**3GPP TSG RAN WG1 #101 R1-20xxxxx**

**e-Meeting, May 25th – June 5th, 2020**

**Source: Moderator (NTT DOCOMO, INC.)**

**Title:** **Summary on [101-e-NR-UEFeatures-2step-01]**

**Agenda Item:** **7.2.11.1**

**Document for:** **Discussion and Decision**

1. Introduction

This contribution summarizes the following email discussion/approval regarding UE features for two-step RACH.

[101-e-NR-UEFeatures-2step-01] Email discussion/approval on feature group structure for two-step RACH (25th – 29th May) – (DCM, Hiroki)

* Discuss and decide whether FG9-3 (Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA) is kept or removed
* Discuss and decide whether FG9-4 (MsgA operation in a band combination including SUL) is kept or removed
* Discuss and decide whether FG9-6 (up to X of msgBs per slot/within the msgB window) is kept or removed
* Discuss and decide whether any other new FG(s) is added or not
* Discuss and decide capability signaling design for FG(s) decided to be kept/added in this email discussion (if any)

1. Discussion on UE features for two-step RACH

## 2.1 FG[9-3]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 9. NR\_2step\_RACH | [9-3] | [Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA] | [Parallel MsgA and SRS./PUCCH/PUSCH transmissions across CCs in inter-band CA with msgA in PCell/PScell] | 9-1  TBD | Yes | N/A | UE cannot transmit an MsgA and other UL transmissions in parallel across CCs in inter-band CA | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |

* **Necessity of FG[9-3]**
  + **FG is removed: [3], [6], [9], [11], [13]**
    - **FG 4-26 should be extended to support 2-step RACH: [3]**
  + **FG is kept: [2], [4], [5], [7], [10], [12]**
    - **FG is updated with only MsgA PUSCH: [2]**

Above remaining issues and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

|  |  |
| --- | --- |
| [2] | **Proposal 2: For FG 9-3, we are fine to keep it with an update to clarify that only MsgA PUSCH is needed to be included in the FG, i.e. parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with msgA in PCell/PScell** |
| [3] | ***Proposal 1:*** If there is a common understanding that 4-26 and 6-16 can be applied to MsgA PRACH and MsgA PUSCH, then there is no need of introducing a different UE feature for Rel-16 2-step RACH. And FG 4-26 and 6-16 should be extended to support 2-step RACH.   |  |  |  | | --- | --- | --- | | 4-26 | Parallel PRACH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | Parallel PRACH (or MsgA PRACH) and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | | 6-16 | Supplemental uplink | 1) RACH (type 1 or type 2), PUSCH, PUCCH, SRS operations in a band combination including SUL  2) Supplemental uplink with same numerology between SUL and non SUL carriers | |
| [4] | **Proposal 2: We suggest keeping FG 9-3 as single FG** |
| [5] | **Proposal 2**   * *FG9-3 and 9-4 are kept.* * *FG9-5 is not needed.* * *FFS on FG9-6, pending on RAN2 feedback.* |
| [6] | ***Proposal 2: remove FG9-3,9-4; adopt FG9-5 (or maybe put in FG9-1).*** |
| [7] | ***Proposal 1:*** Parallel transmission of msgA with other signals and msgA operation in SUL are needed. |
| [9] | **Proposal 2: The feature group 9-3 and 9-6 can be removed.** |
| [10] | **Observations**:   * FG 9-3 may clarify operation for 2-step in RRC connected, but the alternative of relying on Rel-15’s 4-26 also seems workable.   **Proposals**:   * Keep FGs 9-3, 9-4 |
| [11] | **Proposal 1:** **Remove FG of “Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA”.**  **Proposal 2:** **For FG of “Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA”, if some reason for this feature is identified and this feature is kept, this feature should focus on “Parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA”.** |
| [12] | **FG 9-3**  We think it should be kept, since msgA is associated with a new channel structure (i.e. PRACH+ TX Gap+ PUSCH) in NR Rel-16. |
| [13] | * 9-3: Do not introduce the FG. The FG does not make sense for initial access, as for such case the UE could simply rely on 4-step RACH. The gNB would anyway not know the capability during initial access. As optional FG, the potential use cases are much more limited, as gNB may potentially utilize the information of the capability in case of UE in RRC connected mode only. |

Based on above, following FL proposals are made.

### **FL proposal 1:**

* **FG9-3 is kept in the UE features list for 2 step RACH**
  + **FG name and components for FG9-3 are changed to “Parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PSCell”**
  + **“TBD” is removed from prerequisite feature groups for FG9-3**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 9. NR\_2step\_RACH | 9-3 | Parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PSCell | Parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PScell | 9-1 | Yes | N/A | UE cannot transmit an MsgA and other UL transmissions in parallel across CCs in inter-band CA | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |

Companies are encouraged to check above FL proposals and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

Cannot accept the proposals:

|  |  |
| --- | --- |
| Company | Comment |
| Samsung | During last meeting email discussion, and also in our tdoc, we have responsed the comments that “msgA PUSCH with TA=0 is a new UE requirement”, which is incorrect. Clearly by Rel-15 supported TA value range, UE should be able to transmit a PUSCH with TA=0, so it is not new feature at all. We are not ok to keep it. |
| Nokia, NSB | The FG does not make sense for initial access, as for such case the UE could simply rely on 4-step RACH. The gNB would anyway not know the capability during initial access. As optional FG, the potential use cases are much more limited, as gNB may potentially utilize the information of the capability in case of UE in RRC connected mode only. Hence we are not OK to keep it. |
| CATT | Actually MSGA PUSCH surely have some different behaviors such as TA, Intra-slot frequency hopping and data scrambling with nRAPID etc. with normal PUSCH.  For use cases of FG9-3, MSGA in RRC connection mode can be used for MSGA for other SI, transition from RRC\_INACTIVE, Handover, RRCconnection reestablishment, BFR and so on.  In addition, MSGA PUSCH overlapping with other UL signals in intra-band CA is being discussed under 2s RACH session. This means transmission behaviour of MSGA PUSCH is different with that of normal PUSCH. And UE behaviour between intra-band CA and inter-band CA are similar.  We prefer to FG9-3 as single FG.  FL proposal1 on FG9-3 is incomplete because MSGA PRACH can’t be addressed under inter-band CA case.  So there are two alternatives to fix this issue.  **Alt1: FL proposal1+ modification on 4-26 FG as below**   |  |  |  | | --- | --- | --- | | 4-26 | Parallel PRACH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | Parallel PRACH (or MsgA PRACH) and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA |   **Alt2: Change FL proposal1 as below**  “Parallel MsgA ~~PUSCH~~ and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PSCell”  We are fine with above two options. |
|  |  |

## 2.2 FG[9-4]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 9. NR\_2step\_RACH | [9-4] | [MsgA operation in a band combination including SUL] | [MsgA operations in a band combination including SUL] | 9-1, 6-16 TBD | Yes | N/A | UE does not support msgA operations in a band combination including SUL | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |

* **Necessity of FG[9-4]**
  + **FG is removed: [2], [3], [6], [13]**
    - FG 6-16 should be extended to support 2-step RACH: [3]
  + **FG is kept: [4], [5], [7], [10], [12]**

Above remaining issues and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

|  |  |
| --- | --- |
| [2] | **Proposal 3: For FG 9-4, no need to introduce separate FG for 2-step RACH.** |
| [3] | ***Proposal 1:*** If there is a common understanding that 4-26 and 6-16 can be applied to MsgA PRACH and MsgA PUSCH, then there is no need of introducing a different UE feature for Rel-16 2-step RACH. And FG 4-26 and 6-16 should be extended to support 2-step RACH.   |  |  |  | | --- | --- | --- | | 4-26 | Parallel PRACH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | Parallel PRACH (or MsgA PRACH) and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA | | 6-16 | Supplemental uplink | 1) RACH (type 1 or type 2), PUSCH, PUCCH, SRS operations in a band combination including SUL  2) Supplemental uplink with same numerology between SUL and non SUL carriers | |
| [4] | **Proposal 3: We suggest keeping FG 9-4 as single FG** |
| [5] | **Proposal 2**   * *FG9-3 and 9-4 are kept.* * *FG9-5 is not needed.* * *FFS on FG9-6, pending on RAN2 feedback.* |
| [6] | ***Proposal 2: remove FG9-3,9-4; adopt FG9-5 (or maybe put in FG9-1).*** |
| [7] | ***Proposal 1:*** Parallel transmission of msgA with other signals and msgA operation in SUL are needed. |
| [10] | **Observations**:   * FG 9-4 seems needed, since there are specific parameters used with SUL for 2 step.   **Proposals**:   * Keep FGs 9-3, 9-4 |
| [12] | * **FG 9-4**   + It is OK to keep this FG. |
| [13] | * 9-4: Do not introduce the FG. Reasoning is essentially the same as for 9-3. |

Based on above, following FL proposals are made.

### **FL proposal 2:**

* **FG9-4 is kept in the UE features list for 2 step RACH**
  + **“TBD” is removed from prerequisite feature groups for FG9-4**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 9. NR\_2step\_RACH | 9-4 | MsgA operation in a band combination including SUL | MsgA operations in a band combination including SUL | 9-1, 6-16 | Yes | N/A | UE does not support msgA operations in a band combination including SUL | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |

Companies are encouraged to check above FL proposals and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

Cannot accept the proposals:

|  |  |
| --- | --- |
| Company | Comment |
|  |  |
|  |  |
|  |  |
|  |  |

Based on the discussion in Tuesday GTW session, following agreements were made.

**Agreements:**

* **FG9-4 is kept in the UE features list for 2 step RACH**
  + **“TBD” is removed from prerequisite feature groups for FG9-4**

## 2.3 FG[9-6]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 9. NR\_2step\_RACH | [9-6] | [up to X of msgBs per slot/within the msgB window] | [up to X of msgBs per slot/within the msgB window] | TBD | Yes | N/A |  | [Per band] | N/A | N/A | N/A |  | Optional with capability signalling |

* **Necessity of FG[9-6]**
  + **FG is removed: [9], [10], [11], [13]**
    - **Clarify that this feature is for RRC\_CONNECTED UE, and if UE follows Rel-15 feature on the number of unicasts PDSCH reception, i.e., 5-11, 5-11a and 5-11b, this feature can be removed: [11]**
  + **FG is kept: [8], [12]**
    - **RAN2 to make final decision on whether this separate FG is needed: [8]**
  + **FFS (wait for RAN2 LS): [2], [3], [5], [6],**
* **Name of FG[9-6]**
  + **FG 9-6 is modified as up to X of msgBs per slot within the msgB window when msgB carries SuccessRAR with RRC configuration: [8]**
* **Type of FG[9-6]**
  + **Per band: [12]**

Above remaining issues and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

|  |  |
| --- | --- |
| [2] | **Proposal 4: For FG 9-6, wait for RAN2’s further discussion and conclusion on it before introducing the FG.** |
| [3] | Regarding the FG 9-6, as captured in the LS to RAN2 that this may be related to the payload size of MsgB, we can decide whether or not to support this FG after we get the feedback from RAN2, or left it to RAN2 for the final decision. |
| [5] | **Proposal 2**   * *FG9-3 and 9-4 are kept.* * *FG9-5 is not needed.* * *FFS on FG9-6, pending on RAN2 feedback.* |
| [6] | * *[9-6] [up to X of msgBs per slot/within the msgB window] [up to X of msgBs per slot/within the msgB window]*   Wait for RAN2 further reply. |
| [8] | ***Proposal 1***:  **FG 9-6 is modified as up to X of msgBs per slot within the msgB window when msgB carries SuccessRAR with RRC configuration**   * **It is kept without square bracket from RAN1 perspective assuming the maximum payload size can be as large as msg4 of 4-step RACH; a UE must report a value for this FG if reports support of FG 9-1 (similar to *pdsch-ProcessingType1-DifferentTB-PerSlot*)**   **RAN2 to make final decision on whether this separate FG is needed, e.g. after confirming that the maximum payload size of msgB would be similar to msg2 of 4-step RACH** |
| [9] | **Proposal 2: The feature group 9-3 and 9-6 can be removed.** |
| [10] | **Observations**:   * FG 9-6 does not seem to have a clear need yet to us, since the use case for multiple MsgBs in a slot is not really established.   **Proposals**:   * Do not define FGs 9-5, 9-6 |
| [11] | **Proposal 4:** **For FG of “up to X of msgBs per slot/within the msgB window”,**   * **Clarify that this feature is for RRC\_CONNECTED UE.** * **If UE follows Rel-15 feature on the number of unicasts PDSCH reception, i.e., 5-11, 5-11a and 5-11b, this feature can be removed.** |
| [12] | * **FG 9-6** * The type of this FG should be **per band**. * It is OK to be kept. |
| [13] | * 9-6: Do not introduce the FG. When monitoring for the MsgB, the UE will simply monitor configured search spaces for DCI. Also, for initial access the gNB would not know this feature and would hence not be able to act accordingly. For connected mode, it would not make much sense to have limitations compared to initial access. It should be noted that there are no UE features for restrictions on monitoring for Msg2 for 4-step RACH. |

Based on above, following FL proposals are made.

### **FL proposal 3:**

* **FG[9-6] is removed from the UE features list for 2 step RACH**

Companies are encouraged to check above FL proposals and to provide feedback if any in below. If you cannot accept the FL proposals, please put your company name after “Cannot accept the proposals” below and please provide your alternative proposal (in your comment) which could be acceptable to all in your consideration.

Cannot accept the proposals:

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | Cannot accept the proposals.  Alternative 1: keep this FG from RAN1 perspective and revisit it depending on RAN2 reply LS;  Alternative 2: remove it from 2-step RACH UE feature list and revisit it on discussion of FGs proposed in [101-e-NR-UEFeatures-Others-01] where the following is proposed   * Defines whether the UE capable of processing time capability 1 supports reception of up to two, three or seven unicast PDSCHs for several transport blocks with PDSCH scrambled using C-RNTI, msgB-RNTI, TC-RNTI, or CS-RNTI in one serving cell within the same slot per CC that are multiplexed in time domain only. This FG is reported per FS.   + Note PDSCH(s) for MsgB/Msg.4 is included. |
| Samsung | We have included the question to LS to ran2 and ask for their input; we don’t think it is approperate to make this proposed move without getting their reply. Then what’s the point to send the LS question? Suggest to keep it in bracket at least for now. |
| Nokia, NSB | We are not supportive of the FG itself, however we tend to agree that it is fair to keep it in bracket for now so that RAN2 has an opportunity to reply to the LS sent last meeting about this very FG. |
|  |  |

## 2.4 Others

* **Necessity of FG “MsgA PUSCH frequency hopping with non-zero guard period”**
  + **No need (i.e., included in the basic feature): [3], [5], [10], [11], [12], [13]**
  + **Adopt this FG or maybe put in FG9-1: [6]**

Above remaining issues and proposals are identified based on following feedbacks provided in contributions for the RAN1#101-e meeting.

|  |  |
| --- | --- |
| [3] | Regarding the FG 9-5, from gNB vendor’s point of view, we do not think it is necessary to differentiate the intra-slot frequency hopping with and without guard period, and thus it should be included in the basic feature group. |
| [5] | **Proposal 2**   * *FG9-3 and 9-4 are kept.* * *FG9-5 is not needed.* * *FFS on FG9-6, pending on RAN2 feedback.* |
| [6] | ***Proposal 2: remove FG9-3,9-4; adopt FG9-5 (or maybe put in FG9-1).*** |
| [10] | **Observations**:   * FG 9-5 is not so desirable since performance enhancing feature such as frequency hopping need to be widely supported for the net gains in a cell to be achievable.   **Proposals**:   * Do not define FGs 9-5, 9-6 |
| [11] | **Proposal 3:** **MsgA PUSCH frequency hopping with non-zero guard period should not be separate feature group from basic feature group.** |
| [12] | * **FG 9-5** * We don’t think it is needed. |
| [13] | * 9-5: Confirm deletion of FG. Frequency hopping is supported by default, If this FG is introduced, there would be a potential segmentation of the UEs according to the feature. Since the MsgA PUSCH Occasion would be derived with reference to the guard period, it would not be possible to have multiplexing of UEs supporting this FG and UEs not supporting this FG. Hence, for gNB to support UEs supporting this feature, it would need to create two separate PUSCH configurations, which would be an extreme waste of resources. Hence, either all UE support the guard period between hops, or no UE support the guard period between hops (which would be equivalent to dropping the feature completely from specifications). |

Based on above, it seems not necessary to discuss again on the necessity of FG9-5 “MsgA PUSCH frequency hopping with non-zero guard period” as it was already removed from the UE features list for 2 step RACH.

Nevertheless, companies can provide comments if any below.

|  |  |
| --- | --- |
| Company | Comment |
|  |  |
|  |  |
|  |  |
|  |  |

1. Conclusion

**FL proposal 1:**

* **FG9-3 is kept in the UE features list for 2 step RACH**
  + **FG name and components for FG9-3 are changed to “Parallel MsgA PUSCH and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA with MsgA in PCell/PSCell”**
  + **“TBD” is removed from prerequisite feature groups for FG9-3**

**Agreements:**

* **FG9-4 is kept in the UE features list for 2 step RACH**
  + **“TBD” is removed from prerequisite feature groups for FG9-4**

**FL proposal 3:**

* **FG[9-6] is removed from the UE features list for 2 step RACH**

Reference

[1] R1-2003197 Summary on email discussion [100b-e-NR-UEFeatures-Remaining] NR\_2step\_RACH Moderator (NTT DOCOMO, INC.)

[2] R1-2003415 Discussion on UE features for 2-step RACH vivo

[3] R1-2003459 Discussion on the remaining issues of the UE features for two-step RACH ZTE, Sanechips

[4] R1-2003603 Discussion of NR Rel-16 UE features for two-step RACH CATT

[5] R1-2003752 Discussion on UE features for two-step RACH Intel Corporation

[6] R1-2003893 UE features for two-step RACH Samsung

[7] R1-2004137 Discussion on UE features for NR 2step RACH LG Electronics

[8] R1-2004146 Rel-16 UE features for 2-step RACH Huawei, HiSilicon

[9] R1-2004240 Views on NR 2-step RACH UE feature Apple

[10] R1-2004350 UE Features for Two-Step RACH Ericsson

[11] R1-2004400 Discussion on UE features for Two-step RACH NTT DOCOMO, INC.

[12] R1-2004476 Discussion on two step RACH UE features Qualcomm Incorporated

[13] R1-2004559 On UE features or 2-step RACH Nokia, Nokia Shanghai Bell

Appendix: latest version of UE features list for 2 step RACH [1]

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 9. NR\_2step\_RACH | 9-1 | Basic channel structure and procedure of 2-step RACH | 1. RACH type selection for CBRA according to SSB-based RSRP threshold 2. msgA PRACH resource configuration including separately configured ROs not applicable to 4-step RO configuration and fully or partially shared ROs but different preamble sequences partitioning with 4-step RO preamble sequences configuration 3. msgA PUSCH resource (DMRS included) and waveform determination for 2-step CBRA    1. Supporting up to two msgA PUSCH configurations in an UL BWP 4. Validation of MsgA PRACH and PUSCH 5. Mapping between preamble of MsgA PRACH and PUSCH occasion with DMRS resource of MsgA PUSCH 6. msgB monitoring and decoding for 2-step CBRA    1. (for UE in any RRC state) monitoring msgB PDCCH with CRC masked by msgB-RNTI in Type-1 CSS set, and decoding multi-cast msgB PDSCH carrying SuccessRAR, FallbackRAR and BI    2. (for RRC connected UE only) monitoring msgB PDCCH with CRC masked by C-RNTI in USS set, and decoding the unicast PDSCH carrying absolute TA MAC CE 7. PUCCH transmission for HARQ-ACK feedback to a msgB 8. Power control for msgA PRACH, msgA PUSCH and PUCCH carrying HARQ-ACK feedback to msgB |  | Yes | N/A | UE cannot initiate a 2-step RACH process, and thus would not be expected understand the 2-step RACH configurations | per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 9. NR\_2step\_RACH | [9-3] | [Parallel MsgA and SRS/PUCCH/PUSCH transmissions across CCs in inter-band CA] | [Parallel MsgA and SRS./PUCCH/PUSCH transmissions across CCs in inter-band CA with msgA in PCell/PScell] | 9-1  TBD | Yes | N/A | UE cannot transmit an MsgA and other UL transmissions in parallel across CCs in inter-band CA | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |
| 9. NR\_2step\_RACH | [9-4] | [MsgA operation in a band combination including SUL] | [MsgA operations in a band combination including SUL] | 9-1, 6-16 TBD | Yes | N/A | UE does not support msgA operations in a band combination including SUL | Per BC | N/A | N/A | N/A |  | Optional with capability signalling |
| 9. NR\_2step\_RACH | [9-6] | [up to X of msgBs per slot/within the msgB window] | [up to X of msgBs per slot/within the msgB window] | TBD | Yes | N/A |  | [Per band] | N/A | N/A | N/A |  | Optional with capability signalling |