRB that is included in the *drb-CountMSB-InfoList* in the *CounterCheck* message that is not established:

2> include the DRB in the *drb-CountInfoList* in the *CounterCheckResponse* message by including the *drb-Identity*, the *count-Uplink* and the *count-Downlink* with the most significant bits set identical to the corresponding values in the *drb-CountMSB-InfoList* and the least significant bits set to zero;

1> submit the *CounterCheckResponse* message to lower layers for transmission upon which the procedure ends;

5.3.7 RRC connection re-establishment

Editor's note: This procedure is for standalone operation.

5.3.7.1 General

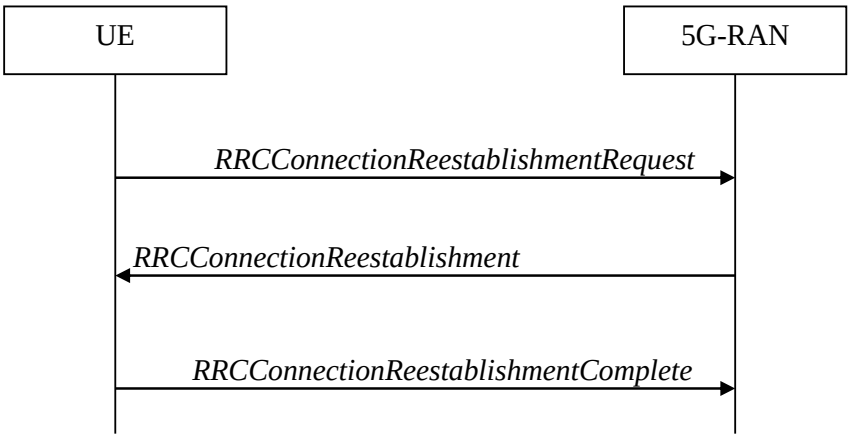

Figure 5.3.7.1-1: RRC connection re-establishment, successful

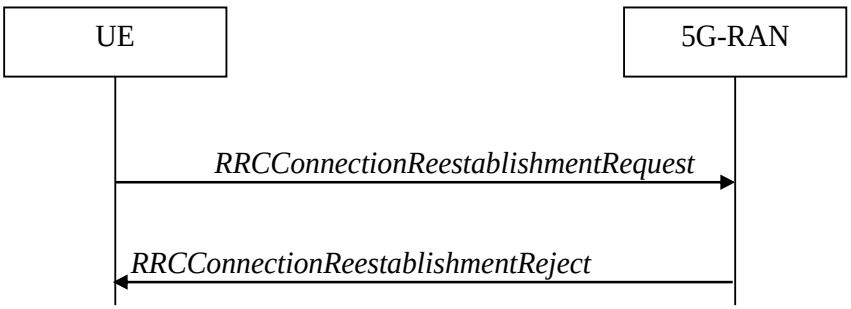

Figure 5.3.7.1-2: RRC connection re-establishment, failure

The purpose of this procedure is to re-establish the RRC connection in standalone operation which involves the resumption of SRB1 operation, the re-activation of security and the configuration of only the PCell.

A UE in RRC_CONNECTED, for which security has been activated, may initiate the procedure in order to continue the RRC connection. The connection re-establishment succeeds only if the concerned cell is prepared i.e. has a valid UE

context. In case 5G-RAN accepts the re-establishment, SRB1 operation resumes while the operation of other radio bearers remains suspended. If AS security has not been activated, the UE does not initiate the procedure but instead moves to RRC_IDLE directly.

5G-RAN applies the procedure as follows:

- to reconfigure SRB1 and to resume data transfer only for this RB;
- to re-activate AS security without changing algorithms.

5.3.7.2 Initiation

The UE shall only initiate the procedure when AS security has been activated. The UE initiates the procedure when one of the following conditions is met:

1> upon detecting radio link failure, in accordance with 5.3.11; or

1> upon UE-based handover execution in accordance with 5.3.5.4; or

1> upon handover failure, in accordance with 5.3.5.6; or

1> upon integrity check failure indication from lower layers; or

1> upon an RRC connection reconfiguration failure, in accordance with 5.3.5.5;

Upon initiation of the procedure, the UE shall:

1> stop timer T310, if running;

1> stop timer T312, if running;

1> start timer T311;

1> suspend all RBs except SRB0;

1> reset MAC;

1> release the SCell(s), if configured, in accordance with 5.3.10.3a;

1> apply the default physical channel configuration as specified in 9.2.3;

1> apply the default MAC main configuration as specified in 9.2.2;

1> start to access to the best target cell upon UE-based handover execution or perform cell selection in accordance with the cell selection process as specified in 3GPP TS 36.304 [4];

5.3.7.3 Actions following cell selection while T311 is running

Upon selecting a suitable 5G-RAN cell, the UE shall:

1> stop timer T311;

1> start timer T301;

1> apply the timeAlignmentTimer;

1> initiate transmission of the *RRCConnectionReestablishmentRequest* message in accordance with 5.3.7.4;

NOTE: This procedure applies also if the UE returns to the source or this procedure applies also if the UE accesses to the best target cell upon UE-based handover execution..

5.3.7.4 Actions related to transmission of *RRCConnectionReestablishmentRequest* message

The UE shall set the contents of *RRCConnectionReestablishmentRequest* message as follows:

1> set the *ue-Identity* as follows:

2> set the *c-RNTI* to the C-RNTI used in the source PCell (UE-based handover execution or handover failure) or used in the PCell in which the trigger for the re-establishment occurred (other cases);

2> set the *physCellId* to the physical cell identity of the source PCell (UE-based handover execution or handover failure) or of the PCell in which the trigger for the re-establishment occurred (other cases);

2> set the *shortMAC-I* to the 16 least significant bits of the MAC-I calculated:

3> over the ASN.1 encoded as per section 8 (i.e., a multiple of 8 bits) *VarShortMAC-Input*;

3> with the K_{RRCint} key and integrity protection algorithm that was used in the source PCell (UE-based handover execution or handover failure) or of the PCell in which the trigger for the re-establishment occurred (other cases); and

3> with all input bits for COUNT, BEARER and DIRECTION set to binary ones;

1> set the *reestablishmentCause* as follows:

2> if the re-establishment procedure was initiated due to reconfiguration failure as specified in 5.3.5.5 (the UE is unable to comply with the reconfiguration):

3> set the *reestablishmentCause* to the value *reconfigurationFailure*;

2> else if the re-establishment procedure was initiated due to UE-based handover execution as specified in 5.3.5.4:

3> set the reestablishmentCause to the value ‘ueBasedHandoverExecution’;

2> else if the re-establishment procedure was initiated due to handover failure as specified in 5.3.5.6:

3> set the *reestablishmentCause* to the value *handoverFailure*;

2> else:

3> set the *reestablishmentCause* to the value *otherFailure*;

The UE shall submit the *RRCConnectionReestablishmentRequest* message to lower layers for transmission.

5.3.7.5 Reception of the *RRCConnectionReestablishment* by the UE

NOTE 1: Prior to this, lower layer signalling is used to allocate a C-RNTI. For further details see 5G.321 [6];

The UE shall:

1> stop timer T301;

1> re-establish PDCP for SRB1;

1> re-establish RLC for SRB1;

1> perform the radio resource configuration procedure in accordance with the received *radioResourceConfigDedicated* and as specified in 5.3.10;

1> resume SRB1;

NOTE 2: 5GRAN should not transmit any message on SRB1 prior to receiving the *RRCConnectionReestablishmentComplete* message.

1> update the 5G K_{eNB} key based on the K_{ASME} key to which the current 5G K_{eNB} is associated, using the *nextHopChainingCount* value indicated in the *RRCConnectionReestablishment* message, as specified in TS 33.401 [11];

1> store the *nextHopChainingCount* value;

1> derive the K_{RRCint} key associated with the previously configured integrity algorithm, as specified in TS 33.401 [11];

1> derive the K_{RRCenc} key and the K_{UPenc} key associated with the previously configured ciphering algorithm, as specified in TS 33.401 [11];

1> configure lower layers to activate integrity protection using the previously configured algorithm and the K_{RRCint} key immediately, i.e., integrity protection shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

1> configure lower layers to apply ciphering using the previously configured algorithm, the K_{RRCenc} key and the K_{UPenc} key immediately, i.e., ciphering shall be applied to all subsequent messages received and sent by the UE, including the message used to indicate the successful completion of the procedure;

1> perform the measurement related actions as specified in 5.5.6.1;

1> perform the measurement identity autonomous removal as specified in 5.5.2.2a;

1> submit the *RRCConnectionReestablishmentComplete* message to lower layers for transmission;

1> the procedure ends;

5.3.7.6 T311 expiry

Upon T311 expiry, the UE shall:

1> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'RRC connection failure';

5.3.7.7 T301 expiry or selected cell no longer suitable

The UE shall:

1> if timer T301 expires; or

1> if the selected cell becomes no longer suitable according to the cell selection:

2> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'RRC connection failure';

5.3.7.8 Reception of *RRCConnectionReestablishmentReject* by the UE

Upon receiving the *RRCConnectionReestablishmentReject* message, the UE shall:

1> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'RRC connection failure';

5.3.8 RRC connection release

5.3.8.1 General

Figure 5.3.8.1-1: RRC connection release, successful

The purpose of this procedure is to release the RRC connection in standalone operation, which includes the release of the established radio bearers as well as all radio resources.

5.3.8.2 Initiation

5G-RAN initiates the RRC connection release procedure to a UE in RRC_CONNECTED.

5.3.8.3 Reception of the *RRCConnectionRelease* by the UE

The UE shall:

1> delay the following actions defined in this sub-clause 60 ms from the moment the *RRCConnectionRelease* message was received or optionally when lower layers indicate that the receipt of the *RRCConnectionRelease* message has been successfully acknowledged, whichever is earlier;

1> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12;

5.3.9 Void

5.3.10 Radio resource configuration

5.3.10.0 General

The UE shall:

1> if the received radioResourceConfigDedicated includes the srb-ToAddModList:

2> perform the SRB addition or reconfiguration as specified in 5.3.10.1;

1> if the received *radioResourceConfigDedicated* includes the *drb-ToReleaseList*:

2> perform DRB release as specified in 5.3.10.2;

1> if the received *radioResourceConfigDedicated* includes the *drb-ToAddModList*:

2> perform DRB addition or reconfiguration as specified in 5.3.10.3;

1> if the received *radioResourceConfigDedicated* includes the *mac-MainConfig*:

2> perform MAC main reconfiguration as specified in 5.3.10.4;

1> if the received *radioResourceConfigDedicated* includes the *physicalConfigDedicated*:

2> reconfigure the physical channel configuration as specified in 5.3.10.6.

1> if the received *radioResourceConfigDedicated* includes the *rach-ConfigDedicated*:

2> reconfigure the random access channel configuration as specified in 5.3.10.7.

1> if the received radioResourceConfigDedicated includes the rlf-TimersAndConstants:

2> reconfigure the values of timers and constants as specified in 5.3.10.7

5.3.10.1 Void

The UE shall:

1> for each srb-Identity value included in the srb-ToAddModList that is not part of the current UE configuration (SRB establishment):

2> apply the specified configuration defined in 9.1.2 for the corresponding SRB;

2> establish a PDCP entity and configure it with the current security configuration, if applicable;

2> establish an RLC entity in accordance with the received rlc-Config;

2> establish a DCCH logical channel in accordance with the received logicalChannelConfig and with the logical channel identity set in accordance with 9.1.2;

1> for each srb-Identity value included in the srb-ToAddModList that is part of the current UE configuration (SRB reconfiguration):

2> reconfigure the RLC entity in accordance with the received rlc-Config;

2> reconfigure the DCCH logical channel in accordance with the received logicalChannelConfig;

5.3.10.2 DRB release

The UE shall:

1> for each *drb-Identity* value included in the *drb-ToReleaseList* that is part of the current UE configuration (DRB release); or

1> for each *drb-identity* value that is to be released as the result of full configuration option according to 5.3.5.8:

2> release the PDCP entity;

2> release the RLC entity or entities;

2> release the DTCH logical channel;

1> if the procedure was triggered due to handover:

2> indicate the release of the DRB(s) and the *eps-BearerIdentity* of the released DRB(s) to upper layers after successful handover;

1> else:

2> indicate the release of the DRB(s) and the *eps-BearerIdentity* of the released DRB(s) to upper layers immediately.

NOTE: The UE does not consider the message as erroneous if the *drb-ToReleaseList* includes any *drb-Identity* value that is not part of the current UE configuration.

5.3.10.3 DRB addition/ modification

The UE shall:

1> for each *drb-Identity* value included in the *drb-ToAddModList* that is not part of the current UE configuration (DRB establishment including the case when full configuration option is used):

2> establish a PDCP entity and configure it with the current security configuration and in accordance with the received *pdcp-Config*;

2> establish an RLC entity or entities in accordance with the received *rlc-Config*;

2> establish a DTCH logical channel in accordance with the received *logicalChannelIdentity* and the received *logicalChannelConfig*;

1> if the *RRCConnectionReconfiguration* message includes the *fullConfig* IE:

2> associate the established DRB with corresponding included *eps-BearerIdentity*;

1> else:

2> indicate the establishment of the DRB(s) and the *eps-BearerIdentity* of the established DRB(s) to upper layers;

1> for each *drb-Identity* value included in the *drb-ToAddModList* that is part of the current UE configuration (DRB reconfiguration):

2> if the *pdcp-Config* is included:

3> reconfigure the PDCP entity in accordance with the received *pdcp-Config*;

2> if the *rlc-Config* is included:

3> reconfigure the RLC entity or entities in accordance with the received *rlc-Config*;

2> if the *logicalChannelConfig* is included:

3> reconfigure the DTCH logical channel in accordance with the received *logicalChannelConfig*;

NOTE: Removal and addition of the same *drb-Identity* in single *radioResourceConfiguration* is not supported.

5.3.10.3a SCell release

The UE shall:

1> if the release is triggered by reception of the *sCellToReleaseList*:

2> for each *sCellIndex* value included in the *sCellToReleaseList*:

3> if the current UE configuration includes an SCell with value *sCellIndex*:

4> release the SCell;

5.3.10.3b SCell addition/ modification

The UE shall:

1> for each *sCellIndex* value included in the *sCellToAddModList* that is not part of the current UE configuration (SCell addition):

2> add the SCell, corresponding to the *cellIdentification*, in accordance with the received *radioResourceConfigDedicatedSCell*;

2> configure lower layers to consider the SCell to be in activated state;

2> for each *measId* included in the *measIdList* within *VarMeasConfig*:

3> if SCells are not applicable for the associated measurement; and

3> if the concerned SCell is included in *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*:

4> remove the concerned SCell from *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

1> for each *sCellIndex* value included in the *sCellToAddModList* that is part of the current UE configuration (SCell modification):

2> modify the SCell configuration in accordance with the received *radioResourceConfigDedicatedSCell*;

5.3.10.4 MAC main reconfiguration

The UE shall:

1> reconfigure the MAC main configuration in accordance with the received *mac-MainConfig;*

5.3.10.5 Void

5.3.10.6 Physical channel reconfiguration

The UE shall:

1> reconfigure the physical channel configuration in accordance with the received *physicalConfigDedicated*;

5.3.10.7 Radio Link Failure Timers and Constants reconfiguration

The UE shall:

1> if the received rlf-TimersAndConstants is set to release:

2> use values for timers T301, T310, T311 and constants N310, N311, as included in default-TimersAndConstants in 9.2.;

1> else:

2> reconfigure the value of timers and constants in accordance with received rlf-TimersAndConstants;

5.3.10.8 Random access channel reconfiguration

The UE shall:

1> reconfigure the random access channel configuration in accordance with the received *rach-ConfigDedicated*;

5.3.11 Radio link failure related actions

5.3.11.1 Detection of physical layer problems in RRC_CONNECTED

The UE shall:

1> upon receiving N310 consecutive "out-of-sync" indications for the PCell from lower layers while neither T300, T301, T304 nor T311 is running:

2> start timer T310;

NOTE: Physical layer monitoring and related autonomous actions do not apply to SCells

5.3.11.2 Recovery of physical layer problems

Upon receiving N311 consecutive "in-sync" indications for the PCell from lower layers while T310 is running, the UE shall:

1> stop timer T310;

1> stop timer T312, if running;

NOTE 1: In this case, the UE maintains the 5G-RRC connection without explicit signalling, i.e. the UE maintains the entire radio resource configuration.

NOTE 2: Periods in time where neither "in-sync" nor "out-of-sync" is reported by layer 1 do not affect the evaluation of the number of consecutive "in-sync" or "out-of-sync" indications.

5.3.11.3 Detection of radio link failure

The UE shall:

1> upon T310 expiry; or

1> upon T312 expiry:or

1> upon random access problem indication from MAC while neither T300, T301, T304 nor T311 is running; or

1> upon indication from RLC that the maximum number of retransmissions has been reached for an SRB or for a DRB:

2> consider radio link failure to be detected i.e. RLF;

2> In standalone,

3> if AS security has not been activated:

4> perform the actions upon leaving RRC_CONNECTED as specified in 5.3.12, with release cause 'other';

3> else:

4> initiate the connection re-establishment procedure as specified in 5.3.7

2> In non-standalone,

3> initiate the measurement report procedure as specified in 5. 5. 5. 2 to report 5G radio link failure;

5.3.12 UE actions upon leaving 5G RRC_CONNECTED

Upon leaving RRC_CONNECTED, the UE shall:

1> reset MAC;

1> stop all timers that are running;

1> release all radio resources, including release of the RLC entity, the MAC configuration and the associated PDCP entity for all established RBs;

1> indicate the release of the RRC connection to upper layers;

1> enter RRC_IDLE;

5.4 Void

5.5 Measurements

5.5.1 Introduction

The UE reports measurement information in accordance with the measurement configuration as provided by 5G-RAN. 5G-RAN provides the measurement configuration applicable for a UE in 5G RRC_CONNECTED by means of dedicated signalling, i.e. using the *RRCConnectionReconfiguration* message.

The UE can be requested to perform the following types of measurements:

- Intra-frequency measurements: measurements at the downlink carrier frequency(ies) of the serving cell(s).

The measurement configuration includes the following parameters:

1. **Measurement objects:** The objects on which the UE shall perform the measurements.
   - For intra-frequency measurements a measurement object is a single 5GRA carrier frequency. A
2. **Reporting configurations**: A list of reporting configurations where each reporting configuration consists of the following:
   - Reporting criterion: The criterion that triggers the UE to send a measurement report. This can either be periodical or a single event description. The criterion can be used for either network-based mobility or UE-based mobility according to the 5GNB's configuration. If it is used for UE-based mobility, the UE does not send a measurement report when the UE satisfies the criterion.
   - Reporting format: The quantities that the UE includes in the measurement report and associated information (e.g. number of cells to report).
3. **Measurement identities**: A list of measurement identities where each measurement identity links one measurement object with one reporting configuration. By configuring multiple measurement identities it is possible to link more than one measurement object to the same reporting configuration, as well as to link more than one reporting configuration to the same measurement object. The measurement identity is used as a reference number in the measurement report.
4. **Quantity configurations:** One quantity configuration is configured. The quantity configuration defines the measurement quantities and associated filtering used for all event evaluation and related reporting of that measurement type. One filter can be configured per measurement quantity.

5G-RAN only configures a single measurement object for a given frequency, i.e. it is not possible to configure two or more measurement objects for the same frequency with different associated parameters, e.g. different offsets. 5G-RAN may configure multiple instances of the same event e.g. by configuring two reporting configurations with different thresholds.

The UE maintains a single measurement object list, a single reporting configuration list, and a single measurement identities list. The measurement object list includes measurement objects, possibly including intra-frequency object(s) (i.e. the object(s) corresponding to the serving frequency(ies)). Any measurement object can be linked to any reporting configuration. Some reporting configurations may not be linked to a measurement object. Likewise, some measurement objects may not be linked to a reporting configuration.

The measurement procedures distinguish the following types of cells:

1. The serving cell(s)– these are the PCell and one or more SCells, if configured for a UE supporting CA.
2. Detected cells - these are cells that are not listed within the measurement object(s) but are detected by the UE on the carrier frequency(ies) indicated by the measurement object(s).

For 5G-RA, the UE measures and reports on the serving cell(s) and detected cells.

Whenever the procedural specification, other than contained in sub-clause 5.5.2, refers to a field it concerns a field included in the *VarMeasConfig* unless explicitly stated otherwise i.e. only the measurement configuration procedure covers the direct UE action related to the received *measConfig*.

5.5.2 Measurement configuration

5.5.2.1 General

5GRAN applies the procedure as follows:

- to ensure that, whenever the UE has a *measConfig*, it includes a *measObject* for each serving frequency;
- for serving frequencies, set the ARFCN-Value5GRAN within the corresponding *measObject* according to the band as used for reception/ transmission;

The UE shall:

1> if the received *measConfig* includes the *measObjectToRemoveList*:

2> perform the measurement object removal procedure as specified in 5.5.2.4;

1> if the received *measConfig* includes the *measObjectToAddModList*:

2> perform the measurement object addition/ modification procedure as specified in 5.5.2.5;

1> if the received *measConfig* includes the *reportConfigToRemoveList*:

2> perform the reporting configuration removal procedure as specified in 5.5.2.6;

1> if the received *measConfig* includes the *reportConfigToAddModList*:

2> perform the reporting configuration addition/ modification procedure as specified in 5.5.2.7;

1> if the received *measConfig* includes the *quantityConfig*:

2> perform the quantity configuration procedure as specified in 5.5.2.8;

1> if the received *measConfig* includes the *measIdToRemoveList*:

2> perform the measurement identity removal procedure as specified in 5.5.2.2;

1> if the received *measConfig* includes the *measIdToAddModList*:

2> perform the measurement identity addition/ modification procedure as specified in 5.5.2.3;

1> if the received *measConfig* includes the *s-Measure*:

2> set the parameter *s-Measure* within *VarMeasConfig* to the lowest value of the RSRP ranges indicated by the received value of *s-Measure*;

5.5.2.2 Measurement identity removal

The UE shall:

1> for each *measId* included in the received *measIdToRemoveList* that is part of the current UE configuration in *VarMeasConfig*:

2> remove the entry with the matching *measId* from the *measIdList* within the *VarMeasConfig*;

2> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

2> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

NOTE: The UE does not consider the message as erroneous if the *measIdToRemoveList* includes any *measId* value that is not part of the current UE configuration.

5.4.2.2a Measurement identity autonomous removal

The UE shall:

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if the associated *reportConfig* concerns an event involving a serving cell while the concerned serving cell is not configured:

3> remove the *measId* from the *measIdList* within the *VarMeasConfig*;

3> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

3> stop the periodical reporting timer if running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

NOTE 1: The above UE autonomous removal of *measId*'s applies only for measurement events A1, A2.

NOTE 2: When performed during re-establishment, the UE is only configured with a primary frequency (i.e. the SCell(s) are released, if configured).

5.5.2.3 Measurement identity addition/ modification

5GRAN applies the procedure as follows:

- configure a *measId* only if the corresponding measurement object, the corresponding reporting configuration and the corresponding quantity configuration, are configured;

The UE shall:

1> for each *measId* included in the received *measIdToAddModList*:

2> if an entry with the matching *measId* exists in the *measIdList* within the *VarMeasConfig*:

3> replace the entry with the value received for this *measId*;

2> else:

3> add a new entry for this *measId* within the *VarMeasConfig*;

2> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

2> stop the periodical reporting timer, whichever one is running, and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

5.5.2.4 Measurement object removal

The UE shall:

1> for each *measObjectId* included in the received *measObjectToRemoveList* that is part of the current UE configuration in *VarMeasConfig*:

2> remove the entry with the matching *measObjectId* from the *measObjectList* within the *VarMeasConfig*;

2> remove all *measId* associated with this *measObjectId* from the *measIdList* within the *VarMeasConfig*, if any;

2> if a *measId* is removed from the *measIdList:*

3> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

3> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

NOTE: The UE does not consider the message as erroneous if the *measObjectToRemoveList* includes any *measObjectId* value that is not part of the current UE configuration.

5.5.2.5 Measurement object addition/ modification

The UE shall:

1> for each *measObjectId* included in the received *measObjectToAddModList*:

2> if an entry with the matching *measObjectId* exists in the *measObjectList* within the *VarMeasConfig*, for this entry:

3> reconfigure the entry with the value received for this *measObject*, except for the fields *cellsToAddModList*, *cellsToRemoveList*;

3> if the received *measObject* includes the *cellsToRemoveList*:

4> for each *cellIndex* included in the *cellsToRemoveList*:

5> remove the entry with the matching *cellIndex* from the *cellsToAddModList*;

3> if the received *measObject* includes the *cellsToAddModList*:

4> for each *cellIndex* value included in the *cellsToAddModList*:

5> if an entry with the matching *cellIndex* exists in the *cellsToAddModList*:

6> replace the entry with the value received for this *cellIndex*;

5> else:

6> add a new entry for the received *cellIndex* to the *cellsToAddModList*;

3> for each *measId* associated with this *measObjectId* in the *measIdList* within the *VarMeasConfig*, if any:

4> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

4> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

2> else:

3> add a new entry for the received *measObject* to the *measObjectList* within *VarMeasConfig*;

5.5.2.6 Reporting configuration removal

The UE shall:

1> for each *reportConfigId* included in the received *reportConfigToRemoveList* that is part of the current UE configuration in *VarMeasConfig*:

2> remove the entry with the matching *reportConfigId* from the *reportConfigList* within the *VarMeasConfig*;

2> remove all *measId* associated with the *reportConfigId* from the *measIdList* within the *VarMeasConfig*, if any;

2> if a *measId* is removed from the *measIdList*:

3> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

3> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

NOTE: The UE does not consider the message as erroneous if the *reportConfigToRemoveList* includes any *reportConfigId* value that is not part of the current UE configuration

5.5.2.7 Reporting configuration addition/ modification

The UE shall:

1> for each *reportConfigId* included in the received *reportConfigToAddModList*:

2> if an entry with the matching *reportConfigId* exists in the *reportConfigList* within the *VarMeasConfig*, for this entry:

3> reconfigure the entry with the value received for this *reportConfig*;

3> for each *measId* associated with this *reportConfigId* included in the *measIdList* within the *VarMeasConfig*, if any:

4> remove the measurement reporting entry for this *measId* from in *VarMeasReportList*, if included;

4> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

2> else:

3> add a new entry for the received *reportConfig* to the *reportConfigList* within the *VarMeasConfig*;

5.5.2.8 Quantity configuration

The UE shall:

1> if*quantityConfig* includes parameter(s):

2> set the corresponding parameter(s) in *quantityConfig* within *VarMeasConfig* to the value of the received *quantityConfig* parameter(s);

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> remove the measurement reporting entry for this *measId* from the *VarMeasReportList*, if included;

2> stop the periodical reporting timer and reset the associated information (e.g. *timeToTrigger*) for this *measId*;

5.5.3 Performing measurements

5.5.3.1 General

For all measurements, the UE receives BRS and measures RSRP for each beam pair. Furthermore, the UE applies the layer 3 filtering as specified in 5.5.3.2, before using the measured results for evaluation of reporting criteria or for measurement reporting.

The UE shall:

1> whenever the UE has a *measConfig*, perform RSRP measurements for each serving cell as follows:

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if *s-Measure* is not configured; or

2> if *s-Measure* is configured and the PCell RSRP, after layer 3 filtering, is lower than this value;

3> perform the corresponding measurements of neighbouring cells on the frequencies indicated in the concerned *measObject* as follows:

2> perform the evaluation of reporting criteria as specified in 5.5.4;

NOTE 3: The *s-Measure* defines when the UE is required to perform measurements.

5.5.3.2 Layer 3 filtering

The UE shall:

1> for each measurement quantity that the UE performs measurements according to 5.5.3.1:

2> filter the measured result, before using for evaluation of reporting criteria or for measurement reporting, by the following formula:

$$F_n = (1-a)\cdot F_{n-1} + a\cdot M_n$$

where

$\boldsymbol{M_n}$ is the latest received measurement result from the physical layer;

$\boldsymbol{F_n}$ is the updated filtered measurement result, that is used for evaluation of reporting criteria or for measurement reporting;

$\boldsymbol{F_{n-1}}$ is the old filtered measurement result, where $\boldsymbol{F_0}$ is set to $\boldsymbol{M_1}$ when the first measurement result from the physical layer is received; and

$\boldsymbol{a} = 1/2^{(\boldsymbol{k}/4)}$, where $\boldsymbol{k}$ is the *filterCoefficient* for the corresponding measurement quantity received by the *quantityConfig*;

2> adapt the filter such that the time characteristics of the filter are preserved at different input rates, observing that the *filterCoefficient* $\boldsymbol{k}$ assumes a sample rate equal to 200 ms;

NOTE 2: If $\boldsymbol{k}$ is set to 0, no layer 3 filtering is applicable.

NOTE 3: The filtering is performed in the same domain as used for evaluation of reporting criteria or for measurement reporting, i.e., logarithmic filtering for logarithmic measurements.

NOTE 4: The filter input rate is implementation dependent.

5.5.4 Measurement report triggering

5.5.4.1 General

If security has been activated successfully, the UE shall:

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if the *eventA1* or *eventA2* is configured in the corresponding *reportConfig*:

3> consider only the serving cell to be applicable;

2> else:

3> consider any neighbouring cell detected on the associated frequency to be applicable;

4> for events involving a serving cell on one frequency and neighbours on another frequency, consider the serving cell on the other frequency as a neighbouring cell;

2> if the *triggerType* is set to *event* and if reportForMobility is set to TRUE for the entry condition applicable for this event, i.e. the event corresponding with the *eventId* of the corresponding *reportConfig* within *VarMeasConfig*, is fulfilled for one or more applicable cells for all measurements after layer 3 filtering taken during *timeToTrigger* defined for this event within the *VarMeasConfig*, while the *VarMeasReportList* does not include an measurement reporting entry for this *measId* (a first cell triggers the event):

3> include a measurement reporting entry within the *VarMeasReportList* for this *measId*;

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> include the concerned cell(s) in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> if the UE supports T312 and if useT312 is included for this event and if T310 is running:

4> if T312 is not running:

5> start timer T312 with the value configured in the corresponding measObject;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> if the *triggerType* is set to *event* and if reportForMobility is set to TRUE for this event and if the entry condition applicable for this event, i.e. the event corresponding with the *eventId* of the corresponding *reportConfig* within *VarMeasConfig*, is fulfilled for one or more applicable cells not included in the *cellsTriggeredList* for all measurements after layer 3 filtering taken during *timeToTrigger* defined for this event within the *VarMeasConfig* (a subsequent cell triggers the event):

3> set the *numberOfReportsSent* defined within the *VarMeasReportList* for this *measId* to 0;

3> include the concerned cell(s) in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> if the UE supports T312 and if useT312 is included for this event and if T310 is running:

4> if T312 is not running:

5> start timer T312 with the value configured in the corresponding measObject;

3> initiate the measurement reporting procedure, as specified in 5.5.5;

2> if the *triggerType* is set to *event* if reportForMobility is set to TRUE for this event and if the leaving condition applicable for this event is fulfilled for one or more of the cells included in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId* for all measurements after layer 3 filtering taken during *timeToTrigger* defined within the *VarMeasConfig* for this event:

3> remove the concerned cell(s) in the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId*;

3> if the UE supports T312 and if useT312 is included for this event and if T310 is running:

4> if T312 is not running:

5> start timer T312 with the value configured in the corresponding measObject;

3> if *reportOnLeave* is set to *TRUE* for the corresponding reporting configuration:

4> initiate the measurement reporting procedure, as specified in 5.5.5;

3> if the *cellsTriggeredList* defined within the *VarMeasReportList* for this *measId* is empty:

4> remove the measurement reporting entry within the *VarMeasReportList* for this *measId*;

4> stop the periodical reporting timer for this *measId*, if running;

2> upon expiry of the periodical reporting timer for this *measId*:

3> initiate the measurement reporting procedure, as specified in 5.5.5;

NOTE 2: The UE does not stop the periodical reporting with *triggerType* set to *event* or to *periodical* while the corresponding measurement is not performed due to the PCell RSRP being equal to or better than *s-Measure* or due to the measurement gap not being setup.

5.5.4.2 Event A1 (Serving 5G cell becomes better than threshold)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A1-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A1-2, as specified below, is fulfilled;

1> for this measurement, consider the primary or secondary cell that is configured on the frequency indicated in the associated *measObject5GRAN* to be the serving cell;

Inequality A1-1 (Entering condition)

$$Ms - Hys > Thresh$$

Inequality A1-2 (Leaving condition)

$$Ms + Hys < Thresh$$

The variables in the formula are defined as follows:

Ms is the measurement result of the serving cell, not taking into account any offsets.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfig5GRA* for this event).

Thresh is the threshold parameter for this event (i.e. *a1-Threshold* as defined within *reportConfig5GRA* for this event).

Ms is expressed in dBm in case of RSRP.

Hys is expressed in dB.

Thresh is expressed in the same unit as ***Ms***.

5.5.4.3 Event A2 (Serving 5G cell becomes worse than threshold)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A2-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A2-2, as specified below, is fulfilled;

1> for this measurement, consider the primary or secondary cell that is configured on the frequency indicated in the associated *measObject5GRAN* to be the serving cell;

Inequality A2-1 (Entering condition)

$$Ms + Hys < Thresh$$

Inequality A2-2 (Leaving condition)

$$Ms - Hys > Thresh$$

The variables in the formula are defined as follows:

Ms is the measurement result of the serving cell, not taking into account any offsets.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfig5GRAN* for this event).

Thresh is the threshold parameter for this event (i.e. *a2-Threshold* as defined within *reportConfig5GRAN* for this event).

Ms is expressed in dBm in case of RSRP.

Hys is expressed in dB.

Thresh is expressed in the same unit as ***Ms***.

5.5.4.4 Event A3 (Neighbour 5G cell becomes offset better than serving 5G cell)

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A3-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A3-2, as specified below, is fulfilled;

NOTE The cell(s) that triggers the event is on the frequency indicated in the associated *measObject* which may be different from the (primary) frequency used by the PCell.

Inequality A3-1 (Entering condition)

$$Mn + Ofn + Ocn - Hys > Mp + Ofp + Ocp + Off$$

Inequality A3-2 (Leaving condition)

$$Mn + Ofn + Ocn + Hys < Mp + Ofp + Ocp + Off$$

The variables in the formula are defined as follows:

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.

Ofn is the frequency specific offset of the frequency of the neighbour cell (i.e. *offsetFreq* as defined within *measObject5GRAN* corresponding to the frequency of the neighbour cell).

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObject5GRAN* corresponding to the frequency of the neighbour cell), and set to zero if not configured for the neighbour cell.

Mp is the measurement result of the PCell, not taking into account any offsets.

Ofp is the frequency specific offset of the primary frequency (i.e. *offsetFreq* as defined within *measObject5GRAN* corresponding to the primary frequency).

Ocp is the cell specific offset of the PCell (i.e. *cellIndividualOffset* as defined within *measObject5GRAN* corresponding to the primary frequency), and is set to zero if not configured for the PCell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfig5GRA* for this event).

Off is the offset parameter for this event (i.e. *a3-Offset* as defined within *reportConfig5GRA* for this event).

Mn, Mp are expressed in dBm in case of RSRP.

Ofn, Ocn, Ofp, Ocp, Hys, Off are expressed in dB.

5.5.4.5 Event A4 Neighbour 5G cell becomes better than threshold.

The UE shall:

1> consider the entering condition for this event to be satisfied when condition A4-1, as specified below, is fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A4-2, as specified below, is fulfilled;

Inequality A4-1 (Entering condition)

$$Mn + Ofn + Ocn - Hys > Thresh$$

Inequality A4-2 (Leaving condition)

$$Mn + Ofn + Ocn + Hys < Thresh$$

The variables in the formula are defined as follows:

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.

Ofn is the frequency specific offset of the frequency of the neighbour cell (i.e. *offsetFreq* as defined within *measObject5GRAN* corresponding to the frequency of the neighbour cell).

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObject5GRAN* corresponding to the frequency of the neighbour cell), and set to zero if not configured for the neighbour cell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfig5GRA* for this event).

Thresh is the threshold parameter for this event (i.e. *a4-Threshold* as defined within *reportConfig5GRA* for this event).

Mn is expressed in dBm in case of RSRP.

Ofn, Ocn, Hys are expressed in dB.

Thresh is expressed in the same unit as ***Mn***.

5.5.4.6 Event A5 (PCell becomes worse than threshold1 and neighbour becomes better than threshold2) (for standalone mode)

The UE shall:

1> consider the entering condition for this event to be satisfied when both condition A5-1 and condition A5-2, as specified below, are fulfilled;

1> consider the leaving condition for this event to be satisfied when condition A5-3 or condition A5-4, i.e. at least one of the two, as specified below, is fulfilled;

1> use the PCell for Mp;

NOTE: The cell(s) that triggers the event is on the frequency indicated in the associated measObject which may be different from the frequency used by the PCell.

Inequality A5-1 (Entering condition 1)

$$Mp + Hys < Thresh1$$

Inequality A5-2 (Entering condition 2)

$Mn + Ofn + Ocn - Hys > Thresh2$

Inequality A5-3 (Leaving condition 1)

$Mp - Hys > Thresh1$

Inequality A5-4 (Leaving condition 2)

$Mn + Ofn + Ocn + Hys < Thresh2$

The variables in the formula are defined as follows:

Mp is the measurement result of the PCell, not taking into account any offsets.

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.

Ofn is the frequency specific offset of the frequency of the neighbour cell (i.e. offsetFreq as defined within measObject5GRAN corresponding to the frequency of the neighbour cell).

Ocn is the cell specific offset of the neighbour cell (i.e. cellIndividualOffset as defined within measObject5GRAN corresponding to the frequency of the neighbour cell), and set to zero if not configured for the neighbour cell.

Hys is the hysteresis parameter for this event (i.e. hysteresis as defined within reportConfig5GRA for this event).

Thresh1 is the threshold parameter for this event (i.e. a5-Threshold1 as defined within reportConfig5GRA for this event).

Thresh2 is the threshold parameter for this event (i.e. a5-Threshold2 as defined within reportConfig5GRA for this event).

Mn, Mp are expressed in dBm in case of RSRP.

Ofn, Ocn, Hys are expressed in dB.

Thresh1 is expressed in the same unit as Mp.

Thresh2 is expressed in the same unit as Mn.

5.5.5 Measurement reporting

Figure 5.4.5-1: Measurement reporting

The purpose of this procedure is to transfer measurement results from the UE to 5G-RAN. For the ordinary measurement reporting, 5.5.5.1 section is applied while 5.5.5.2 section is applied for RLF reporting.

5.5.5.1 Measurement reporting triggered by measurement configuration

For the *measId* for which the measurement reporting procedure was triggered, the UE shall set the *measResults* within the *MeasurementReport* message as follows:

1> set the *measId* to the measurement identity that triggered the measurement reporting;

1> set the *measResultPCell* to include the quantities (i.e. RSRP and 5GNB beam ID) of the PCell;

1> set the *measResultServFreqList* to include for each SCell that is configured, if any, within *measResultSCell* the quantities of the concerned SCell, if available;

1> if the *reportConfig* associated with the *measId* that triggered the measurement reporting includes *reportAddNeighMeas*:

2> for each serving frequency for which *measObjectId* is referenced in the *measIdList*, other than the frequency corresponding with the *measId* that triggered the measurement reporting:

3> set the *measResultServFreqList* to include within *measResultBestNeighCell* the *physCellId* and the quantities of the best non-serving cell, based on RSRP, on the concerned serving frequency;

1> if there is at least one applicable neighbouring cell to report:

2> set the *measResultNeighCells* to include the best neighbouring cells up to *maxReportCells* in accordance with the following:

3> if the *triggerType* is set to '*event*':

4> include the cells included in the *cellsTriggeredList* as defined within the *VarMeasReportList* for this *measId*;

3> else:

4> include the applicable cells for which the new measurement results became available since the last periodical reporting or since the measurement was initiated or reset;

3> for each cell that is included in the *measResultNeighCells*, include the *physCellId*;

1> increment the *numberOfReportsSent* as defined within the *VarMeasReportList* for this *measId* by 1;

1> stop the periodical reporting timer, if running;

1> if the *numberOfReportsSent* as defined within the *VarMeasReportList* for this *measId* is less than the *reportAmount* as defined within the corresponding *reportConfig* for this *measId*:

2> start the periodical reporting timer with the value of *reportInterval* as defined within the corresponding *reportConfig* for this *measId*;

1> else:

2> if the *triggerType* is set to '*periodical*':

3> remove the entry within the *VarMeasReportList* for this *measId*;

3> remove this *measId* from the *measIdList* within *VarMeasConfig*;

1> submit the *MeasurementReport* message to lower layers for transmission, upon which the procedure ends;

5.5.5.2 Measurement reporting triggered by RLF

The UE shall set the contents of the *FailureInformation5G* IE in *MeausrementReport* message as follows:

1> if the UE initiates transmission of the *MeasurementReport* message to provide 5G radio link failure information:

2> include failureType and set it to the trigger for detecting 5G radio link failure;

1> else if the UE initiates transmission of the MeasurementReport message to provide 5G cell change failure information:

2> include failureType and set it to 5GcellChangeFailure;

1> set the *measResultServFreqList* to include for each 5G cell that is configured, if any, within *measResultSCell* the quantities of the concerned SCell, if available

1> for each 5G serving frequency included in *measResultServFreqList*, include within *measResultBestNeighCell* the *physCellId* and the quantities of the best non-serving cell, based on RSRP, on the concerned serving frequency;

NOTE 2: The measured quantities are filtered by the L3 filter as configured in the mobility measurement configuration.

The UE shall submit the *FailureInformation5G* IE in *MeasurementReport* message to lower layers for transmission.

5.5.6 Measurement related actions

5.5.6.1 Actions upon handover and re-establishment

5G-RAN applies the handover procedure as follows:

- when performing the NW-controlled handover procedure (in case of both non-standalone and standalone modes) or the UE-based handover procedure (in case of standalone mode), as specified in 5.3.5.4, ensure that a *measObjectId* corresponding to the handover target carrier frequency is configured as a result of the procedures described in this sub-clause and in 5.3.5.4;

- when performing the connection re-establishment procedure, as specified in 5.3.7, ensure that a *measObjectId* corresponding to the target carrier frequency is configured as a result of the procedure described in this sub-clause and the subsequent connection reconfiguration procedure immediately following the re-establishment procedure;

The UE shall:

1> for each *measId* included in the *measIdList* within *VarMeasConfig*:

2> if the *triggerType* is set to '*periodical*':

3> remove this *measId* from the *measIdList* within *VarMeasConfig*:

1> remove all measurement reporting entries within *VarMeasReportList*;

1> reset the periodical reporting timer, as well as associated information (e.g. *timeToTrigger*) for all *measId*.

5.5.6.2 Initiation of UE-based handover to candidate cells (for standalone mode)

If security has been activated successfully, the UE shall:

1> for each measId included in the measIdList within VarMeasConfig:

2> if the triggerType is set to event and if reportForMobility is set to FALSE for this event and if the entry condition applicable for this event, i.e. the event corresponding with the eventId of the corresponding reportConfig within VarMeasConfig, is fulfilled for one or more candidate cells configured by 5GNB for all measurements after layer 3 filtering taken during timeToTrigger defined for this event within the VarMeasConfig:

3> initiate the RRC connection re-establishment procedure, as specified in 5.3.7;

5.6 Other

5.6.1 DL information transfer

5.6.1.1 General

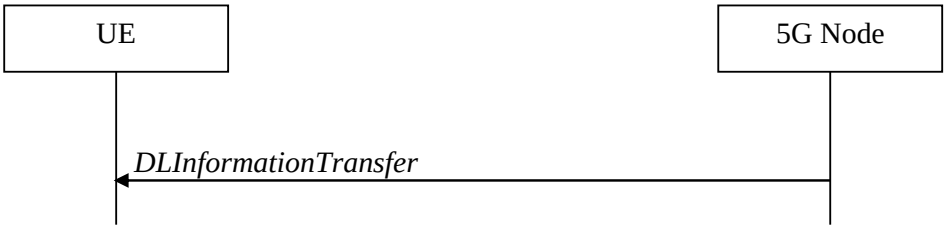

Figure 5.6.1.1-1: DL information transfer

The purpose of this procedure is to transfer NAS information from 5G-RAN to a UE in RRC_CONNECTED in standalone operation

5.6.1.2 Initiation

5G-RAN initiates the DL information transfer procedure whenever there is a need to transfer NAS dedicated information. 5G-RAN initiates the DL information transfer procedure by sending the *DLInformationTransfer* message.

5.6.1.3 Reception of the *DLInformationTransfer* by the UE

Upon receiving *DLInformationTransfer* message, the UE shall:

1> If the *informationType* is set to '*dedicatedInfoNAS*':

2> Forward the *NAS-DedicatedInformation* to the NAS upper layers.

5.6.2 5.6.2 UL information transfer

5.6.2.1 General

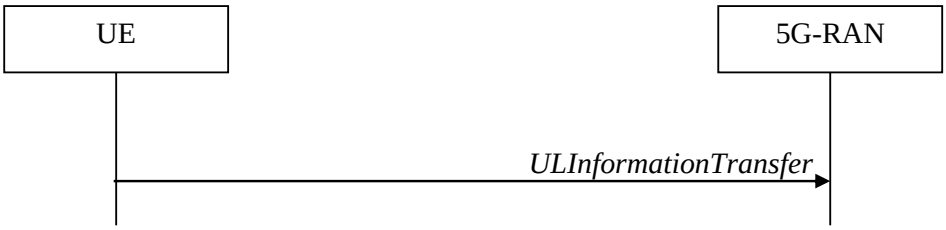

Figure 5.6.2.1-1: UL information transfer

The purpose of this procedure is to transfer NAS from the UE to 5G-RAN in standalone operation.

5.6.2.2 Initiation

A UE in RRC_CONNECTED initiates the UL information transfer procedure whenever there is a need to transfer NAS dedicated information. The UE initiates the UL information transfer procedure by sending the *ULInformationTransfer* message.

5.6.2.3 Actions related to transmission of *ULInformationTransfer* message

The UE shall set the contents of the *ULInformationTransfer* message as follows:

1> if there is a need to transfer NAS information:

2> set the *informationType* to '*dedicatedInfoNAS*'.

2> include the *NAS-DedicatedInformation*.

5.6.2.4 Failure to deliver *ULInformationTransfer* message

The UE shall:

1> if mobility (i.e. handover, RRC connection re-establishment) occurs before the successful delivery of *ULInformationTransfer* messages has been confirmed by lower layers:

2> inform upper layers about the possible failure to deliver the information contained in the concerned *ULInformationTransfer* messages;

5.6.3 UE capability transfer

5.6.3.1 General

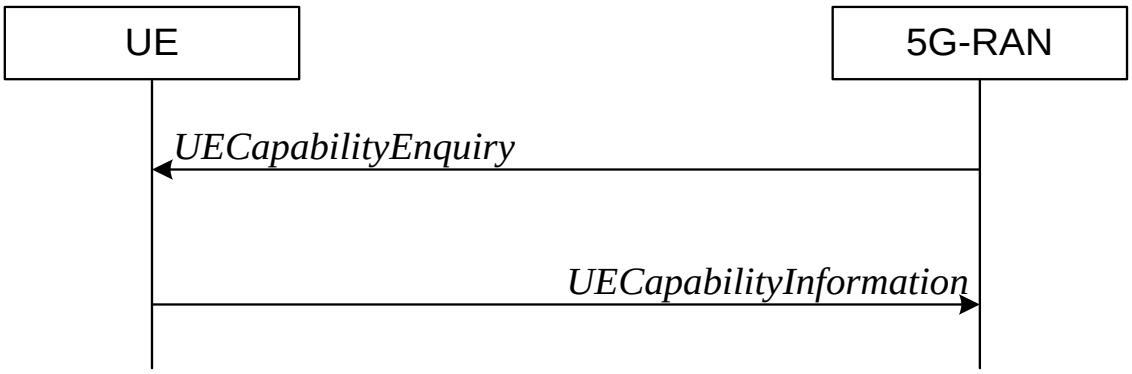

Figure 5.5.1-2: UE 5G capability transfer, network initiated

The purpose of this procedure is to transfer UE radio access capability information from the UE to 5G-RAN.

5.6.3.2 Initiation

5G-RAN initiates the procedure after a successful establishment of LTE DRB corresponding to 5G RRC connection or to a UE in 5G RRC_CONNECTED when it needs (additional) UE radio access capability information.

5.6.3.3 Reception of the 5G *UECapabilityEnquiry* by the UE

The UE shall:

1> set the contents of *UECapabilityInformation* message as follows:

2> If the *ue-RadioAccessCapRequest* includes 5G-RAN:

3> include the *UE-5GRA-Capability* within a *ueCapabilitiesRAT-Container* and with the *rat-Type* set to '*5gra*';

1> submit the *UECapabilityInformation* message to lower layers for transmission, upon which the procedure ends.

5.7 Generic error handling

5.7.1 General

The generic error handling defined in the subsequent sub-clauses applies unless explicitly specified otherwise e.g. within the procedure specific error handling.

The UE shall consider a value as not comprehended when it is set:

- to an extended value that is not defined in the version of the transfer syntax supported by the UE.
- to a spare or reserved value unless the specification defines specific behaviour that the UE shall apply upon receiving the concerned spare/ reserved value.

The UE shall consider a field as not comprehended when it is defined:

- as spare or reserved unless the specification defines specific behaviour that the UE shall apply upon receiving the concerned spare/ reserved field.

5.7.2 ASN.1 violation or encoding error

The UE shall:

1> when receiving an RRC message on the BCCH, for which the abstract syntax is invalid [13]:

2> ignore the message;

NOTE This section applies in case one or more fields is set to a value, other than a spare, reserved or extended value, not defined in this version of the transfer syntax. E.g. in the case the UE receives value 12 for a field defined as INTEGER (1..11). In cases like this, it may not be possible to reliably detect which field is in the error hence the error handling is at the message level

5.7.3 Not supported protocol extension

The UE shall, when receiving an RRC message on the xBCCH or xCCCH:

1> if the UE does not comprehend the message type or version:

2> ignore the message;

The UE shall, when receiving an RRC message on any logical channel:

1> if the message includes a field that is mandatory to include in the message (e.g. because conditions for mandatory presence are fulfilled) and that has a value that the UE does not comprehend:

2> if a default value is defined for this field:

3> treat the rest of the message while using the default value defined for this field;

2> else:

3> ignore the message;

1> if the message includes a field that is optional to include in the message (e.g. because conditions for optional presence are fulfilled) and that has a value that the UE does not comprehend:

2> treat the rest of the message as if the field was absent;

1> if the message includes a protocol extension that the UE does not comprehend:

2> treat the rest of the message as if the extension was absent.

NOTE This section does not apply for the case the received message includes an field that is set to a spare value while the specification defines the UE behaviour for the case the field is set to a spare value, i.e. this section only concerns protocol extensions for which no UE behaviour has been specified.

5.7.4 Other errors

The UE shall, when receiving an RRC message on the xBCCH or xCCCH:

1> if the message includes a field that is mandatory to include because conditions for mandatory presence are fulfilled) and that field is absent:

2> ignore the message.

5.7.5 Field set to a not comprehended value

The UE shall, when receiving an RRC message on LTE DRB:

1> if the message includes a field that has a value that the UE does not comprehend:

2> if a default value is defined for this field:

3> treat the message while using the default value defined for this field;

2> else if the concerned field is optional:

3> treat the message as if the field were absent and in accordance with the need code for absence of the concerned field;

2> else:

3> treat the message as if the field were absent and in accordance with sub-clause 5.7.4;

5.7.6 Mandatory field missing

The UE shall:

1> if the message includes a field that is mandatory to include in the message (e.g. because conditions for mandatory presence are fulfilled) and that field is absent or treated as absent:

2> if the RRC message was received on LTE DRB:

3> ignore the message;

2> else:

3> if the field concerns a (sub-field of) an entry of a list (i.e. a SEQUENCE OF):

4> treat the list as if the entry including the missing or not comprehended field was not present;

3> else if the field concerns a sub-field of another field, referred to as the 'parent' field i.e. the field that is one nesting level up compared to the erroneous field:

4> consider the 'parent' field to be set to a not comprehended value;

4> apply the generic error handling to the subsequent 'parent' field(s), until reaching the top nesting level i.e. the message level;

3> else (field at message level):

4> ignore the message;

NOTE 1: The error handling defined in these sub-clauses implies that the UE ignores a message with the message type or version set to a not comprehended value.

NOTE 2: The nested error handling for messages received on logical channels other than DCCH and CCCH applies for errors in extensions also, even for errors that can be regarded as invalid 5G-RAN operation e.g. 5G-RAN not observing conditional presence.

The following ASN.1 further clarifies the levels applicable in case of nested error handling for errors in extension fields.

```
-- /example/ ASN1START

-- Example with extension addition group

ItemInfoList ::=                    SEQUENCE (SIZE (1..max)) OF ItemInfo

ItemInfo ::=                        SEQUENCE {
    itemIdentity                        INTEGER (1..max),
    field1                              Field1,
    field2                              Field2                  OPTIONAL,           -- Need ON
    ...
    [[  field3-r9                       Field3-r9               OPTIONAL,           -- Cond Cond1
```

```
        field4-r9                       Field4-r9               OPTIONAL            -- Need ON
    ]]
}

-- Example with traditional non-critical extension (empty sequence)

BroadcastInfoBlock1 ::=             SEQUENCE {
    itemIdentity                        INTEGER (1..max),
    field1                              Field1,
    field2                              Field2                  OPTIONAL,           -- Need ON
    nonCriticalExtension                BroadcastInfoBlock1-v940-IEs    OPTIONAL
}

BroadcastInfoBlock1-v940-IEs::= SEQUENCE {
    field3-r9                           Field3-r9               OPTIONAL,           -- Cond Cond1
    field4-r9                           Field4-r9               OPTIONAL,           -- Need ON
    nonCriticalExtension                SEQUENCE {}             OPTIONAL            -- Need OP
}

-- ASN1STOP
```

The UE shall, apply the following principles regarding the levels applicable in case of nested error handling:

- an extension addition group is not regarded as a level on its own. E.g. in the ASN.1 extract in the previous, an error regarding the conditionality of *field3* would result in the entire itemInfo entry to be ignored (rather than just the extension addition group containing *field3* and *field4*)

- a traditional *nonCriticalExtension* is not regarded as a level on its own. E.g. in the ASN.1 extract in the previous, a error regarding the conditionality of *field3* would result in the entire *BroadcastInfoBlock1* to be ignored (rather than just the non critical extension containing *field3* and *field4*).

5.7.7 Not comprehended field

The UE shall, when receiving an RRC message on any logical channel:

1> if the message includes a field that the UE does not comprehend:

2> treat the rest of the message as if the field was absent;

NOTE: This section does not apply to the case of an extension to the value range of a field. Such cases are addressed instead by the requirements in section 5.7.3.

6 Protocol data units, formats and parameters (tabular & ASN.1)

6.1 General

The contents of each RRC message is specified in sub-clause 6.2 using ASN.1 to specify the message syntax and using tables when needed to provide further detailed information about the information elements specified in the message syntax. The syntax of the information elements that are defined as stand-alone abstract types is further specified in a similar manner in sub-clause 6.3.

The need for information elements to be present in a message or an abstract type, i.e., the ASN.1 fields that are specified as OPTIONAL in the abstract notation (ASN.1), is specified by means of comment text tags attached to the OPTIONAL statement in the abstract syntax. All comment text tags are available for use in the downlink direction only. The meaning of each tag is specified in table 6.1-1.

Table 6.1-1: Meaning of abbreviations used to specify the need for information elements to be present

Abbreviation	Meaning

Abbreviation	Meaning
Cond *conditionTag* (Used in downlink only)	*Conditionally present* An information element for which the need is specified by means of conditions. For each *conditionTag*, the need is specified in a tabular form following the ASN.1 segment. In case, according to the conditions, a field is not present, the UE takes no action and where applicable shall continue to use the existing value (and/ or the associated functionality) unless explicitly stated otherwise (e.g. in the conditional presence table or in the description of the field itself).
Need OP (Used in downlink only)	*Optionally present* An information element that is optional to signal. For downlink messages, the UE is not required to take any special action on absence of the IE beyond what is specified in the procedural text or the field description table following the ASN.1 segment. The UE behaviour on absence should be captured either in the procedural text or in the field description.
Need ON (Used in downlink only)	*Optionally present, No action* An information element that is optional to signal. If the message is received by the UE, and in case the information element is absent, the UE takes no action and where applicable shall continue to use the existing value (and/ or the associated functionality).
Need OR (Used in downlink only)	*Optionally present, Release* An information element that is optional to signal. If the message is received by the UE, and in case the information element is absent, the UE shall discontinue/ stop using/ delete any existing value (and/ or the associated functionality).

Any IE with Need ON in system information shall be interpreted as Need OR.

Need codes may not be specified for a parent extension field/ extension group, used in downlink, which includes one or more child extension fields. Upon absence of such a parent extension field/ extension group, the UE shall:

- For each individual child extension field, including extensions that are mandatory to include in the optional group, act in accordance with the need code that is defined for the extension;
- Apply this behaviour not only for child extension fields included directly within the optional parent extension field/ extension group, but also for extension fields defined at further nesting levels as long as for none of the fields in-between the concerned extension field and the parent extension field a need code is specified;

NOTE 1: The above applies for groups of non critical extensions using double brackets (referred to as extension groups), as well as non-critical extensions at the end of a message or at the end of a structure contained in a BIT STRING or OCTET STRING (referred to as parent extension fields).

Need codes, conditions and ASN.1 defaults specified for a particular (child) field only apply in case the (parent) field including the particular field is present. This rule does not apply for optional parent extension fields/ extension groups without need codes,

NOTE 2: The previous rule implies that 5G-RAN has to include such a parent extension field to release a child field that is either:

- Optional with need OR, or
- Conditional while the UE releases the child field when absent.

The handling of need codes as specified in the previous is illustrated by means of an example, as shown in the following ASN.1.

```
-- /example/ ASN1START

RRCMessage-r8-IEs ::=                   SEQUENCE {
    field1                                  InformationElement1,
    field2                                  InformationElement2             OPTIONAL,   -- Need ON
    nonCriticalExtension                    RRCMessage-v8a0-IEs             OPTIONAL
}

RRCMessage-v8a0-IEs ::=                 SEQUENCE {
    field3                                  InformationElement3             OPTIONAL,   -- Need ON
    nonCriticalExtension                    RRCMessage-v940-IEs             OPTIONAL
}

RRCMessage-v940-IEs ::=                 SEQUENCE {
    field4                                  InformationElement4             OPTIONAL,   -- Need OR
    nonCriticalExtension                    SEQUENCE {}                     OPTIONAL
```

```
}

InformationElement1 ::=         SEQUENCE {
    field11                             InformationElement11                OPTIONAL,   -- Need ON
    field12                             InformationElement12                OPTIONAL,   -- Need OR
    ...,
    [[  field13                             InformationElement13            OPTIONAL,   -- Need OR
        field14                             InformationElement14            OPTIONAL    -- Need ON
    ]]
}

InformationElement2 ::=         SEQUENCE {
    field21                             InformationElement11                OPTIONAL,   -- Need OR
    ...
}

-- ASN1STOP
```

The handling of need codes as specified in the previous implies that:

- if *field2* in *RRCMessage-r8-IEs* is absent, the UE does not modify *field21*;
- if *field2* in *RRCMessage-r8-IEs* is present but does not include *field21*, the UE releases *field21*;
- if the extension group containing *field13* is absent, the UE releases *field13* and does not modify *field14*;
- if *nonCriticalExtension* defined by IE *RRCMessage-v8a0-IEs* is absent, the UE does not modify *field3* and releases *field4*;

6.2 RRC messages

NOTE: The messages included in this section reflect the current status of the discussions. Additional messages may be included at a later stage.

6.2.1 General message structure

– 5GRA-RRC-Definitions

This ASN.1 segment is the start of the 5GRA RRC PDU definitions.

```
-- ASN1START

KT5GRA-RRC-Definitions DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

-- ASN1STOP
```

– x*BCCH-BCH-Message*

The x*BCCH-BCH-Message* class is the set of RRC messages that may be sent from the 5G-RAN to the UE via BCH on the xBCCH logical channel.

```
-- ASN1START

XBCCH-BCH-Message ::= CHOICE {
    c1                              CHOICE {
        masterInformationBlock                  MasterInformationBlock,
        xSystemInformationBlock                 XSystemInformationBlock
    },
    messageClassExtension   SEQUENCE {}


}


-- ASN1STOP
```

DL-xCCCH-Message

The *DL-xCCCH-Message* class is the set of RRC messages that may be sent from the 5G-RAN to the UE on the downlink xCCCH logical channel.

```
-- ASN1START

DL-CCCH-Message ::= SEQUENCE {
    message                 DL-CCCH-MessageType
}

DL-CCCH-MessageType ::= CHOICE {
    c1                      CHOICE {
        rrcConnectionReestablishment            RRCConnectionReestablishment,
        rrcConnectionReestablishmentReject      RRCConnectionReestablishmentReject,
    rrcConnectionReject                     RRCConnectionReject,
        rrcConnectionSetup                      RRCConnectionSetup
    },
    messageClassExtension   SEQUENCE {}
}

-- ASN1STOP
```

– *DL-xDCCH-Message*

The *DL-xDCCH-Message* class is the set of RRC messages that may be sent from the 5G-RAN to the UE on the downlink xDCCH logical channel.

```
-- ASN1START

DL-xDCCH-Message ::= SEQUENCE {
    message                 DL-xDCCH-MessageType
}

DL-xDCCH-MessageType ::= CHOICE {
    c1                      CHOICE {
        dlInformationTransfer                   DLInformationTransfer,
        counterCheck                            CounterCheck,
        rrcConnectionReconfiguration            RRCConnectionReconfiguration,
        rrcConnectionRelease                    RRCConnectionRelease,
        securityModeCommand                     SecurityModeCommand,        ueCapabilityEnquiry
                UECapabilityEnquiry,
        spare3 NULL, spare2 NULL, spare1 NULL
    },
    messageClassExtension   SEQUENCE {}
}

-- ASN1STOP
```

– *UL-xCCCH-Message*

The *UL-CCCH-Message* class is the set of RRC messages that may be sent from the UE to the 5G-RAN on the uplink CCCH logical channel.

```
-- ASN1START

UL-xCCCH-Message ::= SEQUENCE {
    message                 UL-xCCCH-MessageType
}

UL-xCCCH-MessageType ::= CHOICE {
    c1                      CHOICE {
        rrcConnectionReestablishmentRequest     RRCConnectionReestablishmentRequest,
        rrcConnectionRequest                    RRCConnectionRequest
    },
    messageClassExtension   SEQUENCE {}
}

-- ASN1STOP
```

– *UL-xDCCH-Message*

The *UL-DCCH-Message* class is the set of RRC messages that may be sent from the UE to the 5G-RAN on the uplink DCCH logical channel.

```
-- ASN1START

UL-xDCCH-Message ::= SEQUENCE {
    message                 UL-xDCCH-MessageType
}

UL-xDCCH-MessageType ::= CHOICE {
    c1                      CHOICE {
        counterCheckResponse                    CounterCheckResponse,
        measurementReport                       MeasurementReport,
        rrcConnectionReconfigurationComplete    RRCConnectionReconfigurationComplete,
        rrcConnectionReestablishmentComplete    RRCConnectionReestablishmentComplete,
        rrcConnectionSetupComplete              RRCConnectionSetupComplete,
        securityModeComplete                    SecurityModeComplete,
        securityModeFailure                     SecurityModeFailure,
        ueCapabilityInformation                 UECapabilityInformation,
        ulInformationTransfer                   ULInformationTransfer,

        spare2 NULL, spare1 NULL
        },
    messageClassExtension   SEQUENCE {}
}

-- ASN1STOP
```

6.2.2 Message definitions

– *CounterCheck*

The *CounterCheck* message is used by the 5G-RAN to indicate the current COUNT MSB values associated to each DRB and to request the UE to compare these to its COUNT MSB values and to report the comparison results to 5G-RAN.

Signalling radio bearer: SRB1

RLC-SAP: AM

Logical channel: DCCH

Direction: 5G-RAN to UE

CounterCheck message

```
-- ASN1START

CounterCheck ::=            SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE {
            counterCheck-r1                     CounterCheck-r1-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

CounterCheck-r1-IEs ::= SEQUENCE {
    drb-CountMSB-InfoList               DRB-CountMSB-InfoList,
    nonCriticalExtension                CounterCheck-v1-IEs                         OPTIONAL
}

CounterCheck-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,   -- Need OP
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL    -- Need OP
}
```

```
DRB-CountMSB-InfoList ::=       SEQUENCE (SIZE (1..maxDRB)) OF DRB-CountMSB-Info

DRB-CountMSB-Info ::=   SEQUENCE {
    drb-Identity                    DRB-Identity,
    countMSB-Uplink                 INTEGER(0..33554431),
    countMSB-Downlink               INTEGER(0..33554431)
}

-- ASN1STOP
```

***CounterCheck* field descriptions**
drb-CountMSB-InfoList Indicates the MSBs of the COUNT values of the DRBs.
count-MSB-Uplink Indicates the value of 25 MSBs from uplink COUNT associated to this DRB.
count-MSB-Downlink Indicates the value of 25 MSBs from downlink COUNT associated to this DRB.

– *CounterCheckResponse*

The *CounterCheckResponse* message is used by the UE to respond to a *CounterCheck* message.

Signalling radio bearer: SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: UE to 5G-RAN

CounterCheckResponse message

```
-- ASN1START

CounterCheckResponse ::=            SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        counterCheckResponse-r1             CounterCheckResponse-r1-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
}

CounterCheckResponse-r1-IEs ::= SEQUENCE {
    drb-CountInfoList                   DRB-CountInfoList,
    nonCriticalExtension                CounterCheckResponse-v1-IEs                         OPTIONAL
}

CounterCheckResponse-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}

DRB-CountInfoList ::=           SEQUENCE (SIZE (0..maxDRB)) OF DRB-CountInfo

DRB-CountInfo ::=   SEQUENCE {
    drb-Identity                    DRB-Identity,
    count-Uplink                    INTEGER(0..4294967295),
    count-Downlink                  INTEGER(0..4294967295)
}

-- ASN1STOP
```

***CounterCheckResponse* field descriptions**
drb-CountInfoList Indicates the COUNT values of the DRBs.
count-Uplink Indicates the value of uplink COUNT associated to this DRB.
count-Downlink Indicates the value of downlink COUNT associated to this DRB.

– *DLInformationTransfer*

The *DLInformationTransfer* message is used for the downlink transfer of dedicated NAS information.

Signalling radio bearer: SRB2 or SRB1 (only if SRB2 not established yet. If SRB2 is suspended, 5G-RAN does not send this message until SRB2 is resumed.)

RLC-SAP: AM

Logical channel: xDCCH

Direction: 5G-RAN to UE

DLInformationTransfer message

```
-- ASN1START

DLInformationTransfer ::=           SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE {
            dlInformationTransfer-r1            DLInformationTransfer-r1-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

DLInformationTransfer-r1-IEs ::=    SEQUENCE {
    informationType     CHOICE {
        dedicatedInfoNAS                    DedicatedInfoNAS,
        spare3 NULL, spare2 NULL, spare1 NULL
    },
    nonCriticalExtension                DLInformationTransfer-v1-IEs                        OPTIONAL
}

DLInformationTransfer-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,   -- Need OP
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL    -- Need OP
}


-- ASN1STOP
```

– *MasterInformationBlock*

The *MasterInformationBlock* includes the system information transmitted on xBCH.

Signalling radio bearer: N/A

RLC-SAP: TM

Logical channel: xBCCH

Direction: 5G-RAN to UE

MasterInformationBlock

```
-- ASN1START

MasterInformationBlock ::=          SEQUENCE {
    systemFrameNumber                   BIT STRING (SIZE (8)),
```

```
    brsTransmissionPeriod               ENUMERATED {mx5, ms5, ms10, ms20},
    ePBCHConfiguration                  ENUMERATED {config0, config1, spare0, spare1},
    spare                               BIT STRING (SIZE (4))
}


-- ASN1STOP
```

***MasterInformationBlock* field descriptions**
systemFrameNumber Defines the SFN.
brsTrasnmissionPeriod *Defines the transmission period of Beam Reference Signal.* Value in number of milliseconds. Value mx5 corresponds 5ms repetition when half subframe is used for xPBCH and BRS transmission. ms5, ms10, ms20 corresponds 5ms 10ms, and 20 ms periodicity when complete subframes are used for BRS transmission.
ePBCHConfiguration *Defines the transmission of ePBCH. It is FFS, whether only precesense is signalled or different periodicities.*
Other paramters to MIB are FFS

– *MeasurementReport (for standalone)*

The *MeasurementReport* message is used for the indication of measurement results.

Signalling radio bearer: SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: UE to 5G-RAN

MeasurementReport message

```
-- ASN1START

MeasurementReport ::=               SEQUENCE {
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            measurementReport-r1                MeasurementReport-r1-IEs,
            spare7 NULL,
            spare6 NULL, spare5 NULL, spare4 NULL,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

MeasurementReport-r1-IEs ::=        SEQUENCE {
    measResults                         MeasResults,
    nonCriticalExtension                 MeasurementReport-v1-IEs                           OPTIONAL
}

MeasurementReport-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}

-- ASN1STOP
```

– *MeasurementReport (for non-standalone)*

The *MeasurementReport* message is used for the indication of measurement results and RLF.

Signalling radio bearer: Dedicated radio bearer for 5G RRC in LTE.

RLC-SAP: AM

Logical channel: DCCH

Direction: UE to 5G-RAN

MeasurementReport message

```
-- ASN1START

MeasurementReport ::=               SEQUENCE {
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            measurementReport-r1                MeasurementReport-r1-IEs,
            failureInformation5G                FailureInformation5G-IEs,
            spare7 NULL,
            spare6 NULL, spare5 NULL, spare4 NULL,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

MeasurementReport-r1-IEs ::=        SEQUENCE {
    measResults                         MeasResults,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}

FailureInformation5G-IEs ::=        SEQUENCE {
    failureReport5G                     FailureReport5G                     OPTIONAL
}

FailureReport5G ::=                 SEQUENCE {
    failureType                         ENUMERATED {t310-Expiry, randomAccessProblem,
                                                    rlc-MaxNumRetx, 5GcellChangeFailure },
    measResultServFreqList          MeasResultServFreqList      OPTIONAL,

    ...

}



-- ASN1STOP
```

– *RRCConnectionReconfiguration*

The *RRCConnectionReconfiguration* message is the command to modify an RRC connection. It may convey information for measurement configuration, mobility control, radio resource configuration (including RBs, MAC main configuration and physical channel configuration) including any associated dedicated NAS information and security configuration.

Signalling radio bearer: Non standalone: Dedicated radio bearer for 5G RRC in LTE. For standalone: SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: 5G-RAN to UE

RRCConnectionReconfiguration message

```
-- ASN1START

RRCConnectionReconfiguration ::=    SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            rrcConnectionReconfiguration-r1     RRCConnectionReconfiguration-r1-IEs,
            spare7 NULL,
            spare6 NULL, spare5 NULL, spare4 NULL,
```

```
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionReconfiguration-r1-IEs ::= SEQUENCE {
    configRelease                       ENUMERATED {true}               OPTIONAL,   -- Cond HO-
release
    fullConfig                          ENUMERATED {true}               OPTIONAL,   -- Cond HO-
Reestab
    measConfig                          MeasConfig                      OPTIONAL,   -- Need ON
    mobilityControlInfo                 MobilityControlInfo             OPTIONAL,   -- Cond HO
    dedicatedInfoNASList                SEQUENCE (SIZE(1..maxDRB)) OF
                                            DedicatedInfoNAS            OPTIONAL,   -- Cond nonHO

    radioResourceConfigDedicated        RadioResourceConfigDedicated    OPTIONAL,   -- Cond HO-
to5GRA
    securityConfigHO                    SecurityConfigHO                OPTIONAL,   -- Cond HO
    sCellToReleaseList                  SCellToReleaseList              OPTIONAL,   -- Need ON
    sCellToAddModList                   SCellToAddModList               OPTIONAL,   -- Need ON
    securityConfigiwk                   SecurityConfigIWK               OPTIONAL,   -- Need ON
    nonCriticalExtension                RRCConnectionReconfiguration-v1-IEs OPTIONAL}
RRCConnectionReconfiguration-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                            OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                             OPTIONAL
}


SCellToAddModList ::=       SEQUENCE (SIZE (1..maxSCell)) OF SCellToAddMod

SCellToAddMod ::=           SEQUENCE {
    sCellIndex                      SCellIndex,
    cellIdentification              SEQUENCE {
        physCellId                      PhysCellId,
        dl-CarrierFreq                  ARFCN-Value5GRA
    }                                                                   OPTIONAL,   -- Cond SCellAdd
    radioResourceConfigCommonSCell  RadioResourceConfigCommonSCell  OPTIONAL,   -- Cond SCellAdd
    radioResourceConfigDedicatedSCell   RadioResourceConfigDedicatedSCell   OPTIONAL    -- Cond
SCellAdd2
}



SCellToReleaseList ::=          SEQUENCE (SIZE (1..maxSCell)) OF SCellIndex

SecurityConfigHO ::=                SEQUENCE {
            securityAlgorithmConfig             SecurityAlgorithmConfig     OPTIONAL,   -- Cond
fullConfig
            keyChangeIndicator                  BOOLEAN,
            nextHopChainingCount                NextHopChainingCount,
            ...

}
SecurityConfigIWK   ::=             SEQUENCE {
            securityKeyConfig                   SecurityKeyConfig           OPTIONAL,   -- Cond
            securityAlgorithmConfig             SecurityAlgorithmConfig     OPTIONAL    -- Cond
}


-- ASN1STOP
```

***RRCConnectionReconfiguration* field descriptions**
configRelease Indicates the full release of 5G configuration option is applicable for the RRC Connection Reconfiguration message.
fullConfig Indicates the full configuration option is applicable for the RRC Connection Reconfiguration message.

Conditional presence	Explanation
fullConfig	This field is mandatory present for handover within 5G-RA when the *fullConfig* is included; otherwise it is optionally present, Need OP.
HO	The field is mandatory present in case of handover within 5G-RA or to 5G-RA; otherwise the field is not present.
HO-Reestab	This field is optionally present, need ON, in case of handover within 5G-RA or upon the first reconfiguration after RRC connection re-establishment; otherwise the field is not present.
HO-to5GRA	The field is mandatory present in case of handover to 5G-RA or for reconfigurations when *fullConfig* is included; otherwise the field is optionally present, need ON.
nonFullConfig	The field is not present in case of handover within 5G-RA when the *fullConfig* is included or in case of handover to 5G-RA; otherwise it is optional present, need ON.
nonHO	The field is not present in case of handover within 5G-RA or to 5G-RA; otherwise it is optional present, need ON.
SCellAdd	The field is mandatory present upon SCell addition; otherwise it is not present.
SCellAdd2	The field is mandatory present upon SCell addition; otherwise it is optionally present, need ON.

– *RRCConnectionReconfigurationComplete*

The *RRCConnectionReconfigurationComplete* message is used to confirm the successful completion of an RRC connection reconfiguration.

Signalling radio bearer: Non standalone:Dedicated radio bearer for 5G RRC in LTE. Standalone:SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: UE to 5G-RAN

RRCConnectionReconfigurationComplete message

```
-- ASN1START

RRCConnectionReconfigurationComplete ::= SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        rrcConnectionReconfigurationComplete-r1
                                            RRCConnectionReconfigurationComplete-r1-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionReconfigurationComplete-r1-IEs ::= SEQUENCE {
    nonCriticalExtension                RRCConnectionReconfigurationComplete-v1-IEs     OPTIONAL
}

RRCConnectionReconfigurationComplete-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}


-- ASN1STOP
```

– *RRCConnectionReestablishment*

The *RRCConnectionReestablishment* message is used to re-establish SRB1.

Signalling radio bearer: SRB0

RLC-SAP: TM

Logical channel: xCCCH

Direction: 5G-RAN to UE

RRCConnectionReestablishment message

```
-- ASN1START

RRCConnectionReestablishment ::=    SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            rrcConnectionReestablishment-r1     RRCConnectionReestablishment-r1-IEs,
            spare7 NULL,
            spare6 NULL, spare5 NULL, spare4    NULL,
            spare3 NULL, spare2 NULL, spare1    NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionReestablishment-r1-IEs ::= SEQUENCE {
    radioResourceConfigDedicated        RadioResourceConfigDedicated,
    nextHopChainingCount                NextHopChainingCount,
    nonCriticalExtension                RRCConnectionReestablishment-v1-IEs OPTIONAL
}

RRCConnectionReestablishment-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}

-- ASN1STOP
```

– *RRCConnectionReestablishmentComplete*

The *RRCConnectionReestablishmentComplete* message is used to confirm the successful completion of an RRC connection reestablishment.

Signalling radio bearer: SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: UE to 5G-RAN

RRCConnectionReestablishmentComplete message

```
-- ASN1START

RRCConnectionReestablishmentComplete ::= SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        rrcConnectionReestablishmentComplete-r1
                                            RRCConnectionReestablishmentComplete-r1-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionReestablishmentComplete-r1-IEs ::= SEQUENCE {
    nonCriticalExtension                RRCConnectionReestablishmentComplete-v1-IEs OPTIONAL
}

RRCConnectionReestablishmentComplete-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}
```

```
-- ASN1STOP
```

– *RRCConnectionReestablishmentReject*

The *RRCConnectionReestablishmentReject* message is used to indicate the rejection of an RRC connection reestablishment request.

Signalling radio bearer: SRB0

RLC-SAP: TM

Logical channel: xCCCH

Direction: 5G-RAN to UE

RRCConnectionReestablishmentReject message

```
-- ASN1START

RRCConnectionReestablishmentReject ::= SEQUENCE {
    criticalExtensions                  CHOICE {
        rrcConnectionReestablishmentReject-r1
                                            RRCConnectionReestablishmentReject-r1-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionReestablishmentReject-r1-IEs ::= SEQUENCE {
    nonCriticalExtension                RRCConnectionReestablishmentReject-v1-IEs   OPTIONAL
}

RRCConnectionReestablishmentReject-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}

-- ASN1STOP
```

– *RRCConnectionReestablishmentRequest*

The *RRCConnectionReestablishmentRequest* message is used to request the reestablishment of an RRC connection.

Signalling radio bearer: SRB0

RLC-SAP: TM

Logical channel: xCCCH

Direction: UE to 5G-RAN

RRCConnectionReestablishmentRequest message

```
-- ASN1START

RRCConnectionReestablishmentRequest ::= SEQUENCE {
    criticalExtensions                  CHOICE {
        rrcConnectionReestablishmentRequest-r1
                                            RRCConnectionReestablishmentRequest-r1-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionReestablishmentRequest-r1-IEs ::= SEQUENCE {
    ue-Identity                         ReestabUE-Identity,
    reestablishmentCause                ReestablishmentCause,
    spare                               BIT STRING (SIZE (2))
}

ReestabUE-Identity ::=              SEQUENCE {
    c-RNTI                              C-RNTI,
    physCellId                          PhysCellId,
```

```
    shortMAC-I                          ShortMAC-I
}

ReestablishmentCause ::=            ENUMERATED {
                                        reconfigurationFailure, handoverFailure,
                                        otherFailure, ueBasedHOExecution}

-- ASN1STOP
```

***RRCConnectionReestablishmentRequest* field descriptions**
physCellId The Physical Cell Identity of the PCell the UE was connected to prior to the failure.
reestablishmentCause Indicates the failure cause that triggered the re-establishment procedure
ue-Identity UE identity included to retrieve UE context and to facilitate contention resolution by lower layers.

– *RRCConnectionReject*

The *RRCConnectionReject* message is used to reject the RRC connection establishment.

Signalling radio bearer: SRB0

RLC-SAP: TM

Logical channel: xCCCH

Direction: 5G-RAN to UE

RRCConnectionReject message

```
-- ASN1START

RRCConnectionReject ::=             SEQUENCE {
    criticalExtensions                  CHOICE {
        c1                                  CHOICE {
            rrcConnectionReject-r1              RRCConnectionReject-r1-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionReject-r1-IEs ::=      SEQUENCE {
    waitTime                            INTEGER (1..16),
    nonCriticalExtension                RRCConnectionReject-v1-IEs              OPTIONAL
}

RRCConnectionReject-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,   -- Need OP
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL    -- Need OP
}


-- ASN1STOP
```

***RRCConnectionReject* field descriptions**
waitTime Wait time value in seconds.

– *RRCConnectionRelease*

The *RRCConnectionRelease* message is used to command the release of an RRC connection.

Signalling radio bearer: SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: 5G-RAN to UE

RRCConnectionRelease message

```
-- ASN1START

RRCConnectionRelease ::=            SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE {
            rrcConnectionRelease-r1             RRCConnectionRelease-r1-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionRelease-r1-IEs ::=     SEQUENCE {
    releaseCause                        ReleaseCause, nonCriticalExtension
    RRCConnectionRelease-v1-IEs     OPTIONAL
}

RRCConnectionRelease-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,   -- Need OP
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL    -- Need OP
}

ReleaseCause ::=                ENUMERATED {spare3, other, spare2, spare1}

-- ASN1STOP
```

– *RRCConnectionRequest*

The *RRCConnectionRequest* message is used to request the establishment of an RRC connection.

Signalling radio bearer: SRB0

RLC-SAP: TM

Logical channel: xCCCH

Direction: UE to 5G-RAN

RRCConnectionRequest message

```
-- ASN1START

RRCConnectionRequest ::=            SEQUENCE {
    criticalExtensions                  CHOICE {
        rrcConnectionRequest-r1             RRCConnectionRequest-r1-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionRequest-r1-IEs ::=     SEQUENCE {
    ue-Identity                         InitialUE-Identity,
    establishmentCause                  EstablishmentCause,
    spare                               BIT STRING (SIZE (1))
}

InitialUE-Identity ::=              CHOICE {
    s-TMSI                              S-TMSI,
    randomValue                         BIT STRING (SIZE (40))
}

EstablishmentCause ::=              ENUMERATED {
```

```
                                    mo-Signalling, mo-Data,
                                    spare1, spare2, spare3, spare4, spare5, spare6}

-- ASN1STOP
```

– *RRCConnectionSetup*

The *RRCConnectionSetup* message is used to establish SRB1.

Signalling radio bearer: SRB0

RLC-SAP: TM

Logical channel: xCCCH

Direction: 5G-RAN to UE

RRCConnectionSetup message

```
-- ASN1START

RRCConnectionSetup ::=              SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE {
            rrcConnectionSetup-r1               RRCConnectionSetup-r1-IEs,
            spare7 NULL,
            spare6 NULL, spare5 NULL, spare4 NULL,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionSetup-r1-IEs ::=       SEQUENCE {
    radioResourceConfigDedicated        RadioResourceConfigDedicated,
    nonCriticalExtension                RRCConnectionSetup-v1-IEs           OPTIONAL

}
RRCConnectionSetup-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}



-- ASN1STOP
```

– *RRCConnectionSetupComplete*

The *RRCConnectionSetupComplete* message is used to confirm the successful completion of an RRC connection establishment.

Signalling radio bearer: SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: UE to 5G-RAN

RRCConnectionSetupComplete message

```
-- ASN1START

RRCConnectionSetupComplete ::=      SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
```

```
            rrcConnectionSetupComplete-r1       RRCConnectionSetupComplete-r1-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

RRCConnectionSetupComplete-r1-IEs ::= SEQUENCE {
    dedicatedInfoNAS                    DedicatedInfoNAS,
    selectedPLMN-Identity               INTEGER (1..maxPLMN),
    registeredMME                       RegisteredMME                       OPTIONAL,
    gummei-Type                         ENUMERATED {native, spare}          OPTIONAL,
    nonCriticalExtension                RRCConnectionSetupComplete-v1-IEs           OPTIONAL
}

RRCConnectionSetupComplete-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}
RegisteredMME ::=                   SEQUENCE {
    plmn-Identity                       PLMN-Identity                       OPTIONAL,
    mmegi                               BIT STRING (SIZE (16)),
    mmec                                MMEC
}

-- ASN1STOP
```

– *SecurityModeCommand*

The *SecurityModeCommand* message is used to command the activation of AS security.

Signalling radio bearer: SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: 5G-RAN to UE

SecurityModeCommand message

```
-- ASN1START

SecurityModeCommand ::=             SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            securityModeCommand-r1              SecurityModeCommand-r1-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

SecurityModeCommand-r1-IEs ::=      SEQUENCE {
    securityConfigSMC                   SecurityConfigSMC,
    nonCriticalExtension                SecurityModeCommand-v1-IEs          OPTIONAL
}

SecurityModeCommand-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,   -- Need OP
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL    -- Need OP
}

SecurityConfigSMC ::=                   SEQUENCE {
    securityAlgorithmConfig             SecurityAlgorithmConfig,
    ...
}
-- ASN1STOP
```

– *SecurityModeComplete*

The *SecurityModeComplete* message is used to confirm the successful completion of a security mode command.

Signalling radio bearer: SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: UE to 5G-RAN

SecurityModeComplete message

```
-- ASN1START

SecurityModeComplete ::=            SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        securityModeComplete-r1             SecurityModeComplete-r1-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
}

SecurityModeComplete-r1-IEs ::=     SEQUENCE {
    nonCriticalExtension                SecurityModeComplete-v1-IEs             OPTIONAL
}

SecurityModeComplete-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}
-- ASN1STOP
```

– *SecurityModeFailure*

The *SecurityModeFailure* message is used to indicate an unsuccessful completion of a security mode command.

Signalling radio bearer: SRB1

RLC-SAP: AM

Logical channel: xDCCH

Direction: UE to 5G-RAN

SecurityModeFailure message

```
-- ASN1START

SecurityModeFailure ::=             SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        securityModeFailure-r1              SecurityModeFailure-r1-IEs,
        criticalExtensionsFuture            SEQUENCE {}
    }
}

SecurityModeFailure-r1-IEs ::=      SEQUENCE {
    nonCriticalExtension                SecurityModeFailure-v1-IEs              OPTIONAL
}

SecurityModeFailure-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}
-- ASN1STOP
```

– *UECapabilityEnquiry*

The *UECapabilityEnquiry* message is used to request the transfer of UE radio access capabilities for 5G-RA.

Signalling radio bearer: Non-standalone: Dedicated radio bearer for 5G RRC in LTE, Standalone:SBR1

RLC-SAP: AM

Logical channel: xDCCH

Direction: 5G-RAN to UE

UECapabilityEnquiry message

```
-- ASN1START

UECapabilityEnquiry ::=             SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE {
            ueCapabilityEnquiry-r1              UECapabilityEnquiry-r1-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

UECapabilityEnquiry-r1-IEs ::=      SEQUENCE {
    ue-CapabilityRequest                UE-CapabilityRequest,
    nonCriticalExtension                UECapabilityEnquiry-v1-IEs          OPTIONAL
}

UECapabilityEnquiry-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,   -- Need OP
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL    -- Need OP
}

UE-CapabilityRequest ::=        SEQUENCE (SIZE (1..maxRAT-Capabilities)) OF RAT-Type

-- ASN1STOP
```

***UECapabilityEnquiry* field descriptions**
ue-CapabilityRequest List of the RATs for which the UE is requested to transfer the UE radio access capabilities. Only 5G-UTRA is valid value in this version of the specification.

– *UECapabilityInformation*

The *UECapabilityInformation* message is used to transfer of UE radio access capabilities requested by the 5G-RAN.

Signalling radio bearer: Non-standalone: Dedicated radio bearer for 5G RRC in LTE. Standalone: SRB1

RLC-SAP: AM

Logical channel: DCCH

Direction: UE to 5G-RAN

UECapabilityInformation message

```
-- ASN1START

UECapabilityInformation ::=         SEQUENCE {
    rrc-TransactionIdentifier           RRC-TransactionIdentifier,
    criticalExtensions                  CHOICE {
        c1                                  CHOICE{
            ueCapabilityInformation-r1          UECapabilityInformation-r1-IEs,
            spare7 NULL,
            spare6 NULL, spare5 NULL, spare4 NULL,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
```

```
        criticalExtensionsFuture            SEQUENCE {}
    }
}

UECapabilityInformation-r1-IEs ::=  SEQUENCE {
    ue-CapabilityRAT-ContainerList      UE-CapabilityRAT-ContainerList,
    nonCriticalExtension                UECapabilityInformation-v1-IEs
    OPTIONAL
}
UECapabilityInformation-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                    OPTIONAL,   -- Need OP
    nonCriticalExtension                SEQUENCE {}                     OPTIONAL    -- Need OP
}

-- ASN1STOP
```

– *ULInformationTransfer*

The *ULInformationTransfer* message is used for the uplink transfer of dedicated NAS information.

Signalling radio bearer: Non-standalone: Dedicated radio bearer for 5G RRC in LTE. Standalone: SRB2 or SRB1(only if SRB2 not established yet). If SRB2 is suspended, the UE does not send this message until SRB2 is resumed

RLC-SAP: AM

Logical channel: xDCCH

Direction: UE to 5G-RAN

ULInformationTransfer message

```
-- ASN1START

ULInformationTransfer ::=           SEQUENCE {
    criticalExtensions                  CHOICE {
        c1                                  CHOICE {
            ulInformationTransfer-r1            ULInformationTransfer-r1-IEs,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture            SEQUENCE {}
    }
}

ULInformationTransfer-r1-IEs ::=    SEQUENCE {
    informationType     CHOICE {
        dedicatedInfoNAS                    DedicatedInfoNAS,
    spare3 NULL, spare2 NULL, spare1 NULL
    },
    nonCriticalExtension                ULInformationTransfer-v1-IEs        OPTIONAL}

ULInformationTransfer-v1-IEs ::= SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}


-- ASN1STOP
```

6.3 RRC information elements

6.3.1 System information blocks

– *XSystemInformationBlock*

The IE *XSystemInformationBlock* contains radio resource configuration information that is common for all UEs.

Signalling radio bearer: N/A

RLC-SAP: TM

Logical channel: xBCCH

Direction: 5G-RAN to UE

XSystemInformationBlock

```
-- ASN1START

XSystemInformationBlock ::=     SEQUENCE {
    plmn-Identity                       PLMN-Identity,
    cellIdentity                        CellIdentity,
    cellBarred                          ENUMERATED {barred, notBarred},
    cellReservedForOperatorUse          ENUMERATED {reserved, notReserved},
    defaultConfigID                     INTEGER(0..15),
    prach-uRoot                         INTEGER (1..70),
    ...
}

-- ASN1STOP
```

6.3.2 Radio resource control information elements

– *AntennaInfoDL*

The IE *AntennaInfoDL*is used to specify the DL antenna configuration. Section 6.2.1 [1]

AntennaInfoDL information elements

```
-- ASN1START


AntennaInfoDL::=            SEQUENCE {
        transmissionMode                    ENUMERATED {tm1, tm2, tm3, spare1}

}


-- ASN1STOP
```

***AntennaInfoDL* field descriptions**
transmissionMode Points to one of Transmission modes defined in 5G.213 [3, 8.1] where tm1 refers to transmission mode 1, tm2 to transmission mode 2 etc.

– *AntennaInfoUL*

The IE *AntennaInfoUL* is used to specify the UL antenna configuration. Section 5.1.1 [1]

***AntennaInfoUL* information elements**

```
-- ASN1START

AntennaInfoUL ::=       SEQUENCE {
    transmissionMode                    ENUMERATED {tm1, tm2, spare2, spare1},

    ...
}

-- ASN1STOP
```

***AntennaInfoUL* field descriptions**
transmissionMode Points to one of Transmission modes defined in 5G.213 [3, 9.1] where tm1 refers to transmission mode 1, tm2 to transmission mode 2 etc.

– *BeamId*

The IE *BeamId* is used to indicate the beam index, as defined in 5G.211 [1, 6.7.4.3].

***BeamId* information elements**

```
-- ASN1START

BeamId ::=                      INTEGER (0..511)

-- ASN1STOP
```

– *BRI-ReportConfig*

The IE *BRI-ReportConfig* is used to specify the BRI reporting configuration.

BRI-ReportConfig information element

```
-- ASN1START

BRI-ReportConfig ::=        SEQUENCE {
    num-of-BRRS-Index                   ENUMERATED {one, two, four, spare1},
    ...
}

-- ASN1STOP
```

– BRRSresourceConfiguration

The IE BRRSresourceConfiguration is used to specify beam refinement reference signals configuration respectively.

***BRRSresourceConfiguration* information element**

```
-- ASN1START


BRRSresourceConfiguration ::=           SEQUENCE {
bRRSresourceConfigurationProcList       BRRSresourceConfigurationProcList
}

BRRSresourceConfigurationProcList ::=           SEQUENCE (SIZE(1..4)) OF
BRRSresourceConfigurationProc

BRRSresourceConfigurationProc ::=               SEQUENCE {
    bRRSresourceConfigurationProcID     INTEGER (0..3),
    measuredAntennaPorts                BIT STRING (SIZE (64)),
    symbolAllocation                    ENUMERATED {subframetype, symboltype},
    vCID                                INTEGER (0..511)
}


-- ASN1STOP
```

***BRRSresourceConfiguration* field descriptions**
bRRSresourceConfigurationProcID BRRS process indication (0..3), as specified in 5G.213 [6.7.5]
measuredAntennaPorts Antenna Ports of BRRS resource ID to be measured, as specified in 5G.211 6.7.5.2
symbolAllocation Symbol allocation value : subframetype, symbol type as specified in 5G.211 6.7.5.2
vCID Virtual cell identity, as specified in 5G.211 [6.7.5].

– *CQI-ReportConfig*

The IE *CQI-ReportConfig* is used to specify the CQI reporting configuration.

***CQI-ReportConfig* information elements**

```
-- ASN1START

CQI-ReportConfig ::=                CHOICE {
    cQI-Report-ProcList                 CQI-Report-ProcList

}



CQI-Report-ProcList ::=   SEQUENCE (SIZE (1..4)) OF CQI-ReportProc



CQI-ReportProc ::=              CHOICE {



    release                             NULL,
    setup                           SEQUENCE {
        cQI-ConfigurationID             INTEGER(0..3),
        cSI-RS-COnfig                   CSI-RS-Config           OPTIONAL, -- Need OR
        pmi-RI-Report                   ENUMERATED {setup}      OPTIONAL, -- Need OR
        cqi-ReportModeAperiodic         CQI-ReportModeAperiodic   OPTIONAL -- Need OR
    },


...
}
CQI-ReportModeAperiodic ::= ENUMERATED {
                                            rm10, rm11, spare2, spare1
}


-- ASN1STOP
```

– *CSI-RS-Config*

The IE *CSI-RS-Config* is used to specify the CSI-RS reporting configuration.

***CSI-RS-Config* information elements**

```
-- ASN1START

CSI-RS-Config ::=               CHOICE {
    release     NULL,
    setup       SEQUENCE {
        pcRatio             INTEGER (-8..15),
        resourceConfig      BIT STRING (SIZE (16)),
        scramblingIdentity  INTEGER (0..503)
    },
    ...
 }
-- ASN1STOP
```

***CSI-RS-Config* field descriptions**
pcRatio pcRatio is the assumed ratio of PDSCH EPRE to CSI-RS EPRE when UE derives CSI feedback and takes values in the range of [-8, 15] dB with 1 dB step size as specified in 5G.213
resourceConfig CSI-RS resource configuration including the information of CSI-RS antenna port and RE mapping. The allowable values and port mapping are given in subclause 6.7.3.2 of 5G.211.
scramblingIdentity scrambling sequence initialization parameter as specified in subclause 6.7.3.1 of 5G.211.

– *DedicatedInfoNAS*

The IE *DedicatedInfoNAS* is used to transfer UE specific NAS layer information between the network and the UE. The RRC layer is transparent for this information.

DedicatedInfoNAS information element

```
-- ASN1START

DedicatedInfoNAS ::=        OCTET STRING

-- ASN1STOP
```

– *DMRS-ConfigDL*

The IE *DMRS-ConfigDL* is the DMRS configuration that 5G-RAN may configure on a serving frequency in DL.

***DMRS-ConfigDL* information elements**

```
-- ASN1START

DMRS-ConfigDL::=        CHOICE {
    release                     NULL,
    setup                       SEQUENCE {
        dmrs-ScramblingSequenceInt-0                INTEGER (0..503),
        dmrs-ScramblingSequenceInt-1                INTEGER (0..503),
        high-speed-flag                             ENUMERATED {true} OPTIONAL,


...
    }
}

-- ASN1STOP
```

DMRS-ConfigDL field descriptions
dmrs-SramblingSequenceInt-0, dmrs-SramblingSequenceInt-1,   The DMRS scrambling sequence initialization parameter $n_{\mathrm{ID}}^{\mathrm{DMRS},i}$ defined in 5G.211 [6.7.2.1].

– *DMRS-ConfigUL*

The IE *DMRS-ConfigUL* is the DMRS configuration that 5G-RAN may configure on a serving frequency in UL.

***DMRS-ConfigUL* information elements**

```
-- ASN1START

DMRS-ConfigUL ::=       CHOICE {
    release                     NULL,
    setup                       SEQUENCE {
        dmrs-ScramblingSequenceInt-0        INTEGER (0..503),
        dmrs-ScramblingSequenceInt-1        INTEGER (0..503),

        high-speed-flag                 ENUMERATED {true}               OPTIONAL,
...
    }
}

-- ASN1STOP
```

DMRS-ConfigUL field descriptions
dmrs-SramblingSequenceInt-0, dmrs-SramblingSequenceInt-1,   The DMRS scrambling sequence initialization parameter $n_{\mathrm{ID}}^{\mathrm{DMRS},i}$ defined in 5G.211 [5.5.2.1]

– *DRB-Identity*

The IE *DRB-Identity* is used to identify a DRB used by a UE.

***DRB-Identity* information elements**

```
-- ASN1START

DRB-Identity ::=                    INTEGER (1..32)

-- ASN1STOP
ASN1STOP
```

– *LogicalChannelConfig*

The IE *LogicalChannelConfig* is used to configure the logical channel parameters.

***LogicalChannelConfig* information element**

```
-- ASN1START

LogicalChannelConfig ::=            SEQUENCE {
    ul-SpecificParameters               SEQUENCE {
        priority                            INTEGER (1..16),
        prioritisedBitRate                  ENUMERATED {
                                                kBps0, kBps8, kBps16, kBps32, kBps64, kBps128,
                                                kBps256, kBps512, kBps1024, kBps2048,
                                                infinity, spare5, spare4, spare3, spare2,
                                                spare1},
        bucketSizeDuration                  ENUMERATED {
                                                ms50, ms100, ms150, ms300, ms500, ms1000, spare2,
                                                spare1},

        logicalChannelGroup                 INTEGER (0..3)      -- Need OR      ...
    }
}

-- ASN1STOP
```

– *MAC-MainConfig*

The IE *MAC-MainConfig* is used to specify the MAC main configuration for signalling and data radio bearers.

***MAC-MainConfig* information element**

```
-- ASN1START

MAC-MainConfig ::=                  SEQUENCE {
    ul-SCH-Config                       SEQUENCE {
        maxHARQ-Tx                          ENUMERATED {
                                                n1, n2, n3, n4, n5, n6, n7, n8,
                                                n10, n12, n16, n20, n24, n28,
                                                spare2, spare1}     OPTIONAL,   -- Need ON
        periodicBSR-Timer                   ENUMERATED {
                                                sf5, sf10, sf16, sf20, sf32, sf40, sf64, sf80,
                                                sf128, sf160, sf320, sf640, sf1280, sf2560,
                                                infinity, spare1}   OPTIONAL,   -- Need ON
        retxBSR-Timer                       ENUMERATED {
                                                sf320, sf640, sf1280, sf2560, sf5120,
                                                sf10240, spare2, spare1},
...
    }                                                               OPTIONAL,   -- Need ON
    drx-Config                          DRX-Config                  OPTIONAL,   -- Need ON
    timeAlignmentTimerDedicated         TimeAlignmentTimer,
    phr-Config                          PHR-Config                  OPTIONAL,   -- Need ON
    brs-Config                          BRS-Config                  OPTIONAL,   -- Need ON
    brrs-Config                         BRRS-Config                 OPTIONAL    -- Need ON

    ...


}
```

```
DRX-Config ::=                      CHOICE {
    release                             NULL,
    setup                               SEQUENCE {
        onDurationTimer                     ENUMERATED {
                                                psf1, psf2, psf3, psf4, psf5, psf6,
                                                psf8, psf10, psf20, psf30, psf40,
                                                psf50, psf60, psf80, psf100,
                                                psf200},
        drx-InactivityTimer                 ENUMERATED {
                                                psf1, psf2, psf3, psf4, psf5, psf6,
                                                psf8, psf10, psf20, psf30, psf40,
                                                psf50, psf60, psf80, psf100,
                                                psf200, psf300, psf500, psf750,
                                                psf1280, psf1920, psf2560, spare10,
                                                spare9, spare8, spare7, spare6,
                                                spare5, spare4, spare3, spare2,
                                                spare1},
        drx-RetransmissionTimer             ENUMERATED {
                                                psf1, psf2, psf4, psf5, psf6, psf8,psf10, psf16,
                                                psf20, psf24, psf30, psf33, psf40, psf50, psf120,
                                                psf165},
        longDRX-CycleStartOffset        CHOICE {
            sf10                            INTEGER(0..9),
            sf20                            INTEGER(0..19),
            sf32                            INTEGER(0..31),
            sf40                            INTEGER(0..39),
            sf64                            INTEGER(0..63),
            sf80                            INTEGER(0..79),
            sf128                           INTEGER(0..127),
            sf160                           INTEGER(0..159),
            sf256                           INTEGER(0..255),
            sf320                           INTEGER(0..319),
            sf512                           INTEGER(0..511),
            sf640                           INTEGER(0..639),
            sf1024                          INTEGER(0..1023),
            sf1280                          INTEGER(0..1279),
            sf2048                          INTEGER(0..2047),
            sf2560                          INTEGER(0..2559)
        },
        shortDRX                        SEQUENCE {
            shortDRX-Cycle                  ENUMERATED  {
                                                sf2, sf5, sf8, sf10, sf16, sf20,
                                                sf32, sf40, sf64, sf80, sf128, sf160,
                                                sf256, sf320, sf512, sf640},
            drxShortCycleTimer              INTEGER (1..16)
        }       OPTIONAL                                        -- Need OR
    },

        ...
}

PHR-Config  ::=                     CHOICE {
        release                         NULL,
        setup                           SEQUENCE {
            periodicPHR-Timer               ENUMERATED {sf10, sf20, sf50, sf100, sf200,
                                                        sf500, sf1000, infinity},
            prohibitPHR-Timer               ENUMERATED {sf0, sf10, sf20, sf50, sf100,
                                                        sf200, sf500, sf1000},
            dl-PathlossChange               ENUMERATED {dB1, dB3, dB6, infinity}
        }
}

BRS-Config  ::=         CHOICE {
        release                         NULL,
        setup                           SEQUENCE {
            beamTriggeringRSRPoffset        ENUMERATED {dB-24, dB-22, dB-20, dB-18, dB-16, dB-14,
                                                dB-12, dB-10, dB-8, dB-6, dB-5, dB-4, dB-3,dB-2,
                                                dB-1, dB0, dB1, dB2, dB3, dB4, dB5,dB6, dB8, dB10,
                                                dB12, dB14, dB16, dB18, dB20, dB22, dB24}

        }
}

BRRS-Config ::=         CHOICE {
        release                         NULL,
        setup                           SEQUENCE {
            barRequestAllowed               ENUMERATED {true}       OPTIONAL,
            prohibitBAR-Timer               ENUMERATED {sf0, sf10, sf20, sf40, sf80,sf160,
```

```
                                                sf320, sf640}   OPTIONAL,   -- Need ON
            ...
        }
}



-- ASN1STOP
```

***MAC-MainConfig* field descriptions**
maxHARQ-Tx Maximum number of transmissions for UL HARQ in 5G.321 [6].
periodicBSR-Timer Timer for BSR reporting in 5G.321 [6]. Value in number of sub-frames. Value sf10 corresponds to 10 sub-frames, sf20 corresponds to 20 sub-frames and so on.
retxBSR-Timer Timer for BSR reporting in 5G.321 [6]. Value in number of sub-frames. Value sf640 corresponds to 640 sub-frames, sf1280 corresponds to 1280 sub-frames and so on.
longDRX-CycleStartOffset *longDRX-Cycle* and *drxStartOffset* in 5G.321 [6]. The value of l*ongDRX-Cycle* is in number of sub-frames. Value sf10 corresponds to 10 sub-frames, sf20 corresponds to 20 sub-frames and so on. If *shortDRX-Cycle* is configured, the value of *longDRX-Cycle* shall be a multiple of the *shortDRX-Cycle* value. The value of *drxStartOffset* value is in number of sub-frames.
periodicPHR-Timer Timer for PHR reporting in 5G.321 [6]. Value in number of sub-frames. Value sf10 corresponds to 10 subframes, sf20 corresponds to 20 subframes and so on
prohibitPHR-Timer Timer for PHR reporting in 5G.321 [6]. Value in number of sub-frames. Value sf0 corresponds to 0 subframes, sf100 corresponds to 100 subframes and so on.
dl-PathlossChange DL Pathloss Change for PHR reporting in 5G.321 [6]. Value in dB. Value dB1 corresponds to 1 dB, dB3 corresponds to 3 dB and so on.
prohibitBAR-Timer Timer for BAR reporting in 5G.321. Value in number of sub-frames. Value sf0 corresponds to 0 subframes, sf640 corresponds to 640 subframes and so on.
beamTriggeringRSRPoffset Indicates the RSRP threshold (in dB) used by the UE to trigger BRS-based beam feedback transmission in 5G.321 [6].

– PDCCH-Config

The IE *PDCCH-Config* is used to specify the UE specific xPDCCH configuration. Subclause 6.6.1 [1]

***PDCCH-Config* information element**

```
-- ASN1START



PDCCH-ConfigDedicated::=        SEQUENCE {
    xpdcch-format           XPDCCH-format,
    dmrs-pdcchConfigDL      DMRS-PDCCHConfigDL,
...
}

XPDCCH-format::=    SEQUENCE {
    xpdcchSymbol    ENUMERATED {sym1, sym2},
...
}
DMRS-PDCCHConfigDL::=   SEQUENCE {
    dmrs-ScramblingSequenceInt  INTEGER (0..503),
    ...
}


-- ASN1STOP
```

***PDCCH-Config* field descriptions**
xPDCCHSymbol Defines the number of symbols used for PDCCH transmission that UE shall monitor.
dmrs-SramblingSequenceInt The DMRS scrambling sequence initialization parameter $n_{ID,i}^{xPDCCH}$ defined in 5G.211 [6.7.1.1].

– *PDCP-Config*

The IE *PDCP-Config* is used to set the configurable PDCP parameters for data radio bearers.

***PDCP-Config* information element**

```
-- ASN1START

PDCP-Config ::=                     SEQUENCE {
    discardTimer                        ENUMERATED {
                                            ms50, ms100, ms150, ms300, ms500,
                                            ms750, ms1500, infinity
    }                                                       OPTIONAL,           -- Cond Setup
    rlc-AM                              SEQUENCE {
        statusReportRequired                BOOLEAN
    }                                                       OPTIONAL            -- Cond Rlc-AM
}

-- ASN1STOP
```

– *PDSCH-ConfigCommon*

The IE *PDSCH-ConfigCommon* is used to specify the common PDSCH configuration respectively.

***PDSCH-ConfigCommon* information element**

```
-- ASN1START


PDSCH-ConfigCommon::=       SEQUENCE {
    beamReferenceSignalPower        INTEGER (-60..50),
    dmrsPrecodingRBGroup        ENUMERATED      {opt1, opt2},
...
}


-- ASN1STOP
```

PDSCH-ConfigCommon field descriptions
beamReferenceSignalPower Parameter: Reference-signal power, which provides the downlink reference-signal EPRE, see TS 5G.213. The actual value in dBm.
dmrsPrecodingRBGroup dmrsPrecodingRBGroup provides information of precoding granularity of xPDSCH where opt1 means four PRBs mapped to a single VRBG index and opt2 means all assigned PRBs in the frequency domain [5G.213]

– *PDSCH-ConfigDedicated*

The IE *PDSCH-ConfigDedicated* is used to specify the UE specific PDSCH configuration respectively.

***PDSCH-Config* information element**

```
-- ASN1START


PDSCH-ConfigDedicated::=        SEQUENCE {
    dmrs-ConfigDL                   DMRS-ConfigDL,
    bRRSresourceConfiguration       BRRSresourceConfiguration,

...
```

```
}


-- ASN1STOP
```

– PhysicalConfigDedicated

The IE *PhysicalConfigDedicated* is used to specify the UE specific physical channel configuration.

PhysicalConfigDedicated information element

```
-- ASN1START

PhysicalConfigDedicated ::=     SEQUENCE {
    pdsch-Config                        PDSCH-ConfigDedicated           OPTIONAL,       -- Need ON
    pdcch-Config                        PDCCH-ConfigDedicated           OPTIONAL,       -- Need ON
    pucch-Config                        PUCCH-ConfigDedicated           OPTIONAL,       -- Need ON
    pusch-Config                        PUSCH-ConfigDedicated           OPTIONAL,       -- Need ON
    antennaInfoDL                       AntennaInfoDL                   OPTIONAL,       -- Need ON
    antennaInfoUL                       AntennaInfoUL                   OPTIONAL,       -- Need ON
    schedulingRequestConfigCommon       SchedulingRequestConfig         OPTIONAL,       -- Need ON
    schedulingRequestConfigBRRS         SchedulingRequestConfig         OPTIONAL,       -- Need ON
    schedulingRequestConfigBeamRecovery SchedulingRequestConfig         OPTIONAL,       -- Need ON
    cqi-ReportConfig                    CQI-ReportConfig                OPTIONAL,       -- Cond CQI
    bri-ReportConfig                    BRI-ReportConfig                OPTIONAL,       -- Need ON
    uplinkPowerControlDedicated         UplinkPowerControlDedicated     OPTIONAL,       -- Need ON
    ...
}

-- ASN1STOP
```

– P-Max

The IE *P-Max* is used to limit the UE's uplink transmission power on a carrier frequency. and is used to calculate the parameter *Pcompensation* defined in 3GPP TS 36.304 [4]. Corresponds to parameter P_{EMAX} or $P_{EMAX,c}$ in 3GPP TS 36.101 [42]. The UE transmit power on one serving cell shall not exceed the configured maximum UE output power of the serving cell determined by this value as specified in 3GPP TS 36.101 [x, 6.2.5 or 6.2.5A].

***P-Max* information element**

```
-- ASN1START

P-Max ::=               INTEGER (-30..33)

-- ASN1STOP
```

– PRACH-ConfigCommon

The IE *PRACH-ConfigCommon* is used to specify PRACH configuration which is common for contentious and non-contentious RACH.

***PRACH-ConfigCommon* information elements**

```
-- ASN1START

PRACH-ConfigCommon ::=          SEQUENCE {
    prach-ConfigIndex               INTEGER (0..3),
    prach-uRoot                     INTEGER (1..70),
    preambleFormat                  INTEGER (0..1)
}
-- ASN1STOP
```

***PRACH-Config* field descriptions**
prach-uRoot the root u as specified in 5G.211 5.7.1
prach-ConfigIndex As specified in 5G.211 table 5.7.1-2
preambleFormat Parameter indicating which RACH preamble format is used in cell, where 0 is for 500 meter coverage and 1 is for 1 killometer coverage.

– *PUCCH-Config*

The IE *PUCCH-ConfigDedicated* is used to specify the UE specific PUCCH configuration.

***PUCCH-Config* information elements**

```
-- ASN1START


PUCCH-ConfigDedicated ::=           SEQUENCE {
    twoAntennaPortActivated             ENUMERATED {true}               OPTIONAL,   -- Need ON
...
}

-- ASN1STOP
```

***PUCCH-ConfigDedicated* field descriptions**
twoAntennaPortActived Indicates whether two antenna ports are configured for PUCCH, see 5G.213[3,11.1].

– *PUSCH-Config*

The IE *PUSCH-ConfigDedicated* is used to specify the UE specific PUSCH configuration.

***PUSCH-Config* information element**

```
-- ASN1START

PUSCH-ConfigDedicated ::=           SEQUENCE {

    dmrs-ConfigUL                   DMRS-ConfigUL,
    soundingRS-UL-ConfigDedicated   SoundingRS-UL-ConfigDedicated   OPTIONAL,       -- Need OR
...
}


-- ASN1STOP
```

- *RACH-ConfigCommon*

The IE *RACH-ConfigCommon* is used to specify the generic random access parameters..

***RACH-ConfigCommon* information elements**

```
-- ASN1START

RACH-ConfigCommon ::=           SEQUENCE {
    numberOfRA-Preambles            ENUMERATED {
                                    n3, n6, n9, n12, n15, n18, n21, n24, n27, n30, n33, n36, n39,
                                    n42, n45, n48},
    powerRampingParameters          PowerRampingParameters,
    ra-SupervisionInfo              SEQUENCE {
        preambleTransMax                PreambleTransMax,
        ra-ResponseWindowSize           ENUMERATED {
                                            sf5, sf10, sf15, sf20, sf25, sf30,
                                            sf40, sf50},
```

```
        mac-ContentionResolutionTimer       ENUMERATED {
                                                sf8, sf16, sf24, sf32, sf40, sf48,
                                                sf56, sf64}
    },
    maxHARQ-Msg3Tx                      INTEGER (1..8)
}



PowerRampingParameters ::=          SEQUENCE {
    powerRampingStep                    ENUMERATED {dB0, dB2,dB4, dB6},
    preambleInitialReceivedTargetPower  ENUMERATED {
                                            dBm-120, dBm-118, dBm-116, dBm-114, dBm-112,
                                            dBm-110, dBm-108, dBm-106, dBm-104, dBm-102,
                                            dBm-100, dBm-98, dBm-96, dBm-94,
                                            dBm-92, dBm-90}
}

PreambleTransMax ::=                ENUMERATED {
                                            n3, n4, n5, n6, n7, n8, n10, n20, n50,
                                            n100, n200}

-- ASN1STOP
```

RACH-ConfigCommon field descriptions
numberOfRA-Preambles NumberOfRA-preamble denotes preamble indices for contention based RACH transmission among available preambles as specified in 5G.213 [7.1]
mac-ContentionResolutionTimer Timer for contention resolution in 5G.321 [6]. Value in subframes. Value sf8 corresponds to 8 subframes, sf16 corresponds to 16 subframes and so on.
maxHARQ-Msg3Tx Maximum number of Msg3 HARQ transmissions in 5G.321 [6], used for contention based random access. Value is an integer.
numberOfRA-Preambles Preamble indices for non-dedicated random access preambles in among available preambles 5G.321 [6]. Value is an integer. Value 2 corresponds to non-dedicated random access preambles until band 2, value 4 corresponds to non-dedicated random access preamblesand so on.
powerRampingStep Power ramping factor in 5G.321 [6]. Value in dB. Value dB0 corresponds to 0 dB, dB2 corresponds to 2 dB and so on.
preambleInitialReceivedTargetPower Initial preamble power in 5G.321 [6]. Value in dBm. Value dBm-120 corresponds to -120 dBm, dBm-118 corresponds to -118 dBm and so on.
preambleTransMax Maximum number of preamble transmission in 5G.321 [6]. Value is an integer. Value n3 corresponds to 3, n4 corresponds to 4 and so on.
ra-ResponseWindowSize Duration of the RA response window in 5G.321 [6]. Value in subframes. Value sf5 corresponds to 5 subframes, sf10 corresponds to 10 subframes and so on. The same value applies for each serving cell (although the associated functionality is performed independently for each cell).

– *RACH-ConfigDedicated*

The IE *RACH-ConfigDedicated* is used to specify the dedicated random access parameters.

RACH-ConfigDedicated information element

```
-- ASN1START

RACH-ConfigDedicated ::=        SEQUENCE {
    ra-PreambleIndex                    INTEGER (0..47)


}
```

```
-- ASN1STOP
```

RACH-ConfigDedicated field descriptions
ra-PreambleIndex
Expicitly signalled Random Access Preamble for RA Resource selection in 5G.321[6].

- *RadioResourceConfigCommon*

The IE *RadioResourceConfigCommon* is used to specify common radio resource configurations in the mobility control information, e.g., the random access parameters and the static physical layer parameters.

***RadioResourceConfigCommon* information element**

```
-- ASN1START

RadioResourceConfigCommon ::=       SEQUENCE {
    rach-ConfigCommon                   RACH-ConfigCommon                   OPTIONAL,   -- Need ON
    prach-Config                        PRACH-ConfigCommon                  OPTIONAL,   -- Need ON
    pdsch-ConfigCommon                  PDSCH-ConfigCommon                  OPTIONAL,   -- Need ON
    uplinkPowerControlCommon            UplinkPowerControlCommon            OPTIONAL,   -- Need ON
    p-Max                               P-Max                               OPTIONAL,   -- Need ON

    ...

}

-- ASN1STOP
```

– *RadioResourceConfigDedicated*

The IE *RadioResourceConfigDedicated* is used to setup/modify/release RBs, to modify the MAC main configuration and to modify dedicated physical configuration.

***RadioResourceConfigDedicated* information element**

```
-- ASN1START

RadioResourceConfigDedicated ::=        SEQUENCE {
    srb-ToAddModList                    SRB-ToAddModList            OPTIONAL,       -- Cond HO-Conn
    drb-ToAddModList                    DRB-ToAddModList            OPTIONAL,       -- Cond HO-
to5GRA
    drb-ToReleaseList                   DRB-ToReleaseList           OPTIONAL,       -- Need ON
    mac-MainConfig      CHOICE {
                        explicitValue   MAC-MainConfig,
                        defaultValue    NULL
    }                                                               OPTIONAL,       -- Cond Ho-
to5GRA
    rach-ConfigDedicated                RACH-ConfigDedicated        OPTIONAL,       -- Need ON
    physicalConfigDedicated             PhysicalConfigDedicated     OPTIONAL,       -- Need ON
    rlf-TimersAndConstants              RLF-TimersAndConstants      OPTIONAL        -- Need ON

    }

SRB-ToAddModList ::=                SEQUENCE (SIZE (1..2)) OF SRB-ToAddMod

SRB-ToAddMod ::=    SEQUENCE {
    srb-Identity                        INTEGER (1..2),
    rlc-Config                          CHOICE {
        explicitValue                       RLC-Config,
        defaultValue                        NULL
    }       OPTIONAL,                                                   -- Cond Setup
    logicalChannelConfig                CHOICE {
        explicitValue                       LogicalChannelConfig,
        defaultValue                        NULL
    }       OPTIONAL,                                                   -- Cond Setup
    ...
}

DRB-ToAddModList ::=                SEQUENCE (SIZE (1..maxDRB)) OF DRB-ToAddMod
```

```
DRB-ToAddMod ::=    SEQUENCE {
    eps-BearerIdentity                  INTEGER (0..15)         OPTIONAL,       -- Cond DRB-Setup
    drb-Identity                        DRB-Identity,
    pdcp-Config                         PDCP-Config             OPTIONAL,       -- Cond PDCP
    rlc-Config                          RLC-Config              OPTIONAL,       -- Cond Setup
    logicalChannelIdentity              INTEGER (3..10)         OPTIONAL,       -- Cond DRB-Setup
    logicalChannelConfig                LogicalChannelConfig    OPTIONAL,       -- Cond Setup
    ...
}

DRB-ToReleaseList ::=               SEQUENCE (SIZE (1..maxDRB)) OF DRB-Identity

RadioResourceConfigDedicatedSCell ::=       SEQUENCE {
    rach-ConfigDedicated                RACH-ConfigDedicated        OPTIONAL,       -- Need ON
    physicalConfigDedicated             PhysicalConfigDedicated     OPTIONAL,       -- Need ON
    pucch-ConfigDedicated               PUCCH-ConfigDedicated       OPTIONAL,       -- Need ON
    soundingRS-UL-ConfigDedicated   SoundingRS-UL-ConfigDedicated   OPTIONAL,       -- Need ON

    ...
    }

RadioResourceConfigCommonSCell ::=      SEQUENCE {
    rach-ConfigCommon                   RACH-ConfigCommon               OPTIONAL,   -- Need ON
    prach-Config                        PRACH-ConfigCommon,
    pdsch-ConfigCommon                  PDSCH-ConfigCommon              OPTIONAL,   -- Need ON
    uplinkPowerControlCommon            UplinkPowerControlCommon        OPTIONAL,   -- Need ON
    p-Max                               P-Max                           OPTIONAL,   -- Need OP
    ...
}



-- ASN1STOP
```

– *RLC-Config*

The IE *RLC-Config* is used to specify the RLC configuration of DRBs.

RLC-Config information element

```
-- ASN1START

RLC-Config ::=              CHOICE {
    am                                  SEQUENCE {
        ul-AM-RLC                           UL-AM-RLC,
        dl-AM-RLC                           DL-AM-RLC
    },
    um-Bi-Directional                   SEQUENCE {
        dl-UM-RLC                           DL-UM-RLC
    }
}

UL-AM-RLC ::=                       SEQUENCE {
    t-PollRetransmit                    T-PollRetransmit,
    pollPDU                             PollPDU,
    pollByte                            PollByte,
    maxRetxThreshold                    ENUMERATED {
                                            t1, t2, t3, t4, t6, t8, t16, t32}
}


DL-AM-RLC ::=                       SEQUENCE {
    t-Reordering                        T-Reordering,
    t-StatusProhibit                    T-StatusProhibit
}



DL-UM-RLC ::=                       SEQUENCE {
    t-Reordering                        T-Reordering
}

T-PollRetransmit ::=                ENUMERATED {
                                        ms1, ms2, ms3, ms4, ms5, ms6, ms7,
                                        ms8, ms9, ms10, ms11, ms12, ms13, ms14,
```

```
                                        ms15, ms16, ms17, ms18, ms19, ms20, ms22,
                                        ms24, ms26, ms28, ms30, ms35, ms40,
                                        ms45, ms50, ms60, ms70, ms80}


PollPDU ::=                             ENUMERATED {
                                        p4, p8, p16, p32, p64, p128, p256, p512, p1024,p2048,
                                        p4096, p6144, p8192, p12288, p16384, pInfinity}

PollByte ::=                            ENUMERATED {
                                        kB25, kB50, kB75, kB100, kB125, kB250, kB375,
                                        kB500, kB750, kB1000, kB1250, kB1500, kB2000,
                                        kB3000, kBinfinity, spare1}

T-Reordering ::=                        ENUMERATED {
                                        ms0, ms1, ms2, ms3, ms4, ms5, ms6, ms7,
                                        ms8, ms9, ms10, ms11, ms12, ms13, ms14,
                                        ms15, ms16, ms17, ms18, ms19, ms20, ms22,
                                        ms24, ms26, ms28, ms30, ms35, ms40,
                                        ms45, ms50, ms60, ms70}

T-StatusProhibit ::=                    ENUMERATED {
                                        ms0, ms1, ms2, ms3, ms4, ms5, ms6, ms7,
                                        ms8, ms9, ms10, ms11, ms12, ms13, ms14,
                                        ms15, ms16, ms17, ms18, ms19, ms20, ms21,
                                        ms22, ms23, ms24, ms25, ms26, ms27,
                                        ms28, ms29, ms30, ms32, ms34, ms36,
                                        ms38, ms40, ms45, ms50, ms55, ms60, ms65,
                                        ms70, ms75, ms80, ms90, ms100, ms110, ms120,
                                        ms130, ms140, ms150, ms160, ms170, ms180, ms190, ms200,
                                        spare8, spare7,spare6, spare5, spare4, spare3, spare2,
                                        spare1}

-- ASN1STOP
```

– *RLF-TimerAndConstants*

The IE *RLF-TimersAndConstants* contains UE specific timers and constants applicable for UEs in 5G RRC_CONNECTED.

RLF-TimersAndConstants information elements

```
-- ASN1START

RLF-TimersAndConstants ::=          CHOICE {
    release                                 NULL,
    setup                                   SEQUENCE {
        t301-r9                             ENUMERATED {
                                                ms100, ms200, ms300, ms400, ms600, ms1000, ms1500,
                                                ms2000},
        t310-r9                             ENUMERATED {
                                                ms0, ms50, ms100, ms200, ms500, ms1000, ms2000},
        n310-r9                             ENUMERATED {
                                                n1, n2, n3, n4, n6, n8, n10, n20},
        t311-r9                             ENUMERATED {
                                                ms1000, ms3000, ms5000, ms10000, ms15000,
                                                ms20000, ms30000},
        n311-r9                             ENUMERATED {
                                                n1, n2, n3, n4, n5, n6, n8, n10},
        ...
    }
}

-- ASN1STOP
```

RLF-TimersAndConstants field descriptions
n3xy Constants are described in section x.x. n1 corresponds with 1, n2 corresponds with 2 and so on.
t3xy Timers are described in section x.x. Value ms0 corresponds with 0 ms, ms50 corresponds with 50 ms and so on.

- *RRC-TransactionIdentifier*

The IE *RRC-TransactionIdentifier* is used, together with the message type, for the identification of an RRC procedure (transaction).

***RRC-TransactionIdentifier* information element**

```
-- ASN1START

RRC-TransactionIdentifier ::=       INTEGER (0..3)

-- ASN1STOP
```

- SchedulingRequest*Config*

The IE *SchedulingRequestConfig* is used to specify the Scheduling Request configuration.

***SchedulingRequestConfig* information elements**

```
-- ASN1START

SchedulingRequestConfig ::=             SEQUENCE {
    prach-uRoot                     INTEGER (1..70),
    srCyclicShiftV                  INTEGER (0..11),
    rachBandIndex                   INTEGER (0..7),
    timeDomainOcsIndexfprime        INTEGER (0..1),
...
}


-- ASN1STOP
```

– *SoundingRS-UL-ConfigDedicated*

The IE *SoundingRS-UL-ConfigDedicated* is used to specify the uplink Sounding RS configuration for aperiodic sounding.

***SoundingRS-UL-ConfigDedicated* information element**

```
-- ASN1START


SoundingRS-UL-ConfigDedicated ::=   CHOICE{
    release                             NULL,
    setup                               SEQUENCE {
        groupHoppingEnabled             BOOLEAN,
        deltaSS                         INTEGER (0..29),
        sequenceHoppingEnabled          BOOLEAN,
        soundingRS-UL-ConfigDCI         SEQUENCE  (SIZE (1..3)) OF SoundingRS-UL-ConfigAp
    }
}
SoundingRS-UL-ConfigAp ::=  CHOICE {
    release             NULL,
    setup               SEQUENCE {
        srs-ProcID                      INTEGER (0..2),
        srs-BandwidthConfig             ENUMERATED {bw0, bw1, bw2, bw3},
        srs-cyclicShift-ap              INTEGER (0..7),
        srs-transmissionComb-ap         INTEGER (0..1),
        srs-freqDomainPos-ap            INTEGER (0..23),
        srs-AntennaPort                 SRS-AntennaPort,
        scramblingIdentity              INTEGER (0..503),

    ...
    }
}

SRS-AntennaPort::=                      ENUMERATED {an1, an2, an4, spare1}


-- ASN1STOP
```

– *S-TMSI*

The IE *S-TMSI* contains an S-Temporary Mobile Subscriber Identity, a temporary UE identity provided by the EPC which uniquely identifies the UE within the tracking area.

S-TMSI information element

```
-- ASN1START

S-TMSI ::=                          SEQUENCE {
    mmec                                MMEC,
    m-TMSI                              BIT STRING (SIZE (32))
}

-- ASN1STOP
```

***S-TMSI* field descriptions**
m-TMSI The first/leftmost bit of the bit string contains the most significant bit of the M-TMSI.

– *TimeAlignmentTimer*

The IE *TimeAlignmentTimer* is used to control how long the UE considers the serving cells belonging to the associated TAG to be uplink time aligned. Corresponds to the Timer for time alignment in 5G.321 [6]. Value in number of sub-frames. Value sf500 corresponds to 500 sub-frames, sf750 corresponds to 750 sub-frames and so on.

TimeAlignmentTimer information element

```
-- ASN1START

TimeAlignmentTimer ::=                  ENUMERATED {
                                                sf500, sf750, sf1280, sf1920, sf2500, sf2560,f3750,
                                                sf5120, sf6400, sf9600, sf10240, sf12800, sf25600,
                                                sf51200,infinity, spare1}
-- ASN1STOP
```

– *UplinkPowerControlCommon*

The IE *UplinkPowerControlCommon* and IE *UplinkPowerControlDedicated* are used to specify parameters for uplink power control in the system information and in the dedicated signalling, respectively.

UplinkPowerControlCommon information elements

```
-- ASN1START

UplinkPowerControlCommon ::=        SEQUENCE {
    p0-NominalPUSCH                     INTEGER (-126..24),
    alpha                               ENUMERATED {al0, al04, al05, al06, al07, al08, al09, al1},
    p0-NominalPUCCH                     INTEGER (-127..-96),
    deltaFList-PUCCH                    DeltaFList-PUCCH,

    deltaPreambleMsg3                   INTEGER (-1..6)
}
DeltaFList-PUCCH ::=                SEQUENCE {
    deltaF-PUCCH-Format1                ENUMERATED {deltaF-2, deltaF0, deltaF2},
    deltaF-PUCCH-Format1b               ENUMERATED {deltaF1, deltaF3, deltaF5},
    deltaF-PUCCH-Format2                ENUMERATED {deltaF-2, deltaF0, deltaF1, deltaF2},
    ...
}


-- ASN1STOP
```

***UplinkPowerControlCommon* field descriptions**
alpha Parameter: α See TS 5G.213 [3, 6.1.1.1] where al0 corresponds to 0, al04 corresponds to value 0.4, al05 to 0.5, al06 to 0.6, al07 to 0.7, al08 to 0.8, al09 to 0.9 and al1 corresponds to 1.
deltaF-PUCCH-FormatX Parameter: $\Delta_{\text{F\_PUCCH}}(F)$ for the PUCCH formats 1, 1b, 2. See TS 5G.213 [3, 6.1.2.1] where deltaF-2 corresponds to -2 dB, deltaF0 corresponds to 0 dB and so on.
deltaPreambleMsg3 Parameter: $\Delta_{PREAMBLE\_Msg3}$ see TS 5G.213 [3, 6.1.1.1]. Actual value = IE value * 2 [dB].
p0-NominalPUCCH Parameter: $P_{\text{O\_NOMINAL\_PUCCH}}$ See TS 5G.213, 6.1.2.1, unit dBm.
p0-NominalPUSCH Parameter: $P_{\text{O\_NOMINAL\_PUSCH}}$ See TS 5G.213, 6.1.1.1, unit dBm.

– *UplinkPowerControlDedicated*

***UplinkPowerControlDedicated* information elements**

```
-- ASN1START

UplinkPowerControlDedicated ::=     SEQUENCE {

    p0-UE-PUSCH                         INTEGER (-8..7),
    deltaMCS-Enabled                    ENUMERATED {en0, en1},
    accumulationEnabled                 BOOLEAN,
    p0-UE-PUCCH                         INTEGER (-8..7),
    pSRS-Offset ap                      INTEGER (0..15),
    filterCoefficient                   FilterCoefficient,
    ...
}


-- ASN1STOP
```

UplinkPowerControlCommon and UplinkPowerControlDedicated field descriptions
accumulationEnabled Parameter: Accumulation-enabled, see 5G.213 [3, 6.1.1.1]. TRUE corresponds to “enabled” whereas FALSE corresponds to “disabled”.
deltaMCS-Enabled Parameter: *Ks* See 5G.213 [3, 6.1.1.1]. en0 corresponds to value 0 corresponding to state “disabled”. en1 corresponds to value 1.25 corresponding to “enabled”.
filterCoefficient Specifies the filtering coefficient for RSRP measurements used to calculate path loss, as specified in 5G.213 [3, 6.1.1.1]. The same filtering mechanism applies as for *quantityConfig* described in 5.4.3.2.
p0-UE-PUCCH Parameter: $P_{\text{O\_UE\_PUCCH}}$ See 5G.213, 6.1.2.1, unit dBm.
p0-UE-PUSCH Parameter: $P_{\text{O\_UE\_PUSCH}}$ See 5G.213, 6.1.1.1, unit dBm.
pSPS-Offset Parameter: pSRS-OFFSET for aperiodic sounding reference signal transmission. See 5G.213 [3, 6.1.3.1]. For Ks=1.25, the actual parameter value is pSRS-Offset value – 3. For Ks=0, the actual parameter value is -10.5 + 1.5*pSRS-Offset value.

6.3.3 Security control information elements

– *NextHopChainingCount*

The IE *NextHopChainingCount* is used to update the 5G K_{eNB} key and corresponds to parameter NCC: See TS 33.401 [32, 7.2.8.4].

NextHopChainingCount information element

```
-- ASN1START

NextHopChainingCount ::=                    INTEGER (0..7)

-- ASN1STOP
```

– *SecurityAlgorithmConfig*

The IE *SecurityAlgorithmConfig* is used to configure AS integrity protection algorithm (SRBs) and AS ciphering algorithm (SRBs and DRBs).

***SecurityAlgorithmConfig* information element**

```
-- ASN1START

SecurityAlgorithmConfig ::=         SEQUENCE {
    cipheringAlgorithm                  ENUMERATED {
                                            eea0, spare7, eea2, spare5, spare4, spare3,
                                            spare2, spare1, ...},
    integrityProtAlgorithm              ENUMERATED {
                                            eia0, spare7, eia2, spare5, spare4, spare3,
                                            spare2, spare1, ...}        OPTIONAL
}

-- ASN1STOP
```

***SecurityAlgorithmConfig* field descriptions**
integrityProtAlgorithm Indicates the integrity protection algorithm to be used for SRBs, as specified in TS 33.401 [5.1.4.2], where eia0 is NULL and eia2 is AES algorithm.
cipheringAlgorithm Indicates the ciphering algorithm to be used for SRBs and DRBs, as specified in TS 33.401 [5.1.3.2], where eea0 is NULL and eea2 is AES algorithm.

– *ShortMAC-I*

The IE *ShortMAC-I* is used to identify and verify the UE at RRC connection re-establishment. The 16 least significant bits of the MAC-I calculated using the security configuration of the source PCell, as specified in 5.3.7.4.

***ShortMAC-I* information element**

```
-- ASN1START

ShortMAC-I ::=                      BIT STRING (SIZE (16))

-- ASN1STOP
```

– *SecurityKeyConfig*

The IE *SecurityKeyConfig* is used as the new 5G K_{eNB} by the UE for deriving AS security keys upon 5G cell addition and/or 5G cell change, as specified in 5.3.5.4.

***SecurityKeyConfig* information element**

```
-- ASN1START
```

```
SecurityKeyConfig ::=                   BIT STRING (SIZE (256))

-- ASN1STOP
```

6.3.4 Mobility control information elements

– *ARFCN-Value5GRAN*

The IE *ARFCN-Value5GRA* is used to indicate the ARFCN applicable for a bi-directional (TDD) 5GRAN carrier frequency. In dedicated signalling, 5GRAN only provides an ARFCN corresponding to an 5G-RA band supported by the UE.

***ARFCN-ValueEUTRA* information element**

```
-- ASN1START

ARFCN-Value5GRA ::=             INTEGER (0..max5GARFCN)

-- ASN1STOP
```

NOTE: For fields using the original value range, as defined by IE *ARFCN-Value5GRA* i.e. without suffix, value *max5GARFCN* indicates that the 5GRA carrier frequency is indicated by means of an extension. In such a case, UEs not supporting the extension consider the field to be set to a not supported value.

– *MobilityControlInfo*

The IE *MobilityControlInfo* includes parameters relevant for network controlled mobility to/within E-UTRA.

***MobilityControlInfo* information element**

```
-- ASN1START

MobilityControlInfo ::=     SEQUENCE {
    targetPhysCellId                    PhysCellId,

    t304                                ENUMERATED {
                                            ms50, ms100, ms150, ms200, ms500, ms1000,
                                            ms2000, spare1},        OPTIONAL,   -- Need ON
    newUE-Identity                      C-RNTI,     OPTIONAL,   -- Need ON
    radioResourceConfigCommon           RadioResourceConfigCommon,      OPTIONAL,   -- Need ON
    rach-ConfigDedicated                RACH-ConfigDedicated            OPTIONAL,   -- Need OP
    candidatecellInfolist               CandidateCellInfoList           OPTIONAL,   -- Need ON


    ...
}
CandidateCellInfoList   ::=     SEQUENCE (SIZE (0..maxCandidateCell)) OF CandidateCellInfo


CandidateCellInfo ::= SEQUENCE {
    candidateCellID         PhysCellId,
...
}


-- ASN1STOP
```

***MobilityControlInfo* field descriptions**
rach-ConfigDedicated The dedicated random access parameters. If absent the UE applies contention based random access as specified in TS 5G.321.
t304 Timer T304 as described in section 7.3. ms50 corresponds with 50 ms, ms100 corresponds with 100 ms and so on.
CandidateCellInfo Candiate cell ID for UE-based mobility support in subclause 5.4.6.2.

– *PhysCellId*

The IE *PhysCellId* is used to indicate the physical layer identity of the cell, as defined in TS 5G.211 [21].

***PhysCellId* information element**

```
-- ASN1START

PhysCellId ::=                      INTEGER (0..503)

-- ASN1STOP
```

– *Q-OffsetRange*

The IE *Q-OffsetRange* is used to indicate a cell or frequency specific offset to be applied when evaluating candidates for cell re-selection or when evaluating triggering conditions for measurement reporting or for beam management. The value in dB. Value dB-24 corresponds to -24 dB, dB-22 corresponds to -22 dB and so on.

***Q- OffsetRange* information element**

```
-- ASN1START

Q-OffsetRange ::=                       ENUMERATED {
                                                dB-24, dB-22, dB-20, dB-18, dB-16, dB-14,
                                                dB-12, dB-10, dB-8, dB-6, dB-5, dB-4, dB-3,
                                                dB-2, dB-1, dB0, dB1, dB2, dB3, dB4, dB5,
                                                dB6, dB8, dB10, dB12, dB14, dB16, dB18,
                                                dB20, dB22, dB24}

-- ASN1STOP
```

6.3.5 Measurement information elements

– *CellIdentity*

The IE *CellIdentity* is used to unambiguously identify a cell within a PLMN.

***CellIdentity* information element**

```
-- ASN1START

CellIdentity ::=                    BIT STRING (SIZE (28))

-- ASN1STOP
```

– *CellIndexList*

The IE *CellIndexList* concerns a list of cell indices, which may be used for different purposes.

***CellIndexList* information element**

```
-- ASN1START

CellIndexList ::=                       SEQUENCE (SIZE (1..maxCellMeas)) OF CellIndex

CellIndex ::=                           INTEGER (1..maxCellMeas)

-- ASN1STOP
```

– *FilterCoefficient*

The IE *FilterCoefficient* specifies the measurement filtering coefficient. Value *fc0* corresponds to k = 0, *fc1* corresponds to k = 1, and so on.

***FilterCoefficient* information element**

```
-- ASN1START

FilterCoefficient ::=                   ENUMERATED {
                                            fc0, fc1, fc2, fc3, fc4, fc5,
                                            fc6, fc7, fc8, fc9, fc11, fc13,
                                            fc15, fc17, fc19, spare1, ...}

-- ASN1STOP
```

– *Hysteresis*

The IE *Hysteresis* is a parameter used within the entry and leave condition of an event triggered reporting condition. The actual value is IE value * 0.5 dB.

***Hysteresis* information element**

```
-- ASN1START

Hysteresis ::=                          INTEGER (0..30)

-- ASN1STOP
```

– *MeasConfig*

The IE *MeasConfig* specifies measurements to be performed by the UE, and covers intra-frequency mobility.

***MeasConfig* information element**

```
-- ASN1START

MeasConfig ::=                      SEQUENCE {
-- Measurement objects
    measObjectToRemoveList              MeasObjectToRemoveList              OPTIONAL,   -- Need ON
    measObjectToAddModList              MeasObjectToAddModList              OPTIONAL,   -- Need ON
    -- Reporting configurations
    reportConfigToRemoveList            ReportConfigToRemoveList            OPTIONAL,   -- Need ON
    reportConfigToAddModList            ReportConfigToAddModList            OPTIONAL,   -- Need ON
    -- Measurement identities
    measIdToRemoveList                  MeasIdToRemoveList                  OPTIONAL,   -- Need ON
    measIdToAddModList                  MeasIdToAddModList                  OPTIONAL,   -- Need ON
    -- Other parameters
    quantityConfig                      QuantityConfig                      OPTIONAL,   -- Need ON
    s-Measure                           RSRP-Range                          OPTIONAL,   -- Need ON
    ...
}

MeasIdToRemoveList ::=              SEQUENCE (SIZE (1..maxMeasId)) OF MeasId

MeasObjectToRemoveList ::=          SEQUENCE (SIZE (1..maxObjectId)) OF MeasObjectId

ReportConfigToRemoveList ::=        SEQUENCE (SIZE (1..maxReportConfigId)) OF ReportConfigId




-- ASN1STOP
```

***MeasConfig* field descriptions**
measObjectToRemoveList List of measurement objects to remove.
measObjectId Used to identify a measurement object configuration.
measObject Specifies measurement object configurations for 5GRAN measurements.
reportConfigToRemoveList List of measurement reporting configurations to remove.
reportConfigId Used to identify a measurement reporting configuration.
reportConfig Specifies measurement reporting configurations for 5GRAN measurements.
measIdToRemoveList List of measurement identities to remove.
s-Measure Serving cell quality threshold controlling whether or not the UE is required to perform measurements of intra-frequency. Value “0” indicates to disable *s-Measure*.

– *MeasId*

The IE *MeasId* is used to identify a measurement configuration, i.e., linking of a measurement object and a reporting configuration.

MeasId information element

```
-- ASN1START

MeasId ::=                          INTEGER (1..maxMeasId)

-- ASN1STOP
```

– *MeasIdToAddModList*

The IE *MeasIdToAddModList* concerns a list of measurement identities to add or modify, with for each entry the *measId*, the associated *measObjectId* and the associated *reportConfigId*.

MeasIdToAddModList information element

```
-- ASN1START

MeasIdToAddModList ::=              SEQUENCE (SIZE (1..maxMeasId)) OF MeasIdToAddMod

MeasIdToAddMod ::=  SEQUENCE {
    measId                              MeasId,
    measObjectId                        MeasObjectId,
    reportConfigId                      ReportConfigId
}

-- ASN1STOP
```

– *MeasObject5GRAN*

The IE *MeasObject5GRAN* specifies information applicable for intra-frequency 5GRAN neighbouring cells.

MeasObject5GRAN information element

```
-- ASN1START

MeasObject5GRAN ::=                 SEQUENCE {
    carrierFreq                         ARFCN-Value5GRA,
    offsetFreq                          Q-OffsetRange               DEFAULT dB0,
    -- Neighbour cell list
    cellsToRemoveList                   CellIndexList               OPTIONAL,       -- Need ON
    cellsToAddModList                   CellsToAddModList           OPTIONAL,       -- Need ON

    t312                        CHOICE {
            release                         NULL,
            setup                           ENUMERATED {ms0, ms50, ms100, ms200,
```

```
                                            ms300, ms400, ms500, ms1000}
        }                                                       OPTIONAL,       -- Need ON

    ...
}

CellsToAddModList ::=               SEQUENCE (SIZE (1..maxCellMeas)) OF CellsToAddMod

CellsToAddMod ::=   SEQUENCE {
    cellIndex                           INTEGER (1..maxCellMeas),
    physCellId                          PhysCellId,
    cellIndividualOffset                Q-OffsetRange,
    ...

}


-- ASN1STOP
```

***MeasObject5GRAN* field descriptions**
carrierFreq Identifies 5GRAN carrier frequency for which this configuration is valid.
offsetFreq Offset value applicable to the carrier frequency. Value dB-24 corresponds to -24 dB, dB-22 corresponds to -22 dB and so on.
cellsToRemoveList List of cells to remove from the neighbouring cell list.
cellsToAddModList List of cells to add/ modify in the neighbouring cell list.
cellIndex Entry index in the neighbouring cell list. An entry may concern a range of cells, in which case this value applies to the entire range.
physCellId Physical cell identity of a cell in neighbouring cell list.
cellIndividualOffset Cell individual offset applicable to a specific neighbouring cell. Value dB-24 corresponds to -24 dB, dB-22 corresponds to -22 dB and so on.
t312 The value of timer T312 which can be configured to UEs in a standalone mode. Value ms0 represents 0 ms, ms50 represents 50 ms and so on.

– *MeasObjectId*

The IE *MeasObjectId* used to identify a measurement object configuration.

MeasObjectId information element

```
-- ASN1START

MeasObjectId ::=                    INTEGER (1..maxObjectId)

-- ASN1STOP
```

– *MeasObjectToAddModList*

The IE *MeasObjectToAddModList* concerns a list of measurement objects to add or modify

MeasObjectToAddModList information element

```
-- ASN1START

MeasObjectToAddModList ::=          SEQUENCE (SIZE (1..maxObjectId)) OF MeasObjectToAddMod

MeasObjectToAddMod ::=  SEQUENCE {
    measObjectId                        MeasObjectId,
    measObject                          CHOICE {
        measObject5GRAN                     MeasObject5GRAN,
        ...
    }
```

```
}

-- ASN1STOP
```

– *MeasResults*

The IE *MeasResults* covers measured results for intra-frequency, mobility.

MeasResults information element

```
-- ASN1START

MeasResults ::=                     SEQUENCE {

    measId                              MeasId,
    measResultPCell                     BeamMeasResultList,
    measResultNeighCells                MeasResultList5GRA              OPTIONAL,

    measResultServFreqList              MeasResultServFreqList          OPTIONAL,
    ...
}

MeasResultList5GRA ::=              SEQUENCE (SIZE (1..maxCellReport)) OF MeasResult5GRA

MeasResult5GRA ::=  SEQUENCE {
    physCellId                          PhysCellId,
    measResult                          BeamMeasResultList              OPTIONAL,
        ...
}
MeasResultServFreqList ::=  SEQUENCE (SIZE (1..maxServCell)) OF MeasResultServFreq

MeasResultServFreq ::=          SEQUENCE {
    servFreqId                      ServCellIndex,
    measResultSCell                 BeamMeasResultList                  OPTIONAL,
    measResultBestNeighCell         SEQUENCE {
        physCellId                      PhysCellId,
        resultNCell                     BeamMeasResultList
    }                                                                   OPTIONAL,
    ...
}

PLMN-IdentityList2 ::=              SEQUENCE (SIZE (1..5)) OF PLMN-Identity

BeamMeasResultList ::=  SEQUENCE (SIZE (1..maxBeamCount)) OF BeamMeasResult

RsrpResultList ::=  SEQUENCE (SIZE (1..maxUERXBeamCount)) OF RSRP-Range


BeamMeasResult ::=          SEQUENCE {
        beamID                  INTEGER (0..511),
        rsrpResult              RSRP-Range,
        rsrpResultList          RsrpResultList OPTIONAL,

        ...
}


-- ASN1STOP
```

***MeasResults* field descriptions**
measId Identifies the measurement identity for which the reporting is being performed.
measResultPCell Measured result of the PCell.
measResultList5GRA List of measured results for the maximum number of reported best cells for a 5GRAN measurement identity.
rsrpResult Measured RSRP result of a 5GRAN cell. The rsrpResult is only reported if configured by the 5GNB.
measResult Measured result of an 5GRAN cell. The rsrpResult is only reported if configured by the 5GNB
MeasResultServFreqList Measured results of the serving frequencies: the measurement result of each SCell, if any, and of the best neighbouring cell on each serving frequency
beamIndex Locigal beam index i=0,…,8·P·N_symb^DL-1 as specified in 5G.211 6.7.4.3
rsrpResultList List measured RSRP result of UE RX beams
maxBeamCount Maximum number of 5GNB beams to be reported in the measurement report
maxUERXBeamCount Maximum number of RSRPs of UE beams for a reported 5GNB beam

.

– *MMEC*

The IE *MMEC* identifies an MME within the scope of an MME Group within a PLMN.

***MMEC* information element**

```
-- ASN1START

MMEC ::=                            BIT STRING (SIZE (8))

-- ASN1STOP
```

– *PLMN-Identity*

The IE *PLMN-Identity* identifies a Public Land Mobile Network. Further information regarding how to set the IE are specified in TS 23.003.

***PLMN-Identity* information element**

```
-- ASN1START

PLMN-Identity ::=                   SEQUENCE {
    mcc                                 MCC                 OPTIONAL,                   -- Cond MCC
    mnc                                 MNC
}

MCC ::=                             SEQUENCE (SIZE (3)) OF
                                            MCC-MNC-Digit

MNC ::=                             SEQUENCE (SIZE (2..3)) OF
                                            MCC-MNC-Digit

MCC-MNC-Digit ::=                   INTEGER (0..9)


-- ASN1STOP
```

– *RSRP-Range*

The IE *RSRP-Range* specifies the value range used in RSRP measurements and thresholds. Integer value for RSRP measurements according to the mapping table in table 6.3.5-1.

RSRP-Range information element

```
-- ASN1START

RSRP-Range ::=                      INTEGER(0..97)

-- ASN1STOP
```

Table 6.3.5-1: RSRP measurement report mapping

Reported value	Measured quantity value	Unit
RSRP_00	RSRP < -140	dBm
RSRP_01	-140 ≤ RSRP < -139	dBm
RSRP_02	-139 ≤ RSRP < -138	dBm
…	…	…
RSRP_95	-46 ≤ RSRP < -45	dBm
RSRP_96	-45 ≤ RSRP < -44	dBm
RSRP_97	-44 ≤ RSRP	dBm

– *SCellIndex*

The IE *SCellIndex* concerns a short identity, used to identify an SCell.

SCellIndex information element

```
-- ASN1START

SCellIndex ::=                      INTEGER (1..7)

-- ASN1STOP
```

–

– *TimeToTrigger*

The IE *TimeToTrigger* specifies the value range used for time to trigger parameter, which concerns the time during which specific criteria for the event needs to be met in order to trigger a measurement report. Value ms0 corresponds to 0 ms, ms40 corresponds to 40 ms, and so on.

TimeToTrigger information element

```
-- ASN1START

TimeToTrigger ::=                   ENUMERATED {
                                        ms0, ms40, ms64, ms80, ms100, ms128, ms160, ms256,
                                        ms320, ms480, ms512, ms640, ms1024, ms1280, ms2560,
                                        ms5120}



-- ASN1STOP
```

– *ReportConfigId*

The IE *ReportConfigId* is used to identify a measurement reporting configuration.

ReportConfigId information element

```
-- ASN1START

ReportConfigId ::=                  INTEGER (1..maxReportConfigId)

-- ASN1STOP
```

– *ReportConfigToAddModList*

The IE *ReportConfigToAddModList* concerns a list of reporting configurations to add or modify

ReportConfigToAddModList information element

```
-- ASN1START

ReportConfigToAddModList ::=        SEQUENCE (SIZE (1..maxReportConfigId)) OF ReportConfigToAddMod

ReportConfigToAddMod ::=    SEQUENCE {
    reportConfigId                      ReportConfigId,
    reportConfig                        CHOICE {
        reportConfig5GRA                    ReportConfig5GRA
    },
    ...
}


-- ASN1STOP
```

– *QuantityConfig*

The IE *QuantityConfig* specifies the measurement quantities and layer 3 filtering coefficients for 5GRAN measurements.

***QuantityConfig* information element**

```
-- ASN1START

QuantityConfig ::=                  SEQUENCE {
    quantityConfig5GRAN                 QuantityConfig5GRAN                 OPTIONAL,   -- Need ON
    ...
}

QuantityConfig5GRAN ::=             SEQUENCE {
    filterCoefficientRSRP               FilterCoefficient                   DEFAULT fc4,
    ...

}

-- ASN1STOP
```

***QuantityConfig* field descriptions**
quantityConfig5GRAN Specifies filter configurations for 5GRAN measurements.
filterCoefficientRSRP Specifies the filtering coefficient used for RSRP.

– *ReportConfig5GRA*

The IE *ReportConfig5GRA* specifies criteria for triggering of an 5GRA measurement reporting event. The 5GRA measurement reporting events are labelled A*N* with *N* equal to 1, 2 and so on.

Event A1: Serving 5G cell becomes better than threshold;

Event A2: Serving 5G cell becomes worse than threshold;

Event A3: Neighbour 5G cell becomes offset better than serving 5G cell;

Event A4: Neighbour 5G cell becomes better than threshold;

Event A5: PCell becomes worse than threshold1 and neighbour becomes better than threshold2 (for standalone mode)

***ReportConfig5GRA* information element**

```
-- ASN1START

ReportConfig5GRA ::=                SEQUENCE {
    triggerType                         CHOICE {
        event                               SEQUENCE {
            eventId                             CHOICE {
                eventA1                             SEQUENCE {
```

```
                    a1-Threshold                        Threshold5GRA,
                    reportForMobility                   BOOLEAN


                },
                eventA2                                 SEQUENCE {
                    a2-Threshold                        Threshold5GRA,
                    reportForMobility                   BOOLEAN


                },
                eventA3                                 SEQUENCE {
                    a3-Offset                           INTEGER (-30..30),
                    reportOnLeave                       BOOLEAN,
                    reportForMobility                   BOOLEAN

                },
                eventA4                                 SEQUENCE {
                    a4-Threshold                        Threshold5GRA,
                    reportForMobility                   BOOLEAN
                },
                eventA5                                 SEQUENCE {
                    a5-Threshold1                       Threshold5GRA,
                    a5-Threshold2                       Threshold5GRA,
                    reportForMobility                   BOOLEAN
                }
            },
            hysteresis                          Hysteresis,
            timeToTrigger                       TimeToTrigger
        },
        periodical                              SEQUENCE {
            purpose                                 ENUMERATED {reportStrongestCells}
        }
    },
    maxReportCells                      INTEGER (1..maxCellReport),
    reportInterval                      ReportInterval,
    reportAmount                        ENUMERATED {r1, r2, r4, r8, r16, r32, r64, infinity},
    reportAddNeighMeas                  ENUMERATED {setup}      OPTIONAL,   -- Need OR
    useT312                             BOOLEAN                 OPTIONAL,   -- Need ON
    ...
}

Threshold5GRA ::=                   CHOICE{
    threshold-RSRP                      RSRP-Range,
    ...
}

-- ASN1STOP
```

***ReportConfig5GRAN* field descriptions**
eventId Choice of 5GRAN event triggered reporting criteria.
aN-ThresholdM Threshold to be used in 5GRAN measurement report triggering condition for event number aN. If multiple thresholds are defined for event number aN, the thresholds are differentiated by M.
a3-Offset Offset value to be used in 5GRAN measurement report triggering condition for event a3. The actual value is IE value * 0.5 dB.
reportOnLeave Indicates whether or not the UE shall initiate the measurement reporting procedure when the leaving condition is met for a cell in *cellsTriggeredList*, as specified in 5.5.4.1.
triggerQuantity The quantities used to evaluate the triggering condition for the event**.** The values rsrp correspond to Reference Signal Received Power (RSRP) see 5G.211
timeToTrigger Time during which specific criteria for the event needs to be met in order to trigger a measurement report.
reportQuantity The quantities to be included in the measurement report**.**
maxReportCells Max number of cells, excluding the serving cell, to include in the measurement report.
reportAmount Number of measurement reports applicable for *triggerType* '*event*' as well as for *triggerType* '*periodical*'.
Threshold5GRAN RSRP based threshold for event evaluation. The actual value is IE value – 140 dBm.. For example, if the IE value is 0, the actual value is -140 dBm.
reportForMobility Indicate whether or not the UE shall initiate the measurement reporting procedure when the entering condition is met for a cell, as specified in 5G.331
useT312 This parameter is used by UEs in a standalone mode. If value TRUE is configured, the UE shall use the timer T312 with the value t312 as specified in the corresponding measObject5GRAN. If the corresponding measObject5GRAN does not include the timer T312 then the timer T312 is considered as not configured. 5GRAN configures value TRUE only if triggerType is set to event.

– *ReportInterval*

The *ReportInterval* indicates the interval between periodical reports. The *ReportInterval* is applicable if the UE performs periodical reporting (i.e. when *reportAmount* exceeds 1), for *triggerType event* as well as for *triggerType periodical*. Value ms120 corresponds with 120 ms, ms240 corresponds with 240 ms and so on, while value min1 corresponds with 1 min, min6 corresponds with 6 min and so on.

***ReportInterval* information element**

```
-- ASN1START

ReportInterval ::=                  ENUMERATED {
                                        ms120, ms240, ms480, ms640, ms1024, ms2048, ms5120, ms10240,
                                        min1, min6, min12, min30, min60, spare3, spare2, spare1}

-- ASN1STOP
```

6.3.6 Other information elements

– *C-RNTI*

The IE *C-RNTI* identifies a UE having a RRC connection within a cell.

***C-RNTI* information element**

```
-- ASN1START
```

```
C-RNTI ::=                          BIT STRING (SIZE (16))

-- ASN1STOP
```

– *UE-CapabilityRAT-ContainerList*

The IE *UE-CapabilityRAT-ContainerList* contains list of containers, one for each RAT for which UE capabilities are transferred, if any.

UE-CapabilityRAT-ContainerList information element

```
-- ASN1START

UE-CapabilityRAT-ContainerList ::=SEQUENCE (SIZE (0..maxRAT-Capabilities)) OF UE-CapabilityRAT-
Container

UE-CapabilityRAT-Container ::= SEQUENCE {
    rat-Type                            RAT-Type,
    ueCapabilityRAT-Container           OCTET STRING
}

-- ASN1STOP
```

***UECapabilityRAT-ContainerList* field descriptions**
ueCapabilityRAT-Container
Container for the UE capabilities of the indicated RAT. The encoding is defined in the specification of each RAT: For 5G-RA: the encoding of UE capabilities is defined in IE *UE-5GRA-Capability*.

– *UE-5GRA-Capability*

The IE *UE-5GRA-Capability* is used to convey the 5G UE Radio Access Capability Parameters.

UE-5GRA-Capability information element

```
-- ASN1START

UE-5GRA-Capability ::=          SEQUENCE {
    accessStratumRelease            AccessStratumRelease,
    ueCapabilityFEC                 BOOLEAN,
    phyLayerParameters              PhyLayerParameters,
    rf-Parameters                   RF-Parameters,
    nonCriticalExtension            UE-5GRA-Capability-v1-IEs   OPTIONAL
}
UE-5GRA-Capability-v1-IEs ::=       SEQUENCE {
    lateNonCriticalExtension            OCTET STRING                        OPTIONAL,
    nonCriticalExtension                SEQUENCE {}                         OPTIONAL
}

AccessStratumRelease ::=            ENUMERATED {
                                        rel1, spare7, spare6, spare5, spare4, spare3,
                                        spare2, spare1, ...}

PhyLayerParameters ::=              SEQUENCE {
    twoAntennaPortsForPUCCH             ENUMERATED {supported}                  OPTIONAL,
    twoAntennaPortsForPUSCH             ENUMERATED {supported}                  OPTIONAL,
        ...

}
RF-Parameters ::=                   SEQUENCE {
    supportedBandList5GRA               SupportedBandList5GRA,
    supportedBandCombination            SupportedBandCombination
}

SupportedBandList5GRA ::=           SEQUENCE (SIZE (1..maxBands)) OF SupportedBand5GRA

SupportedBand5GRA ::=               SEQUENCE {
    band5GRA                            INTEGER (1..64)
}

SupportedBandCombination ::= SEQUENCE (SIZE (1..maxBandComb)) OF BandCombinationParameters

BandCombinationParameters ::= SEQUENCE (SIZE (1..maxSimultaneousBands)) OF BandParameters

BandParameters ::= SEQUENCE {
```

```
    band5GRA                    INTEGER (1..64),
    bandParametersUL            BandParametersUL                    OPTIONAL,
    bandParametersDL            BandParametersDL                    OPTIONAL
}

BandParametersUL ::= SEQUENCE (SIZE (1..maxBandwidthClass)) OF CA-MIMO-ParametersUL

CA-MIMO-ParametersUL ::= SEQUENCE {
    ca-BandwidthClassUL             CA-BandwidthClass,
    numberOffCarriers               INTEGER(1..8),
    supportedMIMO-CapabilityUL      MIMO-CapabilityUL               OPTIONAL
}

BandParametersDL ::= SEQUENCE (SIZE (1..maxBandwidthClass)) OF CA-MIMO-ParametersDL

CA-MIMO-ParametersDL ::= SEQUENCE {
    ca-BandwidthClassDL             CA-BandwidthClass,
    numberOffCarriers               INTEGER(1..8),
    supportedMIMO-CapabilityDL      MIMO-CapabilityDL               OPTIONAL
}

CA-BandwidthClass ::= ENUMERATED {a, b, c, d, e, f, ...}

MIMO-CapabilityUL ::= ENUMERATED {oneLayer, twoLayers }
MIMO-CapabilityDL ::= ENUMERATED {oneLayer, twoLayers }

-- ASN1STOP
```

UE-5GRA-Capability information element
ueCapabilityFEC Indicates the UE capability to support turbro code.
numberOfUEbeam indicates how many TX(RX) beam the UE can make
bandCombinationList5GRA One entry corresponding to each supported band combination listed in the same order as in supportedBandCombination.
Band5GRA 5GRA band as defined in TS 36.101[x].
bandList5GRA One entry corresponding to each supported 5GRA band listed in the same order as in supportedBandList5GRA. This field shall include all bands which are indicated in BandCombinationParameters.
CA-BandwidthClass The CA bandwidth class supported by the UE as defined in TS 36.101[x].
MIMO-CapabilityDL The number of supported layers for spatial multiplexing in DL.
MIMO-CapabilityUL The number of supported layers for spatial multiplexing in UL.
SupportedBandCombinationExt Each entry corresponds to the band combination listed in the same order as in supportedBandCombination.
supportedBandwidthCombinationSet Field encoded as a bit map, where bit N is set to "1" if UE support Bandwidth Combination Set N for this band combination, see 36.133 [42]. The leading / leftmost bit (bit 0) corresponds to the Bandwidth Combination Set 0, the next bit corresponds to the Bandwidth Combination Set 1 and so on. The UE shall neither include the field for a non-CA band combination, nor for a CA band combination for which the UE only supports Bandwidth Combination Set 0.
twoAntennaPortsForPUCCH
twoAntennaPortsForPUSCH

– *RAT-Type*

The IE *RAT-Type* is used to indicate the radio access technology (RAT), including 5G-RA, of the requested/ transferred UE capabilities.

RAT-Type information element

```
-- ASN1START
```

```
RAT-Type ::=                        ENUMERATED {
                                        fivegra, spare7, spare6, spare5, spare4,
                                        spare3, spare2, spare1, ...}

-- ASN1STOP
```

– *UE-TimersAndConstants*

The IE *UE-TimersAndConstants* contains timers and constants used by the UE in either RRC_CONNECTED or RRC_IDLE in standalone mode

6.4 RRC multiplicity and type constraint values

– Multiplicity and type constraint definitions

```
-- ASN1START
maxDRB                  INTEGER ::= 11      -- Maximum number of Data Radio Bearers
maxMeasId               INTEGER ::= 32
maxRAT-Capabilities     INTEGER ::= 8       -- Maximum number of interworking RATs (incl 5GRA)

ServCellIndex ::=       INTEGER (0..7)
ARFCN-Value5GRA ::=     INTEGER (0..max5GARFCN)

maxBandwidthClass       INTEGER ::= 16      -- Maximum number of supported CA BW classes per band
maxBands                INTEGER ::= 16      -- Maximum number of bands listed in UE caps
maxSimultaneousBands    INTEGER ::= 16      -- Maximum number of simultaneously aggregated bands
maxBandComb             INTEGER ::= 64      -- Maximum number of band combinations.
maxCandidateCell        INTEGER ::= 8
maxSCell                INTEGER ::= 7       -- Maximum number of SCells
max5GARFCN              INTEGER ::= 262143  -- Maximum value of 5GRAN carrier frequency
maxCellReport           INTEGER ::= 8       -- Maximum number of reported cells


maxCellMeas             INTEGER ::= 32      -- Maximum number of entries in each of the
                                            -- cell lists in a measurement object
maxObjectId             INTEGER ::= 32
maxPLMN                 INTEGER ::= 6       -- Maximum number of PLMNs
maxReportConfigId       INTEGER ::= 32
maxServCell             INTEGER ::= 8       -- Maximum number of Serving cells
maxBeamCount            INTEGER ::= 8       -- Maximum number of 5GNB beams to be reported
                                            -- in the measurement report
maxUERXBeamCount        INTEGER ::= 4       -- Maximum number of RSRPs of UE beams for a reported
                                            -- 5GNB beam


-- ASN1STOP
```

– End of 5GRA-RRC-Definitions

```
-- ASN1START

END

-- ASN1STOP
```

7 Variables and constants

7.1 UE variables

NOTE: To facilitate the specification of the UE behavioural requirements, UE variables are represented using ASN.1. Unless explicitly specified otherwise, it is however up to UE implementation how to store the variables. The optionality of the IEs in ASN.1 is used only to indicate that the values may not always be available.

– 5GRAN-*UE-Variables*

This ASN.1 segment is the start of the RA UE variable definitions.

```
-- ASN1START

KT5GRAN-UE-Variables DEFINITIONS AUTOMATIC TAGS ::=

BEGIN

IMPORTS
    CellIdentity,
    C-RNTI,
    MeasId,
    MeasIdToAddModList,
    MeasObjectToAddModList,
    PhysCellId,
    PLMN-Identity,
    QuantityConfig,
    ReportConfigToAddModList,
    maxCellMeas,
    maxMeasId,
    CandidateCellInfoList

FROM KT5GRAN-RRC-Definitions;

-- ASN1STOP
```

– *VarMeasConfig*

The UE variable *VarMeasConfig* includes the accumulated configuration of the measurements to be performed by the UE, covering intra-frequency related measurements.

VarMeasConfig UE variable

```
-- ASN1START

VarMeasConfig ::=                   SEQUENCE {
    -- Measurement identities
    measIdList                          MeasIdToAddModList                  OPTIONAL,
    -- Measurement objects
    measObjectList                      MeasObjectToAddModList              OPTIONAL,
    -- Reporting configurations
    reportConfigList                    ReportConfigToAddModList            OPTIONAL,
    -- Other parameters
    quantityConfig                      QuantityConfig                      OPTIONAL,
    s-Measure                           INTEGER (-140..-44)                 OPTIONAL


}

-- ASN1STOP
```

– *VarMeasReportList*

The UE variable VarMeasReportList includes information about the measurements for which the triggering conditions have been met.

***VarMeasReportList* UE variable**

```
-- ASN1START

VarMeasReportList ::=               SEQUENCE (SIZE (1..maxMeasId)) OF VarMeasReport

VarMeasReport ::=                   SEQUENCE {
    -- List of measurement that have been triggered
    measId                              MeasId,
    cellsTriggeredList                  CellsTriggeredList              OPTIONAL,
    numberOfReportsSent                 INTEGER
}

CellsTriggeredList ::=              SEQUENCE (SIZE (1..maxCellMeas)) OF CHOICE {
    physCellId5GRA                          PhysCellId
}
```

```
-- ASN1STOP
```

– *VarShortMAC-Input*

The UE variable VarShortMAC-Input specifies the input used to generate the shortMAC-I.

***VarShortMAC-Input* UE variable**

```
-- ASN1START

VarShortMAC-Input ::=                   SEQUENCE {
    cellIdentity                            CellIdentity,
    physCellId                              PhysCellId,
    c-RNTI                                  C-RNTI
}
-- ASN1STOP
```

***VarShortMAC-Input* field descriptions**
cellIdentity Set to CellIdentity of the current cell.
c-RNTI Set to C-RNTI that the UE had in the PCell it was connected to prior to the failure.
physCellId Set to the physical cell identity of the PCell the UE was connected to prior to the failure.

– End of *5GRA-UE-Variables*

```
-- ASN1START

END

-- ASN1STOP
```

7.2 Timers

Timer	Start	Stop	At expiry
T300	Transmission of *RRCConnectionRequest*	Reception of *RRCConnectionSetup* or *RRCConnectionReject* message, cell re-selection and upon abortion of connection establishment by upper layers	Perform the actions as specified in 5.3.3.6
T301	Transmission of *RRCConnectionReestablishmentRequest*	Reception of *RRCConnectionReestablishment* or *RRCConnectionReestablishmentReject* message as well as when the selected cell becomes unsuitable	Go to RRC_IDLE
T302	Reception of *RRCConnectionReject* while performing RRC connection establishment	Upon entering RRC_CONNECTED and upon cell re-selection	Inform upper layers about barring alleviation as specified in 5.3.3.7
T304	Reception of *RRCConnectionReconfiguration* message including the *MobilityControl Info*	Criterion for successful completion of handover within 5G-RAN, handover to 5G-RAN	In case of intra5G-RAN handover in non-standalone mode, send the *RRCConnectionFailure* message. In case of intra5G-RAN handover in standalone mode, initiate the RRC connection re-establishment procedure
T310	Upon detecting physical layer problems for the PCell i.e. upon receiving N310 consecutive out-of-sync indications from lower layers	Upon receiving N311 consecutive in-sync indications from lower layers for the PCell, upon triggering the handover procedure and upon initiating the connection re-establishment procedure	If security is not activated: go to RRC_IDLE else: initiate the connection re-establishment procedure
T311	Upon initiating the RRC connection re-establishment procedure	Selection of a suitable 5GRA cell.	Enter RRC_IDLE
T312	Upon triggering a measurement report for a measurement identity for which T312 has been configured, while T310 is running	Upon receiving N311 consecutive in-sync indications from lower layers, upon triggering the handover procedure, upon initiating the connection re-establishment procedure, and upon the expiry of T310	If security is not activated: go to RRC_IDLE else: initiate the connection re-establishment procedure

7.3 Constants

Constant	Usage
N310	Maximum number of consecutive "out-of-sync" indications for the PCell received from lower layers
N311	Maximum number of consecutive "in-sync" indications for the PCell received from lower layers

8 Protocol data unit abstract syntax

8.1 General

The RRC PDU contents in clause 6 and clause 10 are described using abstract syntax notation one (ASN.1) as specified in ITU-T Rec. X.680 [13] and X.681 [14]. Transfer syntax for RRC PDUs is derived from their ASN.1 definitions by use of Packed Encoding Rules, unaligned as specified in ITU-T Rec. X.691 [15].

The following encoding rules apply in addition to what has been specified in X.691:

- When a bit string value is placed in a bit-field as specified in 15.6 to 15.11 in X.691, the leading bit of the bit string value shall be placed in the leading bit of the bit-field, and the trailing bit of the bit string value shall be placed in the trailing bit of the bit-field.

NOTE: The terms 'leading bit' and 'trailing bit' are defined in ITU-T Rec. X.680. When using the 'bstring' notation, the leading bit of the bit string value is on the left, and the trailing bit of the bit string value is on the right.

- When decoding types constrained with the ASN.1 Contents Constraint ("CONTAINING"), automatic decoding of the contained type should not be performed because errors in the decoding of the contained type should not cause the decoding of the entire RRC message PDU to fail. It is recommended that the decoder first decodes the outer PDU type that contains the OCTET STRING or BIT STRING with the Contents Constraint, and then decodes the contained type that is nested within the OCTET STRING or BIT STRING as a separate step.

- When decoding a) RRC message PDUs, b) BIT STRING constrained with a Contents Constraint, or c) OCTET STRING constrained with a Contents Constraint, PER decoders are required to never report an error if there are extraneous zero or non-zero bits at the end of the encoded RRC message PDU, BIT STRING or OCTET STRING.

8.2 Structure of encoded RRC messages

An RRC PDU, which is the bit string that is exchanged between peer entities/ across the radio interface contains the basic production as defined in X.691.

RRC PDUs shall be mapped to and from PDCP SDUs (in case of DCCH) or RLC SDUs (in case of PCCH, BCCH, CCCH or MCCH) upon transmission and reception as follows:

- when delivering an RRC PDU as an PDCP SDU to the PDCP layer for transmission, the first bit of the RRC PDU shall be represented as the first bit in the PDCP SDU and onwards; and

- when delivering an RRC PDU as an RLC SDU to the RLC layer for transmission, the first bit of the RRC PDU shall be represented as the first bit in the RLC SDU and onwards; and

- upon reception of an PDCP SDU from the PDCP layer, the first bit of the PDCP SDU shall represent the first bit of the RRC PDU and onwards; and

- upon reception of an RLC SDU from the RLC layer, the first bit of the RLC SDU shall represent the first bit of the RRC PDU and onwards.

8.3 Basic production

The 'basic production' is obtained by applying UNALIGNED PER to the abstract syntax value (the ASN.1 description) as specified in X.691. It always contains a multiple of 8 bits.

8.4 Extension

The following rules apply with respect to the use of protocol extensions:

- A transmitter compliant with this version of the specification shall, unless explicitly indicated otherwise on a PDU type basis, set the extension part empty. Transmitters compliant with a later version may send non-empty extensions;

- A transmitter compliant with this version of the specification shall set spare bits to zero;

8.5 Padding

If the encoded RRC message does not fill a transport block, the RRC layer shall add padding bits. This applies to PCCH and BCCH.

Padding bits shall be set to 0 and the number of padding bits is a multiple of 8.

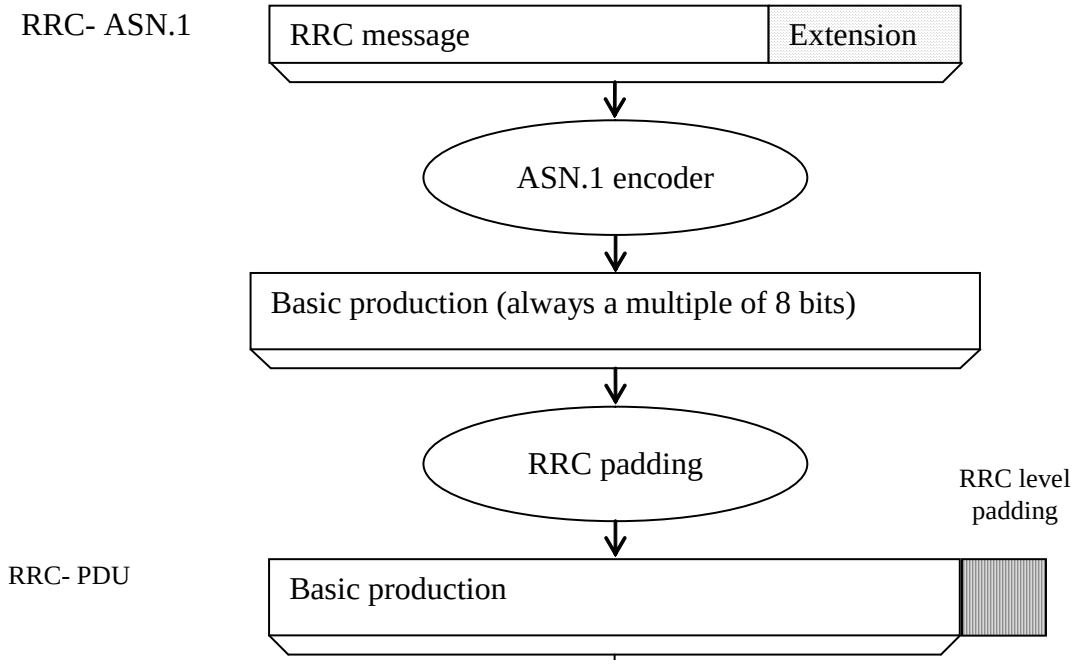

Figure 8.5-1: RRC level padding

9 Specified and default radio configurations

9.1 Specified configurations

9.2 Default radio configurations

The following sections only list default values for REL-1 parameters included in protocol version v1.0. For all fields introduced in a later protocol version, the default value is "released" unless explicitly specified otherwise. If UE is to apply default configuration while it is configured with some critically extended fields, the UE shall apply the original version with only default values. For the following fields, introduced in a protocol version later than v1.0, the default corresponds with "value not applicable":

NOTE 1: Value "N/A" indicates that the UE does not apply a specific value (i.e. upon switching to a default configuration, 5G-RAN cannot assume the UE keeps the previously configured value). This implies that 5G-RAN needs to configure a value before invoking the related functionality.

NOTE 2: In general, the signalling should preferably support a "release" option for fields introduced after v1.0. The "value not applicable" should be used restrictively, mainly limited to for fields which value is relevant only if another field is set to a value other than its default.

9.2.1 SRB configurations

9.2.1.1 SRB1

Parameters

Name	Value	Semantics description	Ver
RLC configuration CHOICE	AM		
ul-RLC-Config *>t-PollRetransmit* *>pollPDU* *>pollByte* *>maxRetxThreshold*	 ms45 infinity infinity t4		
dl-RLC-Config *>t-Reordering* *>t-StatusProhibit*	 ms35 ms0		
Logical channel configuration			
priority	1	Highest priority	
prioritisedBitRate	infinity		
bucketSizeDuration	N/A		
logicalChannelGroup	0		

9.2.1.2 SRB2

Parameters

Name	Value	Semantics description	Ver
RLC configuration CHOICE	AM		
ul-RLC-Config *>t-PollRetransmit* *>pollPDU* *>pollByte* *>maxRetxThreshold*	 ms45 infinity infinity t4		
dl-RLC-Config *>t-Reordering* *>t-StatusProhibit*	 ms35 ms0		
Logical channel configuration			
priority	3		
prioritisedBitRate	infinity		
bucketSizeDuration	N/A		
logicalChannelGroup	0		

9.2.2 Default MAC main configuration

Parameters

Name	Value	Semantics description	Ver
MAC main configuration			
periodicBSR-Timer	infinity		
retxBSR-Timer	sf2560		
drx-Config	release		
phr-Config	release		

9.2.3 Default physical channel configuration

Parameters

Name	Value	Semantics description	Ver
PDSCH-ConfigDedicated *>p-a*	 dB0		
PUCCH-ConfigDedicated *> tdd-AckNackFeedbackMode* *>ackNackRepetition*	 bundling release	Only valid for TDD mode	
PUSCH-ConfigDedicated *>betaOffset-ACK-Index*	 10		

Name	Value	Semantics description	Ver
>betaOffset-RI-Index *>betaOffset-CQI-Index*	12 15		
UplinkPowerControlDedicated *>p0-UE-PUSCH* *>deltaMCS-Enabled* *>accumulationEnabled* *>p0-UE-PUCCH* *>pSRS-Offset* *> filterCoefficient*	 0 en0 (disabled) TRUE 0 7 fc4		
tpc-pdcch-ConfigPUCCH	release		
tpc-pdcch-ConfigPUSCH	release		
CQI-ReportConfig *> CQI-ReportPeriodic* *> cqi-ReportModeAperiodic* *> nomPDSCH-RS-EPRE-Offset*	 release N/A N/A		
SoundingRS-UL-ConfigDedicated	release		
AntennaInfoDedicated *>transmissionMode* *>codebookSubsetRestriction* *>ue-TransmitAntennaSelection*	 tm1, tm2 N/A release	 If the number of PBCH antenna ports is one, tm1 is used as default; otherwise tm2 is used as default	
SchedulingRequestConfig	release		

9.2.4 Default values timers and constants

Parameters

Name	Value	Semantics description	Ver
t300	ms1000		
t301	ms1000		
t310	ms1000		
n310	n1		
t311	ms1000		
n311	n1		

9.2.5 Default Configurations for *XSystemInformationBlock*

This section gives default configurations that UE applies when corresponding Configuration ID is broadcasted in *XSystemInformationBlock*

Name	Value	Value	Value
Default Configuration ID	0	1	2
Q-RxLevMin	X	Y	z
P-Max	X	Y	z
RACH-ConfigCommon > numberOfRA-Preambles > powerRampingStep > preambleInitialReceivedTargetPower > PreambleTransMax > ra-ResponseWindowSize > mac-ContentionResolutionTimer			
PRACH-Config > prach-ConfigIndex > preambleFormat			
PDSCH-ConfigCommon > beamReferenceSignalPower > dmrsPrecodingRBGroup			

Name	Value	Value	Value
UplinkPowerControlCommon > p0-NominalPUSCH > alpha > p0-NominalPUCCH > deltaPreambleMsg3			

10 Void

11 UE capability related constraints and performance requirements

Annex A (informative): Guidelines, mainly on use of ASN.1