**3GPP TSG-RAN WG2 Meeting #118 electronic R2-220xxxx**

**E-Meeting, 9th – 20th May, 2022**

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| *CR-Form-v12.2* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | **38.321** | **CR** | **1261** | **rev** | **1** | **Current version:** | **17.0.0** |  |
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| *For* [***HELP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **x** | Radio Access Network | **x** | Core Network |  |

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| ***Title:*** | MAC Corrections on feMIMO | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Samsung | | | | | | | | | |
| ***Source to TSG:*** | R2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_feMIMO-Core | | | | |  | ***Date:*** | | | 2022-04-25 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | **F** |  | | | | | ***Release:*** | | | Rel-17 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | The changes included in this CR aim to correct the functional corrections and minor errors in the specification.  In RAN2#118 meeting, following agreements are made:  Genearl   1. For Truncated Enhanced BFR MAC CE, BFR information of both TRPs of SpCell is included first before BFR information of SCell. 2. Which type of PHR MAC CE should be generated depend on the feature configuration, i.e., whether either mpe-Reporting-FR2-r17 or twoPHRMode-r17 is configured. Further details FFS 3. Specify the behaviour to obtain the value for MPEi field and SSBRIi or CRIi field, with the feature configuration, as procedure text. 4. Specify the behaviour to obtain PH value by distinguishing SRS-resource set for sTRP and mTRP. 5. R2 assumes no (or very limited) specification change for SP SRS Activation/Deactivation MAC CE i.e. gNB deactivates the SP SRS resource set for antenna switching before the new SP SRS resource set is activated.   BFD-RS Indication MAC CE   1. Support the MAC CE based BFD-RS activation mechanism as below:  * NW configures the candidate BFD-RS resources per set via RRC signaling; * The max number of the BFD-RS per set (i.e. *maxNrofBFDResourcePerSet-r17*) is 64; * The new MAC CE is introduced to indicate the actual used BFD-RS resources per set; * The MAC-CE is to activate 1 or 2 out of the (maximum of) 64 configured BFD-RS resources from the set.  1. For the BFD-RS indication MAC CE design, agree the following principles:  * The MAC CE is designed in the per CC per BWP granularity; * The MAC CE includes 1 or 2 BFD-RS resources out of the configured BFD-RS resources from the set; * The MAC CE should indicate whether 1 or 2 BFD-RS resources are activated per set.  1. For the BFD-RS indication MAC CE design, agree the following principles:  * The MAC CE always includes the all the activated BFD-RS of two sets; * UE deactivates all the previous activated BFD-RS upon receiving the new MAC CE.  1. Take the following BFD-RS indication MAC CE format (in R2-2206577) with the variable length design as baseline.   SRS indication MAC CE   1. For the SRS TCI state indication, introduce a new MAC CE (SP/AP SRS TCI State Indication MAC CE) corresponding to Enhanced SP/AP SRS Spatial Relation Indication MAC CE. 2. For the SRS TCI state indication, introduce a new MAC CE (Serving Cell Set based SRS TCI State Indication MAC CE) corresponding to Serving Cell Set based SRS Spatial Relation Indication MAC CE. 3. The field F\_i is replaced by a reserved bit in the new MAC CE. 4. The new MAC CE(s) are identified by a MAC subheader with a new eLCID(s). 5. The proposed MAC CE (in R2-2206443) is the baseline.   MPE MAC CE   1. For MPE MAC CE, Beam presence indication (i.e. Bi field) is needed and indicates the presence of {SSBRI/CRI new MPE/R} for this beam.   PHR   1. Clarify that the index of the TRP is SRS resource set id. Order of two PHs for a serving cell is set based on SRS resource set id. 2. If twoPHRMode is configured for one MAC entity, the UE shall reporttwo PHRs for all activated serving cells configured with mTRP PUSCH repetition belonging to this MAC entity, and one PHR for activated serving cells with sTRP PUSCH belonging to this MAC entity. 3. If PHR is transmitted towards a MAC entity NOT configured with twoPHRMode (LTE or NR):  * Legacy PHR MAC CE is generated. * For all Serving Cells across the different MAC entities: * UE should report one PH value for all serving cells  1. If PHR is transmitted towards a MAC entity configured with twoPHRMode:  * Enhanced PHR MAC CE is generated.   For all Serving Cells of different MAC entities:   * UE should report one or two PH values for the serving cell belonging to the MAC entity which is configured with twoPHRMode, acc to P9. * UE should report one PH value for the serving cell belonging to the MAC entity which is not configured twoPHRMode  1. gNB knows how many PH values are present in serving cell(s) in case of DC by being informed of configuration by inter-node message. 2. RAN2 confirms that the PCMAX,f,c value should be kept only one for each serving cell, if UE is configured with twoPHRMode with the mTRP PUSCH repetition.   BFD/BFR   1. Agree below proposals:  * All BFRs triggered for an SCell shall be cancelled when a MAC PDU is transmitted and this PDU includes an Enhanced BFR MAC CE or Truncated Enhanced BFR MAC CE which contains beam failure information of that SCell. * If the Serving Cell is SCell and a PDCCH addressed to C-RNTI indicating uplink grant for a new transmission is received for the HARQ process used for the transmission of the Enhanced BFR MAC CE or Truncated Enhanced BFR MAC CE which contains beam failure recovery information of this Serving Cell, the MAC entity shall set BFI\_COUNTER to 0, consider the Beam Failure Recovery procedure successfully completed and cancel all the triggered BFRs for this Serving Cell. * The MAC entity shall cancel the pending SR and stop the corresponding sr-ProhibitTimer, if running, if this SR was triggered by beam failure recovery of an SCell and a MAC PDU is transmitted and this PDU includes an Enhanced BFR MAC CE or a Truncated Enhanced BFR MAC CE which contains beam failure recovery information for this SCell. * The MAC entity may stop, if any, ongoing Random Access procedure due to a pending SR for BFR of an SCell, which has no valid PUCCH resources configured, if a MAC PDU is transmitted using a UL grant other than a UL grant provided by Random Access Response or a UL grant determined for the transmission of the MSGA payload, and this PDU contains an Enhanced BFR MAC CE or a Truncated Enhanced BFR MAC CE which includes beam failure recovery information of that SCell.  1. Changes for section 5.17 in [R2-2205837](https://nokia.sharepoint.com/sites/Users/mtk65284/Documents/3GPP/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205837.zip) are agreed. 2. Proposed changes for section 6.1.3.43 in [R2-2205837](https://nokia.sharepoint.com/sites/Users/mtk65284/Documents/3GPP/tsg_ran/WG2_RL2/TSGR2_118-e/Docs/R2-2205837.zip) are agreed. 3. In order to avoid the issue of NW not being able to deduce if the SpCell BFR happened to both BFD-RS sets, LCID is used for Enhanced Truncated BFR MAC CE with 1 octet Ci field. 4. Agree the following changes for section 6.1.3.43  * For Enhanced BFR MAC CE, a single octet Ci bitmap is used when the highest ServCellIndex of this MAC entity's SCell for which beam failure is detected for SCell or for at least one BFD-RS set of SCell and the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed is less than 8, otherwise four octets Ci bitmap is used. * For Truncated Enhanced BFR MAC CE, a single octet Ci bitmap is used for the following cases, otherwise four octets Ci bitmap is used:   - the highest *ServCellIndex* of this MAC entity's SCell for which beam failure is detected is detected for SCell or for at least one BFD-RS set of SCell and the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed is less than 8; | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | This CR includes the following change:   * Add abbreviation of “TRP” in 3.2. * Change the field name of candidateBeamresourceList/ candidateBeamresourceList2 to candidateBeamRSList-r17/ *candidateBeamRSList2-r17* * Introduce the new BFD-RS indication MAC CE (in 5.18.XX and 6.1.3.xx) * Introduce the new SP/AP SRS TCI State Indication MAC CE (in 5.18.7. and 6.1.3.aa) * Introduce the new Serving Cell Set based SRS TCI State Indication MAC CE (in 5.18.16. and 6.1.3.bb) * In 5.4.6, specifiy the procedures for PHR operations  1. Which type of PHR MAC CE should be generated depend on the feature configuration, i.e., whether either mpe-Reporting-FR2-r17 or twoPHRMode-r17 is configured. Further details FFS 2. Specify the behaviour to obtain the value for MPEi field and SSBRIi or CRIi field, with the feature configuration, as procedure text. 3. Specify the behaviour to obtain PH value by distinguishing SRS-resource set for sTRP and mTRP.  * In 5.17, procedure update applying the agreements for BFD/BFR, * In 6.1.3.50/51, MAC CE format update and the revision of descriptions applying the agreements for mTRP PHR. * In 6.2.1, update the tables for 6.2.1-1b, 6.2.1-2 and 6.2.1-2b for newly added MAC CEs. | | | | | | | | |
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| ***Consequences if not approved:*** | | Miscellaneous non-controversial errors will remain in the specification. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 3.2, 5.4.4,5.4.6, 5.17, 5.18.22, 5.18.xx, 6.13.17, 6.13.26, 6.1.3.43, 6.13. 48, 6.1.3.49, 6.1.3.50, 6.1.3.51, 6.1.3.xx, 6.1.3.aa,6.1.3.bb, 6.2.1 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  | **X** | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  | **X** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

START OF CHANGE

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**Dormant BWP:** The dormant BWP is one of downlink BWPs configured by the network via dedicated RRC signaling. In the dormant BWP, the UE stop monitoring PDCCH on/for the SCell, but continues performing CSI measurements, Automatic Gain Control (AGC) and beam management, if configured.

**DRX group:** A group of Serving Cells that is configured by RRC and that have the same DRX Active Time.

**HARQ information:** HARQ information for DL-SCH, for UL-SCH, or for SL-SCH transmissions consists of New Data Indicator (NDI), Transport Block Size (TBS), Redundancy Version (RV), and HARQ process ID.

**IAB-donor:** gNB that provides network access to UEs via a network of backhaul and access links.

**IAB-node:** RAN node that supports NR access links to UEs and NR backhaul links to parent nodes and child nodes.

**Listen Before Talk**: A procedure according to which transmissions are not performed if the channel is identified as being occupied, see TS 37.213 [18].

**Msg3**: Message transmitted on UL-SCH containing a C-RNTI MAC CE or CCCH SDU, submitted from upper layer and associated with the UE Contention Resolution Identity, as part of a Random Access procedure.

**Non-terrestrial network:** An NG-RAN consisting of gNBs, which provide non-terrestrial NR access to UEs by means of an NTN payload embarked on an airborne or space-borne NTN vehicle and an NTN Gateway.

**NR backhaul link:** NR link used for backhauling between an IAB-node and an IAB-donor, and between IAB-nodes in case of a multi-hop backhauling.

**NR sidelink communication**: AS functionality enabling at least V2X Communication as defined in TS 23.287 [19], between two or more nearby UEs, using NR technology but not traversing any network node.

**PDCCH occasion**: A time duration (i.e. one or a consecutive number of symbols) during which the MAC entity is configured to monitor the PDCCH.

**PRS Processing Window**: A time window during which UE may perform PRS measurement inside the active DL BWP with the same numerology as the active DL BWP without measurement gap.

**RedCap UE:** A UE with reduced capabilities as specified in clause 4.2.21.1 in TS 38.306 [25].

**Serving Cell:** A PCell, a PSCell, or an SCell in TS 38.331 [5].

**Sidelink transmission information:** Sidelink transmission information included in an SCI for an SL-SCH transmission as specified in clause 8.3 and 8.4 of TS 38.212 [9] consists of Sidelink HARQ information including NDI, RV, Sidelink process ID, HARQ feedback enabled/disabled indicator, Sidelink identification information including cast type indicator, Source Layer-1 ID and Destination Layer-1 ID, and Sidelink other information including CSI request, a priority, a communication range requirement and Zone ID.

**Special Cell:** For Dual Connectivity operation the term Special Cell refers to the PCell of the MCG or the PSCell of the SCG depending on if the MAC entity is associated to the MCG or the SCG, respectively. Otherwise the term Special Cell refers to the PCell. A Special Cell supports PUCCH transmission and contention-based Random Access, and is always activated.

**Timing Advance Group:** A group of Serving Cells that is configured by RRC and that, for the cells with a UL configured, using the same timing reference cell and the same Timing Advance value. A Timing Advance Group containing the SpCell of a MAC entity is referred to as Primary Timing Advance Group (PTAG), whereas the term Secondary Timing Advance Group (STAG) refers to other TAGs.

**U2N Relay UE:** a UE that provides functionality to support connectivity to the network for U2N Remote UE(s).

**U2N Remote UE:** a UE that communicates with the network via a U2N Relay UE.

**UE-gNB RTT:** For non-terrestrial networks, the sum of the UE's Timing Advance value (see TS 38.211 [8] clause 4.3.1) and *kmac* provided in *NTN-Config*.

**V2X sidelink communication**: AS functionality enabling V2X Communication as defined in TS 23.285 [20], between nearby UEs, using E-UTRA technology but not traversing any network node.

NOTE 1: A timer is running once it is started, until it is stopped or until it expires; otherwise it is not running. A timer can be started if it is not running or restarted if it is running. A Timer is always started or restarted from its initial value. The duration of a timer is not updated until it is stopped or expires (e.g. due to BWP switching). When the MAC entity applies zero value for a timer, the timer shall be started and immediately expire unless explicitly stated otherwise.

NOTE 2: In this version of the specification, the SRS in the procedural description includes Positioning SRS except for the Positioning SRS for transmission in RRC\_INACTIVE as in clause 5.26. Positioning SRS except for the Positioning SRS for transmission in RRC\_INACTIVE is treated the same as SRS by the UE unless explicitly stated otherwise.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

AP Aperiodic

BFR Beam Failure Recovery

BSR Buffer Status Report

BWP Bandwidth Part

CE Control Element

CG Cell Group

CG-SDT Configured Grant-based SDT

CI-RNTI Cancellation Indication RNTI

CSI Channel State Information

CSI-IM CSI Interference Measurement

CSI-RS CSI Reference Signal

CS-RNTI Configured Scheduling RNTI

DAPS Dual Active Protocol Stack

DCP DCI with CRC scrambled by PS-RNTI

DL-PRS DownLink-Positioning Reference Signal

G-CS-RNTI Group Configured Scheduling RNTI

G-RNTI Group RNTI

IAB Integrated Access and Backhaul

INT-RNTI Interruption RNTI

LBT Listen Before Talk

LCG Logical Channel Group

LCP Logical Channel Prioritization

MBS Multicast/Broadcast Services

MCCH MBS Control Channel

MCCH-RNTI MBS Control Channel RNTI

MCG Master Cell Group

MPE Maximum Permissible Exposure

MTCH MBS Traffic Channel

NUL Normal Uplink

NZP CSI-RS Non-Zero Power CSI-RS

PDB Packet Delay Budget

PHR Power Headroom Report

PS-RNTI Power Saving RNTI

PTAG Primary Timing Advance Group

PTM Point to Multipoint

PTP Point to Point

QCL Quasi-colocation

PPW PRS Processing Window

PRS Positioning Reference Signal

RA-SDT Random Access-based SDT

RS Reference Signal

SCG Secondary Cell Group

SDT Small Data Transmission

SFI-RNTI Slot Format Indication RNTI

SI System Information

SL-RNTI Sidelink RNTI

SLCS-RNTI Sidelink Configured Scheduling RNTI

SpCell Special Cell

SP Semi-Persistent

SP-CSI-RNTI Semi-Persistent CSI RNTI

SPS Semi-Persistent Scheduling

SR Scheduling Request

SS Synchronization Signals

SSB Synchronization Signal Block

STAG Secondary Timing Advance Group

SUL Supplementary Uplink

TAG Timing Advance Group

TCI Transmission Configuration Indicator

TPC-SRS-RNTI Transmit Power Control-Sounding Reference Signal-RNTI

TRIV Time Resource Indicator Value

TRP Transmit/Receive Point

TRS CSI-RS for tracking

U2N UE-to-Network

UCI Uplink Control Information

V2X Vehicle-to-Everything

ZP CSI-RS Zero Power CSI-RS

# 5 MAC procedures

## 5.1 Random Access procedure

Editor's NOTE: Msg.1 based early identification captured in 5.1.1 and 5.1.1a part will be handled together with other features (e.g. coverage, slicing, SDT, etc.) in common MAC running CR for RACH indication and partitioning.

### 5.1.1 Random Access procedure initialization

The Random Access procedure described in this clause is initiated by a PDCCH order, by the MAC entity itself, or by RRC for the events in accordance with TS 38.300 [2]. There is only one Random Access procedure ongoing at any point in time in a MAC entity. The Random Access procedure on an SCell shall only be initiated by a PDCCH order with *ra-PreambleIndex* different from 0b000000.

NOTE 1: If a new Random Access procedure is triggered while another is already ongoing in the MAC entity, it is up to UE implementation whether to continue with the ongoing procedure or start with the new procedure (e.g. for SI request).

NOTE 2: If there was an ongoing Random Access procedure that is triggered by a PDCCH order while the UE receives another PDCCH order indicating the same Random Access Preamble, PRACH mask index and uplink carrier, the Random Access procedure is considered as the same Random Access procedure as the ongoing one and not initialized again.

When a Random Access procedure is initiated, UE selects a set of Random Access resources as specified in clause 5.1.1b and initialises the following parameters for the Random Access procedure according to the values configured by RRC for the selected set of Random Access resources:

- *prach-ConfigurationIndex*: the available set of PRACH occasions for the transmission of the Random Access Preamble for Msg1. These are also applicable to the MSGA PRACH if the PRACH occasions are shared between 2-step and 4-step RA types;

- *prach-ConfigurationPeriodScaling-IAB*: the scaling factor defined in TS 38.211 [8] and applicable to IAB-MTs, extending the periodicity of the PRACH occasions baseline configuration indicated by *prach-ConfigurationIndex*;

- *prach-ConfigurationFrameOffset-IAB*: the frame offset defined in TS 38.211 [8] and applicable to IAB-MTs, altering the ROs frame defined in the baseline configuration indicated by *prach-ConfigurationIndex*;

- *prach-ConfigurationSOffset-IAB*: the subframe/slot offset defined in TS 38.211 [8] and applicable to IAB-MTs, altering the ROs subframe or slot defined in the baseline configuration indicated by *prach-ConfigurationIndex*;

- *msgA-PRACH-ConfigurationIndex*: the available set of PRACH occasions for the transmission of the Random Access Preamble for MSGA in 2-step RA type;

- *preambleReceivedTargetPower*: initial Random Access Preamble power for 4-step RA type;

- *msgA-PreambleReceivedTargetPower*: initial Random Access Preamble power for 2-step RA type;

- *rsrp-ThresholdSSB*: an RSRP threshold for the selection of the SSB for 4-step RA type. If the Random Access procedure is initiated for beam failure recovery, *rsrp-ThresholdSSB* used for the selection of the SSB within *candidateBeamRSList* refers to *rsrp-ThresholdSSB* in *BeamFailureRecoveryConfig* IE;

- *rsrp-ThresholdCSI-RS*: an RSRP threshold for the selection of CSI-RS for 4-step RA type. If the Random Access procedure is initiated for beam failure recovery, *rsrp-ThresholdCSI-RS* is equal to *rsrp-ThresholdSSB* in *BeamFailureRecoveryConfig* IE;

- *msgA-RSRP-ThresholdSSB*: an RSRP threshold for the selection of the SSB for 2-step RA type;

- *rsrp-ThresholdSSB-SUL*: an RSRP threshold for the selection between the NUL carrier and the SUL carrier;

*- msgA-RSRP-Threshold*: an RSRP threshold for selection between 2-step RA type and 4-step RA type when both 2-step and 4-step RA type Random Access Resources are configured in the UL BWP;

*- rsrp-ThresholdMsg3*: an RSRP threshold for MSG3 repetition (see clause 5.1.1b);

*- featurePriorities*: priorities for features, such as REDCAP, Slice group(s), etc. (see clause 5.1.1d);

- *msgA-TransMax*: The maximum number of MSGA transmissions when both 4-step and 2-step RA type Random Access Resources are configured;

- *candidateBeamRSList*: a list of reference signals (CSI-RS and/or SSB) identifying the candidate beams for recovery and the associated Random Access parameters;

- *recoverySearchSpaceId*: the search space identity for monitoring the response of the beam failure recovery request;

- *powerRampingStep*: the power-ramping factor;

- *msgA-PreamblePowerRampingStep*: the power ramping factor for MSGA preamble;

- *powerRampingStepHighPriority*: the power-ramping factor in case of prioritized Random Access procedure;

- *scalingFactorBI*: a scaling factor for prioritized Random Access procedure;

- *ra-PreambleIndex*: Random Access Preamble;

- *ra-ssb-OccasionMaskIndex*: defines PRACH occasion(s) associated with an SSB in which the MAC entity may transmit a Random Access Preamble (see clause 7.4);

- *msgA-SSB-SharedRO-MaskIndex*: Indicates the subset of 4-step RA type PRACH occasions shared with 2-step RA type PRACH occasions for each SSB. If 2-step RA type PRACH occasions are shared with 4-step RA type PRACH occasions and *msgA-SSB-SharedRO-MaskIndex* is not configured, then all 4-step RA type PRACH occasions are available for 2-step RA type (see clause 7.4);

- *ra-OccasionList*: defines PRACH occasion(s) associated with a CSI-RS in which the MAC entity may transmit a Random Access Preamble;

- *ra-PreambleStartIndex*: the starting index of Random Access Preamble(s) for on-demand SI request;

- *startPreambleForThisPartition*: the first preamble associated with the set of Random Access Resources applicable to the Random Access procedure;

- *preambleTransMax*: the maximum number of Random Access Preamble transmission;

- *ssb-perRACH-OccasionAndCB-PreamblesPerSSB*: defines the number of SSBs mapped to each PRACH occasion for 4-step RA type and the number of contention-based Random Access Preambles mapped to each SSB;

- *msgA-CB-PreamblesPerSSB-PerSharedRO*: defines the number of contention-based Random Access Preambles for 2-step RA type mapped to each SSB when the PRACH occasions are shared between 2-step and 4-step RA types;

- *msgA-SSB-PerRACH-OccasionAndCB-PreamblesPerSSB*: defines the number of SSBs mapped to each PRACH occasion for 2-step RA type and the number of contention-based Random Access Preambles mapped to each SSB;

- *numberOfPreamblesForThisPartition*: the number of consequtive preambles associated with the set of Random Access Resources applicable to the Random Access procedure;

- *msgA-PUSCH-ResourceGroupA*: defines MSGA PUSCH resources that the UE shall use when performing MSGA transmission using Random Access Preambles group A;

- *msgA-PUSCH-ResourceGroupB*: defines MSGA PUSCH resources that the UE shall use when performing MSGA transmission using Random Access Preambles group B;

- *msgA-PUSCH-Resource-Index*: identifies the index of the PUSCH resource used for MSGA in case of contention-free Random Access with 2-step RA type;

- if *groupBconfigured* is configured, then Random Access Preambles group B is configured for 4-step RA type.

- Amongst the contention-based Random Access Preambles associated with an SSB (as defined in TS 38.213 [6]), the first *numberOfRA-PreamblesGroupA* included in *groupBconfigured* Random Access Preambles belong to Random Access Preambles group A. The remaining Random Access Preambles associated with the SSB belong to Random Access Preambles group B (if configured).

- if *groupB-ConfiguredTwoStepRA* is configured, then Random Access Preambles group B is configured for 2-step RA type.

- Amongst the contention-based Random Access Preambles for 2-step RA type associated with an SSB (as defined in TS 38.213 [6]), the first *numberOfRA-PreamblesGroupA* included in *GroupB-ConfiguredTwoStepRA* Random Access Preambles belong to Random Access Preambles group A. The remaining Random Access Preambles associated with the SSB belong to Random Access Preambles group B (if configured).

NOTE 3: If Random Access Preambles group B is supported by the cell Random Access Preambles group B is included for each SSB.

- if Random Access Preambles group B is configured for 4-step RA type:

- *ra-Msg3SizeGroupA*: the threshold to determine the groups of Random Access Preambles for 4-step RA type;

- *msg3-DeltaPreamble*: ∆*PREAMBLE\_Msg3* in TS 38.213 [6];

- *messagePowerOffsetGroupB*: the power offset for preamble selection included in *groupBconfigured*;

- *numberOfRA-PreamblesGroupA*: defines the number of Random Access Preambles in Random Access Preamble group A for each SSB included in *groupBconfigured*.

- if Random Access Preambles group B is configured for 2-step RA type:

- *msgA-DeltaPreamble*: ∆*MsgA\_PUSCH* in TS 38.213 [6];

- *messagePowerOffsetGroupB*: the power offset for preamble selection included in *GroupB-ConfiguredTwoStepRA*;

- *numberOfRA-PreamblesGroupA*: defines the number of Random Access Preambles in Random Access Preamble group A for each SSB included in *GroupB-ConfiguredTwoStepRA*;

- *ra-MsgA-SizeGroupA*: the threshold to determine the groups of Random Access Preambles for 2-step RA type.

- the set of Random Access Preambles and/or PRACH occasions for SI request, if any;

- the set of Random Access Preambles and/or PRACH occasions for beam failure recovery request, if any;

- the set of Random Access Preambles and/or PRACH occasions for reconfiguration with sync, if any;

- *ra-ResponseWindow*: the time window to monitor RA response(s) (SpCell only);

- *ra-ContentionResolutionTimer*: the Contention Resolution Timer (SpCell only);

- *msgB-ResponseWindow*: the time window to monitor RA response(s) for 2-step RA type (SpCell only);

- *ta-Report*: indicates whether Timing Advance reporting during Random Access procedure is enabled (see clause 5.4.8).

In addition, the following information for related Serving Cell is assumed to be available for UEs:

- if Random Access Preambles group B is configured:

- if the Serving Cell for the Random Access procedure is configured with supplementary uplink as specified in TS 38.331 [5], and SUL carrier is selected for performing Random Access Procedure:

- PCMAX,f,c of the SUL carrier as specified in TS 38.101-1 [14], TS 38.101-2 [15], and TS 38.101-3 [16].

- else:

- PCMAX,f,c of the NUL carrier as specified in TS 38.101-1 [14], TS 38.101-2 [15], and TS 38.101-3 [16].

The following UE variables are used for the Random Access procedure:

- *PREAMBLE\_INDEX*;

- *PREAMBLE\_TRANSMISSION\_COUNTER*;

- *PREAMBLE\_POWER\_RAMPING\_COUNTER*;

- *PREAMBLE\_POWER\_RAMPING\_STEP*;

- *PREAMBLE\_RECEIVED\_TARGET\_POWER*;

- *PREAMBLE\_BACKOFF*;

- *PCMAX*;

- *SCALING\_FACTOR\_BI*;

- *TEMPORARY\_C-RNTI*;

- *RA\_TYPE*;

- *POWER\_OFFSET\_2STEP\_RA*;

- *MSGA\_PREAMBLE\_POWER\_RAMPING\_STEP*.

When the Random Access procedure is initiated on a Serving Cell, the MAC entity shall:

1> flush the Msg3 buffer;

1> flush the MSGA buffer;

1> set the *PREAMBLE\_TRANSMISSION\_COUNTER* to 1;

1> set the *PREAMBLE\_POWER\_RAMPING\_COUNTER* to 1;

1> set the *PREAMBLE\_BACKOFF* to 0 ms;

1> set *POWER\_OFFSET\_2STEP\_RA* to 0 dB;

1> if the carrier to use for the Random Access procedure is explicitly signalled:

2> select the signalled carrier for performing Random Access procedure;

2> set the *PCMAX* to PCMAX,f,c of the signalled carrier.

1> else if the carrier to use for the Random Access procedure is not explicitly signalled; and

1> if the Serving Cell for the Random Access procedure is configured with supplementary uplink as specified in TS 38.331 [5]; and

1> if the RSRP of the downlink pathloss reference is less than *rsrp-ThresholdSSB-SUL*:

2> select the SUL carrier for performing Random Access procedure;

2> set the *PCMAX* to PCMAX,f,c of the SUL carrier.

1> else:

2> select the NUL carrier for performing Random Access procedure;

2> set the *PCMAX* to PCMAX,f,c of the NUL carrier.

NOTE 4: The network configures the same value for *rsrp-ThresholdSSB-SUL* in all BWPs. So, the UE can obtain this parameter from any Random Access configuration.

1> perform the BWP operation as specified in clause 5.15;

1> select the set of Random Access resources applicable to the current Random Access procedure according to clause 5.1.1b;

1> if the Random Access procedure is initiated by PDCCH order and if the *ra-PreambleIndex* explicitly provided by PDCCH is not 0b000000; or

1> if the Random Access procedure was initiated for SI request (as specified in TS 38.331 [5]) and the Random Access Resources for SI request have been explicitly provided by RRC; or

1> if the Random Access procedure was initiated for SpCell beam failure recovery (as specified in clause 5.17) and if the contention-free Random Access Resources for beam failure recovery request for 4-step RA type have been explicitly provided by RRC for the BWP selected for Random Access procedure; or

1> if the Random Access procedure was initiated for reconfiguration with sync and if the contention-free Random Access Resources for 4-step RA type have been explicitly provided in *rach-ConfigDedicated* for the BWP selected for Random Access procedure:

2> set the *RA\_TYPE* to *4-stepRA*.

1> else if the BWP selected for Random Access procedure is configured with both 2-step and 4-step RA type Random Access Resources which are available and the RSRP of the downlink pathloss reference is above *msgA-RSRP-Threshold*; or

1> if the BWP selected for Random Access procedure is only configured with 2-step RA type Random Access resources (i.e. no 4-step RACH RA type resources configured); or

1> if the Random Access procedure was initiated for reconfiguration with sync and if the contention-free Random Access Resources for 2-step RA type have been explicitly provided in *rach-ConfigDedicated* for the BWP selected for Random Access procedure:

2> set the *RA\_TYPE* to *2-stepRA*.

1> else:

2> set the *RA\_TYPE* to *4-stepRA*.

1> perform initialization of variables specific to Random Access type as specified in clause 5.1.1a;

1> if *RA\_TYPE* is set to *2-stepRA*:

2> perform the Random Access Resource selection procedure for 2-step RA type (see clause 5.1.2a).

1> else:

2> perform the Random Access Resource selection procedure (see clause 5.1.2).

### 5.1.1a Initialization of variables specific to Random Access type

The MAC entity shall:

1> if *RA\_TYPE* is set to *2-stepRA*:

2> set *PREAMBLE\_POWER\_RAMPING\_STEP* to *msgA-PreamblePowerRampingStep*;

2> set *SCALING\_FACTOR\_BI* to 1;

2> apply *preambleTransMax* included in the *RACH-ConfigGenericTwoStepRA*;

2> if the Random Access procedure was initiated for reconfiguration with sync or for SCG activation; and

2> if *cfra-TwoStep* is configured for the selected carrier:

3> if *msgA-TransMax* is configured in the *cfra-TwoStep*:

4> apply *msgA-TransMax* configured in the *cfra-TwoStep*.

2> else if *msgA-TransMax* is included in the *RACH-ConfigCommonTwoStepRA*:

3> apply *msgA-TransMax* included in the *RACH-ConfigCommonTwoStepRA*.

2> if the Random Access procedure was initiated for SpCell beam failure recovery (as specified in clause 5.17); and

2> if *beamFailureRecoveryConfig* is configured for the active UL BWP of the selected carrier; and

2> if *ra-PrioritizationTwoStep* is configured in the *beamFailureRecoveryConfig*:

3> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority* included in the *ra-PrioritizationTwoStep* in *beamFailureRecoveryConfig*;

3> if *scalingFactorBI* is configured in the *ra-PrioritizationTwoStep* in *beamFailureRecoveryConfig*:

4> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> else if the Random Access procedure was initiated for reconfiguration with sync or for SCG activation; and

2> if *rach-ConfigDedicated* is configured for the selected carrier; and

2> if *ra-PrioritizationTwoStep* is configured in the *rach-ConfigDedicated*:

3> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority* included in the *ra-PrioritizationTwoStep* in *rach-ConfigDedicated*;

3> if *scalingFactorBI* is configured in *ra-PrioritizationTwoStep* in the *rach-ConfigDedicated*:

4> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> else if both *ra-PrioritizationForSlicingTwoStep* for a slice group identity and *ra-PrioritizationForAccessIdentityTwoStep* are configured for the selected carrier; and

2> if the MAC entity is provided by upper layers with both this slice group identity and Access Identity 1 or 2; and

2> if for at least one of these Access Identities the corresponding bit in the *ra-PrioritizationForAI* is set to *one*:

3> if *enableRA-PrioritizationForSlicing* in *BWP-UplinkCommon* is set to *true*:

4> if *powerRampingStepHighPriority* is configured in the *ra-PrioritizationForSlicingTwoStep* for this slice group identity:

5> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority*.

4> if *scalingFactorBI* is configured in the *ra-PrioritizationForSlicingTwoStep* for this slice group identity:

5> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

3> else:

4> if *powerRampingStepHighPriority* is configured in the *ra-PrioritizationForAccessIdentityTwoStep*:

5> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority*.

4> if *scalingFactorBI* is configured in the *ra-PrioritizationForAccessIdentityTwoStep*:

5> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> else if *ra-PrioritizationForSlicingTwoStep* for a slice group identity is configured for the selected carrier; and

2> if the MAC entity is provided by upper layers with this slice group identity:

3> if *powerRampingStepHighPriority* is configured in the *ra-PrioritizationForSlicingTwoStep* for this slice group identity:

4> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority*.

3> if *scalingFactorBI* is configured in the *ra-PrioritizationForSlicingTwoStep* for this slice group identity:

4> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> else if *ra-PrioritizationForAccessIdentityTwoStep* is configured for the selected carrier; and

2> if the MAC entity is provided by upper layers with Access Identity 1 or 2; and

2> if for at least one of these Access Identities the corresponding bit in the *ra-PrioritizationForAI* is set to *one*:

3> if *powerRampingStepHighPriority* is configured in the *ra-PrioritizationForAccessIdentityTwoStep*:

4> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority*.

3> if *scalingFactorBI* is configured in the *ra-PrioritizationForAccessIdentityTwoStep*:

4> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> set *MSGA\_PREAMBLE\_POWER\_RAMPING\_STEP* to *PREAMBLE\_POWER\_RAMPING\_STEP*.

1> else (i.e. *RA\_TYPE* is set to *4-stepRA*):

2> set *PREAMBLE\_POWER\_RAMPING\_STEP* to *powerRampingStep*;

2> set *SCALING\_FACTOR\_BI* to 1;

2> set *preambleTransMax* to *preambleTransMax* included in the *RACH-ConfigGeneric*;

2> if the Random Access procedure was initiated for SpCell beam failure recovery (as specified in clause 5.17); and

2> if *beamFailureRecoveryConfig* is configured for the active UL BWP of the selected carrier:

3> start the *beamFailureRecoveryTimer*, if configured;

3> apply the parameters *powerRampingStep*, *preambleReceivedTargetPower*, and *preambleTransMax* configured in the *beamFailureRecoveryConfig*.

2> if the Random Access procedure was initiated for beam failure recovery (as specified in clause 5.17); and

2> if *beamFailureRecoveryConfig* is configured for the active UL BWP of the selected carrier; and

2> if *ra-Prioritization* is configured in the *beamFailureRecoveryConfig*:

3> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority* included in the *ra-Prioritization* in *beamFailureRecoveryConfig*;

3> if *scalingFactorBI* is configured in *ra-Prioritization* in the *beamFailureRecoveryConfig*:

4> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> else if the Random Access procedure was initiated for reconfiguration with sync or for SCG activation; and

2> if *rach-ConfigDedicated* is configured for the selected carrier; and

2> if *ra-Prioritization* is configured in the *rach-ConfigDedicated*:

3> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority* included in the *ra-Prioritization* in *rach-ConfigDedicated*;

3> if *scalingFactorBI* is configured in *ra-Prioritization* in the *rach-ConfigDedicated*:

4> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> else if both *ra-PrioritizationForSlicing* for a slice group identity and *ra-PrioritizationForAccessIdentity* are configured for the selected carrier; and

2> if the MAC entity is provided by upper layers with both this slice group identity and Access Identity 1 or 2; and

2> if for at least one of these Access Identities the corresponding bit in the *ra-PrioritizationForAI* is set to *one*:

3> if *enableRA-PrioritizationForSlicing* in *BWP-UplinkCommon* is set to *true*:

4> if *powerRampingStepHighPriority* is configured in the *ra-PrioritizationForSlicing* for this slice group identity:

5> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority*.

4> if *scalingFactorBI* is configured in the *ra-PrioritizationForSlicing* for this slice group identity:

5> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

3> else:

4> if *powerRampingStepHighPriority* is configured in the *ra-PrioritizationForAccessIdentity*:

5> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority*.

4> if *scalingFactorBI* is configured in the *ra-PrioritizationForAccessIdentity*:

5> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> else if *ra-PrioritizationForSlicing* for a slice group identity is configured for the selected carrier; and

2> if the MAC entity is provided by upper layers with this slice group identity:

3> if *powerRampingStepHighPriority* is configured in the *ra-PrioritizationForSlicing* for this slice group identity:

4> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority*.

3> if *scalingFactorBI* is configured in the *ra-PrioritizationForSlicing* for this slice group identity:

4> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> else if *ra-PrioritizationForAccessIdentity* is configured for the selected carrier; and

2> if the MAC entity is provided by upper layers with Access Identity 1 or 2; and

2> if for at least one of these Access Identities the corresponding bit in the *ra-PrioritizationForAI* is set to *one*:

3> if *powerRampingStepHighPriority* is configured in the *ra-PrioritizationForAccessIdentity*:

4> set *PREAMBLE\_POWER\_RAMPING\_STEP* to the *powerRampingStepHighPriority*.

3> if *scalingFactorBI* is configured in the *ra-PrioritizationForAccessIdentity*:

4> set *SCALING\_FACTOR\_BI* to the *scalingFactorBI*.

2> if *RA\_TYPE* is switched from *2-stepRA* to *4-stepRA* during this Random Access procedure:

3> set *POWER\_OFFSET\_2STEP\_RA* to (*PREAMBLE\_POWER\_RAMPING\_COUNTER* – 1) × (*MSGA\_PREAMBLE\_POWER\_RAMPING\_STEP* – *PREAMBLE\_POWER\_RAMPING\_STEP*).

NOTE: If *enableRA-PrioritizationForSlicing* is not configured in *BWP-UplinkCommon* and if both the provided slice group identity and the provided Access Identity whose corresponding bit in the *ra-PrioritizationForAI* is set to *one* are configured with *ra-Prioritization* either in *RACH-ConfigCommon* or *RACH-ConfigCommonTwoStepRA*, it is up to UE implementation how to determine the values of *PREAMBLE\_POWER\_RAMPING\_STEP* and *SCALING\_FACTOR\_BI*.

Editor's Note (RAN Slicing): At least for 5.1.1 and 5.1.1a, leave RACH partitioning for Slicing to general MAC CR and capture RA prioritization for Slicing in Slicing MAC CR. Note that all these changes in Slicing MAC CR are subject to the final decisions in the common RACH session, which will reflect in the combined MAC CR.

### 5.1.1b Selection of the set of Random Access resources applicable to the Random Access procedure

The MAC entity shall:

1> if configured for MSG3 repetition and if the RSRP of the downlink pathloss reference is less than *rsrp-ThresholdMsg3*:

2> assume MSG3 repetition is applicable for the current Random Access procedure.

1> else:

2> assume MSG3 repetition is not applicable for the current Random Access procedure.

NOTE: On a given BWP, the network configures the same value for *rsrp-ThresholdMsg3*. So, the UE can obtain this parameter from any Random Access configuration within the BWP selected for the Random Access procedure.

1> if contention-free Random Access Resources have not been provided for this Random Access procedure and one or more of the features including REDCAP and/or a specific slice group(s) and/or SDT and/or MSG3 repetition is applicable for this Random Access procedure:

Editor's Note: FFS if some clarification is needed on how feature applicability is known (e.g. from RRC etc)

2> if none of the sets of Random Access resources are available for the current Random Access procedure (as specified in clause 5.1.1c):

3> select the set of Random Access resources that are not associated with any feature indication (as specified in clause 5.1.1c) for this Random Access procedure.

2> else if there are one or more set(s) of Random Access resources available (as specified in clause 5.1.1c) and one of these set(s) of Random Access resources can be used for indicating all features triggering this Random Access procedure:

3> select the available set of Random Access resources for this Random Access procedure.

2> else (i.e. there are one or more sets of Random Access resources available that are configured with indication(s) for a subset of all features triggering the RACH procedure):

3> select a set of Random Access resources from the available set of Random Access resources based on the priority order indicated in the system information as specified in clause 5.1.1d for this Random Access Procedure.

1> else (i.e. CFRA or none of the REDCAP and/or a specific slice group and/or SDT and or MSG3 repetition is applicable):

2> select the set of Random Access resources that are not associated with any feature indication (as specified in clause 5.1.1c) for the current Random Access procedure.

Editor's Note: FFS if some special handling is needed for the case of fallback from CFRA to CBRA for REDCAP UE

### 5.1.1c Availability of Random Access resource partitions

The MAC entity shall for each set of configured Random Access resources for 4-step RA type and for each set of configured Random Access resources for 2-step RA type:

1> if REDCAP indication is configured for a set of Random Access resources:

2> consider the set of Random Access resources as not available for a RACH procedure for which REDCAP indication is not applicable.

1> if SDT indication is configured for a set of Random Access resources:

2> consider the set of Random Access resources as not available for the RACH procedure which is not triggered for SDT.

1> if slice group indication is configured for a set of Random Access resources:

2> consider the set of Random Access resources as not available for the RACH procedure unless it is triggered for the corresponding slice group indication.

1> if MSG3 repetition indication is configured for a set of Random Access resources:

2> consider the set of Random Access resources as not available for the RACH procedure if MSG3 repetition is not applicable.

1> if a set of Random Access resources is not configured with any of the REDCAP or SDT or slice group(s) or MSG3 repetition indications:

2> consider the set of Random Access resources to not associated with any feature indication.

### 5.1.1d Random Access resources selection based on feature prioritization

The MAC entity shall:

1> among the available sets of Random Access resources, identify those configured with a feature which has the highest priority assigned in *featurePriorities* among all the features applicable to this Random Access procedure as specified in TS 38.331 [5].

1> if a single set of Random Access resources is identified:

2> select this set of Random Access resources.

1> else if more than one set of Random Access resources is identified:

2> repeat the procedure taking as an input the identified subset of sets of Random Access resources and the feature applicable to the current RACH procedure with the highest priority assigned in *featurePriorities* among all the features applicable to this RACH procedure, except the features considered already.

1> else (i.e. no set of Random Access resources is identified):

2> repeat the procedure taking as an input the previous identified available sets of Random Access resources and the feature applicable to the current RACH procedure with the highest priority assigned in *featurePriorities* among all the features applicable to this RACH procedure, except the features considered already.

Editor's Note: FFS if some modification/simplification for the above procedure is needed.

### 5.1.2 Random Access Resource selection

If the selected *RA\_TYPE* is set to *4-stepRA*, the MAC entity shall:

1> if the Random Access procedure was initiated for SpCell beam failure recovery (as specified in clause 5.17); and

1> if the *beamFailureRecoveryTimer* (in clause 5.17) is either running or not configured; and

1> if the contention-free Random Access Resources for beam failure recovery request associated with any of the SSBs and/or CSI-RSs have been explicitly provided by RRC; and

1> if at least one of the SSBs with SS-RSRP above *rsrp-ThresholdSSB* amongst the SSBs in *candidateBeamRSList* or the CSI-RSs with CSI-RSRP above *rsrp-ThresholdCSI-RS* amongst the CSI-RSs in *candidateBeamRSList* is available:

2> select an SSB with SS-RSRP above *rsrp-ThresholdSSB* amongst the SSBs in *candidateBeamRSList* or a CSI-RS with CSI-RSRP above *rsrp-ThresholdCSI-RS* amongst the CSI-RSs in *candidateBeamRSList*;

2> if CSI-RS is selected, and there is no *ra-PreambleIndex* associated with the selected CSI-RS:

3> set the *PREAMBLE\_INDEX* to a *ra-PreambleIndex* corresponding to the SSB in *candidateBeamRSList* which is quasi-colocated with the selected CSI-RS as specified in TS 38.214 [7].

2> else:

3> set the *PREAMBLE\_INDEX* to a *ra-PreambleIndex* corresponding to the selected SSB or CSI-RS from the set of Random Access Preambles for beam failure recovery request.

1> else if the *ra-PreambleIndex* has been explicitly provided by PDCCH; and

1> if the *ra-PreambleIndex* is not 0b000000:

2> set the *PREAMBLE\_INDEX* to the signalled *ra-PreambleIndex*;

2> select the SSB signalled by PDCCH.

1> else if the contention-free Random Access Resources associated with SSBs have been explicitly provided in *rach-ConfigDedicated* and at least one SSB with SS-RSRP above *rsrp-ThresholdSSB* amongst the associated SSBs is available:

2> select an SSB with SS-RSRP above *rsrp-ThresholdSSB* amongst the associated SSBs;

2> set the *PREAMBLE\_INDEX* to a *ra-PreambleIndex* corresponding to the selected SSB.

1> else if the contention-free Random Access Resources associated with CSI-RSs have been explicitly provided in *rach-ConfigDedicated* and at least one CSI-RS with CSI-RSRP above *rsrp-ThresholdCSI-RS* amongst the associated CSI-RSs is available:

2> select a CSI-RS with CSI-RSRP above *rsrp-ThresholdCSI-RS* amongst the associated CSI-RSs;

2> set the *PREAMBLE\_INDEX* to a *ra-PreambleIndex* corresponding to the selected CSI-RS.

1> else if the Random Access procedure was initiated for SI request (as specified in TS 38.331 [5]); and

1> if the Random Access Resources for SI request have been explicitly provided by RRC:

2> if at least one of the SSBs with SS-RSRP above *rsrp-ThresholdSSB* is available:

3> select an SSB with SS-RSRP above *rsrp-ThresholdSSB*.

2> else:

3> select any SSB.

2> select a Random Access Preamble corresponding to the selected SSB, from the Random Access Preamble(s) determined according to *ra-PreambleStartIndex* as specified in TS 38.331 [5];

2> set the *PREAMBLE\_INDEX* to selected Random Access Preamble.

1> else (i.e. for the contention-based Random Access preamble selection):

2> if at least one of the SSBs with SS-RSRP above *rsrp-ThresholdSSB* is available:

3> select an SSB with SS-RSRP above *rsrp-ThresholdSSB*.

2> else:

3> select any SSB.

2> if the *RA\_TYPE* is switched from *2-stepRA* to *4-stepRA*:

3> if a Random Access Preambles group was selected during the current Random Access procedure:

4> select the same group of Random Access Preambles as was selected for the 2-step RA type.

3> else:

4> if Random Access Preambles group B is configured; and

4> if the transport block size of the MSGA payload configured in the *rach-ConfigDedicated* corresponds to the transport block size of the MSGA payload associated with Random Access Preambles group B:

5> select the Random Access Preambles group B.

4> else:

5> select the Random Access Preambles group A.

2> else if Msg3 buffer is empty:

3> if Random Access Preambles group B is configured:

4> if the potential Msg3 size (UL data available for transmission plus MAC subheader(s) and, where required, MAC CEs) is greater than *ra-Msg3SizeGroupA* and the pathloss is less than *PCMAX* (of the Serving Cell performing the Random Access Procedure) – *preambleReceivedTargetPower* – *msg3-DeltaPreamble* – *messagePowerOffsetGroupB*; or

4> if the Random Access procedure was initiated for the CCCH logical channel and the CCCH SDU size plus MAC subheader is greater than *ra-Msg3SizeGroupA*:

5> select the Random Access Preambles group B.

4> else:

5> select the Random Access Preambles group A.

3> else:

4> select the Random Access Preambles group A.

2> else (i.e. Msg3 is being retransmitted):

3> select the same group of Random Access Preambles as was used for the Random Access Preamble transmission attempt corresponding to the first transmission of Msg3.

2> select a Random Access Preamble randomly with equal probability from the Random Access Preambles associated with the selected SSB and the selected Random Access Preambles group;

2> set the *PREAMBLE\_INDEX* to the selected Random Access Preamble.

1> if the Random Access procedure was initiated for SI request (as specified in TS 38.331 [5]); and

1> if *ra-AssociationPeriodIndex* and *si-RequestPeriod* are configured:

2> determine the next available PRACH occasion from the PRACH occasions corresponding to the selected SSB in the association period given by *ra-AssociationPeriodIndex* in the *si-RequestPeriod*permitted by the restrictions given by the *ra-ssb-OccasionMaskIndex* if configured (the MAC entity shall select a PRACH occasion randomly with equal probability amongst the consecutive PRACH occasions according to clause 8.1 of TS 38.213 [6] corresponding to the selected SSB).

1> else if an SSB is selected above:

2> determine the next available PRACH occasion from the PRACH occasions corresponding to the selected SSB permitted by the restrictions given by the *ra-ssb-OccasionMaskIndex* if configured or indicated by PDCCH (the MAC entity shall select a PRACH occasion randomly with equal probability amongst the consecutive PRACH occasions according to clause 8.1 of TS 38.213 [6] regardless the FR2 UL gap, corresponding to the selected SSB; the MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH occasion corresponding to the selected SSB).

1> else if a CSI-RS is selected above:

2> if there is no contention-free Random Access Resource associated with the selected CSI-RS:

3> determine the next available PRACH occasion from the PRACH occasions, permitted by the restrictions given by the *ra-ssb-OccasionMaskIndex* if configured, corresponding to the SSB in *candidateBeamRSList* which is quasi-colocated with the selected CSI-RS as specified in TS 38.214 [7] (the MAC entity shall select a PRACH occasion randomly with equal probability amongst the consecutive PRACH occasions according to clause 8.1 of TS 38.213 [6] regardless the FR2 UL gap, corresponding to the SSB which is quasi-colocated with the selected CSI-RS; the MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH occasion corresponding to the SSB which is quasi-colocated with the selected CSI-RS).

2> else:

3> determine the next available PRACH occasion from the PRACH occasions in *ra-OccasionList* corresponding to the selected CSI-RS (the MAC entity shall select a PRACH occasion randomly with equal probability amongst the PRACH occasions occurring simultaneously but on different subcarriers regardless the FR2 UL gap, corresponding to the selected CSI-RS; the MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH occasion corresponding to the selected CSI-RS).

1> perform the Random Access Preamble transmission procedure (see clause 5.1.3).

NOTE 1: When the UE determines if there is an SSB with SS-RSRP above *rsrp-ThresholdSSB* or a CSI-RS with CSI-RSRP above *rsrp-ThresholdCSI-RS*, the UE uses the latest unfiltered L1-RSRP measurement.

NOTE 2: Void.

NOTE 3: If a RedCap UE in RRC\_IDLE or RRC\_INACTIVE mode is configured with a BWP indicated by *initialDownlinkBWP-RedCap* which is not associated with any SSB, SS-RSRP measurement is performed based on the SSB associated with the BWP indicated by *initialDownlinkBWP*.

Editor's NOTE: Postpone the discussion on whether and how to capture the agreement: *From RAN2 perspective, if a RedCap UE in idle/inactive mode is configured with a separate initial BWP associated with no SSB (CD or NCD) for RACH, it is up to UE implementation to perform new RSRP measurement in a DL BWP associated with CD-SSB before Msg1/A retransmission.*

### 5.1.2a Random Access Resource selection for 2-step RA type

If the selected *RA\_TYPE* is set to *2-stepRA*, the MAC entity shall:

1> if the contention-free 2-step RA type Resources associated with SSBs have been explicitly provided in *rach-ConfigDedicated* and at least one SSB with SS-RSRP above *msgA-RSRP-ThresholdSSB* amongst the associated SSBs is available:

2> select an SSB with SS-RSRP above *msgA-RSRP-ThresholdSSB* amongst the associated SSBs;

2> set the *PREAMBLE\_INDEX* to a *ra-PreambleIndex* corresponding to the selected SSB.

1> else (i.e. for the contention-based Random Access Preamble selection):

2> if at least one of the SSBs with SS-RSRP above *msgA-RSRP-ThresholdSSB* is available:

3> select an SSB with SS-RSRP above *msgA-RSRP-ThresholdSSB*.

2> else:

3> select any SSB.

2> if contention-free Random Access Resources for 2-step RA type have not been configured and if Random Access Preambles group has not yet been selected during the current Random Access procedure:

3> if Random Access Preambles group B for 2-step RA type is configured:

4> if the potential MSGA payload size (UL data available for transmission plus MAC subheader and, where required, MAC CEs) is greater than the *ra-MsgA-SizeGroupA* and the pathloss is less than *PCMAX* (of the Serving Cell performing the Random Access Procedure) – *msgA-PreambleReceivedTargetPower* – *msgA-DeltaPreamble* – *messagePowerOffsetGroupB*; or

4> if the Random Access procedure was initiated for the CCCH logical channel and the CCCH SDU size plus MAC subheader is greater than *ra-MsgA-SizeGroupA*:

5> select the Random Access Preambles group B.

4> else:

5> select the Random Access Preambles group A.

3> else:

4> select the Random Access Preambles group A.

2> else if contention-free Random Access Resources for 2-step RA type have been configured and if Random Access Preambles group has not yet been selected during the current Random Access procedure:

3> if Random Access Preambles group B for 2-step RA type is configured; and

3> if the transport block size of the MSGA payload configured in the *rach-ConfigDedicated* corresponds to the transport block size of the MSGA payload associated with Random Access Preambles group B:

4> select the Random Access Preambles group B.

3> else:

4> select the Random Access Preambles group A.

2> else (i.e. Random Access preambles group has been selected during the current Random Access procedure):

3> select the same group of Random Access Preambles as was used for the Random Access Preamble transmission attempt corresponding to the earlier transmission of MSGA.

2> select a Random Access Preamble randomly with equal probability from the 2-step RA type Random Access Preambles associated with the selected SSB and the selected Random Access Preambles group;

2> set the *PREAMBLE\_INDEX* to the selected Random Access Preamble.

1> determine the next available PRACH occasion from the PRACH occasions corresponding to the selected SSB permitted by the restrictions given by the *msgA-SSB-SharedRO-MaskIndex* if configured and *ra-ssb-OccasionMaskIndex* if configured (the MAC entity shall select a PRACH occasion randomly with equal probability among the consecutive PRACH occasions allocated for 2-step RA type according to clause 8.1 of TS 38.213 [6] regardless the FR2 UL gap, corresponding to the selected SSB; the MAC entity may take into account the possible occurrence of measurement gaps when determining the next available PRACH occasion corresponding to the selected SSB);

1> if the Random Access Preamble was not selected by the MAC entity among the contention-based Random Access Preamble(s):

2> select a PUSCH occasion from the PUSCH occasions configured in *msgA-CFRA-PUSCH* corresponding to the PRACH slot of the selected PRACH occasion, according to *msgA-PUSCH-resource-Index* corresponding to the selected SSB;

2> determine the UL grant and the associated HARQ information for the MSGA payload in the selected PUSCH occasion;

2> deliver the UL grant and the associated HARQ information to the HARQ entity.

1> else:

2> select a PUSCH occasion corresponding to the selected preamble and PRACH occasion according to clause 8.1A of TS 38.213 [6];

2> determine the UL grant for the MSGA payload according to the PUSCH configuration associated with the selected Random Access Preambles group and determine the associated HARQ information;

2> if the selected preamble and PRACH occasion is mapped to a valid PUSCH occasion as specified in clause 8.1A of TS 38.213 [6]:

3> deliver the UL grant and the associated HARQ information to the HARQ entity.

1> perform the MSGA transmission procedure (see clause 5.1.3a).

NOTE 1: To determine if there is an SSB with *SS-RSRP* above *msgA-RSRP-ThresholdSSB*, the UE uses the latest unfiltered *L1-RSRP* measurement.

NOTE 2: If a RedCap UE in RRC\_IDLE or RRC\_INACTIVE mode is configured with a BWP indicated by *initialDownlinkBWP-RedCap* which is not associated with any SSB, SS-RSRP measurement is performed based on the SSB associated with the BWP indicated by *initialDownlinkBWP*.

### 5.1.3 Random Access Preamble transmission

The MAC entity shall, for each Random Access Preamble:

1> if *PREAMBLE\_TRANSMISSION\_COUNTER* is greater than one; and

1> if the notification of suspending power ramping counter has not been received from lower layers; and

1> if LBT failure indication was not received from lower layers for the last Random Access Preamble transmission; and

1> if SSB or CSI-RS selected is not changed from the selection in the last Random Access Preamble transmission:

2> increment *PREAMBLE\_POWER\_RAMPING\_COUNTER* by 1.

1> select the value of *DELTA\_PREAMBLE* according to clause 7.3;

1> set *PREAMBLE\_RECEIVED\_TARGET\_POWER* to *preambleReceivedTargetPower* + *DELTA\_PREAMBLE* + (*PREAMBLE\_POWER\_RAMPING\_COUNTER* – 1) × *PREAMBLE\_POWER\_RAMPING\_STEP* *+* *POWER\_OFFSET\_2STEP\_RA*;

1> except for contention-free Random Access Preamble for beam failure recovery request, compute the RA-RNTI associated with the PRACH occasion in which the Random Access Preamble is transmitted;

1> instruct the physical layer to transmit the Random Access Preamble using the selected PRACH occasion, corresponding RA-RNTI (if available), *PREAMBLE\_INDEX*, and *PREAMBLE\_RECEIVED\_TARGET\_POWER*.

1> if LBT failure indication is received from lower layers for this Random Access Preamble transmission:

2> if *lbt-FailureRecoveryConfig* is configured:

3> perform the Random Access Resource selection procedure (see clause 5.1.2).

2> else:

3> increment *PREAMBLE\_TRANSMISSION\_COUNTER* by 1;

3> if *PREAMBLE\_TRANSMISSION\_COUNTER* = *preambleTransMax* + 1:

4> if the Random Access Preamble is transmitted on the SpCell:

5> indicate a Random Access problem to upper layers;

5> if this Random Access procedure was triggered for SI request:

6> consider the Random Access procedure unsuccessfully completed.

4> else if the Random Access Preamble is transmitted on an SCell:

5> consider the Random Access procedure unsuccessfully completed.

3> if the Random Access procedure is not completed:

4> perform the Random Access Resource selection procedure (see clause 5.1.2).

The RA-RNTI associated with the PRACH occasion in which the Random Access Preamble is transmitted, is computed as:

RA-RNTI = 1 + s\_id + 14 × t\_id + 14 × 80 × f\_id + 14 × 80 × 8 × ul\_carrier\_id

where s\_id is the index of the first OFDM symbol of the PRACH occasion (0 ≤ s\_id < 14), t\_id is the index of the first slot of the PRACH occasion in a system frame (0 ≤ t\_id < 80), where the subcarrier spacing to determine t\_id is based on the value of μ specified in clause 5.3.2 in TS 38.211 [8] for μ = {0, 1, 2, 3}, and for μ = {5, 6}, t\_id is the index of the 120 kHz slot in a system frame that contains the PRACH occasion (0 ≤ t\_id < 80), f\_id is the index of the PRACH occasion in the frequency domain (0 ≤ f\_id < 8), and ul\_carrier\_id is the UL carrier used for Random Access Preamble transmission (0 for NUL carrier, and 1 for SUL carrier).

### 5.1.3a MSGA transmission

The MAC entity shall, for each MSGA:

1> if *PREAMBLE\_TRANSMISSION\_COUNTER* is greater than one; and

1> if the notification of suspending power ramping counter has not been received from lower layers; and

1> if LBT failure indication was not received from lower layers for the last MSGA Random Access Preamble transmission; and

1> if SSB selected is not changed from the selection in the last Random Access Preamble transmission:

2> increment *PREAMBLE\_POWER\_RAMPING\_COUNTER* by 1.

1> select the value of *DELTA\_PREAMBLE* according to clause 7.3;

1> set *PREAMBLE\_RECEIVED\_TARGET\_POWER* to *msgA-PreambleReceivedTargetPower* + *DELTA\_PREAMBLE* + (*PREAMBLE\_POWER\_RAMPING\_COUNTER* – 1) × *PREAMBLE\_POWER\_RAMPING\_STEP*;

1> if this is the first MSGA transmission within this Random Access procedure:

2> if the transmission is not being made for the CCCH logical channel:

3> indicate to the Multiplexing and assembly entity to include a C-RNTI MAC CE in the subsequent uplink transmission.

2> if the Random Access procedure was initiated for SpCell beam failure recovery and *spCell-BFR-CBRA* with value *true* is configured:

3> if there is at least one Serving Cell of this MAC entity configured with two BFD-RS sets:

4> indicate to the Multiplexing and assembly entity to include an Enhanced BFR MAC CE or a Truncated Enhanced BFR MAC CE in the subsequent uplink transmission.

3> else:

4> indicate to the Multiplexing and assembly entity to include a BFR MAC CE or a Truncated BFR MAC CE in the subsequent uplink transmission.

2> else if the Random Access procedure was initiated for beam failure recovery of both BFD-RS sets of SpCell:

3> indicate to the Multiplexing and assembly entity to include an Enhanced BFR MAC CE or a Truncated Enhanced BFR MAC CE in the subsequent uplink transmission.

2> obtain the MAC PDU to transmit from the Multiplexing and assembly entity according to the HARQ information determined for the MSGA payload (see clause 5.1.2a) and store it in the MSGA buffer.

1> compute the MSGB-RNTI associated with the PRACH occasion in which the Random Access Preamble is transmitted;

1> instruct the physical layer to transmit the MSGA using the selected PRACH occasion and the associated PUSCH resource of MSGA (if the selected preamble and PRACH occasion is mapped to a valid PUSCH occasion), using the corresponding RA-RNTI, MSGB-RNTI, *PREAMBLE\_INDEX*, *PREAMBLE\_RECEIVED\_TARGET\_POWER*, *msgA-PreambleReceivedTargetPower*, and the amount of power ramping applied to the latest MSGA preamble transmission (i.e. (*PREAMBLE\_POWER\_RAMPING\_COUNTER* – 1) × *PREAMBLE\_POWER\_RAMPING\_STEP*);

1> if LBT failure indication is received from lower layers for the transmission of this MSGA Random Access Preamble:

2> instruct the physical layer to cancel the transmission of the MSGA payload on the associated PUSCH resource;

2> if *lbt-FailureRecoveryConfig* is configured:

3> perform the Random Access Resource selection procedure for 2-step RA type (see clause 5.1.2a).

2> else:

3> increment *PREAMBLE\_TRANSMISSION\_COUNTER* by 1;

3> if *PREAMBLE\_TRANSMISSION\_COUNTE*R = *preambleTransMax* + 1:

4> indicate a Random Access problem to upper layers;

4> if this Random Access procedure was triggered for SI request:

5> consider this Random Access procedure unsuccessfully completed.

3> if the Random Access procedure is not completed:

4> if *msgA-TransMax* is applied (see clause 5.1.1a) and *PREAMBLE\_TRANSMISSION\_COUNTER* = *msgA-TransMax* + 1:

5> set the *RA\_TYPE* to *4-stepRA*;

5> perform initialization of variables specific to Random Access type as specified in clause 5.1.1a;

5> if the Msg3 buffer is empty:

6> obtain the MAC PDU to transmit from the MSGA buffer and store it in the Msg3 buffer;

5> flush HARQ buffer used for the transmission of MAC PDU in the MSGA buffer;

5> discard explicitly signalled contention-free 2-step RA type Random Access Resources, if any;

5> perform the Random Access Resource selection procedure as specified in clause 5.1.2.

4> else:

5> perform the Random Access Resource selection procedure for 2-step RA type (see clause 5.1.2a).

NOTE: The MSGA transmission includes the transmission of the PRACH Preamble as well as the contents of the MSGA buffer in the PUSCH resource corresponding to the selected PRACH occasion and *PREAMBLE\_INDEX* (see TS 38.213 [6])

The MSGB-RNTI associated with the PRACH occasion in which the Random Access Preamble is transmitted, is computed as:

MSGB-RNTI = 1 + s\_id + 14 × t\_id + 14 × 80 × f\_id + 14 × 80 × 8 × ul\_carrier\_id + 14 × 80 × 8 × 2

where s\_id is the index of the first OFDM symbol of the PRACH occasion (0 ≤ s\_id < 14), t\_id is the index of the first slot of the PRACH occasion in a system frame (0 ≤ t\_id < 80), where the subcarrier spacing to determine t\_id is based on the value of μ specified in clause 5.3.2 in TS 38.211 [8] for μ = {0, 1, 2, 3}, and for μ = {5, 6}, t\_id is the index of the 120 kHz slot in a system frame that contains the PRACH occasion (0 ≤ t\_id < 80), f\_id is the index of the PRACH occasion in the frequency domain (0 ≤ f\_id < 8), and ul\_carrier\_id is the UL carrier used for Random Access Preamble transmission (0 for NUL carrier, and 1 for SUL carrier). The RA-RNTI is calculated as specified in clause 5.1.3.

### 5.1.4 Random Access Response reception

Once the Random Access Preamble is transmitted and regardless of the possible occurrence of a measurement gap, the MAC entity shall:

1> if the contention-free Random Access Preamble for beam failure recovery request was transmitted by the MAC entity:

2> if the contention-free Random Access Preamble for beam failure recovery request was transmitted on a non-terrestrial network:

3> start the *ra-ResponseWindow* configured in *BeamFailureRecoveryConfig* at the PDCCH occasion as specified in TS 38.213 [6].

2> else:

3> start the *ra-ResponseWindow* configured in *BeamFailureRecoveryConfig* at the first PDCCH occasion as specified in TS 38.213 [6] from the end of the Random Access Preamble transmission.

2> monitor for a PDCCH transmission on the search space indicated by *recoverySearchSpaceId* of the SpCell identified by the C-RNTI while *ra-ResponseWindow* is running.

1> else:

2> if the Random Access Preamble was transmitted on a non-terrestrial network:

3> start the *ra-ResponseWindow* configured in *RACH-ConfigCommon* at the PDCCH occasion as specified in TS 38.213 [6].

2> else:

3> start the *ra-ResponseWindow* configured in *RACH-ConfigCommon* at the first PDCCH occasion as specified in TS 38.213 [6] from the end of the Random Access Preamble transmission.

2> monitor the PDCCH of the SpCell for Random Access Response(s) identified by the RA-RNTI while the *ra-ResponseWindow* is running.

1> if notification of a reception of a PDCCH transmission on the search space indicated by *recoverySearchSpaceId* is received from lower layers on the Serving Cell where the preamble was transmitted; and

1> if PDCCH transmission is addressed to the C-RNTI; and

1> if the contention-free Random Access Preamble for beam failure recovery request was transmitted by the MAC entity:

2> consider the Random Access procedure successfully completed.

1> else if a valid (as specified in TS 38.213 [6]) downlink assignment has been received on the PDCCH for the RA-RNTI and the received TB is successfully decoded:

2> if the Random Access Response contains a MAC subPDU with Backoff Indicator:

3> set the *PREAMBLE\_BACKOFF* to value of the BI field of the MAC subPDU using Table 7.2-1, multiplied with *SCALING\_FACTOR\_BI*.

2> else:

3> set the *PREAMBLE\_BACKOFF* to 0 ms.

2> if the Random Access Response contains a MAC subPDU with Random Access Preamble identifier corresponding to the transmitted *PREAMBLE\_INDEX* (see clause 5.1.3):

3> consider this Random Access Response reception successful.

2> if the Random Access Response reception is considered successful:

3> if the Random Access Response includes a MAC subPDU with RAPID only:

4> consider this Random Access procedure successfully completed;

4> indicate the reception of an acknowledgement for SI request to upper layers.

3> else:

4> apply the following actions for the Serving Cell where the Random Access Preamble was transmitted:

5> process the received Timing Advance Command (see clause 5.2);

5> indicate the *preambleReceivedTargetPower* and the amount of power ramping applied to the latest Random Access Preamble transmission to lower layers (i.e. (*PREAMBLE\_POWER\_RAMPING\_COUNTER* – 1) × *PREAMBLE\_POWER\_RAMPING\_STEP*);

5> if the Random Access procedure for an SCell is performed on uplink carrier where *pusch-Config* is not configured:

6> ignore the received UL grant.

5> else:

6> process the received UL grant value and indicate it to the lower layers.

4> if the Random Access Preamble was not selected by the MAC entity among the contention-based Random Access Preamble(s):

5> consider the Random Access procedure successfully completed.

4> else:

5> set the *TEMPORARY\_C-RNTI* to the value received in the Random Access Response;

5> if this is the first successfully received Random Access Response within this Random Access procedure:

6> if the transmission is not being made for the CCCH logical channel:

7> indicate to the Multiplexing and assembly entity to include a C-RNTI MAC CE in the subsequent uplink transmission.

6> if the Random Access procedure was initiated for SpCell beam failure recovery and *spCell-BFR-CBRA* with value *true* is configured:

7> if there is at least one Serving Cell of this MAC entity configured with two BFD-RS sets:

8> indicate to the Multiplexing and assembly entity to include an Enhanced BFR MAC CE or a Truncated Enhanced BFR MAC CE in the subsequent uplink transmission.

7> else:

8> indicate to the Multiplexing and assembly entity to include a BFR MAC CE or a Truncated BFR MAC CE in the subsequent uplink transmission.

6> else if the Random Access procedure was initiated for beam failure recovery of both BFD-RS sets of SpCell:

7> indicate to the Multiplexing and assembly entity to include an Enhanced BFR MAC CE or a Truncated Enhanced BFR MAC CE in the subsequent uplink transmission.

6> obtain the MAC PDU to transmit from the Multiplexing and assembly entity and store it in the Msg3 buffer.

NOTE: If within a Random Access procedure, an uplink grant provided in the Random Access Response for the same group of contention-based Random Access Preambles has a different size than the first uplink grant allocated during that Random Access procedure, the UE behavior is not defined.

1> if *ra-ResponseWindow* configured in *BeamFailureRecoveryConfig* expires and if a PDCCH transmission on the search space indicated by *recoverySearchSpaceId* addressed to the C-RNTI has not been received on the Serving Cell where the preamble was transmitted; or

1> if *ra-ResponseWindow* configured in *RACH-ConfigCommon* expires, and if the Random Access Response containing Random Access Preamble identifiers that matches the transmitted *PREAMBLE\_INDEX* has not been received:

2> consider the Random Access Response reception not successful;

2> increment *PREAMBLE\_TRANSMISSION\_COUNTER* by 1;

2> if *PREAMBLE\_TRANSMISSION\_COUNTER* = *preambleTransMax* + 1:

3> if the Random Access Preamble is transmitted on the SpCell:

4> indicate a Random Access problem to upper layers;

4> if this Random Access procedure was triggered for SI request:

5> consider the Random Access procedure unsuccessfully completed.

3> else if the Random Access Preamble is transmitted on an SCell:

4> consider the Random Access procedure unsuccessfully completed.

2> if the Random Access procedure is not completed:

3> select a random backoff time according to a uniform distribution between 0 and the *PREAMBLE\_BACKOFF*;

3> if the criteria (as defined in clause 5.1.2) to select contention-free Random Access Resources is met during the backoff time:

4> perform the Random Access Resource selection procedure (see clause 5.1.2);

3> else if the Random Access procedure for an SCell is performed on uplink carrier where *pusch-Config* is not configured:

4> delay the subsequent Random Access transmission until the Random Access Procedure is triggered by a PDCCH order with the same *ra-PreambleIndex*, *ra-ssb-OccasionMaskIndex*, and UL/SUL indicator TS 38.212 [9].

3> else:

4> perform the Random Access Resource selection procedure (see clause 5.1.2) after the backoff time.

The MAC entity may stop *ra-ResponseWindow* (and hence monitoring for Random Access Response(s)) after successful reception of a Random Access Response containing Random Access Preamble identifiers that matches the transmitted *PREAMBLE\_INDEX*.

HARQ operation is not applicable to the Random Access Response reception.

### 5.1.4a MSGB reception and contention resolution for 2-step RA type

Once the MSGA preamble is transmitted, regardless of the possible occurrence of a measurement gap, the MAC entity shall:

1> start the *msgB-ResponseWindow* at the PDCCH occasion as specified in TS 38.213 [6], clause 8.2A;

1> monitor the PDCCH of the SpCell for a Random Access Response identified by MSGB-RNTI while the *msgB-ResponseWindow* is running;

1> if C-RNTI MAC CE was included in the MSGA:

2> monitor the PDCCH of the SpCell for Random Access Response identified by the C-RNTI while the *msgB-ResponseWindow* is running.

1> if notification of a reception of a PDCCH transmission of the SpCell is received from lower layers:

2> if the C-RNTI MAC CE was included in MSGA:

3> if the Random Access procedure was initiated for SpCell beam failure recovery or for beam failure recovery of both BFD-RS sets of SpCell (as specified in clause 5.17) and the PDCCH transmission is addressed to the C-RNTI:

4> consider this Random Access Response reception successful;

4> stop the *msgB-ResponseWindow*;

4> consider this Random Access procedure successfully completed.

3> else if the *timeAlignmentTimer* associated with the PTAG is running:

4> if the PDCCH transmission is addressed to the C-RNTI and contains a UL grant for a new transmission:

5> consider this Random Access Response reception successful;

5> stop the *msgB-ResponseWindow*;

5> consider this Random Access procedure successfully completed.

3> else:

4> if a downlink assignment has been received on the PDCCH for the C-RNTI and the received TB is successfully decoded:

5> if the MAC PDU contains the Absolute Timing Advance Command MAC CE:

6> process the received Timing Advance Command (see clause 5.2);

6> consider this Random Access Response reception successful;

6> stop the *msgB-ResponseWindow*;

6> consider this Random Access procedure successfully completed and finish the disassembly and demultiplexing of the MAC PDU.

2> if a valid (as specified in TS 38.213 [6]) downlink assignment has been received on the PDCCH for the MSGB-RNTI and the received TB is successfully decoded:

3> if the MSGB contains a MAC subPDU with Backoff Indicator:

4> set the *PREAMBLE\_BACKOFF* to value of the BI field of the MAC subPDU using Table 7.2-1, multiplied with *SCALING\_FACTOR\_BI*.

3> else:

4> set the *PREAMBLE\_BACKOFF* to 0 ms.

3> if the MSGB contains a fallbackRAR MAC subPDU; and

3> if the Random Access Preamble identifier in the MAC subPDU matches the transmitted *PREAMBLE\_INDEX* (see clause 5.1.3a):

4> consider this Random Access Response reception successful;

4> apply the following actions for the SpCell:

5> process the received Timing Advance Command (see clause 5.2);

5> indicate the *msgA-PreambleReceivedTargetPower* and the amount of power ramping applied to the latest Random Access Preamble transmission to lower layers (i.e. (*PREAMBLE\_POWER\_RAMPING\_COUNTER* – 1) × *PREAMBLE\_POWER\_RAMPING\_STEP*);

5> if the Random Access Preamble was not selected by the MAC entity among the contention-based Random Access Preamble(s):

6> consider the Random Access procedure successfully completed;

6> process the received UL grant value and indicate it to the lower layers.

5> else:

6> set the *TEMPORARY\_C-RNTI* to the value received in the Random Access Response;

6> if the Msg3 buffer is empty:

7> obtain the MAC PDU to transmit from the MSGA buffer and store it in the Msg3 buffer;

6> process the received UL grant value and indicate it to the lower layers and proceed with Msg3 transmission.

NOTE: If within a 2-step RA type procedure, an uplink grant provided in the fallback RAR has a different size than the MSGA payload, the UE behavior is not defined.

3> else if the MSGB contains a successRAR MAC subPDU; and

3> if the CCCH SDU was included in the MSGA and the UE Contention Resolution Identity in the MAC subPDU matches the CCCH SDU:

4> stop *msgB-ResponseWindow*;

4> if this Random Access procedure was initiated for SI request:

5> indicate the reception of an acknowledgement for SI request to upper layers.

4> else:

5> set the C-RNTI to the value received in the *successRAR*;

5> apply the following actions for the SpCell:

6> process the received Timing Advance Command (see clause 5.2);

6> indicate the *msgA-PreambleReceivedTargetPower* and the amount of power ramping applied to the latest Random Access Preamble transmission to lower layers (i.e. (*PREAMBLE\_POWER\_RAMPING\_COUNTER* – 1) × *PREAMBLE\_POWER\_RAMPING\_STEP*).

4> deliver the *TPC*, *PUCCH resource Indicator*, *ChannelAccess-CPext* (if indicated), and *HARQ feedback Timing Indicator* received in successRAR to lower layers.

4> consider this Random Access Response reception successful;

4> consider this Random Access procedure successfully completed;

4> finish the disassembly and demultiplexing of the MAC PDU.

1> if *msgB-ResponseWindow* expires, and the Random Access Response Reception has not been considered as successful based on descriptions above:

2> increment *PREAMBLE\_TRANSMISSION\_COUNTER* by 1;

2> if *PREAMBLE\_TRANSMISSION\_COUNTE*R = *preambleTransMax* + 1:

3> indicate a Random Access problem to upper layers;

3> if this Random Access procedure was triggered for SI request:

4> consider this Random Access procedure unsuccessfully completed.

2> if the Random Access procedure is not completed:

3> if *msgA-TransMax* is applied (see clause 5.1.1a) and *PREAMBLE\_TRANSMISSION\_COUNTER* = *msgA-TransMax* + 1:

4> set the *RA\_TYPE* to *4-stepRA*;

4> perform initialization of variables specific to Random Access type as specified in clause 5.1.1a;

4> if the Msg3 buffer is empty:

5> obtain the MAC PDU to transmit from the MSGA buffer and store it in the Msg3 buffer;

4> flush HARQ buffer used for the transmission of MAC PDU in the MSGA buffer;

4> discard explicitly signalled contention-free 2-step RA type Random Access Resources, if any;

4> perform the Random Access Resource selection procedure as specified in clause 5.1.2.

3> else:

4> select a random backoff time according to a uniform distribution between 0 and the *PREAMBLE\_BACKOFF*;

4> if the criteria (as defined in clause 5.1.2a) to select contention-free Random Access Resources is met during the backoff time:

5> perform the Random Access Resource selection procedure for 2-step RA type Random Access (see clause 5.1.2a).

4> else:

5> perform the Random Access Resource selection procedure for 2-step RA type Random Access (see clause 5.1.2a) after the backoff time.

Upon receiving a fallbackRAR, the MAC entity may stop *msgB-ResponseWindow* once the Random Access Response reception is considered as successful.

### 5.1.5 Contention Resolution

Once Msg3 is transmitted the MAC entity shall:

1> if Msg3 is transmitted on a non-terrestrial network:

2> start the *ra-ContentionResolutionTimer* and restart the *ra-ContentionResolutionTimer* at each HARQ retransmission in the first symbol after the end of the Msg3 transmission plus the UE estimate of UE-gNB RTT.

1> else if the Msg3 transmission (i.e. initial transmission or HARQ retransmission) is scheduled with Type A PUSCH repetition:

2> start or restart the *ra-ContentionResolutionTimer* in the first symbol after the end of all repetitions of the Msg3 transmission.

1> else:

2> start or restart the *ra-ContentionResolutionTimer* in the first symbol after the end of the Msg3 transmission.

1> monitor the PDCCH while the *ra-ContentionResolutionTimer* is running regardless of the possible occurrence of a measurement gap;

1> if notification of a reception of a PDCCH transmission of the SpCell is received from lower layers:

2> if the C-RNTI MAC CE was included in Msg3:

3> if the Random Access procedure was initiated for SpCell beam failure recovery or for beam failure recovery of both BFD-RS sets of SpCell (as specified in clause 5.17) and the PDCCH transmission is addressed to the C-RNTI; or

3> if the Random Access procedure was initiated by a PDCCH order and the PDCCH transmission is addressed to the C-RNTI; or

3> if the Random Access procedure was initiated by the MAC sublayer itself or by the RRC sublayer and the PDCCH transmission is addressed to the C-RNTI and contains a UL grant for a new transmission:

4> consider this Contention Resolution successful;

4> stop *ra-ContentionResolutionTimer*;

4> discard the *TEMPORARY\_C-RNTI*;

4> consider this Random Access procedure successfully completed.

2> else if the CCCH SDU was included in Msg3 and the PDCCH transmission is addressed to its *TEMPORARY\_C-RNTI*:

3> if the MAC PDU is successfully decoded:

4> stop *ra-ContentionResolutionTimer*;

4> if the MAC PDU contains a UE Contention Resolution Identity MAC CE; and

4> if the UE Contention Resolution Identity in the MAC CE matches the CCCH SDU transmitted in Msg3:

5> consider this Contention Resolution successful and finish the disassembly and demultiplexing of the MAC PDU;

5> if this Random Access procedure was initiated for SI request:

6> indicate the reception of an acknowledgement for SI request to upper layers.

5> else:

6> set the C-RNTI to the value of the *TEMPORARY\_C-RNTI*;

5> discard the *TEMPORARY\_C-RNTI*;

5> consider this Random Access procedure successfully completed.

4> else:

5> discard the *TEMPORARY\_C-RNTI*;

5> consider this Contention Resolution not successful and discard the successfully decoded MAC PDU.

1> if *ra-ContentionResolutionTimer* expires:

2> if Msg3 is transmitted on a non-terrestrial network and *ra-ContentionResolutionTimer* expires prior to the first symbol after the end of a Msg3 retransmission plus the UE estimate of UE-gNB RTT:

3> do not consider the Contention Resolution unsuccessful.

2> else:

3> discard the *TEMPORARY\_C-RNTI*;

3> consider the Contention Resolution not successful.

1> if the Contention Resolution is considered not successful:

2> flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer;

2> increment *PREAMBLE\_TRANSMISSION\_COUNTER* by 1;

2> if *PREAMBLE\_TRANSMISSION\_COUNTER* = *preambleTransMax* + 1:

3> indicate a Random Access problem to upper layers.

3> if this Random Access procedure was triggered for SI request:

4> consider the Random Access procedure unsuccessfully completed.

2> if the Random Access procedure is not completed:

3> if the *RA\_TYPE* is set to *4-stepRA*:

4> select a random backoff time according to a uniform distribution between 0 and the *PREAMBLE\_BACKOFF*;

4> if the criteria (as defined in clause 5.1.2) to select contention-free Random Access Resources is met during the backoff time:

5> perform the Random Access Resource selection procedure (see clause 5.1.2);

4> else:

5> perform the Random Access Resource selection procedure (see clause 5.1.2) after the backoff time.

3> else (i.e. the *RA\_TYPE* is set to *2-stepRA*):

4> if *msgA-TransMax* is applied (see clause 5.1.1a) and *PREAMBLE\_TRANSMISSION\_COUNTER* = *msgA-TransMax* + 1:

5> set the *RA\_TYPE* to *4-stepRA*;

5> perform initialization of variables specific to Random Access type as specified in clause 5.1.1a;

5> flush HARQ buffer used for the transmission of MAC PDU in the MSGA buffer;

5> discard explicitly signalled contention-free 2-step RA type Random Access Resources, if any;

5> perform the Random Access Resource selection as specified in clause 5.1.2.

4> else:

5> select a random backoff time according to a uniform distribution between 0 and the *PREAMBLE\_BACKOFF*;

5> if the criteria (as defined in clause 5.1.2a) to select contention-free Random Access Resources is met during the backoff time:

6> perform the Random Access Resource selection procedure for 2-step RA type as specified in clause 5.1.2a.

5> else:

6> perform the Random Access Resource selection for 2-step RA type procedure (see clause 5.1.2a) after the backoff time.

### 5.1.6 Completion of the Random Access procedure

Upon completion of the Random Access procedure, the MAC entity shall:

1> discard any explicitly signalled contention-free Random Access Resources for 2-step RA type and 4-step RA type except the 4-step RA type contention-free Random Access Resources for beam failure recovery request, if any;

1> flush the HARQ buffer used for transmission of the MAC PDU in the Msg3 buffer and the MSGA buffer.

Upon successful completion of the Random Access procedure initiated for DAPS handover, the target MAC entity shall:

1> indicate the successful completion of the Random Access procedure to the upper layers.

### 5.4.3 Multiplexing and assembly

#### 5.4.3.1 Logical Channel Prioritization

##### 5.4.3.1.1 General

The Logical Channel Prioritization (LCP) procedure is applied whenever a new transmission is performed.

RRC controls the scheduling of uplink data by signalling for each logical channel per MAC entity:

- *priority* where an increasing priority value indicates a lower priority level;

- *prioritisedBitRate* which sets the Prioritized Bit Rate (PBR);

- *bucketSizeDuration* which sets the Bucket Size Duration (BSD).

RRC additionally controls the LCP procedure by configuring mapping restrictions for each logical channel:

- *allowedSCS-List* which sets the allowed Subcarrier Spacing(s) for transmission;

- *maxPUSCH-Duration* which sets the maximum PUSCH duration allowed for transmission;

- *configuredGrantType1Allowed* which sets whether a configured grant Type 1 can be used for transmission;

- *allowedServingCells* which sets the allowed cell(s) for transmission;

- *allowedCG-List* which sets the allowed configured grant(s) for transmission;

- *allowedPHY-PriorityIndex* which sets the allowed PHY priority index(es) of a dynamic grant for transmission;

- *allowedHARQ-mode* which sets the allowed HARQ mode for transmission.

The following UE variable is used for the Logical channel prioritization procedure:

- *Bj* which is maintained for each logical channel *j*.

The MAC entity shall initialize *Bj* of the logical channel to zero when the logical channel is established.

For each logical channel *j*, the MAC entity shall:

1> increment *Bj* by the product PBR × T before every instance of the LCP procedure, where T is the time elapsed since *Bj* was last incremented;

1> if the value of *Bj* is greater than the bucket size (i.e. PBR × BSD):

2> set *Bj* to the bucket size.

NOTE: The exact moment(s) when the UE updates *Bj* between LCP procedures is up to UE implementation, as long as *Bj* is up to date at the time when a grant is processed by LCP.

##### 5.4.3.1.2 Selection of logical channels

The MAC entity shall, when a new transmission is performed:

1> select the logical channels for each UL grant that satisfy all the following conditions:

2> the set of allowed Subcarrier Spacing index values in *allowedSCS-List*, if configured, includes the Subcarrier Spacing index associated to the UL grant; and

2> *maxPUSCH-Duration*, if configured, is larger than or equal to the PUSCH transmission duration associated to the UL grant; and

2> *configuredGrantType1Allowed*, if configured, is set to *true* in case the UL grant is a Configured Grant Type 1; and

2> *allowedServingCells*, if configured, includes the Cell information associated to the UL grant. Does not apply to logical channels associated with a DRB configured with PDCP duplication within the same MAC entity (i.e. CA duplication) when CA duplication is deactivated for this DRB in this MAC entity; and

2> *allowedCG-List*, if configured, includes the configured grant index associated to the UL grant; and

2> *allowedPHY-PriorityIndex*, if configured, includes the priority index (as specified in clause 9 of TS 38.213 [6]) associated to the dynamic UL grant; and

2> *allowedHARQ-mode*, if configured, includes the HARQ mode for the HARQ process associated to the UL grant.

NOTE: The Subcarrier Spacing index, PUSCH transmission duration, Cell information, and priority index are included in Uplink transmission information received from lower layers for the corresponding scheduled uplink transmission.

##### 5.4.3.1.3 Allocation of resources

Before the successful completion of the Random Access procedure initiated for DAPS handover, the target MAC entity shall not select the logical channel(s) corresponding to non-DAPS DRB(s) for the uplink grant received in a Random Access Response or the uplink grant for the transmission of the MSGA payload. The source MAC entity shall select only the logical channel(s) corresponding to DAPS DRB(s) during DAPS handover.

The MAC entity shall, when a new transmission is performed:

1> allocate resources to the logical channels as follows:

2> logical channels selected in clause 5.4.3.1.2 for the UL grant with *Bj* > 0 are allocated resources in a decreasing priority order. If the PBR of a logical channel is set to *infinity*, the MAC entity shall allocate resources for all the data that is available for transmission on the logical channel before meeting the PBR of the lower priority logical channel(s);

2> decrement *Bj* by the total size of MAC SDUs served to logical channel *j* above;

2> if any resources remain, all the logical channels selected in clause 5.4.3.1.2 are served in a strict decreasing priority order (regardless of the value of *Bj*) until either the data for that logical channel or the UL grant is exhausted, whichever comes first. Logical channels configured with equal priority should be served equally.

NOTE 1: The value of *Bj* can be negative.

If the MAC entity is requested to simultaneously transmit multiple MAC PDUs, or if the MAC entity receives the multiple UL grants within one or more coinciding PDCCH occasions (i.e. on different Serving Cells), it is up to UE implementation in which order the grants are processed.

The UE shall also follow the rules below during the scheduling procedures above:

- the UE should not segment an RLC SDU (or partially transmitted SDU or retransmitted RLC PDU) if the whole SDU (or partially transmitted SDU or retransmitted RLC PDU) fits into the remaining resources of the associated MAC entity;

- if the UE segments an RLC SDU from the logical channel, it shall maximize the size of the segment to fill the grant of the associated MAC entity as much as possible;

- the UE should maximise the transmission of data;

- if the MAC entity is given a UL grant size that is equal to or larger than 8 bytes (when eLCID is not used) or 10 bytes (when eLCID is used) while having data available and allowed (according to clause 5.4.3.1) for transmission, the MAC entity shall not transmit only padding BSR and/or padding.

The MAC entity shall:

1> if the MAC entity is configured with *enhancedSkipUplinkTxDynamic* with value *true* and the grant indicated to the HARQ entity was addressed to a C-RNTI, or if the MAC entity is configured with *enhancedSkipUplinkTxConfigured* with value *true* and the grant indicated to the HARQ entity is a configured uplink grant:

2> if there is no UCI to be multiplexed on this PUSCH transmission as specified in TS 38.213 [6]; and

2> if there is no aperiodic CSI requested for this PUSCH transmission as specified in TS 38.212 [9]; and

2> if the MAC PDU includes zero MAC SDUs; and

2> if the MAC PDU includes only the periodic BSR and there is no data available for any LCG, or the MAC PDU includes only the padding BSR:

3> not generate a MAC PDU for the HARQ entity.

1> else if the MAC entity is configured with *skipUplinkTxDynamic* with value *true* and the grant indicated to the HARQ entity was addressed to a C-RNTI, or the grant indicated to the HARQ entity is a configured uplink grant; and

1> if there is no aperiodic CSI requested for this PUSCH transmission as specified in TS 38.212 [9]; and

1> if the MAC PDU includes zero MAC SDUs; and

1> if the MAC PDU includes only the periodic BSR and there is no data available for any LCG, or the MAC PDU includes only the padding BSR:

2> not generate a MAC PDU for the HARQ entity.

Logical channels shall be prioritised in accordance with the following order (highest priority listed first):

- C-RNTI MAC CE or data from UL-CCCH;

- Configured Grant Confirmation MAC CE or MAC CEs for BFR or Multiple Entry Configured Grant Confirmation MAC CE;

- Sidelink Configured Grant Confirmation MAC CE;

- LBT failure MAC CE;

- MAC CE for Timing Advance Report;

- MAC CE for SL-BSR prioritized according to clause 5.22.1.6;

- MAC CE for BSR, with exception of BSR included for padding;

- Single Entry PHR MAC CE or Multiple Entry PHR MAC CE;

- MAC CE for the number of Desired Guard Symbols;

- MAC CE for Pre-emptive BSR;

- MAC CE for SL-BSR, with exception of SL-BSR prioritized according to clause 5.22.1.6 and SL-BSR included for padding;

- data from any Logical Channel, except data from UL-CCCH;

- MAC CE for Recommended bit rate query;

- MAC CE for BSR included for padding;

- MAC CE for SL-BSR included for padding.

NOTE 2: Prioritization among Configured Grant Confirmation MAC CE, Multiple Entry Configured Grant Confirmation MAC CE, and MAC CEs for BFR is up to UE implementation.

The MAC entity shall prioritize any MAC CE listed in a higher order than 'data from any Logical Channel, except data from UL-CCCH' over transmission of NR sidelink communication.

#### 5.4.3.2 Multiplexing of MAC Control Elements and MAC SDUs

The MAC entity shall multiplex MAC CEs and MAC SDUs in a MAC PDU according to clauses 5.4.3.1 and 6.1.2.

NOTE: Content of a MAC PDU does not change after being built for transmission on a dynamic uplink grant, regardless of LBT outcome.

### 5.4.4 Scheduling Request

The Scheduling Request (SR) is used for requesting UL-SCH resources for new transmission.

The MAC entity may be configured with zero, one, or more SR configurations. An SR configuration consists of a set of PUCCH resources for SR across different BWPs and cells. For a logical channel or for SCell beam failure recovery (see clause 5.17) and for consistent LBT failure recovery (see clause 5.21), at most one PUCCH resource for SR is configured per BWP. For a logical channel serving a radio bearer configured with SDT, PUCCH resource for SR is not configured for SDT. For beam failure recovery of BFD-RS set(s) of Serving Cell, up to two PUCCH resources for SR is configured per BWP.

Each SR configuration corresponds to one or more logical channels and/or to SCell beam failure recovery and/or to consistent LBT failure recovery and/or to beam failure recovery of BFD-RS set(s). Each logical channel, SCell beam failure recovery, beam failure recovery of BFD-RS set and consistent LBT failure recovery, may be mapped to zero or one SR configuration, which is configured by RRC. The SR configuration of the logical channel that triggered a BSR (clause 5.4.5) or the SCell beam failure recovery or the beam failure recovery of BFD-RS set or the consistent LBT failure recovery (clause 5.21) (if such a configuration exists) is considered as corresponding SR configuration for the triggered SR. Any SR configuration may be used for an SR triggered by Pre-emptive BSR (clause 5.4.7).

RRC configures the following parameters for the scheduling request procedure:

- *sr-ProhibitTimer* (per SR configuration);

- *sr-TransMax* (per SR configuration).

The following UE variables are used for the scheduling request procedure:

- *SR\_COUNTER* (per SR configuration).

If an SR is triggered and there are no other SRs pending corresponding to the same SR configuration, the MAC entity shall set the *SR\_COUNTER* of the corresponding SR configuration to 0.

When an SR is triggered, it shall be considered as pending until it is cancelled.

All pending SR(s) for BSR triggered according to the BSR procedure (clause 5.4.5) prior to the MAC PDU assembly shall be cancelled and each respective *sr-ProhibitTimer* shall be stopped when the MAC PDU is transmitted and this PDU includes a Long or Short BSR MAC CE which contains buffer status up to (and including) the last event that triggered a BSR (see clause 5.4.5) prior to the MAC PDU assembly. All pending SR(s) for BSR triggered according to the BSR procedure (clause 5.4.5) shall be cancelled and each respective *sr-ProhibitTimer* shall be stopped when the UL grant(s) can accommodate all pending data available for transmission.

The MAC entity shall for each pending SR not triggered according to the BSR procedure (clause 5.4.5) for a Serving Cell:

1> if this SR was triggered by Pre-emptive BSR procedure (see clause 5.4.7) prior to the MAC PDU assembly and a MAC PDU containing the relevant Pre-emptive BSR MAC CE is transmitted; or

1> if this SR was triggered by beam failure recovery (see clause 5.17) of an SCell and a MAC PDU is transmitted and this PDU includes a MAC CE for BFR which contains beam failure recovery information for this SCell; or

1> if this SR was triggered by beam failure recovery (see clause 5.17) for a BFD-RS set of a Serving Cell and a MAC PDU is transmitted and this PDU includes an Enhanced BFR MAC CE or a Truncated Enhanced BFR MAC CE which contains beam failure recovery information for this BFD-RS set of the Serving Cell; or

1> if this SR was triggered by beam failure recovery (see clause 5.17) of an SCell and this SCell is deactivated (see clause 5.9); or

1> if this SR was triggered by beam failure recovery (see clause 5.17) for a BFD-RS set of an SCell and this SCell is deactivated (see clause 5.9); or

1> if this SR was triggered by consistent LBT failure recovery (see clause 5.21) of an SCell and a MAC PDU is transmitted and the MAC PDU includes an LBT failure MAC CE that indicates consistent LBT failure for this SCell; or

1> if this SR was triggered by consistent LBT failure recovery (see clause 5.21) of an SCell and all the triggered consistent LBT failure(s) for this SCell are cancelled:

2> cancel the pending SR and stop the corresponding *sr-ProhibitTimer*, if running.

Only PUCCH resources on a BWP which is active at the time of SR transmission occasion are considered valid.

As long as at least one SR is pending, the MAC entity shall for each pending SR:

1> if the MAC entity has no valid PUCCH resource configured for the pending SR:

2> initiate a Random Access procedure (see clause 5.1) on the SpCell and cancel the pending SR.

1> else, for the SR configuration corresponding to the pending SR:

2> when the MAC entity has an SR transmission occasion on the valid PUCCH resource for SR configured; and

2> if *sr-ProhibitTimer* is not running at the time of the SR transmission occasion; and

2> if the PUCCH resource for the SR transmission occasion does not overlap with a measurement gap:

3> if the PUCCH resource for the SR transmission occasion overlaps with neither a UL-SCH resource whose simultaneous transmission with the SR is not allowed by configuration of *simultaneousPUCCH-PUSCH* nor an SL-SCH resource; or

3> if the MAC entity is able to perform this SR transmission simultaneously with the transmission of the SL-SCH resource; or

3> if the MAC entity is configured with *lch-basedPrioritization*, and the PUCCH resource for the SR transmission occasion does not overlap with the PUSCH duration of an uplink grant received in a Random Access Response or with the PUSCH duration of an uplink grant addressed to Temporary C-RNTI or with the PUSCH duration of a MSGA payload, and the PUCCH resource for the SR transmission occasion for the pending SR triggered as specified in clause 5.4.5 overlaps with any other UL-SCH resource(s), and the physical layer can signal the SR on one valid PUCCH resource for SR, and the priority of the logical channel that triggered SR is higher than the priority of the uplink grant(s) for any UL-SCH resource(s) where the uplink grant was not already de-prioritized and its simultaneous transmission with the SR is not allowed by configuration of *simultaneousPUCCH-PUSCH*, and the priority of the uplink grant is determined as specified in clause 5.4.1; or

3> if both *sl-PrioritizationThres* and *ul-PrioritizationThres* are configured and the PUCCH resource for the SR transmission occasion for the pending SR triggered as specified in clause 5.22.1.5 overlaps with any UL-SCH resource(s) carrying a MAC PDU, and the value of the priority of the triggered SR determined as specified in clause 5.22.1.5 is lower than *sl-PrioritizationThres* and the value of the highest priority of the logical channel(s) in the MAC PDU is higher than or equal to *ul-PrioritizationThres* and any MAC CE prioritized as described in clause 5.4.3.1.3 is not included in the MAC PDU and the MAC PDU is not prioritized by upper layer according to TS 23.287 [19]; or

3> if an SL-SCH resource overlaps with the PUCCH resource for the SR transmission occasion for the pending SR triggered as specified in clause 5.4.5, and the MAC entity is not able to perform this SR transmission simultaneously with the transmission of the SL-SCH resource, and either transmission on the SL-SCH resource is not prioritized as described in clause 5.22.1.3.1a or the priority value of the logical channel that triggered SR is lower than *ul-PrioritizationThres*, if configured; or

3> if an SL-SCH resource overlaps with the PUCCH resource for the SR transmission occasion for the pending SR triggered as specified in clause 5.22.1.5, and the MAC entity is not able to perform this SR transmission simultaneously with the transmission of the SL-SCH resource, and the priority of the triggered SR determined as specified in clause 5.22.1.5 is higher than the priority of the MAC PDU determined as specified in clause 5.22.1.3.1a for the SL-SCH resource:

4> consider the SR transmission as a prioritized SR transmission.

4> consider the other overlapping uplink grant(s), if any, as a de-prioritized uplink grant(s);

4> if the de-prioritized uplink grant(s) is a configured uplink grant configured with *autonomousTx* whose PUSCH has already started:

5> stop the *configuredGrantTimer* for the corresponding HARQ process of the de-prioritized uplink grant(s);

5> stop the *cg-RetransmissionTimer* for the corresponding HARQ process of the de-prioritized uplink grant(s).

4> if *SR\_COUNTER* < *sr-TransMax*:

5> instruct the physical layer to signal the SR on one valid PUCCH resource for SR;

5> if LBT failure indication is not received from lower layers:

6> increment *SR\_COUNTER* by 1;

6> start the *sr-ProhibitTimer*.

5> else if *lbt-FailureRecoveryConfig* is not configured:

6> increment *SR\_COUNTER* by 1.

4> else:

5> notify RRC to release PUCCH for all Serving Cells;

5> notify RRC to release SRS for all Serving Cells;

5> clear any configured downlink assignments and uplink grants;

5> clear any PUSCH resources for semi-persistent CSI reporting;

5> initiate a Random Access procedure (see clause 5.1) on the SpCell and cancel all pending SRs.

3> else:

4> consider the SR transmission as a de-prioritized SR transmission.

NOTE 1: Except for SR for SCell beam failure recovery, the selection of which valid PUCCH resource for SR to signal SR on when the MAC entity has more than one overlapping valid PUCCH resource for the SR transmission occasion is left to UE implementation.

NOTE 2: If more than one individual SR triggers an instruction from the MAC entity to the PHY layer to signal the SR on the same valid PUCCH resource, the *SR\_COUNTER* for the relevant SR configuration is incremented only once.

NOTE 3: When the MAC entity has pending SR for SCell beam failure recovery and the MAC entity has one or more PUCCH resources (other than PUCCH resources of pending SR for beam failure recovery of BFD-RS set) overlapping with PUCCH resource for SCell beam failure recovery for the SR transmission occasion, the MAC entity considers only the PUCCH resource for SCell beam failure recovery as valid. When the MAC entity has pending SR for beam failure recovery of a BFD-RS set of Serving Cell and the MAC entity has one or more PUCCH resources (other than PUCCH resources of pending SR for beam failure recovery) overlapping with PUCCH resource for beam failure recovery of that BFD-RS set for the SR transmission occasion, the MAC entity considers only the PUCCH resource for beam failure recovery of that BFD-RS set as valid.

NOTE 4: For a UE operating in a semi-static channel access mode as described in TS 37.213 [18], PUCCH resources overlapping with the set of consecutive symbols where the UE does not transmit before the start of a next channel occupancy time are not considered valid.

NOTE 5: If the MAC entity is configured with *lch-basedPrioritization*, the MAC entity does not take UCI multiplexing according to the procedure specified in TS 38.213 [6] into account when determining whether the valid PUCCH resource for the SR transmission can be signalled by the physical layer and the SR transmission occasion overlaps with the PUSCH duration of an uplink grant of a MSGA payload.

NOTE 6: When the MAC entity has PUCCH resource for pending SR for SCell beam failure recovery overlapping with PUCCH resource for pending SR for beam failure recovery of BFD-RS set for the SR transmission occasion, it's up to UE implementation to select PUCCH resource for SCell beam failure recovery or PUCCH resource for beam failure recovery of BFD-RS set

The MAC entity may stop, if any, ongoing Random Access procedure due to a pending SR for BSR, which was initiated by the MAC entity prior to the MAC PDU assembly and which has no valid PUCCH resources configured, if:

- a MAC PDU is transmitted using a UL grant other than a UL grant provided by Random Access Response or a UL grant determined as specified in clause 5.1.2a for the transmission of the MSGA payload, and this PDU includes a BSR MAC CE which contains buffer status up to (and including) the last event that triggered a BSR (see clause 5.4.5) prior to the MAC PDU assembly; or

- the UL grant(s) can accommodate all pending data available for transmission.

The MAC entity may stop, if any, ongoing Random Access procedure due to a pending SR for SL-BSR and/or SL-CSI reporting, which was initiated by the MAC entity prior to the sidelink MAC PDU assembly and which has no valid PUCCH resources configured, if:

- a MAC PDU is transmitted using a UL grant other than a UL grant provided by Random Access Response or a UL grant determined as specified in clause 5.1.2a for the transmission of the MSGA payload, and this PDU includes an SL-BSR MAC CE which contains buffer status up to (and including) the last event that triggered an SL-BSR (see clause 5.22.1.6) prior to the MAC PDU assembly; or

- the SL grant(s) can accommodate all pending data available and/or SL-CSI reporting MAC CE for transmission.

The MAC entity may stop, if any, ongoing Random Access procedure due to a pending SR for BFR of an SCell, which has no valid PUCCH resources configured, if:

- a MAC PDU is transmitted using a UL grant other than a UL grant provided by Random Access Response or a UL grant determined as specified in clause 5.1.2a for the transmission of the MSGA payload, and this PDU contains a MAC CE for BFR which includes beam failure recovery information of that SCell; or

- the SCell is deactivated (as specified in clause 5.9) and all triggered BFRs for SCells are cancelled.

The MAC entity may stop, if any, ongoing Random Access procedure due to a pending SR for BFR of a BFD-RS set of a Serving Cell, which has no valid PUCCH resources configured, if:

- a MAC PDU is transmitted using a UL grant other than a UL grant provided by Random Access Response or a UL grant determined as specified in clause 5.1.2a for the transmission of the MSGA payload, and this PDU contains an Enhanced BFR MAC CE or a Truncated Enhanced BFR MAC CE which includes beam failure recovery information of that BFD-RS set of the Serving Cell.

The MAC entity may stop, if any, ongoing Random Access procedure due to a pending SR for consistent LBT failure recovery, which has no valid PUCCH resources configured, if:

- a MAC PDU is transmitted using a UL grant other than a UL grant provided by Random Access Response or a UL grant determined as specified in clause 5.1.2a for the transmission of the MSGA payload, and this PDU includes an LBT failure MAC CE that indicates consistent LBT failure for all the SCells that triggered consistent LBT failure; or

- all the SCells that triggered consistent LBT failure recovery are deactivated (see clause 5.9).

### 5.4.6 Power Headroom Reporting

The Power Headroom reporting procedure is used to provide the serving gNB with the following information:

- Type 1 power headroom: the difference between the nominal UE maximum transmit power and the estimated power for UL-SCH transmission per activated Serving Cell;

- Type 2 power headroom: the difference between the nominal UE maximum transmit power and the estimated power for UL-SCH and PUCCH transmission on SpCell of the other MAC entity (i.e. E-UTRA MAC entity in EN-DC, NE-DC, and NGEN-DC cases);

- Type 3 power headroom: the difference between the nominal UE maximum transmit power and the estimated power for SRS transmission per activated Serving Cell;

- MPE P-MPR: the power backoff to meet the MPE FR2 requirements for a Serving Cell operating on FR2.

RRC controls Power Headroom reporting by configuring the following parameters:

- *phr-PeriodicTimer*;

- *phr-ProhibitTimer*;

- *phr-Tx-PowerFactorChange*;

- *phr-Type2OtherCell*;

- *phr-ModeOtherCG*;

- *multiplePHR*;

- *mpe-Reporting-FR2*;

- *mpe-ProhibitTimer*;

- *mpe-Threshold*;

- *numberOfN*;

- *mpe-ResourcePoo*l;

- *twoPHRMode*.

A Power Headroom Report (PHR) shall be triggered if any of the following events occur:

- *phr-ProhibitTimer* expires or has expired and the path loss has changed more than *phr-Tx-PowerFactorChange* dB for at least one RS used as pathloss reference for one activated Serving Cell of any MAC entity of which the active DL BWP is not dormant BWP since the last transmission of a PHR in this MAC entity when the MAC entity has UL resources for new transmission;

NOTE 1: The path loss variation for one cell assessed above is between the pathloss measured at present time on the current pathloss reference and the pathloss measured at the transmission time of the last transmission of PHR on the pathloss reference in use at that time, irrespective of whether the pathloss reference has changed in between. The current pathloss reference for this purpose does not include any pathloss reference configured using *pathlossReferenceRS-Pos* in TS 38.331 [5].

- *phr-PeriodicTimer* expires;

- upon configuration or reconfiguration of the power headroom reporting functionality by upper layers, which is not used to disable the function;

- activation of an SCell of any MAC entity with configured uplink of which *firstActiveDownlinkBWP-Id* is not set to dormant BWP;

- activation of an SCG;

- addition of the PSCell except if the SCG is deactivated (i.e. PSCell is newly added or changed);

- *phr-ProhibitTimer* expires or has expired, when the MAC entity has UL resources for new transmission, and the following is true for any of the activated Serving Cells of any MAC entity with configured uplink:

- there are UL resources allocated for transmission or there is a PUCCH transmission on this cell, and the required power backoff due to power management (as allowed by P-MPRc as specified in TS 38.101-1 [14], TS 38.101-2 [15], and TS 38.101-3 [16]) for this cell has changed more than *phr-Tx-PowerFactorChange* dB since the last transmission of a PHR when the MAC entity had UL resources allocated for transmission or PUCCH transmission on this cell.

- Upon switching of activated BWP from dormant BWP to non-dormant DL BWP of an SCell of any MAC entity with configured uplink;

- if *mpe-Reporting-FR2* is configured, and *mpe-ProhibitTimer* is not running:

- the measured P-MPR applied to meet FR2 MPE requirements as specified in TS 38.101-2 [15] is equal to or larger than *mpe-Threshold* for at least one activated FR2 Serving Cell since the last transmission of a PHR in this MAC entity; or

- the measured P-MPR applied to meet FR2 MPE requirements as specified in TS 38.101-2 [15] has changed more than *phr-Tx-PowerFactorChange* dB for at least one activated FR2 Serving Cell since the last transmission of a PHR due to the measured P-MPR applied to meet MPE requirements being equal to or larger than *mpe-Threshold* in this MAC entity.

in which case the PHR is referred below to as 'MPE P-MPR report'.

NOTE 2: The MAC entity should avoid triggering a PHR when the required power backoff due to power management decreases only temporarily (e.g. for up to a few tens of milliseconds) and it should avoid reflecting such temporary decrease in the values of PCMAX,f,c/PH when a PHR is triggered by other triggering conditions.

NOTE 3: If a HARQ process is configured with *cg-RetransmissionTimer* and if the PHR is already included in a MAC PDU for transmission on configured grant by this HARQ process, but not yet transmitted by lower layers, it is up to UE implementation how to handle the PHR content.

If the MAC entity has UL resources allocated for a new transmission the MAC entity shall:

1> if it is the first UL resource allocated for a new transmission since the last MAC reset:

2> start *phr-PeriodicTimer*.

1> if the Power Headroom reporting procedure determines that at least one PHR has been triggered and not cancelled; and

1> if the allocated UL resources can accommodate the MAC CE for PHR which the MAC entity is configured to transmit, plus its subheader, as a result of LCP as defined in clause 5.4.3.1:

2> if *multiplePHR* with value *true* is configured:

3> for each activated Serving Cell with configured uplink associated with any MAC entity of which the active DL BWP is not dormant BWP; and

3> for each activated Serving Cell with configured uplink associated with E-UTRA MAC entity:

4> if this MAC entity is configured with *twoPHRMode*:

5> if this Serving Cell is configured with multiple TRP PUSCH repetition and the MAC entity this Serving Cell belongs to is configured with *twoPHRMode*:

6> obtain two values of the Type 1 or the value of Type 3 power headroom for the corresponding uplink carrier as specified in clause 7.7 of TS 38.213 [6] for NR Serving Cell;

5> else:

6> obtain the value of the Type 1 or Type 3 power headroom for the corresponding uplink carrier as specified in clause 7.7 of TS 38.213 [6] for NR Serving Cell and clause 5.1.1.2 of TS 36.213 [17] for E-UTRA Serving Cell;

4> else (i.e. this MAC entity is not configured with *twoPHRMode*):

5> if this Serving Cell is configured with multiple TRP PUSCH repetition and the MAC entity this Serving Cell belongs to is configured with *twoPHRMode*:

6> obtain the value of the Type 1 power headroom associated with the SRS-ResourceSet with a lower *srs-ResourceSetID* from two calculated values of different TRPs for the corresponding uplink carrier as specified in clause 7.7 of TS 38.213 [6] for NR Serving Cell and obtain the value; or

6> obtain the value of the Type 3 power headroom for the corresponding uplink carrier as specified in clause 7.7 of TS 38.213 [6] for NR Serving Cell;

5> else:

6> obtain the value of the Type 1 or Type 3 power headroom for the corresponding uplink carrier as specified in clause 7.7 of TS 38.213 [6] for NR Serving Cell and clause 5.1.1.2 of TS 36.213 [17] for E-UTRA Serving Cell;

4> if this MAC entity has UL resources allocated for transmission on this Serving Cell; or

4> if the other MAC entity, if configured, has UL resources allocated for transmission on this Serving Cell and *phr-ModeOtherCG* is set to *real* by upper layers:

5> obtain the value for the corresponding PCMAX,f,c field from the physical layer.

5> if *mpe-Reporting-FR2* is configured and this Serving Cell operates on FR2 and this Serving Cell is associated to this MAC entity:

6> obtain the value for the corresponding MPE field from the physical layer.

5> if *mpe-Reporting-FR2-r17* is configured and this Serving Cell operates on FR2 and this Serving Cell is associated to this MAC entity:

6> obtain the value for the corresponding MPEi field from the physical layer;

6> obtain the value for the corresponding Resourcei field from the physical layer.3> if *phr-Type2OtherCell* with value *true* is configured:

4> if the other MAC entity is E-UTRA MAC entity:

5> obtain the value of the Type 2 power headroom for the SpCell of the other MAC entity (i.e. E-UTRA MAC entity);

5> if *phr-ModeOtherCG* is set to *real* by upper layers:

6> obtain the value for the corresponding PCMAX,f,c field for the SpCell of the other MAC entity (i.e. E-UTRA MAC entity) from the physical layer.

3> instruct the Multiplexing and Assembly procedure to generate and transmit the Enhanced Multiple entry PHR as defined in clause 6.1.3.49 if this MAC entity is configured with *mpe-Reporting-FR2-r17* or the Enhanced Multiple Entry PHR for multiple TRP MAC CE as defined in clause 6.1.3.51 if this MAC entity is configured with *twoPHRMode* or the Multiple Entry PHR MAC CE as defined in clause 6.1.3.9 otherwise based on the values reported by the physical layer.

2> else (i.e. Single Entry PHR format is used):

3> if this MAC entity is configured with *twoPHRMode*:

4> obtain two values of the Type 1 power headroom from the physical layer for the corresponding uplink carrier of the PCell;

3> else:

4> obtain the value of the Type 1 power headroom from the physical layer for the corresponding uplink carrier of the PCell;

3> obtain the value for the corresponding PCMAX,f,c field from the physical layer;

3> if *mpe-Reporting-FR2* is configured and this Serving Cell operates on FR2:

4> obtain the value for the corresponding MPE field from the physical layer.

3> if *mpe-Reporting-FR2-r17* is configured and this Serving Cell operates on FR2 and this Serving Cell is associated to this MAC entity:

4> obtain the value for the corresponding MPEi field from the physical layer;

4> obtain the value for the corresponding Resourcei field from the physical layer.

3> instruct the Multiplexing and Assembly procedure to generate and transmit the Enhanced Single entry PHR as defined in clause 6.1.3.48 if this MAC entity is configured with *mpe-Reporting-FR2-r17* or the Enhanced Single Entry PHR for multiple TRP MAC CE as defined in clause 6.1.3.50 if this MAC entity is configured with *twoPHRMode* or the Single Entry PHR MAC CE as defined in clause 6.1.3.8 otherwise based on the values reported by the physical layer.

2> if this PHR report is an MPE P-MPR report:

3> start or restart the *mpe-ProhibitTimer*;

3> cancel triggered MPE P-MPR reporting for Serving Cells included in the PHR MAC CE.

2> start or restart *phr-PeriodicTimer*;

2> start or restart *phr-ProhibitTimer*;

2> cancel all triggered PHR(s).

All triggered PHRs shall be cancelled when there is an ongoing SDT procedure as in clause 5.27 and the UL grant(s) can accommodate all pending data available for transmission but is not sufficient to additionally accommodate the PHR MAC CE plus its subheader.

## 5.17 Beam Failure Detection and Recovery procedure

The MAC entity may be configured by RRC per Serving Cell with a beam failure recovery procedure which is used for indicating to the serving gNB of a new SSB or CSI-RS when beam failure is detected on the serving SSB(s)/CSI-RS(s). Beam failure is detected by counting beam failure instance indication from the lower layers to the MAC entity. If *beamFailureRecoveryConfig* is reconfigured by upper layers during an ongoing Random Access procedure for beam failure recovery for SpCell, the MAC entity shall stop the ongoing Random Access procedure and initiate a Random Access procedure using the new configuration.

RRC configures the following parameters in the *BeamFailureRecoveryConfig*, *BeamFailureRecoverySCellConfig*, *BeamFailureRecoveryServingCellConfig* and the *RadioLinkMonitoringConfig* for the Beam Failure Detection and Recovery procedure:

- *beamFailureInstanceMaxCount* for the beam failure detection (per Serving Cell or per BFD-RS set of Serving Cell configured with two BFD-RS sets);

- *beamFailureDetectionTimer* for the beam failure detection (per Serving Cell or per BFD-RS set of Serving Cell configured with two BFD-RS sets);

- *beamFailureRecoveryTimer* for the beam failure recovery procedure;

- *rsrp-ThresholdSSB*: an RSRP threshold for the SpCell beam failure recovery;

- *rsrp-ThresholdBFR*: an RSRP threshold for the SCell beam failure recovery or for the beam failure recovery of BFD-RS set of Serving Cell;

- *powerRampingStep*: *powerRampingStep* for the SpCell beam failure recovery;

- *powerRampingStepHighPriority*: *powerRampingStepHighPriority* for the SpCell beam failure recovery;

- *preambleReceivedTargetPower*: *preambleReceivedTargetPower* for the SpCell beam failure recovery;

- *preambleTransMax*: *preambleTransMax* for the SpCell beam failure recovery;

- *scalingFactorBI*: *scalingFactorBI* for the SpCell beam failure recovery;

- *ssb-perRACH-Occasion*: *ssb-perRACH-Occasion* for the SpCell beam failure recovery using contention-free Random Access Resources;

- *ra-ResponseWindow*: the time window to monitor response(s) for the SpCell beam failure recovery using contention-free Random Access Resources;

- *prach-ConfigurationIndex*: *prach-ConfigurationIndex* for the SpCell beam failure recovery using contention-free Random Access Resources;

- *ra-ssb-OccasionMaskIndex*: *ra-ssb-OccasionMaskIndex* for the SpCell beam failure recovery using contention-free Random Access Resources;

- *ra-OccasionList*: *ra-OccasionList* for the SpCell beam failure recovery using contention-free Random Access Resources;

- *candidateBeamRSList*: list of candidate beams for SpCell beam failure recovery;

- *candidateBeamRSSCellList*: list of candidate beams for SCell beam failure recovery;

- *candidateBeamRSList-r17*: list of candidate beams for beam failure recovery of BFD-RS set 1 of Serving Cell;

- *candidateBeamRSList2-r17*: list of candidate beams for beam failure recovery of BFD-RS set 2 of Serving Cell.

The following UE variables are used for the beam failure detection procedure:

- *BFI\_COUNTER* (per Serving Cell or per BFD-RS set of Serving Cell configured with two BFD-RS sets): counter for beam failure instance indication which is initially set to 0.

The MAC entity shall for each Serving Cell configured for beam failure detection:

1> if the Serving Cell is configured with two BFD-RS sets:

2> if beam failure instance indication for a BFD-RS set has been received from lower layers:

3> start or restart the *beamFailureDetectionTimer* of the BFD-RS set;

3> increment *BFI\_COUNTER* of the BFD-RS set by 1;

3> if *BFI\_COUNTER* of the BFD-RS set >= *beamFailureInstanceMaxCount*:

4> trigger a BFR for this BFD-RS set of the Serving Cell;

2> if BFR is triggered for both BFD-RS sets of the SpCell and the Beam Failure Recovery procedure is not successfully completed for any of the BFD-RS sets:

3> initiate a Random Access procedure (see clause 5.1) on the SpCell;

2> if the Serving Cell is SpCell and the Random Access procedure initiated for beam failure recovery of both BFD-RS sets of SpCell is successfully completed (see clause 5.1):

3> set *BFI\_COUNTER* of each BFD-RS set of SpCell to 0.

3> consider the Beam Failure Recovery procedure successfully completed.

2> if the *beamFailureDetectionTimer* of this BFD-RS set expires; or

2> if *beamFailureDetectionTimer*, *beamFailureInstanceMaxCount*, or any of the reference signals used for beam failure detection is reconfigured by upper layers associated with a BFD-RS set of the Serving Cell:

3> set *BFI\_COUNTER* of the BFD-RS set to 0.

2> if a PDCCH addressed to C-RNTI indicating uplink grant for a new transmission is received for the HARQ process used for the transmission of the Enhanced BFR MAC CE or Truncated Enhanced BFR MAC CE which contains beam failure recovery information of this BFD-RS set of the Serving Cell:

3> set *BFI\_COUNTER* of the BFD-RS set to 0;

3> consider the Beam Failure Recovery procedure successfully completed for this BFD-RS set and cancel all the triggered BFRs of this BFD-RS set of the Serving Cell.

2> if the Serving Cell is SCell and the SCell is deactivated as specified in clause 5.9:

3> set *BFI\_COUNTER* of each BFD-RS set of SCell to 0;

3> consider the Beam Failure Recovery procedure successfully completed and cancel all the triggered BFRs of all BFD-RS sets of the Serving Cell.

1> else:

2> if beam failure instance indication has been received from lower layers:

3> start or restart the *beamFailureDetectionTimer*;

3> increment *BFI\_COUNTER* by 1;

3> if *BFI\_COUNTER* >= *beamFailureInstanceMaxCount*:

4> if the Serving Cell is SCell:

5> trigger a BFR for this Serving Cell;

4> else if the Serving Cell is PSCell, the SCG is deactivated and beam failure of the PSCell was not indicated to upper layers since the SCG was deactivated:

5> indicate beam failure of the PSCell to upper layers.

4> else

5> initiate a Random Access procedure (see clause 5.1) on the SpCell.

2> if the *beamFailureDetectionTimer* expires; or

2> if *beamFailureDetectionTimer*, *beamFailureInstanceMaxCount*, or any of the reference signals used for beam failure detection is reconfigured by upper layers associated with this Serving Cell:

3> set *BFI\_COUNTER* to 0.

2> if the Serving Cell is SpCell and the Random Access procedure initiated for SpCell beam failure recovery is successfully completed (see clause 5.1):

3> set *BFI\_COUNTER* to 0;

3> stop the *beamFailureRecoveryTimer*, if configured;

3> consider the Beam Failure Recovery procedure successfully completed.

2> else if the Serving Cell is SCell, and a PDCCH addressed to C-RNTI indicating uplink grant for a new transmission is received for the HARQ process used for the transmission of the MAC CE for BFR which contains beam failure recovery information of this Serving Cell; or

2> if the SCell is deactivated as specified in clause 5.9:

3> set *BFI\_COUNTER* to 0;

3> consider the Beam Failure Recovery procedure successfully completed and cancel all the triggered BFRs for this Serving Cell.

The MAC entity shall:

1> if the Beam Failure Recovery procedure determines that at least one BFR has been triggered and not cancelled for an SCell for which evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed and if none of the Serving Cell(s) of this MAC entity are configured with two BFD-RS sets:

2> if UL-SCH resources are available for a new transmission and if the UL-SCH resources can accommodate the BFR MAC CE plus its subheader as a result of LCP:

3> instruct the Multiplexing and Assembly procedure to generate the BFR MAC CE.

2> else if UL-SCH resources are available for a new transmission and if the UL-SCH resources can accommodate the Truncated BFR MAC CE plus its subheader as a result of LCP:

3> instruct the Multiplexing and Assembly procedure to generate the Truncated BFR MAC CE.

2> else:

3> trigger the SR for SCell beam failure recovery for each SCell for which BFR has been triggered, not cancelled, and for which evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed.

1> if the Beam Failure Recovery procedure determines that at least one BFR for BFD-RS set has been triggered and not cancelled for an SCell for which evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed; or

1> if the Beam Failure Recovery procedure determines that at least one BFR for BFD-RS set for only one BFD-RS set has been triggered and not cancelled for an SpCell for which evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed; or

1> if the Beam Failure Recovery procedure determines that at least one BFR has been triggered and not cancelled for an SCell for which evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed and if at least one Serving Cell of this MAC entity is configured with two BFD-RS sets:

2> if UL-SCH resources are available for a new transmission and if the UL-SCH resources can accommodate the Enhanced BFR MAC CE plus its subheader as a result of LCP:

3> instruct the Multiplexing and Assembly procedure to generate the Enhanced BFR MAC CE.

2> else if UL-SCH resources are available for a new transmission and if the UL-SCH resources can accommodate the Truncated Enhanced BFR MAC CE plus its subheader as a result of LCP:

3> instruct the Multiplexing and Assembly procedure to generate the Truncated Enhanced BFR MAC CE.

2> else:

3> trigger the SR for beam failure recovery of each BFD-RS set for which BFR has been triggered, not cancelled, and for which evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed;

3> trigger the SR for SCell beam failure recovery for each SCell for which BFR has been triggered, not cancelled, and for which evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed.

All BFRs triggered for an SCell shall be cancelled when a MAC PDU is transmitted and this PDU includes a MAC CE for BFR which contains beam failure information of that SCell. All BFRs triggered for a BFD-RS set of a Serving Cell shall be cancelled when a MAC PDU is transmitted and this PDU includes an Enhanced BFR MAC CE or Truncated Enhanced BFR MAC CE which contains beam failure recovery information of that BFD-RS set of the Serving Cell.

## 5.18 Handling of MAC CEs

### 5.18.1 General

This clause specifies the requirements upon reception of the following MAC CEs:

- SP CSI-RS/CSI-IM Resource Set Activation/Deactivation MAC CE;

- Aperiodic CSI Trigger State Subselection MAC CE;

- TCI States Activation/Deactivation for UE-specific PDSCH MAC CE;

- TCI State Indication for UE-specific PDCCH MAC CE;

- SP CSI reporting on PUCCH Activation/Deactivation MAC CE;

- SP SRS Activation/Deactivation MAC CE;

- PUCCH spatial relation Activation/Deactivation MAC CE;

- Enhanced PUCCH spatial relation Activation/Deactivation MAC CE;

- SP ZP CSI-RS Resource Set Activation/Deactivation MAC CE;

- Recommended Bit Rate MAC CE;

- Enhanced SP/AP SRS Spatial Relation Indication MAC CE;

- SRS Pathloss Reference RS Update MAC CE;

- PUSCH Pathloss Reference RS Update MAC CE;

- Serving Cell set based SRS Spatial Relation Indication MAC CE;

- SP Positioning SRS Activation/Deactivation MAC CE;

- Timing Delta MAC CE;

- Guard Symbols MAC CEs;

- Positioning Measurement Gap Activation/Deactivation Command MAC CE;

- PPW Activation/Deactivation Command MAC CE;

- PUCCH spatial relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE;

- PUCCH Power Control Set Update for multiple TRP PUCCH repetition MAC CE;

- Unified TCI States Activation/Deactivation for UE-specific PDSCH MAC CE;

- Differential Koffset MAC CE.

### 5.18.4 Activation/Deactivation of UE-specific PDSCH TCI state

The network may activate and deactivate the configured TCI states for PDSCH of a Serving Cell or a set of Serving Cells configured in *simultaneousTCI-UpdateList1* or *simultaneousTCI-UpdateList2* by sending the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE described in clause 6.1.3.14. The network may activate and deactivate the configured TCI states for a codepoint of the DCI *Transmission configuration indication* field as specified in TS 38.212 [9] for PDSCH of a Serving Cell by sending the Enhanced TCI States Activation/Deactivation for UE-specific PDSCH MAC CE described in clause 6.1.3.24. The configured TCI states for PDSCH are initially deactivated upon (re-)configuration by upper layers and after reconfiguration with sync.

The MAC entity shall:

1> if the MAC entity receives a TCI States Activation/Deactivation for UE-specific PDSCH MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the TCI States Activation/Deactivation for UE-specific PDSCH MAC CE.

1> if the MAC entity receives an Enhanced TCI States Activation/Deactivation for UE-specific PDSCH MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the Enhanced TCI States Activation/Deactivation for UE-specific PDSCH MAC CE.

### 5.18.5 Indication of TCI state for UE-specific PDCCH

The network may indicate a TCI state for PDCCH reception for a CORESET of a Serving Cell or a set of Serving Cells configured in *simultaneousTCI-UpdateList1* or *simultaneousTCI-UpdateList2* by sending the TCI State Indication for UE-specific PDCCH MAC CE described in clause 6.1.3.15. The network may also indicate two TCI states for PDCCH reception for a CORESET of a Serving Cell or a set of Serving Cells configured in *simultaneousTCI-UpdateList1* or *simultaneousTCI-UpdateList2* by sending the Enhanced TCI States Indication for UE-specific PDCCH MAC CE described in clause 6.1.3.44.

The MAC entity shall:

1> if the MAC entity receives a TCI State Indication for UE-specific PDCCH MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the TCI State Indication for UE-specific PDCCH MAC CE.

1> if the MAC entity receives an Enhanced TCI States Indication for UE-specific PDCCH MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the Enhanced TCI States Indication for UE-specific PDCCH MAC CE.

### 5.18.7 Activation/Deactivation of Semi-persistent SRS and Indication of spatial relation of SP/AP SRS

The network may activate and deactivate the configured Semi-persistent SRS resource sets of a Serving Cell by sending the SP SRS Activation/Deactivation MAC CE described in clause 6.1.3.17. The network may also activate and deactivate the configured Semi-persistent SRS resource sets of a Serving Cell by sending the Enhanced SP/AP SRS Spatial Relation Indication MAC CE described in clause 6.1.3.26. The network may also activate and deactivate the configured Semi-persistent SRS resource sets of a Serving Cell by sending the SP/AP SRS TCI State Indication MAC CE described in clause 6.1.3.aa. The configured Semi-persistent SRS resource sets are initially deactivated upon (re-)configuration by upper layers and after reconfiguration with sync. The network may indicate the spatial relation info of SP/AP SRS resource sets of a Serving Cell by sending the Enhanced SP/AP SRS spatial relation Indication MAC CE described in clause 6.1.3.26.

The MAC entity shall:

1> if the MAC entity receives an SP SRS Activation/Deactivation MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the SP SRS Activation/Deactivation MAC CE.

1> if the MAC entity receives an Enhanced SP/AP SRS Spatial Relation Indication MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the Enhanced SP/AP SRS Spatial Relation Indication MAC CE.

1> if the MAC entity receives an SP/AP SRS TCI State Indication MAC CE on a Serving Cell:

### 2> indicate to lower layers the information regarding the SP/AP SRS TCI State Indication MAC CE.5.18.8 Activation/Deactivation of spatial relation of PUCCH resource

The network may activate and deactivate a spatial relation for a PUCCH resource of a Serving Cell by sending the PUCCH spatial relation Activation/Deactivation MAC CE described in clause 6.1.3.18. The network may also activate and deactivate a spatial relation for a PUCCH resource or a PUCCH resource group of a Serving Cell by sending the Enhanced PUCCH spatial relation Activation/Deactivation MAC CE described in clause 6.1.3.25. The configured spatial relation for a PUCCH resource is initially deactivated upon (re-)configuration by upper layers and after reconfiguration with sync. The network may also activate and deactivate the two spatial relations for a PUCCH resource or a PUCCH resource group of a Serving Cell by sending the PUCCH spatial relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE described in clause 6.1.3.45.

The MAC entity shall:

1> if the MAC entity receives a PUCCH spatial relation Activation/Deactivation MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the PUCCH spatial relation Activation/Deactivation MAC CE.

1> if the MAC entity receives an Enhanced PUCCH spatial relation Activation/Deactivation MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the Enhanced PUCCH spatial relation Activation/Deactivation MAC CE.

1> if the MAC entity receives an PUCCH spatial relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the PUCCH spatial relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE.

### 5.18.16 Indication of spatial relation of SRS resource for a Serving Cell set

The network may indicate the spatial relation info of SRS resource of a set of Serving Cells configured in *simultaneousSpatial-UpdatedList1* or *simultaneousSpatial-UpdatedList2* by sending the Serving Cell set based SRS Spatial Relation Indication MAC CE and the Serving Cell Set based SRS TCI State Indication MAC CE described in clause 6.1.3.29 and 6.1.3.bb, respectively.

The MAC entity shall:

1> if the MAC entity receives a Serving Cell set based SRS Spatial Relation Indication MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the Serving Cell set based SRS Spatial Relation Indication MAC CE.

1> if the MAC entity receives a Serving Cell Set based SRS TCI State Indication MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the Serving Cell Set based SRS TCI State Indication MAC CE.

### 5.18.22 Update of PUCCH Power Control Set for multiple TRP PUCCH repetition

The network may activate and deactivate PUCCH power control set(s) for multiple TRP PUCCH repetition for a PUCCH resource or a PUCCH resource group of a Serving Cell by sending the PUCCH Power Control Set Update for multiple TRP PUCCH repetition MAC CE described in clause 6.1.3.46.

The MAC entity shall:

1> if the MAC entity receives a PUCCH Power Control Set Update for multiple TRP PUCCH repetition MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the PUCCH power control set update for multiple TRP PUCCH repetition MAC CE.

### 5.18.23 Unified TCI States Activation/Deactivation MAC CE

The network may activate and deactivate the configured unified TCI states of a Serving Cell or a set of Serving Cells configured in *simultaneousU-TCI-UpdateList1*, *simultaneousU-TCI-UpdateList2*, *simultaneousU-TCI-UpdateList3* or *simultaneousU-TCI-UpdateList4* by sending the Unified TCI States Activation/Deactivation MAC CE described in clause 6.1.3.47.

1> if the MAC entity receives a Unified TCI States Activation/Deactivation MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the Unified TCI States Activation/Deactivation MAC CE.

### 5.18.XX BFD-RS Indication MAC CE

The network may activate and deactivate the configured beam failure detection resources of a Serving Cell by sending the BFD-RS indication MAC CE described in clause 6.1.3.xx.

1> if the MAC entity receives a BFD-RS indication MAC CE on a Serving Cell:

2> indicate to lower layers the information regarding the BFD-RS Indication MAC CE.

### 6.1.3 MAC Control Elements (CEs)

#### 6.1.3.14 TCI States Activation/Deactivation for UE-specific PDSCH MAC CE

The TCI States Activation/Deactivation for UE-specific PDSCH MAC CE is identified by a MAC subheader with LCID as specified in Table 6.2.1-1. It has a variable size consisting of following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits. If the indicated Serving Cell is configured as part of a *simultaneousTCI-UpdateList1* or *simultaneousTCI-UpdateList2* as specified in TS 38.331 [5], this MAC CE applies to all the Serving Cells configured in the set *simultaneousTCI-UpdateList1* or *simultaneousTCI-UpdateList2*, respectively;

- BWP ID: This field indicates a DL BWP for which the MAC CE applies as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9]. The length of the BWP ID field is 2 bits. This field is ignored if this MAC CE applies to a set of Serving Cells;

- Ti: If there is a TCI state with *TCI-StateId* i as specified in TS 38.331 [5], this field indicates the activation/deactivation status of the TCI state with *TCI-StateId* i, otherwise MAC entity shall ignore the Ti field. The Ti field is set to 1 to indicate that the TCI state with *TCI-StateId* i shall be activated and mapped to the codepoint of the DCI *Transmission Configuration Indication* field, as specified in TS 38.214 [7]. The Ti field is set to 0 to indicate that the TCI state with *TCI-StateId* i shall be deactivated and is not mapped to the codepoint of the DCI *Transmission Configuration Indication* field. The codepoint to which the TCI State is mapped is determined by its ordinal position among all the TCI States with Ti field set to 1, i.e. the first TCI State with Ti field set to 1 shall be mapped to the codepoint value 0, second TCI State with Ti field set to 1 shall be mapped to the codepoint value 1 and so on. The maximum number of activated TCI states is 8. The activated TCI states can be associated with at most one PCI different from the Serving Cell PCI at a time;

- CORESET Pool ID: This field indicates that mapping between the activated TCI states and the codepoint of the DCI *Transmission Configuration Indication* set by field Ti is specific to the *ControlResourceSetId* configured with CORESET Pool ID as specified in TS 38.331 [5]. This field set to 1 indicates that this MAC CE shall be applied for the DL transmission scheduled by CORESET with the CORESET pool ID equal to 1, otherwise, this MAC CE shall be applied for the DL transmission scheduled by CORESET pool ID equal to 0. If the *coresetPoolIndex* is not configured for any CORESET, MAC entity shall ignore the CORESET Pool ID field in this MAC CE when receiving the MAC CE. If the Serving Cell in the MAC CE is configured in a cell list that contains more than one Serving Cell, the CORSET Pool ID field shall be ignored when receiving the MAC CE.



Figure 6.1.3.14-1: TCI States Activation/Deactivation for UE-specific PDSCH MAC CE

#### 6.1.3.17 SP SRS Activation/Deactivation MAC CE

The SP SRS Activation/Deactivation MAC CE is identified by a MAC subheader with LCID as specified in Table 6.2.1-1. It has a variable size with following fields:

- A/D: This field indicates whether to activate or deactivate indicated SP SRS resource set. The field is set to 1 to indicate activation, otherwise it indicates deactivation;

- SRS Resource Set's Cell ID: This field indicates the identity of the Serving Cell, which contains activated/deactivated SP SRS Resource Set. If the C field is set to 0, this field also indicates the identity of the Serving Cell which contains all resources indicated by the Resource IDi fields. The length of the field is 5 bits;

- SRS Resource Set's BWP ID: This field indicates a UL BWP as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9], which contains activated/deactivated SP SRS Resource Set. If the C field is set to 0, this field also indicates the identity of the BWP which contains all resources indicated by the Resource IDi fields. The length of the field is 2 bits;

- C: This field indicates whether the octets containing Resource Serving Cell ID field(s) and Resource BWP ID field(s) are present. If this field is set to 1, the octets containing Resource Serving Cell ID field(s) and Resource BWP ID field(s) are present, otherwise they are not present;

- SUL: This field indicates whether the MAC CE applies to the NUL carrier or SUL carrier configuration. This field is set to 1 to indicate that it applies to the SUL carrier configuration, and it is set to 0 to indicate that it applies to the NUL carrier configuration;

- SP SRS Resource Set ID: This field indicates the SP SRS Resource Set ID identified by *SRS-ResourceSetId* as specified in TS 38.331 [5], which is to be activated or deactivated. The length of the field is 4 bits;

- Fi: This field indicates the type of a resource used as a spatial relationship for SRS resource within SP SRS Resource Set indicated with SP SRS Resource Set ID field. F0 refers to the first SRS resource within the resource set, F1 to the second one and so on. The field is set to 1 to indicate NZP CSI-RS resource index is used, and it is set to 0 to indicate either SSB index or SRS resource index is used. The length of the field is 1 bit. This field is only present if MAC CE is used for activation, i.e. the A/D field is set to 1;

- Resource IDi: This field contains an identifier of the resource used for spatial relationship derivation for SRS resource i. Resource ID0 refers to the first SRS resource within the resource set, Resource ID1 to the second one and so on. If Fi is set to 0, and the first bit of this field is set to 1, the remainder of this field contains *SSB-Index* as specified in TS 38.331 [5]. If Fi is set to 0, and the first bit of this field is set to 0, the remainder of this field contains *SRS-ResourceId* as specified in TS 38.331 [5]. The length of the field is 7 bits. This field is only present if MAC CE is used for activation, i.e. the A/D field is set to 1;

- Resource Serving Cell IDi: This field indicates the identity of the Serving Cell on which the resource used for spatial relationship derivation for SRS resource i is located. The length of the field is 5 bits;

- Resource BWP IDi: This field indicates a UL BWP as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9], on which the resource used for spatial relationship derivation for SRS resource i is located. The length of the field is 2 bits;

- R: Reserved bit, set to 0.



Figure 6.1.3.17-1: SP SRS Activation/Deactivation MAC CE

#### 6.1.3.26 Enhanced SP/AP SRS Spatial Relation Indication MAC CE

The Enhanced SP/AP SRS Spatial Relation Indication MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-1b. It has a variable size with following fields:

- A/D: This field indicates whether to activate or deactivate indicated SP SRS resource set. The field is set to 1 to indicate activation, otherwise it indicates deactivation. If the indicated SRS resource set ID is for the AP SRS resource set, MAC entity shall ignore this field;

- SRS Resource Set's Cell ID: This field indicates the identity of the Serving Cell, which contains the indicated SP/AP SRS Resource Set. If the C field is set to 0, this field also indicates the identity of the Serving Cell which contains all resources indicated by the Resource IDi fields. The length of the field is 5 bits;

- SRS Resource Set's BWP ID: This field indicates a UL BWP as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9], which contains the indicated SP/AP SRS Resource Set. If the C field is set to 0, this field also indicates the identity of the BWP which contains all resources indicated by the Resource IDi fields. The length of the field is 2 bits;

- C: This field indicates whether the octets containing Resource Serving Cell ID field(s) and Resource BWP ID field(s) are present. If this field is set to 1, Resource Serving Cell ID field(s) and Resource BWP ID field(s) are present, otherwise they are not present so MAC entity shall ignore Resource Serving Cell ID field(s) and Resource BWP ID field(s);

- SUL: This field indicates whether the MAC CE applies to the NUL carrier or SUL carrier configuration. This field is set to 1 to indicate that it applies to the SUL carrier configuration, and it is set to 0 to indicate that it applies to the NUL carrier configuration;

- SRS Resource Set ID: This field indicates the SP/AP SRS Resource Set ID identified by *SRS-ResourceSetId* as specified in TS 38.331 [5]. The length of the field is 4 bits;

- Fi: This field indicates the type of a resource used as a spatial relationship for SRS resource within SP/AP SRS Resource Set indicated with SP/AP SRS Resource Set ID field. F0 refers to the first SRS resource within the resource set, F1 to the second one and so on. The field is set to 1 to indicate NZP CSI-RS resource index is used, and it is set to 0 to indicate either SSB index or SRS resource index is used. The length of the field is 1 bit. This field is only present if MAC CE is used for activation of SP SRS resource set, i.e. the A/D field is set to 1, or for AP SRS resource set;

- Resource Serving Cell IDi: This field indicates the identity of the Serving Cell on which the resource used for spatial relationship derivation for SRS resource i is located. The length of the field is 5 bits;

- Resource BWP IDi: This field indicates a UL BWP as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9], on which the resource used for spatial relationship derivation for SRS resource i is located. The length of the field is 2 bits;

- Resource IDi: This field contains an identifier of the resource used for spatial relationship derivation for SRS resource i. Resource ID0 refers to the first SRS resource within the resource set, Resource ID1 to the second one and so on. If Fi is set to 0, the first bit of this field is always set to 0. If Fi is set to 0, and the second bit of this field is set to 1, the remainder of this field contains *SSB-Index* as specified in TS 38.331 [5]. If Fi is set to 0, and the second bit of this field is set to 0, the remainder of this field contains *SRS-ResourceId* as specified in TS 38.331 [5]. The length of the field is 8 bits. This field is only present if MAC CE is used for activation of SP SRS resource set, i.e. the A/D field is set to 1, or for AP SRS resource set;

- R: Reserved bit, set to 0.



Figure 6.1.3.26-1: Enhanced SP/AP SRS spatial relation Indication MAC CE

#### 6.1.3.28 PUSCH Pathloss Reference RS Update MAC CE

The PUSCH Pathloss Reference RS Update MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-1b. It has a variable size and consists of the following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell, which contains activated PUSCH Pathloss Reference RS. The length of the field is 5 bits;

- BWP ID: This field indicates a UL BWP as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9], which contains activated PUSCH Pathloss Reference RS. The length of the field is 2 bits;

- T: If the UE is configured with two SRS resources sets for codebook or non-codebook, as specified in TS 38.331 [5], in the indicated bandwidth part of the indicated Serving Cell, if this field is set to 0, SRI ID(s) to be updated are the ones associated with the first SRS resource set, and if is set to 1 the SRI ID(s) to be updated are the ones associated with the second SRS resource set. Otherwise, this field is a reserved bit set to 0;

- PUSCH Pathloss Reference RS ID: This field indicates the PUSCH Pathloss Reference RS ID identified by *PUSCH-PathlossReferenceRS-Id* as specified in TS 38.331 [5], which is to be updated in the SRI PUSCH power control mappings indicated by SRI ID fields indicated in the same MAC CE. The length of the field is 6 bits;

- C: This field indicates the presence of the additional SRI ID in the last octet of this MAC CE. If this field is set to 1, two SRI ID(s) are present in the last octet. Otherwise only one SRI ID (i.e. the first SRI ID) is present in the last octet;

- SRI ID: This field indicates the SRI PUSCH power control ID identified by *sri-PUSCH-PowerControlId* as specified in TS 38.331 [5]. The length of the field is 4 bits;

- R: Reserved bit, set to 0.



Figure 6.1.3.28-1: PUSCH Pathloss Reference RS Update MAC CE

#### 6.1.3.43 Enhanced BFR MAC CEs

The Enhanced MAC CEs for BFR consists of either:

- Enhanced BFR MAC CE; or

- Truncated Enhanced BFR MAC CE.

The Enhanced BFR MAC CE and Truncated Enhanced BFR MAC CE are identified by a MAC subheader with eLCID/LCID as specified in Table 6.2.1-2 and Table 6.2.1-2b.

The Enhanced BFR MAC CE and Truncated Enhanced BFR MAC CE have a variable size. They include a SP field, Ci bitmap (single octet or four octets), Sj bitmap (0 to 4 octets), beam failure recovery information i.e. octets containing candidate beam availability indication (AC) for BFD-RS set(s) of SpCell configured with two BFD-RS sets, and in ascending order based on ServCellIndex, beam failure recovery information i.e. octets containing candidate beam availability indication (AC) for BFD-RS set(s) of SCells indicated in the Ci bitmap. For Enhanced BFR MAC CE, a single octet Ci bitmap is used when the highest ServCellIndex of this MAC entity's SCell for which beam failure is detected for SCell or for at least one BFD-RS set of SCell and the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed is less than 8, otherwise four octets Ci bitmap is used. A MAC PDU shall contain at most one MAC CE for BFR.

For Truncated Enhanced BFR MAC CE, a single octet Ci bitmap is used for the following cases, otherwise four octets Ci bitmap is used:

- the highest *ServCellIndex* of this MAC entity's SCell for which beam failure is detected for SCell or for at least one BFD-RS set of SCell and the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed is less than 8; or

- beam failure is detected for SpCell (as specified in Clause 5.17) not configured with two BFD-RS sets, and the SpCell is to be indicated in a Truncated Enhanced BFR MAC CE and the UL-SCH resources available for transmission cannot accommodate the Truncated Enhanced BFR MAC CE with the four octets Ci bitmap plus its subheader as a result of LCP; or

- Random Access procedure is initiated for beam failure recovery of both BFD-RS sets of SpCell (as specified in Clause 5.17) configured with two BFD-RS sets and the SpCell is to be indicated in a Truncated Enhanced BFR MAC CE and the UL-SCH resources available for transmission cannot accommodate the Truncated Enhanced BFR MAC CE with the four octets Ci bitmap plus its subheader as a result of LCP.

For Enhanced BFR MAC CE and Truncated Enhanced BFR MAC CE, a single octet Sk bitmap is included if the total number of Serving Cells configured with two BFD-RS sets for which SP/Ci field set to 1 is greater than 0 and less than 9; a two octets Sk bitmap is included if the total number of Serving Cells configured with two BFD-RS sets for which SP/Ci field set to 1 is greater than 8 and less than 17; a three octets Sk bitmap is included if the total number of Serving Cells configured with two BFD-RS sets for which SP/Ci field is set to 1 is greater than 16 and less than 25; a four octets Sk bitmap is included if the total number of Serving Cells configured with two BFD-RS sets for which SP/Ci field set to 1 is greater than 24; Sk bitmap is not included if the total number of Serving Cells configured with two BFD-RS sets for which SP/Ci field is set to 1 is zero.

For Truncated Enhanced BFR MAC CE, octet(s) containing the AC field, if any, are included for SpCell first, then one octet containing the AC field is included for SCell(s) (in ascending order of the *ServCellIndex*) and then the second octet containing the AC field, if any, is included for SCell(s) (in ascending order of the *ServCellIndex*), while not exceeding the available grant size. The number of the octets containing the AC field in the Truncated Enhanced BFR MAC CE can be zero.

The fields in the Enhanced BFR MAC CEs are defined as follows:

- SP (Enhanced BFR MAC CE): This field indicates beam failure detection (as specified in clause 5.17) for the SpCell of this MAC entity and the presence of octet(s) containing the AC field if the SpCell is configured with multiple BFD-RS sets. For the SpCell configured with two BFD-RS sets, this field set to 1 indicates that beam failure is detected for at least one BFD-RS set, the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed, and the octet(s) containing the AC field is present for the SpCell; otherwise, it is set to 0. The octet(s) containing the AC field for SpCell are included before those of SCell(s). For the SpCell not configured with multiple BFD-RS sets, the SP field is set to 1 to indicate that beam failure is detected for SpCell when Enhanced BFR MAC CE is to be included into a MAC PDU as part of Random Access Procedure (as specified in 5.1.3a and 5.1.4); otherwise, it is set to 0;

- SP (Truncated Enhanced BFR MAC CE): This field indicates beam failure detection (as specified in clause 5.17) for the SpCell of this MAC entity. For the SpCell configured with two BFD-RS sets, this field set to 1 indicates that beam failure is detected for at least one BFD-RS set, the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed, and the octet(s) containing the AC field may be present for the SpCell; otherwise, it is set to 0. For the SpCell not configured with multiple BFD-RS sets, the SP field is set to 1 to indicate that beam failure is detected for SpCell when Enhanced BFR MAC CE is to be included into a MAC PDU as part of Random Access Procedure (as specified in 5.1.3a and 5.1.4); otherwise, it is set to 0;

- Ci (Enhanced BFR MAC CE): This field indicates beam failure detection (as specified in clause 5.17) and the presence of octet(s) containing the AC field for the SCell with *ServCellIndex* i as specified in TS 38.331 [5]. The Ci field set to 1 indicates that beam failure is detected for at least one BFD-RS set, the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed, and the octet(s) containing the AC field is present for the SCell with *ServCellIndex* i. The Ci field set to 0 indicates that the beam failure is either not detected for any BFD-RS set or the beam failure is detected for at least one BFD-RS set but the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has not been completed, and the octets containing the AC field is not present for the SCell with *ServCellIndex* i. The octets containing the AC field are present in ascending order based on the *ServCellIndex* and are included after the octets containing the AC field for SpCell, if any;

- Ci (Truncated Enhanced BFR MAC CE): This field indicates beam failure detection (as specified in clause 5.17) for the SCell with *ServCellIndex* i as specified in TS 38.331 [5]. The Ci field set to 1 indicates that beam failure is detected for at least one BFD-RS set, the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed, and the octet(s) containing the AC field for the SCell with *ServCellIndex* i may be present. The Ci field set to 0 indicates that the beam failure is either not detected for any BFD-RS set or the beam failure is detected for at least one BFD-RS set but the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has not been completed, and the octet(s) containing the AC field is not present for the SCell with *ServCellIndex* i;

- Sk (Enhanced BFR MAC CE): This field corresponds to the kth Serving Cell for which SP/Ci field is set to 1 and is configured with two BFD-RS sets. The Serving Cells for which SP/Ci field is set to 1 and are configured with two BFD-RS sets, are indexed sequentially starting with SpCell and followed by SCells in ascending order of *ServCellIndex* i. This field indicates whether beam failure is detected for one or both BFD-RS sets and presence of one or two octets containing the AC field of the Serving Cell. The Sk field set to 1 indicates that beam failure is detected for both the BFD-RS sets, the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed for both the BFD-RS sets, and the octets containing the AC field is present for both the BFD-RS sets, of the Serving Cell. The Sk field set to 0 indicates that beam failure is either detected for one of the BFD-RS sets and the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed or beam failure is detected for both the BFD-RS sets but the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has not been completed for both the BFD-RS sets, and the octet containing the AC field is present for only one BFD-RS set of the Serving Cell. The Sk field not mapped to any Serving Cell is set to 0;

- Sk (Truncated Enhanced BFR MAC CE): This field corresponds to the kth Serving Cell for which SP/Ci field is set to 1 and is configured with two BFD-RS sets. The Serving Cells for which SP/Ci field is set to 1 and are configured with two BFD-RS sets, are indexed sequentially starting with SpCell and followed by SCells in ascending order of *ServCellIndex* i. This field indicates whether beam failure is detected for one or both BFD-RS sets of the Serving Cell. The Sk field set to 1 indicates that beam failure is detected for both the BFD-RS sets, the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed for both the BFD-RS sets, and the octet containing the AC field is present for zero, one or two BFD-RS sets of the Serving Cell. The Sk field set to 0 indicates that beam failure is either detected for one of the BFD-RS sets and the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has been completed or beam failure is detected for both the BFD-RS sets but the evaluation of the candidate beams according to the requirements as specified in TS 38.133 [11] has not been completed for both the BFD-RS sets or the octet containing the AC field is present for zero or one BFD-RS set of the Serving Cell. The Sk field not mapped to any Serving Cell is set to 0;

- AC: This field indicates the presence of the Candidate RS ID field in this octet. If at least one of the SSBs with SS-RSRP above *rsrp-ThresholdBFR* amongst the SSBs in list of candidate beams (i.e. *candidateBeamRSSCellList* for the SCell not configured with two BFD-RS sets, *candidateBeamRSList-r17* or *candidateBeamRSList2-r17* for Serving Cell configured with two BFD-RS sets) or the CSI-RSs with CSI-RSRP above *rsrp-ThresholdBFR* amongst the CSI-RSs in list of candidate beams is available, the AC field is set to 1; otherwise, it is set to 0. If the AC field set to 1, the Candidate RS ID field is present. If the AC field set to 0, R bits are present instead;

- ID: This field indicates the identity of the BFD-RS set. It is set to 0 if this octet corresponds to BFD-RS set one, *failureDetectionSet1-r17*. It is set to 1 if this octet corresponds to BFD-RS set two, *failureDetectionSet2-r17*. For the Serving cell not configured with two BFD-RS sets, this field is set to 0;

- Candidate RS ID: This field is set to the index of an SSB with SS-RSRP above *rsrp-ThresholdBFR* amongst the SSBs in list of candidate beams (i.e. *candidateBeamRSSCellList* for the SCell not configured with two BFD-RS sets, *candidateBeamRSList-r17* or *candidateBeamRSList2-r17* for Serving Cell configured with two BFD-RS sets) or to the index of a CSI-RS with CSI-RSRP above *rsrp-ThresholdBFR* amongst the CSI-RSs in the list of candidate beams. Index of an SSB or CSI-RS is the index of an entry in the list of candidate beams corresponding to the SSB or CSI-RS. Index 0 corresponds to the first entry in the list of candidate beams, index 1 corresponds to the second entry in the list and so on. The length of this field is 6 bits;

- R: Reserved bit, set to 0.



Figure 6.1.3.43-1: Enhanced BFR and Truncated Enhanced BFR MAC CE with one octet Ci field



Figure 6.1.3.43-2: Enhanced BFR and Truncated Enhanced BFR MAC CE with four octets Ci field

#### 6.1.3.44 Enhanced TCI States Indication for UE-specific PDCCH MAC CE

The Enhanced TCI States Indication for UE-specific PDCCH MAC CE is identified by a MAC PDU subheader with eLCID as specified in Table 6.2.1-1b. It has a fixed size of 24 bits with following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits. If the indicated Serving Cell is configured as part of a *simultaneousTCI-UpdateList1* or *simultaneousTCI-UpdateList2* as specified in TS 38.331 [5], this MAC CE applies to all theServing Cells in the set *simultaneousTCI-UpdateList1* or *simultaneousTCI-UpdateList2*, respectively;

- CORESET ID: This field indicates a Control Resource Set identified with *ControlResourceSetId* as specified in TS 38.331 [5], for which the TCI State is being indicated. In case the value of the field is 0, the field refers to the Control Resource Set configured by *controlResourceSetZero* as specified in TS 38.331 [5]. The length of the field is 4 bits;

- TCI state IDi: This field indicates the TCI state identified by *TCI-StateId* as specified in TS 38.331 [5] applicable to the Control Resource Set identified by CORESET ID field. If the field of CORESET ID is set to the other value than 0, this field indicates a *TCI-StateId* configured by *tci-StatesPDCCH-ToAddList* and *tci-StatesPDCCH-ToReleaseList* in the *controlResourceSet* identified by the indicated CORESET ID. The length of the field is 7 bits.

NOTE 1: The Enhanced TCI State Indication for UE specific PDCCH MAC CE is not applicable to any of the configured CORESETs in a BWP if the CORESETs are configured with different *CORESETPoolindex* values in the BWP.

NOTE 2: The Enhanced TCI State Indication for UE specific PDCCH MAC CE is applied only if *sfnSchemePdcch* is configured.



Figure 6.1.3.44-1: Enhanced TCI States Indication for UE-specific PDCCH MAC CE

#### 6.1.3.45 PUCCH spatial relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE

The PUCCH Spatial Relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-1b. It has a variable size with following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;

- BWP ID: This field indicates a UL BWP for which the MAC CE applies as the codepoint of the DCI bandwidth part indicator field as specified in TS 38.212 [9]. The length of the BWP ID field is 2 bits;

- C: This field indicates whether single or two spatial relation info(s) is activated for the indicated PUCCH Resource ID. If this field is set to 1, octet containing the second spatial relation info for the indicated PUCCH Resource is present. If this field is set to 0, octet containing the second spatial relation info for the indicated PUCCH Resource is not present;

- PUCCH Resource ID: This field contains an identifier of the PUCCH resource ID identified by *PUCCH-ResourceId* as specified in TS 38.331 [5], which is to be activated with a spatial relations indicated by Spatial Relation Info IDi fields in the subsequent octet(s). The length of the field is 7 bits. If the indicated PUCCH Resource ID is included in a PUCCH Resource Group (configured via *resourceGroupToAddModList* as specified in TS 38.331 [5]) of the indicated UL BWP, no other PUCCH Resources within the same PUCCH Resource group are indicated in the MAC CE, and this MAC CE applies to all the PUCCH Resources in the PUCCH Resource group;

- Spatial Relation Info IDi: This field contains *PUCCH-SpatialRelationInfoId–r16* where *PUCCH-SpatialRelationInfoId* is the identifier of the PUCCH Spatial Relation Info in *PUCCH-Config* in which the PUCCH Resource ID is configured, as specified in TS 38.331 [5], where i is the index of the activated spatial relation info ID. The length of the field is 6 bits;

- R: Reserved bit, set to 0.



Figure 6.1.3.45-1: PUCCH spatial relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE

#### 6.1.3.46 PUCCH Power Control Set Update for multiple TRP PUCCH repetition MAC CE

The PUCCH Power Control Set Update for multiple TRP PUCCH repetition MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-1b. It has a variable size with following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;

- BWP ID: This field indicates a UL BWP for which the MAC CE applies as the codepoint of the DCI bandwidth part indicator field as specified in TS 38.212 [9]. The length of the BWP ID field is 2 bits;

- C: This field indicates whether single or two power control set(s) is activated for the indicated PUCCH Resource ID. If this field is set to 1, the second power control set index (i.e. Power Control Set ID1) for the indicated PUCCH Resource is present. If this field is set to 0, the second power control set index (i.e. Power Control Set ID1) for the indicated PUCCH Resource is not present;

- PUCCH Resource ID: This field contains an identifier of the PUCCH resource ID identified by *PUCCH-ResourceId* as specified in TS 38.331 [5], which is to be activated with a power control set(s) indicated by Power Control Set IDi fields in the subsequent octet. The length of the field is 7 bits. If the indicated PUCCH Resource ID is included in a PUCCH Resource Group (configured via *resourceGroupToAddModList* as specified in TS 38.331 [5]) of the indicated UL BWP, no other PUCCH Resources within the same PUCCH Resource group are indicated in the MAC CE, and this MAC CE applies to all the PUCCH Resources in the PUCCH Resource group;

- Power Control Set IDi: This field contains *PUCCH-PowerControlSetInfoId* where *PUCCH-PowerControlSetInfoId* is the identifier of the PUCCH Power Control Set in *PUCCH-Config* in which the PUCCH Resource ID is configured, as specified in TS 38.331 [5], where i is the index of the power control set ID. The length of the field is 3 bits;

- R: Reserved bit, set to 0.



Figure 6.1.3.46-1: PUCCH power control set update for multiple TRP PUCCH repletion MAC CE

#### 6.1.3.47 Unified TCI States Activation/Deactivation MAC CE

The Unified TCI States Activation/Deactivation MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-1b. It has a variable size consisting of following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits. If the indicated Serving Cell is configured as part of a *simultaneousU-TCI-UpdateList1*, *simultaneousU-TCI-UpdateList2*, *simultaneousU-TCI-UpdateList3* or *simultaneousU-TCI-UpdateList4* as specified in TS 38.331 [5], this MAC CE applies to all theServing Cells in the set *simultaneousU-TCI-UpdateList1*, *simultaneousU-TCI-UpdateList2*, *simultaneousU-TCI-UpdateList3* or *simultaneousU-TCI-UpdateList4*, respectively;

- DL BWP ID: This field indicates a DL BWP for which the MAC CE applies as the codepoint of the DCI bandwidth *part indicator* field as specified in TS 38.212 [9]. The length of the BWP ID field is 2 bits;

- UL BWP ID: This field indicates a UL BWP for which the MAC CE applies as the codepoint of the DCI bandwidth *part indicator* field as specified in TS 38.212 [9]. The length of the BWP ID field is 2 bits;

- Pi: This field indicates whether each TCI codepoint has multiple TCI states or single TCI state. If Pi field set to 1, it indicates that ith TCI codepoint includes the DL TCI state and the UL TCI state. If Pi field set to 0, it indicates that ith TCI codepoint includes only the DL TCI state or the UL TCI state;

- D/U: This field indicate whether the TCI state ID in the same octet is for joint/downlink or uplink TCI state. If this field is set to 1, the TCI state ID in the same octet is for joint/downlink. If this field is set to 0, the TCI state ID in the same octet is for uplink;

- TCI state ID: This field indicates the TCI state identified by *TCI-StateId* as specified in TS 38.331 [5]. If D/U is set to 1, 7-bits length TCI state ID i.e. *TCI-StateId* as specified in TS 38.331 [5] is used. If D/U is set to 0, the most significant bit of TCI state ID is considered as the reserved bit and remainder 6 bits indicate the *UL-TCIState-Id* as specified in TS 38.331 [5]. The maximum number of activated TCI states is 16;

- R: Reserved bit, set to 0.



Figure 6.1.3.47-1: Unified TCI state activation/deactivation MAC CE

#### 6.1.3.48 Enhanced Single Entry PHR MAC CE

The Enhanced Single Entry PHR MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-2b. It has a variable size with following fields:

- R: Reserved bit, set to 0;

- Power Headroom (PH): This field indicates the power headroom level. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.8-1 below (the corresponding measured values in dB are specified in TS 38.133 [11]);

- P: If *mpe-Reporting-FR2* is configured and the Serving Cell operates on FR2, the MAC entity shall set this field to 0 if the applied P-MPR value, to meet MPE requirements, as specified in TS 38.101-2 [15], is less than P-MPR\_00 as specified in TS 38.133 [11] and to 1 otherwise. If *mpe-Reporting-FR2* is not configured or the Serving Cell operates on FR1, this field indicates whether power backoff is applied due to power management (as allowed by P-MPRc as specified in TS 38.101-1 [14], TS 38.101-2 [15], and TS 38.101-3 [16]). The MAC entity shall set the P field to 1 if the corresponding PCMAX,f,c field would have had a different value if no power backoff due to power management had been applied;

- PCMAX,f,c: This field indicates the PCMAX,f,c (as specified in TS 38.213 [6]) used for calculation of the preceding PH field. The reported PCMAX,f,c and the corresponding nominal UE transmit power levels are shown in Table 6.1.3.8-2 (the corresponding measured values in dBm are specified in TS 38.133 [11]);

- MPE: If *mpe-Reporting-FR2* is configured, and the Serving Cell operates on FR2, and if the P field is set to 1, this field indicates the applied power backoff to meet MPE requirements, as specified in TS 38.101-2 [15]. This field indicates an index to Table 6.1.3.8-3 and the corresponding measured values of P-MPR levels in dB are specified in TS 38.133 [11]. The length of the field is 2 bits. If *mpe-Reporting-FR2* is not configured, or if the Serving Cell operates on FR1, or if the P field is set to 0, R bits are present instead;

- Bi: This field indicates whether the candidate beam information identified by Resourcei is present or not. If the B1 field is set to 1, the first octet containing Resource1 is present and if the B2 field is set to 1, the second octet containing Resource2 is present, and so on;

- P i: If *mpe-Reporting-FR2-r17* is configured and the Serving Cell operates on FR2, the MAC entity shall set this field to 0 if the applied P-MPR value, to meet MPE requirements, as specified in TS 38.101-2 [15], is less than P-MPR\_00 as specified in TS 38.133 [11] and to 1 otherwise;

- MPE i: If *mpe-Reporting-FR2-r17* is configured, and the Serving Cell operates on FR2, and if the corresponding P i field is set to 1, this field indicates the applied power backoff to meet MPE requirements, as specified in TS 38.101-2 [15]. This field indicates an index to Table 6.1.3.8-3 and the corresponding measured values of P-MPR levels in dB are specified in TS 38.133 [11]. The length of the field is 2 bits. If *mpe-Reporting-FR2-r17* is not configured, or if the Serving Cell operates on FR1, or if the P i field is set to 0, R bits are present instead;

- Resourcei : This field indicates the candidate beam identified by the number of entries in the corresponding *mpe-ResourcePoolToAddModList* as specified in TS 38.331 [5]. The length of this field 6 bits;

- R: Reserved bit, set to 0.



Figure 6.1.3.48-1: Enhanced Single Entry PHR MAC CE

#### 6.1.3.49 Enhanced Multiple Entry PHR MAC CE

The Enhanced Multiple Entry PHR MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-2b. It has a variable size with following fields:

- Ci: This field indicates the presence of P-MPR values with SSBRI(s)/CRI(s) for the Serving Cell with *ServCellIndex* i as specified in TS 38.331 [5]. The Ci field set to 1 indicates that P-MPR values with SSBRI(s)/CRI(s) for the Serving Cell with *ServCellIndex* i is reported. The Ci field set to 0 indicates that P-MPR values with SSBRI(s)/CRI(s) for the Serving Cell with *ServCellIndex* i is not reported;

- R: Reserved bit, set to 0;

- V: This field indicates if the PH value is based on a real transmission or a reference format. For Type 1 PH, the V field set to 0 indicates real transmission on PUSCH and the V field set to 1 indicates that a PUSCH reference format is used. For Type 2 PH, the V field set to 0 indicates real transmission on PUCCH and the V field set to 1 indicates that a PUCCH reference format is used. For Type 3 PH, the V field set to 0 indicates real transmission on SRS and the V field set to 1 indicates that an SRS reference format is used. Furthermore, for Type 1, Type 2, and Type 3 PH, the V field set to 0 indicates the presence of the octet containing the associated PCMAX,f,c field and the MPE field, and the V field set to 1 indicates that the octet containing the associated PCMAX,f,c field and the MPE field is omitted;

- Power Headroom (PH): This field indicates the power headroom level. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.8-1 (the corresponding measured values in dB for the NR Serving Cell are specified in TS 38.133 [11] while the corresponding measured values in dB for the E-UTRA Serving Cell are specified in TS 36.133 [12]);

- P: If *mpe-Reporting-FR2* is configured and the Serving Cell operates on FR2, the MAC entity shall set this field to 0 if the applied P-MPR value, to meet MPE requirements, as specified in TS 38.101-2 [15], is less than P-MPR\_00 as specified in TS 38.133 [11] and to 1 otherwise. If *mpe-Reporting-FR2* is not configured or the Serving Cell operates on FR1, this field indicates whether power backoff is applied due to power management (as allowed by P-MPRc as specified in TS 38.101-1 [14], TS 38.101-2 [15], and TS 38.101-3 [16]). The MAC entity shall set the P field to 1 if the corresponding PCMAX,f,c field would have had a different value if no power backoff due to power management had been applied;

- PCMAX,f,c: If present, this field indicates the PCMAX,f,c (as specified in TS 38.213 [6]) for the NR Serving Cell and the PCMAX,c or P̃CMAX,c (as specified in TS 36.213 [17]) for the E-UTRA Serving Cell used for calculation of the preceding PH field. The reported PCMAX,f,c and the corresponding nominal UE transmit power levels are shown in Table 6.1.3.8-2 (the corresponding measured values in dBm for the NR Serving Cell are specified in TS 38.133 [11] while the corresponding measured values in dBm for the E-UTRA Serving Cell are specified in TS 36.133 [12]);

- MPE: If *mpe-Reporting-FR2* is configured, and the Serving Cell operates on FR2, and if the P field is set to 1, this field indicates the applied power backoff to meet MPE requirements, as specified in TS 38.101-2 [15]. This field indicates an index to Table 6.1.3.8-3 and the corresponding measured values of P-MPR levels in dB are specified in TS 38.133 [11]. The length of the field is 2 bits. If *mpe-Reporting-FR2* is not configured, or if the Serving Cell operates on FR1, or if the P field is set to 0, R bits are present instead;

- Bi: This field indicates whether the candidate beam information identified by either Resourcei is present or not. If the B1 field is set to 1, the first octet containing Resource1 is present and if the B2 field is set to 1, the second octet containing Resource2 is present, and so on.

- Pi: If *mpe-Reporting-FR2-r17* is configured and the Serving Cell operates on FR2, the MAC entity shall set this field to 0 if the applied P-MPR value, to meet MPE requirements, as specified in TS 38.101-2 [15], is less than P-MPR\_00 as specified in TS 38.133 [11] and to 1 otherwise;

- MPEi: If *mpe-Reporting-FR2-r17* is configured, and the Serving Cell operates on FR2, and if the corresponding P i field is set to 1, this field indicates the applied power backoff to meet MPE requirements, as specified in TS 38.101-2 [15]. This field indicates an index to Table 6.1.3.8-3 and the corresponding measured values of P-MPR levels in dB are specified in TS 38.133 [11]. The length of the field is 2 bits. If *mpe-Reporting-FR2-r17* is not configured, or if the Serving Cell operates on FR1, or if the P i field is set to 0, R bits are present instead;

- Resourcei: This field indicates the candidate beam identified by by the number of entries in the corresponding *mpe-ResourcePoolToAddModList* as specified in TS 38.331 [5]. The length of this field 6 bits.

- R: Reserved bit, set to 0.



Figure 6.1.3.49-1: Enhanced Multiple Entry PHR MAC CE with the highest ServCellIndex of Serving Cell with configured uplink is less than 8



Figure 6.1.3.49-2: Enhanced Multiple Entry PHR MAC CE with the highest ServCellIndex of Serving Cell with configured uplink is equal to or higher than 8

#### 6.1.3.50 Enhanced Single Entry PHR for multiple TRP MAC CE

The Enhanced Single Entry PHR for multiple TRP MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-2b.

The two PHs together with one PCMAX,f,c for the Serving Cell are reported if UE is configured with *twoPHRMode* with the multiple TRP PUSCH repetition feature is configured.

It has a fixed size and consists of three octets defined as follows (Figure 6.1.3.50-1):

- R: Reserved bit, set to 0;

- Power Headroom i (PH i): This field indicates the power headroom level, where PH 1 is associated with the SRS-ResourceSet with a lower srs-ResourceSetID and PH 2 is associated with the SRS-ResourceSet with a higher srs-ResourceSetID. PH fields for a Serving Cell are included in ascending order based on i. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.8-1 (the corresponding measured values in dB are specified in TS 38.133 [11]);

- P: If *mpe-Reporting-FR2* is configured and the Serving Cell operates on FR2, the MAC entity shall set this field to 0 if the applied P-MPR value, to meet MPE requirements, as specified in TS 38.101-2 [15], is less than P-MPR\_00 as specified in TS 38.133 [11] and to 1 otherwise. If *mpe-Reporting-FR2* is not configured or the Serving Cell operates on FR1, this field indicates whether power backoff is applied due to power management (as allowed by P-MPRc as specified in TS 38.101-1 [14], TS 38.101-2 [15], and TS 38.101-3 [16]). The MAC entity shall set the P field to 1 if the corresponding PCMAX,f,c field would have had a different value if no power backoff due to power management had been applied;

- V: This field indicates if the PH value for the corresponding TRP is based on a real transmission or a reference format. For Type 1 PH, the V field set to 0 indicates real transmission on PUSCH and the V field set to 1 indicates that a PUSCH reference format is used;

- PCMAX,f,c: This field indicates the PCMAX,f,c (as specified in TS 38.213 [6]) used for calculation of the preceding PH field. The reported PCMAX,f,c and the corresponding nominal UE transmit power levels are shown in Table 6.1.3.8-2 (the corresponding measured values in dBm are specified in TS 38.133 [11]);

- MPE: If *mpe-Reporting-FR2* is configured, and the Serving Cell operates on FR2, and if the P field is set to 1, this field indicates the applied power backoff to meet MPE requirements, as specified in TS 38.101-2 [15]. This field indicates an index to Table 6.1.3.8-3 and the corresponding measured values of P-MPR levels in dB are specified in TS 38.133 [11]. The length of the field is 2 bits. If *mpe-Reporting-FR2* is not configured, or if the Serving Cell operates on FR1, or if the P field is set to 0, R bits are present instead.



Figure 6.1.3.50-1: Enhanced Single Entry PHR for multiple TRP MAC CE

#### 6.1.3.51 Enhanced Multiple Entry PHR for multiple TRP MAC CE

The Enhanced Multiple Entry PHR for multiple TRP MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-2b.

It has a variable size, and includes the bitmaps, a Type 2 PH field and an octet containing the associated PCMAX,f,c field (if reported) for SpCell of the other MAC entity, a Type 1 PH field and an octet containing the associated PCMAX,f,c field (if reported) for the PCell. It further includes, in ascending order based on the *ServCellIndex*, one or multiple of Type X PH fields and octets containing the associated PCMAX,f,c fields (if reported) for Serving Cells other than PCell indicated in the bitmap for indicating the presence of PH(s). X is either 1 or 3 according to TS 38.213 [6] and TS 36.213 [17].

The presence of Type 2 PH field for SpCell of the other MAC entity is configured by *phr-Type2OtherCell* with value *true*.

A single octet bitmap is used for indicating the presence of PH(s) per Serving Cell when the highest *ServCellIndex* of Serving Cell with configured uplink is less than 8, otherwise four octets are used.

The MAC entity determines whether PH value for an activated Serving Cell is based on real transmission or a reference format by considering the configured grant(s) and downlink control information which has been received until and including the PDCCH occasion in which the first UL grant for a new transmission that can accommodate the MAC CE for PHR as a result of LCP as defined in clause 5.4.3.1 is received since a PHR has been triggered if the PHR MAC CE is reported on an uplink grant received on the PDCCH or until the first uplink symbol of PUSCH transmission minus PUSCH preparation time as defined in clause 7.7 of TS 38.213 [6] if the PHR MAC CE is reported on a configured grant.

For a band combination in which the UE does not support dynamic power sharing, the UE may omit the octets containing Power Headroom field and PCMAX,f,c field for Serving Cells in the other MAC entity except for the PCell in the other MAC entity and the reported values of Power Headroom and PCMAX,f,c for the PCell are up to UE implementation.

The two PHs together with one PCMAX,f,c for the Serving Cell configured with the multiple TRP PUSCH repetition feature is configured are reported if the MAC entity is configured with *twoPHRMode*

The Enhanced Multiple Entry PHR for multiple TRP MAC CEs are defined as follows:

- Ci: This field indicates the presence of PH field(s) for the Serving Cell with *ServCellIndex* i as specified in TS 38.331 [5]. The Ci field set to 1 indicates that PH field(s) for the Serving Cell with *ServCellIndex* i is reported. The Ci field set to 0 indicates that a PH field for the Serving Cell with *ServCellIndex* i is not reported;

- R: Reserved bit, set to 0;

- V: This field indicates if the PH value is based on a real transmission or a reference format. For Type 1 PH, the V field set to 0 indicates real transmission on PUSCH and the V field set to 1 indicates that a PUSCH reference format is used. For Type 2 PH, the V field set to 0 indicates real transmission on PUCCH and the V field set to 1 indicates that a PUCCH reference format is used. For Type 3 PH, the V field set to 0 indicates real transmission on SRS and the V field set to 1 indicates that an SRS reference format is used. Furthermore, for Type 1, Type 2, and Type 3 PH, the V field set to 0 indicates the presence of the octet containing the associated PCMAX,f,c field and the MPE field, and all of the V field(s) for the Serving Cell set to 1 indicates that the octet containing the associated PCMAX,f,c field and the MPE field is omitted;

- Power Headroom i (PH i): This field indicates the power headroom level, where PH 1 is associated with the SRS-ResourceSet with a lower *srs-ResourceSetId* and PH 2 is associated with the SRS-ResourceSet with a higher *srs-ResourceSetId* PH fields for a Serving Cell are included in ascending order based on i. The length of the field is 6 bits. The reported PH and the corresponding power headroom levels are shown in Table 6.1.3.8-1 (the corresponding measured values in dB for the NR Serving Cell are specified in TS 38.133 [11] while the corresponding measured values in dB for the E-UTRA Serving Cell are specified in TS 36.133 [12]);

- P: If *mpe-Reporting-FR2* is configured and the Serving Cell operates on FR2, the MAC entity shall set this field to 0 if the applied P-MPR value, to meet MPE requirements, as specified in TS 38.101-2 [15], is less than P-MPR\_00 as specified in TS 38.133 [11] and to 1 otherwise. If *mpe-Reporting-FR2* is not configured or the Serving Cell operates on FR1, this field indicates whether power backoff is applied due to power management (as allowed by P-MPRc as specified in TS 38.101-1 [14], TS 38.101-2 [15], and TS 38.101-3 [16]). The MAC entity shall set the P field to 1 if the corresponding PCMAX,f,c field would have had a different value if no power backoff due to power management had been applied;

- PCMAX,f,c: If present, this field indicates the PCMAX,f,c (as specified in TS 38.213 [6]) for the NR Serving Cell and the PCMAX,c or P̃CMAX,c (as specified in TS 36.213 [17]) for the E-UTRA Serving Cell used for calculation of the preceding PH field. The reported PCMAX,f,c and the corresponding nominal UE transmit power levels are shown in Table 6.1.3.8-2 (the corresponding measured values in dBm for the NR Serving Cell are specified in TS 38.133 [11] while the corresponding measured values in dBm for the E-UTRA Serving Cell are specified in TS 36.133 [12]);

- MPE: If *mpe-Reporting-FR2* is configured, and the Serving Cell operates on FR2, and if the P field is set to 1, this field indicates the applied power backoff to meet MPE requirements, as specified in TS 38.101-2 [15]. This field indicates an index to Table 6.1.3.8-3 and the corresponding measured values of P-MPR levels in dB are specified in TS 38.133 [11]. The length of the field is 2 bits. If *mpe-Reporting-FR2* is not configured, or if the Serving Cell operates on FR1, or if the P field is set to 0, R bits are present instead.



Figure 6.1.3.51-1: Enhanced Multiple Entry PHR for multiple TRP MAC CE with the highest ServCellIndex of Serving Cell with configured uplink is less than 8



Figure 6.1.3.51-2: Enhanced Multiple Entry PHR for multiple TRP MAC CE with the highest ServCellIndex of Serving Cell with configured uplink is equal to or higher than 8

#### 6.1.3.xx BFD-RS Indication MAC CE

The BFD-RS Indication MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-1b. It has a variable size, and includes a BFD-RS-ID0 field and a BFD-RS-ID1 field (optional) of *failureDetectionSet1*, and a BFD-RS-ID0 field and a BFD-RS-ID1 field (optional) of *failureDetectionSet2*.

It has a variable size consisting of following fields:

- Serving Cell ID: This field indicates the identity of the Serving Cell for which the MAC CE applies. The length of the field is 5 bits;

- BWP ID: This field indicates a DL BWP for which the MAC CE applies as the codepoint of the DCI bandwidth *part indicator* field as specified in TS 38.213 [6]. The length of the BWP ID field is 2 bits;

- S: This field indicates the presence of the octet containing the BFD-RS ID1 of the same BFD-RS set. The S field set to 1 indicates that the the octet containing BFD-RS ID1 is included; The S field set to 0 indicates that the octet containing the BFD-RS ID1 of the same BFD-RS set is not included.

- BFD-RS IDi: This field indicates the BFD-RS resource from *failureDetectionSet1* or *failureDetectionSet2* as specified in TS 38.331 [5].

- R: Reserved bit, set to 0.



**Figure 6.1.3.xx-1: BFD-RS Indication MAC CE**

#### 6.1.3.aa SP/AP SRS TCI State Indication MAC CE

The SP/AP SRS TCI State Indication MAC CE is identified by a MAC subheader with eLCID as specified in Table 6.2.1-1b. It has a variable size with following fields:

- A/D: This field indicates whether to activate or deactivate indicated SP SRS resource set. The field is set to 1 to b1indicate activation, otherwise it indicates deactivation. If the indicated SRS resource set ID is for the AP SRS resource set, MAC entity shall ignore this field;

- SRS Resource Set's Cell ID: This field indicates the identity of the Serving Cell, which contains the indicated SP/AP SRS Resource Set. If the C field is set to 0, this field also indicates the identity of the Serving Cell associated with all TCI states indicated by the TCI State IDi fields. The length of the field is 5 bits;

- SRS Resource Set's BWP ID: This field indicates a UL BWP as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9], which contains the indicated SP/AP SRS Resource Set. If the C field is set to 0, this field also indicates the identity of the BWP associated with all TCI states indicated by the TCI State IDi fields. The length of the field is 2 bits;

- C: This field indicates whether the octets containing TCI State Serving Cell ID field(s) and TCI State BWP ID field(s) are present. If this field is set to 1, TCI State Serving Cell ID field(s) and TCI State BWP ID field(s) are present, otherwise they are not present so MAC entity shall ignore TCI State Serving Cell ID field(s) and TCI State BWP ID field(s);

- SUL: This field indicates whether the MAC CE applies to the NUL carrier or SUL carrier configuration. This field is set to 1 to indicate that it applies to the SUL carrier configuration, and it is set to 0 to indicate that it applies to the NUL carrier configuration;

- SRS Resource Set ID: This field indicates the SP/AP SRS Resource Set ID identified by *SRS-ResourceSetId* as specified in TS 38.331 [5]. The length of the field is 4 bits;

- TCI State Serving Cell IDi: This field indicates the identity of the Serving Cell on which the TCI State used for SRS resource i is located. The length of the field is 5 bits;

- TCI State BWP IDi: This field indicates a UL BWP as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9], on which the TCI State used for SRS resource i is located. The length of the field is 2 bits;

- TCI State IDi: This field contains an identifier of the TCI state used for SRS resource i. TCI State ID0 refers to the first SRS resource within the resource set, TCI State ID1 refers to the second one and so on. If joint/downlink TCI State is used, 7-bits length TCI state ID i.e. *TCI-StateId* as specified in TS 38.331 [5] is used. If separate downlink and uplink TCI State is used, the most significant bit of TCI state ID is considered as a reserved bit and the remaining 6 bits indicate the *UL-TCIState-Id* as specified in TS 38.331 [5]. The length of the field is 7 bits. This field is only present if MAC CE is used for activation of SP SRS resource set, i.e. the A/D field is set to 1, or for AP SRS resource set;

- R: Reserved bit, set to 0.



**Figure 6.1.3.aa-1: SP/AP SRS TCI State Indication MAC CE**

#### 6.1.3.bb Serving Cell Set based SRS TCI State Indication MAC CE

The Serving Cell Set based SRS TCI State Indication MAC CE is identified by a MAC subheader with eLCID as specified. It has a variable size with following fields:

- SRS Resource's Cell ID: This field indicates the identity of the Serving Cell, which contains the indicated SP/AP SRS Resource. If the C field is set to 0, this field also indicates the identity of the Serving Cell associated with all TCI States indicated by the TCI State IDi fields. The length of the field is 5 bits. The indicated Serving Cell is configured as part of *simultaneousSpatial-UpdatedList1* or *simultaneousSpatial-UpdatedList2* in TS 38.331 [5], and this MAC CE applies to all the Serving Cells configured in the set *simultaneousSpatial-UpdatedList1* or *simultaneousSpatial-UpdatedList2*, respectively;

- SRS Resource's BWP ID: This field indicates a UL BWP as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9], which contains the indicated AP/SP SRS Resource. If the C field is set to 0, this field also indicates the identity of the BWP associated with all TCI States indicated by the TCI State IDi fields. The length of the field is 2 bits;

- C: This field indicates whether the octets containing TCI State Serving Cell ID field(s) and TCI State BWP ID field(s) are present. If this field is set to 1, the TCI State Serving Cell ID field(s) and TCI State BWP ID field(s) are present, otherwise they are not present so MAC entity shall ignore TCI State Serving Cell ID field(s) and TCI State BWP ID field(s);

- SRS Resource IDi: This field indicates the SP/AP SRS Resource ID identified by *SRS-ResourceId* as specified in TS 38.331 [5]. The length of the field is 6 bits;

- TCI State Serving Cell IDi: This field indicates the identity of the Serving Cell on which the TCI State used for SRS Resource IDi is located. The length of the field is 5 bits;

- TCI State BWP IDi: This field indicates a UL BWP as the codepoint of the DCI *bandwidth part indicator* field as specified in TS 38.212 [9], on which the TCI State used for SRS Resource IDi is located. The length of the field is 2 bits;

- TCI State IDi: This field contains an identifier of the TCI state used for SRS resource i. TCI State ID0 refers to the first SRS resource which is indicated SRS Resource ID0, TCI State ID1 refers to the second one and so on. If joint/downlink TCI State is used, 7-bits length TCI state ID i.e. *TCI-StateId* as specified in TS 38.331 [5] is used. If separate downlink and uplink TCI State is used, the most significant bit of TCI state ID is considered as a reserved bit and the remaining 6 bits indicate the *UL-TCIState-Id* as specified in TS 38.331 [5]. The length of the field is 7 bits.

- R: Reserved bit, set to 0.



**Figure 6.1.3.bb-1: Serving Cell Set based SRS TCI State Indication MAC CE**

## 6.2 Formats and parameters

### 6.2.1 MAC subheader for DL-SCH and UL-SCH

The MAC subheader consists of the following fields:

- LCID: The Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or the type of the corresponding MAC CE or padding as described in Tables 6.2.1-1, 6.2.1-1c and 6.2.1-2 for the DL-SCH and UL-SCH respectively. There is one LCID field per MAC subheader. The size of the LCID field is 6 bits. If the LCID field is set to 34, one additional octet is present in the MAC subheader containing the eLCID field and follow the octet containing LCID field. If the LCID field is set to 33, two additional octets are present in the MAC subheader containing the eLCID field and these two additional octets follow the octet containing LCID field;

NOTE 1: For MBS broadcast, a logical channel is identified based on G-RNTI and LCID if the same LCID is allocated for logical channels corresponding to different G-RNTIs.

- eLCID: The extended Logical Channel ID field identifies the logical channel instance of the corresponding MAC SDU or the type of the corresponding MAC CE as described in tables 6.2.1-1a, 6.2.1-1b, 6.2.1-2a and 6.2.1-2b for the DL-SCH and UL-SCH respectively. The size of the eLCID field is either 8 bits or 16 bits.

NOTE 2: The extended Logical Channel ID space using two-octet eLCID and the relevant MAC subheader format is used, only when configured, on the NR backhaul links between IAB nodes or between IAB node and IAB Donor, or for multicast MTCHs.

- L: The Length field indicates the length of the corresponding MAC SDU or variable-sized MAC CE in bytes. There is one L field per MAC subheader except for subheaders corresponding to fixed-sized MAC CEs, padding, and MAC SDUs containing UL CCCH. The size of the L field is indicated by the F field;

- F: The Format field indicates the size of the Length field. There is one F field per MAC subheader except for subheaders corresponding to fixed-sized MAC CEs, padding, and MAC SDUs containing UL CCCH. The size of the F field is 1 bit. The value 0 indicates 8 bits of the Length field. The value 1 indicates 16 bits of the Length field;

- R: Reserved bit, set to 0.

The MAC subheader is octet aligned.

Table 6.2.1-1 Values of LCID for DL-SCH

|  |  |
| --- | --- |
| Codepoint/Index | LCID values |
| 0 | CCCH |
| 1–32 | Identity of the logical channel of DCCH, DTCH and multicast MTCH |
| 33 | Extended logical channel ID field (two-octet eLCID field) |
| 34 | Extended logical channel ID field (one-octet eLCID field) |
| 35–46 | Reserved |
| 47 | Recommended bit rate |
| 48 | SP ZP CSI-RS Resource Set Activation/Deactivation |
| 49 | PUCCH spatial relation Activation/Deactivation |
| 50 | SP SRS Activation/Deactivation |
| 51 | SP CSI reporting on PUCCH Activation/Deactivation |
| 52 | TCI State Indication for UE-specific PDCCH |
| 53 | TCI States Activation/Deactivation for UE-specific PDSCH |
| 54 | Aperiodic CSI Trigger State Subselection |
| 55 | SP CSI-RS/CSI-IM Resource Set Activation/Deactivation |
| 56 | Duplication Activation/Deactivation |
| 57 | SCell Activation/Deactivation (four octets) |
| 58 | SCell Activation/Deactivation (one octet) |
| 59 | Long DRX Command |
| 60 | DRX Command |
| 61 | Timing Advance Command |
| 62 | UE Contention Resolution Identity |
| 63 | Padding |

Table 6.2.1-1a Values of two-octet eLCID for DL-SCH

|  |  |  |
| --- | --- | --- |
| Codepoint | Index | LCID values |
| 0 to (216 – 1) | 320 to (216 + 319) | Identity of the logical channel |

Table 6.2.1-1b Values of one-octet eLCID for DL-SCH

|  |  |  |
| --- | --- | --- |
| Codepoint | Index | LCID values |
| 0 to 226 | 64 to 290 | Reserved |
| 227 | 291 | Serving Cell Set based SRS TCI State Indication MAC CE |
| 228 | 292 | SP/AP SRS TCI State Indication MAC CE |
| 229 | 293 | BFD-RS Indication MAC CE |
| 230 | 294 | Differential Koffset |
| 231 | 295 | Enhanced SCell Activation/Deactivation MAC CE with one octet Ci field |
| 232 | 296 | Enhanced SCell Activation/Deactivation MAC CE with four octet Ci field |
| 233 | 297 | Unified TCI States Activation/Deactivation MAC CE |
| 234 | 298 | PUCCH Power Control Set Update for multiple TRP PUCCH repetition MAC CE |
| 235 | 299 | PUCCH spatial relation Activation/Deactivation for multiple TRP PUCCH repetition MAC CE |
| 236 | 300 | Enhanced TCI States Indication for UE-specific PDCCH |
| 237 | 301 | Positioning Measurement Gap Activation/Deactivation Command |
| 238 | 302 | PPW Activation/Deactivation Command |
| 239 | 303 | DL Tx Power Adjustment |
| 240 | 304 | Timing Case Indication |
| 241 | 305 | Child IAB-DU Restricted Beam Indication |
| 242 | 306 | Case-7 Timing advance offset |
| 243 | 307 | Provided Guard Symbols for Case-6 timing |
| 244 | 308 | Provided Guard Symbols for Case-7 timing |
| 245 | 309 | Serving Cell Set based SRS Spatial Relation Indication |
| 246 | 310 | PUSCH Pathloss Reference RS Update |
| 247 | 311 | SRS Pathloss Reference RS Update |
| 248 | 312 | Enhanced SP/AP SRS Spatial Relation Indication |
| 249 | 313 | Enhanced PUCCH Spatial Relation Activation/Deactivation |
| 250 | 314 | Enhanced TCI States Activation/Deactivation for UE-specific PDSCH |
| 251 | 315 | Duplication RLC Activation/Deactivation |
| 252 | 316 | Absolute Timing Advance Command |
| 253 | 317 | SP Positioning SRS Activation/Deactivation |
| 254 | 318 | Provided Guard Symbols |
| 255 | 319 | Timing Delta |

Table 6.2.1-1c Values of LCID for MBS broadcast on DL-SCH

|  |  |
| --- | --- |
| Codepoint/Index | LCID values |
| 0 | MCCH |
| 1–32 | Identity of the logical channel of broadcast MTCH |
| 33–63 | Reserved |

Table 6.2.1-2 Values of LCID for UL-SCH

|  |  |  |
| --- | --- | --- |
| Codepoint/Index | | LCID values |
| 0 | | CCCH of size 64 bits (referred to as "CCCH1" in TS 38.331 [5]), except for a RedCap UE |
| 1–32 | | Identity of the logical channel of DCCH and DTCH |
| 33 | | Extended logical channel ID field (two-octet eLCID field) |
| 34 | | Extended logical channel ID field (one-octet eLCID field) |
| 35 | CCCH of size 48 bits (referred to as "CCCH" in TS 38.331 [5]) for a RedCap UE | |
| 36 | CCCH1 of size 64 bits (referred to as "CCCH1" in TS 38.331 [5]) for a RedCap UE | |
| 37–42 | | Reserved |
| 43 | | Truncated Enhanced BFR (one octet Ci) |
| 44 | | Timing Advance Report |
| 45 | | Truncated Sidelink BSR |
| 46 | | Sidelink BSR |
| 47 | | Reserved |
| 48 | | LBT failure (four octets) |
| 49 | | LBT failure (one octet) |
| 50 | | BFR (one octet Ci) |
| 51 | | Truncated BFR (one octet Ci) |
| 52 | | CCCH of size 48 bits (referred to as "CCCH" in TS 38.331 [5]), except for a RedCap UE |
| 53 | | Recommended bit rate query |
| 54 | | Multiple Entry PHR (four octets Ci) |
| 55 | | Configured Grant Confirmation |
| 56 | | Multiple Entry PHR (one octet Ci) |
| 57 | | Single Entry PHR |
| 58 | | C-RNTI |
| 59 | | Short Truncated BSR |
| 60 | | Long Truncated BSR |
| 61 | | Short BSR |
| 62 | | Long BSR |
| 63 | | Padding |

Table 6.2.1-2a Values of two-octet eLCID for UL-SCH

|  |  |  |
| --- | --- | --- |
| Codepoint | Index | LCID values |
| 0 to (216 – 1) | 320 to (216 + 319) | Identity of the logical channel |

Table 6.2.1-2b Values of one-octet eLCID for UL-SCH

|  |  |  |
| --- | --- | --- |
| Codepoint | Index | LCID values |
| 0 to 228 | 64 to 292 | Reserved |
| 229 | 293 | Enhanced Multiple Entry PHR for multiple TRP (four octets Ci) |
| 230 | 294 | Enhanced Multiple Entry PHR for multiple TRP (one octets Ci) |
| 231 | 295 | Enhanced Single Entry PHR for multiple TRP |
| 232 | 296 | Enhanced Multiple Entry PHR (four octets Ci) |
| 233 | 297 | Enhanced Multiple Entry PHR (one octets Ci) |
| 234 | 298 | Enhanced Single Entry PHR |
| 235 | 299 | Enhanced BFR (one octet Ci) |
|  |  |  |
| 236 | 300 | Enhanced BFR (four octet Ci) |
| 237 | 301 | Truncated Enhanced BFR (four octet Ci) |
| 238 | 302 | Positioning Measurement Gap Activation/Deactivation Request |
| 239 | 303 | IAB-MT Recommended Beam Indication |
| 240 | 304 | Desired IAB-MT PSD range |
| 241 | 305 | Desired DL Tx Power Adjustment |
| 242 | 306 | Case-6 Timing Request |
| 243 | 307 | Desired Guard Symbols for Case 6 timing |
| 244 | 308 | Desired Guard Symbols for Case 7 timing |
| 245 | 309 | Extended Short Truncated BSR |
| 246 | 310 | Extended Long Truncated BSR |
| 247 | 311 | Extended Short BSR |
| 248 | 312 | Extended Long BSR |
| 249 | 313 | Extended Pre-emptive BSR |
| 250 | 314 | BFR (four octets Ci) |
| 251 | 315 | Truncated BFR (four octets Ci) |
| 252 | 316 | Multiple Entry Configured Grant Confirmation |
| 253 | 317 | Sidelink Configured Grant Confirmation |
| 254 | 318 | Desired Guard Symbols |
| 255 | 319 | Pre-emptive BSR |

END OF CHANGE