**3GPP TSG-RAN WG2 Meeting #129bis *R2-2501463***

**Wuhan, China, April 7 – 11, 2025**

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| *CR-Form-v12.3* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | **38.321** | **CR** | **xxxx** | **rev** |  | **Current version:** | **18.4.0** |  |
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| *For* [***HE******LP***](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:*** | Running MAC CR for network energy saving | | | | | | | | | |
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| ***Source to WG:*** | InterDigital | | | | | | | | | |
| ***Source to TSG:*** | R2 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | Netw\_Energy\_NR\_enh-Core | | | | |  | ***Date:*** | | | 2025-03-04 |
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| ***Category:*** | **B** |  | | | | | ***Release:*** | | | Rel-19 |
|  | *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-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)  Rel-20 (Release 20)* | |
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| ***Reason for change:*** | | Introduction of Rel-19 network energy saving to TS 38.321 | | | | | | | | |
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| ***Summary of change:*** | | Change is introduced to support the following objectives: - On-demand SSB for SCell operation  - On-demand SIB1 for idle/inactive UEs  - Adaptation of common channels/signals  The following color code is used to categorize agreements interms of if/how they have been captured. It will be removed when the CR is finalized.  Fully implemented Already specified in MAC Not/partially implemented but additional agreements/FFSs needed before conclusion Doesn’t impact MAC spec  **RAN2 Agreements**  **On-demand SSB for SCell operation**  **RAN2#127**  RAN2 start the discussion from Scenario 2/2A and wait for RAN1 conclusion on Scenario 3A/3B  RRC based OD-SSB transmission indication is used to indicate at least the initial activation/deactivation state of OD-SSB configuration. FFS on reconfiguration.  New MAC-CE for OD-SSB transmission indication is introduced. We will not change legacy SCell activation/deactivation MAC CE. FFS if we need further optimization for scenario 2A.  Measurement based on OD-SSB in both case 1 and case 2 will be considered. (case 1 and case 2 defined in RAN1).  For Case #1, the UE does not expect to measure SSB when on-demand SSB transmission is deactivated. In other words, the UE expects to measure SSB when on-demand SSB transmission is activated.  RAN2 does not handle the issue raised in R2-2407414 in OD-SSB based measurements.  R2-2407414: Proposal 3: RAN2 WG to discuss the issue of false measurement report triggering due to no SSB transmission when on-demand SSB is deactivated.   * RAN2 does not handle this issue in OD-SSB   RAN2 study how the UE to perform L3 measurement according to OD-SSB L3 RRM configuration.  **RAN2#127bis**  No need to restrict the OD-SSB activation/deactivation state indication in RRC to initial configuration. No special specification effort is required.  Don’t introduce further new MAC CE that combines SCell activation/deactivation and OD-SSB indication for scenario 2A.  NW should be able to send OD-SSB indication for multiple SCells simultaneously by a MAC CE.  **RAN2#129**  RAN2 leave it to RAN4 to conclude whether always-on SSB and/or OD-SSB are measured when both are transmitted in OD-SSB case 2.  **On-demand SIB1 for idle/inactive UEs**  **RAN2#125bis**  At least RAN2 starts scenario 1a. Other scenarios are not excluded.   * Scenario 1a: Cell A SIB assisted intra-cell WUS. And WUS and SIB1 is sent to/from NES cell. with below potential RAN2 impacts:   + Add WUS configuration in SIB of cell A.   + Cell reselection from cell A to NES cell, including trigger condition and cell barring changes.   + Whether allow camping, paging and SIB update in NES cell.   + Cell reselection from NES cell to cell A or normal cell.   Contents of UL WUS   * RAN2 assumes that RACH procedure is reused for UE to request on-demand SIB1. * UL WUS configuration includes at least below information:   + RACH configuration * A UE needs to know a UL WUS configuration to request SIB1 of which cell.   On-demand SIB1 acquisition procedure  - Existing Msg 1 based on-demand procedure is reused for on-demand SIB1 acquisition procedure. FFS on Msg 3. FFS if / when the UE monitors the OD-SIB1 upon reception of RAR. FFS:T whether introduce specified UE behavior if RACH failure of OD-SIB1 request.  The UE first should acquire valid SIB1 (e.g. via SIB1 request) for camping to NES cell (if the UE knows the cell doesn’t broadcast SIB1 and supports on-demand SIB1).  **RAN2#126**  Study on-demand SIB1 provisioning for NES Cell(s) in versions of Scenario 1a with multiple Cells A and/or NES Cells:   * More than one Cell A may provide configuration for the same NES cell. * The same Cell A may assist more than one NES Cells.   RRC release message assisted intra-cell WUS can be discussed as option of signaling details in stage 3.  Can use the PCI and frequency of a NES Cell to associate the UL WUS configuration with a NES Cell.  For Message 1 based on-demand SIB1 request, the on-demand SI request configuration that currently included in SIB1 may be used as the design baseline.  Cell A’s SIB can be used to configure on-demand SIB1 related configuration for neighbour NES cells, e.g., via new SIB or the existing SIB.  If the UE chooses the NES cell using legacy intra-F/inter-F cell re-selection procedure (as baseline), the UE triggers WUS transmission.  After UE successfully receives OD-SIB1 for that NES Cell and if it is a suitable cell, UE camps in the NES Cell “similar” to a legacy Cell.  RAN2 not to support on-demand SIB1 request that is combined with an initial access to perform RRC connection establishment/resume on the NES cell.  NW need to bar the legacy UE from accessing the on-demand SIB1 cell (e.g. based on the existing barring mechanism).  How to avoid/deprioritize the legacy UE camping at the Cell A attempting to switch to the NES Cell (but allowing the R19 NES UE to do that).  If the NES UE is unable to acquire the SIB1 of NES Cell before UE initiates OD-SIB1 procedure, it will not consider it as barred at that moment. R19 NES UE bars the cell if the UE fails to acquire SIB1 via on-demand SIB1 for NES cell.  After Rel-19 NES UEs camp in NES cell, the UE behaviour is same as the one defined as legacy normal camped state, e.g. paging reception, SIB1 update, etc.  RAN2 assumes the UE is expected to receive the RAR responding to the preamble transmission for Msg1-based on-demand SIB1 procedure, as the baseline.  As baseline, upon random access procedure failure of OD-SIB1 request, UE regards OD-SIB1 can’t be acquired in the NES cell and considers it as barred. It doesn’t exclude the option to leave the determination to the UE implementation.  Once the NES UE camps on the NES cell, if the UE receives SIB change notification, the UE is expected to receive SIB1 from NES cell.  RAN2 to wait for RAN1’s progress whether to support scenario 3.  **RAN2#127**  No consensus for RAN1 case 3 in RAN2.  We can rely on legacy UE behaviour to ensure UE has valid SIB1 for the cell (i.e. UE reacquire SIB1 whenever (re)selecting cell).  Further UE keeps SIB1 updated while on cell via regular SI modification procedure (confirmation of earlier RAN2 agreement).  Once Rel-19 NES UE camps on the NES cell, the UE expects to receive UL WUS configuration updates from the NES Cell, e.g., via legacy SI modification procedures.  Msg 3 based OD-SI procedure is not supported for on-demand SIB1 request in case 2 (for requesting to the NES Cell).  Following example options to handle legacy UEs (i.e. UEs not supporting OD-SIB1) can be considered in normative work. Details and further analysis need to be further discussed in normative work. Other existing options are not excluded.   * Option 1: Legacy UEs bar the OD-SIB1 cell based on cellBarred bit set to barred in MIB. * Option 2: Legacy UEs bar the OD-SIB1 cell based on no SIB1 indication via ssb-SubcarrierOffset in MIB. * Option 3: Network includes cells supporting OD-SIB1 to list of excluded cells.   RAN2 understands the NW can avoid impact on legacy RRC connected UE and R19 RRC connected UE due to on-demand SIB1 (e.g. NES cell with OD-SIB1 is measured by legacy RRC\_CONNECTED UE and can be configured as its PSCell/SCells/target cell).  RAN2 conclude that on-demand SIB1 is feasible from RAN2 perspective and recommend normative work of case 2 for on-demand SIB1.  **RAN2#127bis**  We will inherit all agreements made during SI phase to WI phase.  A NES cell can include neighbouring NES cell’s WUS configuration.  NES cell’s WUS configuration, it is included in a new SIB (including its own WUS configuration).  In on-demand SIB1 procedure, the UE considers RACH failure when PREAMBLE\_TRANSMISSION\_COUNTER = preambleTransMax + 1.  The MAC layer will indicate the RACH failure for SI request to upper layers. FFS: after that the UE upper layer will consider the cell as barred.  The legacy UE behaviour can be reused upon on-demand SIB1 acquisition failure, i.e., the NES UE should follow the intraFreqReselection in MIB of NES cell.  A cell for which SIB1 request configuration is available, can periodically broadcast SIB1.  If UE has SIB1 request configuration of a cell, UE needs to check if SIB1 is currently being broadcasted or provided on demand for that cell before requesting SIB1 of that cell.  Legacy UEs bar the OD-SIB1 cell based on no SIB1 indication in MIB e.g. via ssb-SubcarrierOffset. Detailed solution is up to RAN1. If this works, no separate barring bit for R19 NES UEs is introduced.  NES UEs should be allowed to reselect to cells that are prevented from legacy UEs (e.g. by excluded cell list, reselection priorities).  RAN2 will not start the discussion on the issue when the UL WUS configuration update in Cell A is not synchronised with the UL WUS configuration update in the NES cell, unless we’re asked to do that by other WG, e.g. RAN3.  **RAN2#128**  Let’s wait for more RAN1 progress on Kssb discussion.  NES UE with SIB1 request configuration of a NES cell assumes that a NES cell, with SSB containing K\_SSB < 24 for FR1 and K\_SSB < 12 for FR2, will acquire SIB1 as in legacy.  New NES-specific reselection priority parameters for NES UEs are defined for the purpose of prioritizing/deprioritizing a NES frequency.  Introduce new IntraFreqExcludedCellList-NES / InterFreqExcludedCellList-NES IEs enable proper reselection behaviour of legacy and NES UEs.  Reuse legacy cell reselection criterion as trigger condition of OD-SIB1 acquisition. No need to specify other conditions (e.g. a new RSRP threshold).  The existing 1-second rule in the cell reselection criteria is still applied to the triggering condition of UL WUS transmission.  The UE considers the cell as barred after MAC indicates max number of preamble transmission for the OD-SIB1 request.  If MSG2 (ACK) is received, but UE fails to receive SIB1 then the UE may consider this cell as barred, no spec impact.  A UE bars the NES/SIB1 less cell and/or excludes it as a candidate for reselection since the UE had no corresponding UL WUS configuration, the UE would treat this cell as if cell status is “not barred” and consider it as candidate for cell reselection once it has received a UL-WUS configuration to request SIB1 for this cell.  UE considers WUS configuration only valid in directly succeeding cell reselection from cell where UE acquired WUS configuration. FFS on SI validity area rather than cell level.  Wait one cycle of RAN discussion (i.e. to see whether WID is updated or not to handle RRC connected UEs)  Working assumption: UL-WUS configuration in RRC release is not supported.  **RAN2#128**  There is no need for additional barring mechanisms (in addition to the k\_ssb signaling “no SIB1” indication in MIB) to handle legacy to be able to bar cell using OD-SIB1.  Specify the following UE behavior to allow the UEs in RRC\_CONNECTED state to acquire OD-SIB1 when T311 is running:   * When T311 is running, the UE can trigger the OD-SIB1 acquisition procedure with stored UL WUS configuration in SIB-X, if it is still valid. * The legacy cell selection criteria are reused as the trigger condition of OD-SIB1 acquisition. * The OD-SIB1 acquisition behavior is same as that of RRC\_IDLE/IANCTIV UEs.   The UE follows the legacy validity principle of stored SIB.  For Rel-19 NES UE in RRC\_CONNECTED, rely on the NW dedicated RRC for SIB1 delivery if searchSpaceSIB1 is not configured. It is legacy UE behavior and no spec change is expected.  SIB-x can be cell specific or area specific, as legacy.  Upon reception of RAR, the UE monitors OD-SIB1 in the window agreed by RAN1.  **Adaptation of common channels/signals**  **RAN2#125bis**  From the UE point of view, UE will monitor one PEI/PO every paging DRX cycle, i.e. the UE doesn’t skip PO in paging DRX cycle.  For adaptation of paging occasions in time domain, RAN2 to study a) bundle paging frames and b) extend the values of N to have increased interval between PFs (e.g. T/64, T/128 ...) and compensating decrease in number of PFs by increasing POs per PF.  For Paging adaptation, R2 discusses the following options on compatibility of legacy RRC\_IDLE/RRC\_INACTIVE UE:   * Option 1: Prevent the access of legacy UE via barring; * Option 2: Separate paging resources for legacy UEs and Rel-19 NES UEs (assuming there are legacy UEs)   **RAN2#127**  Option-a) is about the bundling of PF for R19 NES UEs.  R2 observe that the option-a) and option-b) can be designed to configure the PO:s at same time position.  **RAN2#127bis**  Select option-b as baseline for R19 NES paging enhancement.  R2 should aim at signaling overhead minimization (e.g., Ns=8 and FFS for other larger values)  Allowing legacy and R19 UEs to co-ex in the same PF/PO is possible, based on NW configuration.  Legacy UE is not barred.  Rel-19 UEs only monitor the PO(s) according to Rel-19 paging configuration.  **RAN2#128**  Introduce value for Ns=8. FFS on 16.  Introduce value for N= T/32. FFS on T/64, T/128, T/256.  **RAN2#129**  For N, values smaller than T/32 are not supported.  The maximum possible value for Ns is 8.  Introduce a separate PEI configuration.  Paging adaptations are configured semi-statically and updated via system information update notification.  A new UE capability is added for R19 NES paging enhancement, and the new capability is included in UE-RadioPagingInfo. FFS on whether we have a common capability for all NES features.  RAN2 confirms SSB adaptation in time domain is not supported for RRC idle/inactive UEs and Rel-19 NES-capable UE’s PCell.  RAN2 preference is to keep SMTC based L3 RRM framework and to introduce additional SMTC configuration according to SSB adaptation for L3 RRM measurement on SCell with SSB adaptation.  For L3 measurement, RAN2 assumes the adapted SSB on neighbor cell is measured based on legacy SMTC.  Legacy UEs and UEs non-capable of time domain PRACH adaptation are expected to use legacy PRACH resources per legacy configuration and procedures. No barring is needed.  RAN2 starts CBRA for RACH adaptation.  RAN2 starts 4-step RACH adaptation.  From R2 perspective, not apply time-domain RACH adaptation to RACH resources for MSG1-based SI request.  From R2 perspective, not apply time-domain RACH adaptation to IAB RACH resources.  From R2 perspective, RACH adaptation is not modelled as RA feature(s).  From R2 perspective, RACH partitioning with all the features, i.e. RedCap, SDT, and Slicing, and feature combinations, are supported for PRACH adaption in time domain.  Will follow legacy mechanism regarding how to select RACH resource.  **Relevant R1 Agreements:**  **On-demand SSB for SCell operation**  **RAN1#119**  For a cell supporting on-demand SSB SCell operation, support at least the following options to deactivate on-demand SSB transmission from a UE perspective.   * Option 1: Explicit indication of deactivation for on-demand SSB via MAC-CE for on-demand SSB transmission indication   + Deactivation by RRC is up to RAN2   + FFS: Which scenario Option 1 is used * Option 2: Configuration/indication of the number N of on-demand SSB bursts to be transmitted after on-demand SSB is indicated   + FFS: Whether Option 4, 4a is needed in addition to Option 2   + FFS: Whether the value of N can be implicitly determined using a timer   **RAN1#118**  For a cell supporting on-demand SSB SCell operation,   * Support RRC based signaling to indicate on-demand SSB transmission on the cell at least for the case where this RRC also configures the SCell, activates the SCell, and provides on-demand SSB configuration.   + FFS: Whether to support RRC based signaling for other cases. * Support MAC CE based signaling to indicate on-demand SSB transmission on the cell for Scenarios #2 and #2A.   For a cell supporting on-demand SSB SCell operation, at least for the following parameter(s), multiple candidate values can be configured by RRC and the applicable value can be indicated by MAC CE for on-demand SSB transmission indication for the cell.   * Periodicity of the on-demand SSB * FFS: Any other relevant parameters   **On-demand SIB1**  **RAN1#119**  At least the contents of RAR in response to SI request are included in RAR in response to UL WUS  There is no RAN1 consensus to support UL WUS repetition in R19.  The mapping rule between *ra-PreambleStartIndex* for OD-SIB1 and SSB follows the mapping rule between *ra-PreambleStartIndex* for OSI request and SSB as in legacy specification.  **RAN1#118bis**  No further optimization in RAN1 on power control and power ramp-up procedure for UL WUS in R19.  For the purpose of “WUS transmission”, at least the following parameters are included in the UL-WUS configuration:   * *rsrp-ThresholdSSB* * *prach-RootSequenceIndex* * *msg1-SubcarrierSpacing* * *restrictedSetConfig*   Note: In legacy spec, the parameters above are under the IE RACH-ConfigCommon  It is up to gNB to configure whether RACH occasions for UL WUS are shared or separated from the RACH occasions for other usages.  **RAN1#117**  For further study of on-demand SIB1 in idle/inactive mode, on the spatial relationships among PDCCH/PDSCH of on-demand SIB1, SSB, and UL WUS, as UL WUS is using dedicated PRACH resource, it is assumed that spatial relationships among PDCCH/PDSCH of on-demand SIB1, SSB and UL WUS can follow legacy mechanism.  **Adaptation of common signals and channels**  **RAN1#120**  For adaptation of PRACH in time-domain, for determining the additional PRACH resources in time-domain,   * When an additional RO is overlapped with legacy valid RO in both time and frequency domain, the additional RO is invalid before the SSB-RO mapping   + Note: the overlapped RO for legacy resource is not impacted   + FFS: Clarification on configuration of legacy ROs   For adaption of PRACH in time-domain, for a connected mode UE, support a 1-bit field in DCI 1\_0 with C-RNTI used to trigger PRACH (i.e. PDCCH order) to indicate whether the additional PRACH resource(s) is available for the triggered PRACH.   * FFS: UE behaviour (e.g. applicable resources for PRACH mask index) when it is indicated of additional PRACH resource(s) * FFS: Details on how to reuse existing bit for the 1-bit indication   For DCI-based adaptation for additional PRACH resources, DCI 1\_0 with P-RNTI indicates the availability information for additional PRACH resource from a reference point and for a validity time duration   * FFS: Validity time duration for availability is configured by higher layer signaling or predefined * FFS: Location of the reference point defined in the specification * FFS: Value/granularity of the validity time duration. * FFS: Whether DCI can be used to explicitly deactivate the additional PRACH resources   **RAN1#119**  At least msg1-FrequencyStart can be configured separately for the additional PRACH resources at least for 4-step RACH.  For DCI-based adaptation for additional PRACH resources, select only from the following alternatives:   * Alt 1: (PRACH resource configuration level) DCI-based adaptation to indicate whether the additional PRACH resources provided by semi-static signalling are available or not   + FFS: details * Alt 2: (subset of PRACH resource level) DCI-based adaptation to indicate whether a subset of the additional PRACH resources provided by semi-static signalling are available or not   + FFS: Maximum number of subsets of the additional PRACH resources= [2 or 3 or 4 or 16]   + FFS: whether the subset of the additional PRACH resources is in     - Alt 2-1: RO level per SSB     - Alt 2-2: SSB-to-RO mapping cycle level     - Alt 2-3: PRACH association period level     - Alt 2-4: PRACH association pattern period level     - Alt 2-5: SFN level     - Alt 2-6: Network configured time period   **RAN1#118bis**  For adaptation of PRACH in time-domain, support both of the following   * Alt 1: The PRACH configuration index for the additional PRACH resources is same as the PRACH configuration index for the legacy resources * Alt 2: The PRACH configuration index for the additional PRACH resources is different from the PRACH configuration index for the legacy resources * FFS: Additional details   **RAN1#118**  Extend the RAN1#117 agreement on SSB-RO mapping rule for additional PRACH resources to Case 1   * Case 1: no time-domain overlap between the additional PRACH resources for NES-capable UEs and the PRACH resources for legacy UEs   ***RAN1#117 Agreement***  At least for the case where legacy ROs and additional ROs overlap in neither time nor frequency domain, for adaptation of PRACH in time-domain, the SSB-RO mapping rule for additional PRACH resources follows the legacy SSB-RO mapping rule.   * Mapping SS/PBCH block indexes to valid additional PRACH occasions provided by semi-static signalling follows the legacy mapping order for preamble/time resource/frequency/PRACH slot indexes.   + Note: This mapping is not impacted by time domain PRACH adaptation * Validation rules for the additional PRACH resources follow the legacy validation rules for PRACH resources configured for legacy UEs.   For SSB-RO mapping rule for additional PRACH resources for Case 2.   * Extend the RAN1#117 and RAN1#118 agreements on SSB-RO mapping   **RAN1#116bis**  For adaptation of PRACH in time-domain, support at least the following:   * Adaptation based on additional PRACH resources for NES-capable UEs in addition to PRACH resources for legacy UEs (if any)   + Note: NES-capable UEs can use both additional PRACH resources and PRACH resources for legacy UEs   + Configuration of additional PRACH resources is provided by semi-static signalling     - FFS: details including whether there is overlap of additional PRACH resources and PRACH resources for legacy UEs   + FFS: adaptation mechanism for additional PRACH resources   + Note: No change to the existing PRACH configuration tables in 38.211   Support adaptation mechanisms of PRACH in time-domain for following:   * UE in idle/inactive mode * UE in connected mode | | | | | | | | |
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| ***Consequences if not approved:*** | | Release-19 network energy saving is not supported | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 5.1.1, 5.1.2, 5.1.3, 5.1.4, 6.1.3, 6.1.5, 6.2.2 | | | | | | | | |
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|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS 38.300  TS 38.331 | | |
| ***affected:*** | |  |  | Test specifications | | | | TS 38.213 | | |
| ***(show related CRs)*** | |  |  | O&M Specifications | | | |  | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

====================================CHAGNE BEGINS===================================

# 5 MAC procedures

## 5.1 Random Access procedure

### 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 or an LTM candidate cell 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-ThresholdMsg1-RepetitionNum2*: an RSRP threshold for Msg1 repetition with repetition number 2 (see clause 5.1.1b);

*- rsrp-ThresholdMsg1-RepetitionNum4*: an RSRP threshold for Msg1 repetition with repetition number 4 (see clause 5.1.1b);

*- rsrp-ThresholdMsg1-RepetitionNum8*: an RSRP threshold for Msg1 repetition with repetition number 8 (see clause 5.1.1b);

*- rsrp-ThresholdMsg3*: an RSRP threshold for Msg3 repetition (see clause 5.1.1b);

*- rsrp-SIB1ThresholdSSB*: an RSRP threshold for the selection of the SSB for on-demand SIB1 request.*- FeatureCombination*: feature or a combination of features associated with a set of Random Access resources;

*- featurePriorities*: priorities for features, such as (e)RedCap, Slicing, 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);

- *ssb-SharedRO-MaskIndex*: defines PRACH occasions, on which preambles are allocated for a feature or a combination of features, associated with an SSB in which the MAC entity may transmit a Random Access Preamble (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;

- *ra-SIB1PreambleStartIndex*: the starting index of Random Access Preamble(s) for on-demand SIB1 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;

- *preambleTransMax-Msg1-Repetition*: the maximum number of Random Access Preamble transmissions with a given Msg1 repetition number before switching to Msg1 repetition with the next available higher Msg1 repetition number;

- *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;

- *numberOfPreamblesPerSSB-ForThisPartition*: defines the number ofconsecutive preambles for a feature or a combination of features mapped to each SSB;

- *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 SIB1 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).

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 or for an LTM candidate cell, the MAC entity shall:

1> flush the Msg3 buffer;

1> flush the MSGA buffer;

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

1> if the Random Access procedure is initiated on a Serving Cell; or

1> if the Random Access procedure is initiated by the PDCCH order for an LTM candidate cell and the PDCCH order indicates preamble initial transmission; or

1> if the Random Access procedure is initiated by the PDCCH order for an LTM candidate cell, which is different from the cell to which the UE performed the last Random Access Preamble transmission, and the PDCCH order indicates preamble re-transmission:

2> 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: Void.

1> perform the BWP operation as specified in clause 5.15, except when the Random Access procedure is initiated by the PDCCH order for an LTM candidate cell;

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 not initiated for recovery using an LTM candidate configuration as specified in TS 38.331 [5] clause 5.3.7.3 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; or

1> if the contention-free Random Access Resources have been explicitly provided in the LTM Cell Switch Command MAC CE; or

1> if the Random Access procedure was initiated for SIB1 request (as specified in TS 38.331 [5]) and the Random Access Resources for SIB1 request have been provided by RRC:

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 within the selected set of Random Access resources (as specified in clause 5.1.1b) 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 within the selected set of Random Access resources according to clause 5.1.1b; or

1> if the Random Access procedure was initiated for reconfiguration with sync not initiated for recovery using an LTM candidate configuration as specified in TS 38.331 [5] clause 5.3.7.3 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).

Editor’s note: how to capture selection of additional RACH resources for RACH adaptation is TBD.

Editor’s note: names of OD-SIB1 configuration parameter may be updated in accordance with RRC names.

Editor’s note: FFS whether there is a need to clarify that a preamble can be transmitted and RAR received on “SpCell or a cell supporting SIB1 request” instead of just “SpCell”.=================================unchanged text omitted===================================

### 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 contention-free Random Access Resources have been explicitly provided by an LTM Cell Switch Command MAC CE and the SS-RSRP of the SSB signalled by the LTM Cell Switch Command MAC CE is above *rsrp-ThresholdSSB*:

2> set the *PREAMBLE\_INDEX* to the Random Access Preamble index signalled by the LTM Cell Switch Command MAC CE;

2> select the SSB signalled by the LTM Cell Switch Command MAC CE.

1> else if contention-free Random Access Resources have not been explicitly provided by an LTM Cell Switch Command MAC CE, the Random Access procedure was not initiated for recovery using an LTM candidate configuration as specified in TS 38.331 [5] clause 5.3.7.3, 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 contention-free Random Access Resources have not been explicitly provided by an LTM Cell Switch Command MAC CE, the Random Access procedure was not initiated for recovery using an LTM candidate configuration as specified in TS 38.331 [5] clause 5.3.7.3, 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> if the Random Access procedure was initiated for SIB1 request (as specified in TS 38.331 [5]); and

1> if the Random Access Resources for SIB1 request have been provided by RRC:

2> if at least one of the SSBs with SS-RSRP above *rsrp-SIB1ThresholdSSB* is available:

3> select an SSB with SS-RSRP above *rsrp-SIB1ThresholdSSB*.

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-SIB1PreambleStartIndex* 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> if the Random Access procedure was initiated for SIB1 request (as specified in TS 38.331 [5]); and

1> if *ra-AssociationPeriodIndexSib1* and *sib1-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-AssociationPeriodIndexSib1* in the *sib1-RequestPeriod* permitted by the restrictions given by the *ra-ssb-OccasionMaskIndexSib1* 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> if the set of Random Access resources associated with Msg1 repetition is selected for this Random Access procedure:

3> determine the next available set of PRACH occasions (as specified in TS 38.213 [6]) for the Msg1 repetition number applicable for this Random Access procedure corresponding to the selected SSB (the MAC entity shall select a set of PRACH occasions randomly with equal probability amongst sets of PRACH occasions according to clause 8.1 of TS 38.213 [6] regardless the FR2 UL gap, corresponding to the selected SSB and selected Msg1 repetition number for this Random Access procedure; the MAC entity may take into account the possible occurrence of measurement gaps and MUSIM gaps when determining the next available set of PRACH occasions corresponding to the selected SSB).

2> else:

3> 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 *ssb-SharedRO-MaskIndex* if configured, or indicated by PDCCH, or indicated by the LTM Cell Switch Command MAC CE (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 and MUSIM 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 and MUSIM 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 and MUSIM 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 an (e)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*. If an (e)RedCap UE in RRC\_INACTIVE mode is configured with SDT and with a BWP indicated by *initialDownlinkBWP-RedCap* which is associated with NCD-SSB, SS-RSRP measurement can also be performed based on this NCD-SSB during SDT.

NOTE 4: If an (e)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 for RACH, it is up to the UE implementation to perform a new RSRP measurements before Msg1/MsgA retransmission.

Editor’s note: names of OD-SIB1 configuration parameter may be updated in accordance with RRC names.

Editor’s note: whether any changes are required for when the UE can select any SSB for SIB1 request in case there are no SSBs measured above rsrp-SIB1ThresholdSSB is available, dependent on RAN1.

=================================unchanged text omitted===================================

### 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; and

1> if the Random Access procedure is not initiated by the PDCCH order for an LTM candidate cell:

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

1> if the Random Access procedure is initiated by the PDCCH order for an LTM candidate cell as preamble re-transmission; and

1> if the PDCCH order indicates the same LTM candidate cell and the same SSB as 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 and contention-free Random Access Preamble triggered by a PDCCH order for an LTM candidate cell, 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 the Random Access Procedure is triggered by a PDCCH order for an LTM candidate cell:

2> consider this Random Access procedure completed.

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 or SIB1 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 or the RA-RNTI associated with the last valid PRACH occasion in the set of PRACH occasions (as specified in TS 38.213 [6]) for Msg1 repetition, 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).

=================================unchanged text omitted===================================

### 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> if the Random Access Preamble is transmitted with repetitions:

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

3> else:

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

2> else if the Random Access Preamble is transmitted with repetitions:

3> start the *ra-ResponseWindow* configured in *RACH-ConfigCommon* at the first PDCCH occasion from the end of all repetitions of the Random Access Preamble transmission 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> if the Random Access procedure was initiated for SIB1 request:

5> indicate the reception of an acknowledgement for SIB1 request to upper layers.

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

5> 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 1: 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 or SIB1 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> if the Random Access Preamble is transmitted with repetitions and neither contention-free Random Access Resources nor Random Access resources for SI request have been provided for this Random Access procedure:

4> if *PREAMBLE\_TRANSMISSION\_COUNTER* = [*preambleTransMax-Msg1-Repetition*] + 1; or

4> if *PREAMBLE\_TRANSMISSION\_COUNTER* = 2 × [*preambleTransMax-Msg1-Repetition*] + 1:

5> if set of Random Access resources configured with the same *prach-ConfigurationIndex* and associated with a higher Msg1 repetition number with the same feature or feature combination as the current set of Random Access resources is available:

6> select the set of Random Access resources associated with the next higher Msg1 repetition number with the same feature or feature combination for this Random Access procedure;

6> initialize *startPreambleForThisPartition*, *numberOfPreamblesPerSSB-ForThisPartition*, *numberOfRA-PreamblesGroupA* and *msg1-RepetitionTimeOffsetROGroup* parameters for the Random Access procedure according to the values configured by RRC for the selected set of Random Access resources.

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.

NOTE 2: For the case that RAR PDSCH bandwidth is larger than the bandwidth the eRedCap UE can receive or process per slot, and the UL grant in RAR indicates that the time is not enough for Msg3 transmission, as specified in TS 38.213 [6], it is up to UE implementation, e.g. either to consider the Random Access Response reception not successful, or transmit Msg3.

Editor’s note: FFS whether any changes are required for handling preamble backoff during SIB1 request procedure.

Editor’s note: FFS whether any changes are required for RAR handling when an RO for SIB1 request is shared with other RA usages.

=====================================NEXT CHANGE===================================

# 6 Protocol Data Units, formats and parameters

### 6.1.3 MAC Control Elements (CEs)

#### 6.1.3.x On-demand SSB Activation/Deactivation MAC CE

Editor’s note: contents of the new MAC CE are TBD.

Editor’s note: The exact name of the MAC CE is TBD.

=====================================NEXT CHANGE===================================

### 6.1.5 MAC PDU (Random Access Response)

A MAC PDU consists of one or more MAC subPDUs and optionally padding. Each MAC subPDU consists one of the following:

- a MAC subheader with Backoff Indicator only;

- a MAC subheader with RAPID only (i.e. acknowledgment for SI request or SIB1 request);

- a MAC subheader with RAPID and MAC RAR.

A MAC subheader with Backoff Indicator consists of five header fields E/T/R/R/BI as described in Figure 6.1.5-1. A MAC subPDU with Backoff Indicator only is placed at the beginning of the MAC PDU, if included. 'MAC subPDU(s) with RAPID only' and 'MAC subPDU(s) with RAPID and MAC RAR' can be placed anywhere between MAC subPDU with Backoff Indicator only (if any) and padding (if any).

A MAC subheader with RAPID consists of three header fields E/T/RAPID as described in Figure 6.1.5-2.

Padding is placed at the end of the MAC PDU if present. Presence and length of padding is implicit based on TB size, size of MAC subPDU(s).



Figure 6.1.5-1: E/T/R/R/BI MAC subheader



Figure 6.1.5-2: E/T/RAPID MAC subheader



Figure 6.1.5-3: Example of MAC PDU consisting of MAC RARs

=====================================NEXT CHANGE===================================

### 6.2.2 MAC subheader for Random Access Response

The MAC subheader consists of the following fields:

- E: The Extension field is a flag indicating if the MAC subPDU including this MAC subheader is the last MAC subPDU or not in the MAC PDU. The E field is set to 1 to indicate at least another MAC subPDU follows. The E field is set to 0 to indicate that the MAC subPDU including this MAC subheader is the last MAC subPDU in the MAC PDU;

- T: The Type field is a flag indicating whether the MAC subheader contains a Random Access Preamble ID or a Backoff Indicator. The T field is set to 0 to indicate the presence of a Backoff Indicator field in the subheader (BI). The T field is set to 1 to indicate the presence of a Random Access Preamble ID field in the subheader (RAPID);

- R: Reserved bit, set to 0;

- BI: The Backoff Indicator field identifies the overload condition in the cell. The size of the BI field is 4 bits;

- RAPID: The Random Access Preamble IDentifier field identifies the transmitted Random Access Preamble (see clause 5.1.3). The size of the RAPID field is 6 bits. If the RAPID in the MAC subheader of a MAC subPDU corresponds to one of the Random Access Preambles configured for SI request or SIB1 request, MAC RAR is not included in the MAC subPDU.

The MAC subheader is octet aligned.

===============================CHANGE ENDS=========================================