**3GPP TSG RAN WG1 #102e R1-2007014**

**e-Meeting, August 17th – 28th, 2020**

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

**Title:** **Summary on [102-e-NR-UEFeatures-NRU-02]**

**Agenda Item:** **7.2.11**

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

1. Introduction

This contribution summarizes the following email discussion/approval in AI 7.2.11.

[102-e-NR-UEFeatures-NRU-02] Email discussion/approval on basic feature groups for NR-U deployment scenarios (after the completion of the NRU-01 email thread) till 8/26 – Hiroki (DCM)

* How to define basic FG(s) for each of particular NR-U deployment scenarios based on completed FGs

In addition to above, it was agreed in [102-e-NR-UEFeatures-NRU-01] that following issue is also discussed in this email discussion.

* Whether each of FGs10-9/9b/9c/9d/15/16/20a is applicable to licensed bands or not (i.e., the note “the signaling is per band but is only expected for a band where shared spectrum channel access must be used” is added)
1. Applicability of NR-U features to licensed band

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| 10. NR-unlicensed | 10-9 | Search space set group switching with DCI 2\_0 monitoring | 1. Two groups of search space sets2. Monitor DCI 2\_0 with a search space set switching field 3. Support switching the search space set group with PDCCH decoding in group 1 4. Support a timer to switch back to original search space set group5. Monitor DCI 2\_0 for channel occupancy time and use the end of channel occupancy time to switch back to the original search space set group |  | Yes | N/A |  | Per band  | N/A | N/A | N/A | Being configured with two groups of search spaces, and switch between them. Some search space sets can be configured in both groups. | Optional with capability signalling |
| 10. NR-unlicensed | 10-9b | Search space set group switching with implicit PDCCH decoding without DCI 2\_0 monitoring | 1. Two groups of search space sets2. Support switching the search space set group with PDCCH decoding in group 1 3. Support a timer to switch back to original search space set group |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Being configured with two groups of search spaces, and switch between them. Some search space sets can be configured in both groups. | Optional with capability signalling |
| 10. NR-unlicensed | 10-9c | Joint search space group switching across multiple cells | 1. Configured with a group of cells and switch search space set group jointly over these cells
 | one of {10-9, 10-9b} | Yes | N/A |  | Per BC | N/A | N/A | N/A | Without this capability, the UE will switch search space set groups for different cells independently | Optional with capability signalling |
| 10. NR-unlicensed | 10-9d | Support Search space set group switching capability 2 | 1. Search space set group switching Capability-2: P=10/12/22 symbols for µ = 0/1/2 SCS
 | one of {10-9, 10-9b} | Yes | N/A |  | Per band | N/A | N/A | N/A | Without this capability, the UE supports search space set group switching capability-1: P=25/25/25 symbols for µ=0/1/2 | Optional with capability signalling |
| 10. NR-unlicensed | 10-15 | Enhanced dynamic HARQ codebook | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1 (configuration of nfi-TotalDAI-Included)2. Support of bit field in DCI 0\_1 for other group total DAI if configured. (configuration of ul-TotalDAI-Included)3. Support the retransmission of HARQ ACK (pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16) |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Enhanced dynamic HARQ codebook supporting grouping of HARQ ACK and triggering the retransmission of HARQ ACK in each groups | Optional with capability signalling |
| 10. NR-unlicensed | 10-16 | One-shot HARQ ACK feedback | 1. Support feedback of type 3 HARQ-ACK codebook, triggered by a DCI 1\_1 scheduling a PDSCH
2. Support feedback of type 3 HARQ-ACK codebook , triggered by a DCI 1\_1 without scheduling a PDSCH using a reserved FDRA value
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Upon triggering, UE reports A/N for all HARQ processes and all CCs in a PUCCH group.  | Optional with capability signalling |
| 10. NR-unlicensed | 10-20a | Support coreset configuration with rb-Offset | 1. Support coreset configuration with rb-Offset  |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signaling |

Following proposals are made in contributions.

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| [2] | **Regarding licensed applicability of FGs**, 3 FGs are agreed to extend to licensed spectrum and 4 FGs are applicable for unlicensed band only as summarized below according to the agreements in RAN1 101-e:

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| --- | --- | --- |
| 10-8 | Type B PDSCH length {3, 5, 6, 8, 9, 10, 11, 12, 13} without DMRS shift due to CRS collision | Both licensed and unlicensed band |
| 10-11 | SRS starting position at any OFDM symbol in a slot | Both licensed and unlicensed band |
| 10-17 | Multi-PUSCH UL grant | Both licensed and unlicensed band |
| 10-10 | RSSI and channel occupancy measurement and reporting | Unlicensed band only |
| 10-20 | Support search space set configuration with freqMonitorLocation-r16 | Unlicensed band only |
| 10-14 | Non-numerical PDSCH to HARQ-ACK timing | Unlicensed band only |
| 10-28 | Configured grant with Rel-16 enhanced resource configuration | Unlicensed band only |

For other FGs, the baseline for each NRU UE feature should be applicable to unlicensed band only unless it is agreed to extend to licensed band if beneficial for licensed operation. In [2], the following FGs are listed as candidates for continual discussion on whether to extend licensed band:* 10-9 Search space set group switching with explicit DCI 2\_0 bit field trigger or with implicit PDCCH decoding with DCI 2\_0 monitoring
* 10-9b Search space set group switching with implicit PDCCH decoding without DCI 2\_0 monitoring
* 10-9c Joint search space group switching across multiple cells
* 10-9d Support Search space set group switching capability 2
* 10-15 Enhanced dynamic HARQ codebook
* 10-16 One-shot HARQ ACK feedback

For search space set (SS) group switching related features (10-9, 10-9b, 10-9c, 10-9d), it is beneficial for power saving purpose in licensed band, i.e. one SS with sparse PDCCH monitoring in power saving mode and switch to another SS with frequent PDCCH monitoring when traffic arrives. For other features such as 10-15 and 10-16, we do not see the need of extension to licensed band since it is introduced due to LBT requirement on unlicensed band which doesn’t exist in licensed band. ***Proposal 2.1: SS group switching related features (10-9, 10-9b, 10-9c, 10-9d) could be extended to licensed band.******Proposal 2.2: For FGs that are not agreed to be extended to licensed use, they are unlicensed band only in default and add a note “the signaling is per band but is only expected for a band where shared spectrum channel access must be used”.*** |
| [5] | Many issues for NR-U UE features were resolved at RAN1#101-e, including extending the applicability of certain NR-U FGs to licensed bands, reporting type and most FFS points. The list of UE feature groups clearly notes that for some FGs with per band reporting, “the signaling is per band but is only expected for a band where shared spectrum channel access must be used”. This is the case for 10-14, 10-20, 10-28 and 10-10, for which such explicit agreement was made at RAN1#101-e.All the FGs with per band reporting without this note could then be considered as applicable in licensed bands (for example FG10-8 was explicitly agreed to be applicable to licensed bands). But this poses a problem because the note is not present for most FGs. While it may be obvious that the note should have been there for some FGs that are irrelevant for licensed bands (such as those associated with channel access mechanisms), there may be a risk for ambiguity for some other FGs once RAN2 designs the signaling. The FGs for which the note should likely be added are 10-1/1a/2/2a/2b/2c/2d/2f/2g/2h/2i, 10-19a/b/c/d/e/f, 10-23, 10-25, 10-27, 10-29, 10-30, 10-26/26a, 10-3, 10-3a, 10-12, 10-13a, 10-18. 10-21a/21b, 10-24.A number of FFS points remain in agreements made at RAN1#101-e:* FFS: FG10-20a is also applicable to licensed bands (coreset configuration with rb-Offset)
* FFS: FG10-15 is only for unlicensed bands (Enhanced dynamic HARQ codebook)
* FFS: FG10-16 is only for unlicensed bands (One-shot HARQ ACK feedback)
* FFS: FG10-9/9b/9c/9d are also applicable to licensed bands (search space set group switching)

It was not clear whether FG10-17 (Multi-PUSCH UL grant) is applicable to licensed bands, since the FFS point was deleted (~~FFS: FG10-17 is only for unlicensed bands~~) but it was not replaced by an agreement.**Proposal NRU-1: it should be consistently noted that “the signaling is per band but is only expected for a band where shared spectrum channel access must be used” for all FGs that are reported per band but that are not applicable for licensed bands:*** **Add the note “the signaling is per band but is only expected for a band where shared spectrum channel access must be used” to the following FGs:**
	+ **10-1/1a/2/2a/2b/2c/2d/2f/2g/2h/2i, 10-9/9b/9c/9d, 10-19a/b/c/d/e/f, 10-23, 10-25, 10-27, 10-29, 10-30, 10-26/26a, 10-3, 10-3a, 10-12, 10-13a, 10-18, 10-20a, 10-21a/21b, 10-24, 10-31**
* **Further discuss applicability of FG10-15 and FG10-16 for licensed bands**
* **Consider allowing FG10-20a (Support coreset configuration with rb-Offset) for licensed bands, for increasing FDRA flexibility for CORESET**
 |
| [7] | However, it is still FFS (see [3]) on some FGs whether they are applicable to licensed bands or shall be restricted to operation with shared spectrum channel access, namely:* FG 10-9/9b/9c/9d, -15, -16, -20a

In our view, all these FGs are generically useful features, and should be applicable to licensed bands:* FG 10-9/9b/9c/9d are generically useful for UE power saving applications
	+ Note that if FG 10-9 is used in licensed bands, then Component 5 regarding channel occupancy signaling is not needed
* FG-15 and -16 are generically useful HARQ enhancements
* FG 10-20a is useful feature for licensed bands; it is beneficial to be able to PRB align CORESET0 and a regular CORESET to reduce PDCCH blocking.
1. The following FGs are applicable to licensed operation (i.e., NOT restricted to shared spectrum channel access only): 10-9/9b/9c/9d, -15, -16, -20a. For FG 10-9 in licensed bands, Component 5 is not required.

~As discussed above, this feature is generically useful for UE power saving applications regardless of the licensed/unlicensed operation. Hence, we propose**FGs 10-9/9b/9c/9d are supported for licensed bands. For operation in licensed bands, Component 5 of FG 10-9 is not needed.** ~As discussed above, this feature provides a generically useful enhancement to dynamic HARQ codebooks regardless of licensed/unlicensed operation. Hence, we propose**FGs 10-15 is supported for licensed bands.**~As discussed above, this feature provides a generically useful enhancement and gives the gNB the option to request HARQ feedback when needed for example to in case of dropped HARQ-ACK codebook which can occur in licensed band due to prioritization. This feature is very useful regardless of licensed/unlicensed operation. Hence, we propose**FGs 10-16 is supported for licensed bands.**~As discussed above, this feature is generically useful to reduce PDCCH blocking regardless of licensed/unlicensed operation. Hence, we propose**FG 10-20a is supported for licensed bands.** |

Based on the above contributions, it is agreed to discuss following point in the email discussion [9].

**Discussion point #3**

* **Whether each of FGs10-9/9b/9c/9d/15/16/20a is applicable to licensed bands or not (i.e., the note “the signaling is per band but is only expected for a band where shared spectrum channel access must be used” is added)**

## 2.1 Proposal and discussion

Based on contribution and above inputs during preparation phase discussion, following proposal is made.

**FL proposal 1:**

* **The FG10-9/9b/9c/9d are also applicable to licensed bands.**
* **The FG10-20a is also applicable to licensed bands.**
* **The FG10-15/16 are only applicable to unlicensed bands, and the note “the signaling is per band but is only expected for a band where shared spectrum channel access must be used” is added for the FGs.**

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| 10. NR-unlicensed | 10-15 | Enhanced dynamic HARQ codebook | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1 (configuration of nfi-TotalDAI-Included)2. Support of bit field in DCI 0\_1 for other group total DAI if configured. (configuration of ul-TotalDAI-Included)3. Support the retransmission of HARQ ACK (pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16) |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Enhanced dynamic HARQ codebook supporting grouping of HARQ ACK and triggering the retransmission of HARQ ACK in each groupsthe signaling is per band but is only expected for a band where shared spectrum channel access must be used | Optional with capability signalling |
| 10. NR-unlicensed | 10-16 | One-shot HARQ ACK feedback | 1. Support feedback of type 3 HARQ-ACK codebook, triggered by a DCI 1\_1 scheduling a PDSCH
2. Support feedback of type 3 HARQ-ACK codebook , triggered by a DCI 1\_1 without scheduling a PDSCH using a reserved FDRA value
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Upon triggering, UE reports A/N for all HARQ processes and all CCs in a PUCCH group. the signaling is per band but is only expected for a band where shared spectrum channel access must be used | Optional with capability signalling |

Companies are encouraged to check above FL proposal 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 |
| DOCOMO | Support the proposal.For FG10-15/16, following observations were made in RAN1#101-e. As the combination of eType2/Type3 HARQ feedback and the two priorities of HARQ-ACK is not supported in Rel.16, the benefit for applying FG10-15/16 to lisenced bands is limited. Enhancement for licensed bands can be discussed in Rel.17 URLLC/IIoT.Observations:Examples of joint configurations/signaling for eURLLC and NR-U that can work in Rel-16:* Example 1: Handling of NNK1 value (dl-DataToUL-ACK-r1 with value -1) with Type-2 HARQ-ACK codebook and two HARQ-ACK codebook priorities (when UE is provided with PDSCH-HARQ-ACK-CodebookList-r16), using DCI format 1\_1 and/or DCI format 1\_2, when the NNK1 value is signaled in DCI format 1\_1.

Examples of joint configurations/signaling for eURLLC and NR-U that cannot work in Rel-16:* Example 2: Joint configuration of Enhanced Type-2 HARQ-ACK codebook and two HARQ-ACK codebook priorities (when UE is provided with PDSCH-HARQ-ACK-CodebookList-r16)
	+ RAN1’s understanding is that the RRC parameter PDSCH-HARQ-ACK-CodebookList-r16 cannot configure the UE with Enhanced Type-2 HARQ-ACK codebook, although RAN1 specifications can support reporting with Enhanced Type-2 HARQ-ACK codebook when two HARQ-ACK codebook priorities can be indicated using DCI format 1\_1/1\_0, and can also support handling of NNK1 value in this case
* Example 3: Reporting Type-3 HARQ-ACK codebook when different HARQ processes have been scheduled with different PUCCH priorities (when UE is provided with PDSCH-HARQ-ACK-CodebookList-r16)
 |
| LG Electronics | Support FL proposal for FG 10-15 and FG 10-16. However, we don’t see a strong motivation/benefit to extend FG 10-9/9b/9c/9d/20a in licensed bands. |
| MediaTek | * We prefer not to extend FGs10-9/9b/9c/9d/15/16/20a for licensed operation unless use cases and benefits are clearly justified.
 |
| Huawei, HiSilicon | We agree with LG’s and Mediatek’s comments. |
| Apple | We shared MTK’s views and prefer not to extend them. It should be noted that there are still some modifications are needed if we want to extend the FG 10-9x to licensed band as being discussed in different Rel-17 power saving agenda. Considering the current maitainance stage, we would prefer to limit it to licensed and have a full study and extend it to licensed in Rel-17 if benefit is justified. On FG 10-20a, we understand there can have some scheduling flexibility literally. However, we fail to see a clear use case. Simliarly, FG 15/16 are being discussed as part of Rel-17 URLLC WI already.  |
| Ericsson | * We support the 1st bullet of the FL proposal
	+ This functionality is generic – and indeed beneficial – to enable power saving at the UE. Hence, this feature should be applicable also to licensed bands. We understand that Compoonent 5 of 10-9 that refers to monitoring DCI 2\_0 for channel "channel occupancy" is not relevant for licensed operation. However, the spec supports not configuring this field in DCI 2\_0 in which case the UE switches back to monitoring the default search space group at the end of the indicated SFI (or timer expiry, which ever occurs first). Hence, 10-9 and 10-9b are relevant in licensed bands.
* We support the 2nd bullet of the FL proposal
	+ This functionaly is beneficial for licensed bands to enable shifting a CORESET off the 6-RB grid to enable alignment with CORESET0 (which is not restricted to the 6-RB grid). This is a useful feature in both licensed and unlicensed bands to enable efficient use of control channel resources and reduce PDCCH blocking.
* For the 3rd bullet, we disagree with FL proposal and propose instead: **The FG10-15/16 are applicable to licensed bands**. These HARQ enhancements are generic in nature, and are beneficial for operation in licensed bands.
	+ The functionalities developed for these two features (as a result of extensive work), enable mechanisms to request AGAIN HARQ-ACK feedback when gNB has missed the reception of HARQ-ACK feedback. A strong motivation under NR-U was LBT failure as UE, but we fail to understand that the only use case for such features can be limited to compensate for LBT failure. Firstly, it is well understood that HARQ-ACK miss detection can occur also in licensed band. For example, gNB  may miss reception of PUCCH due to interference. Secondly, during Rel-16, priority based transmission is extensively developed which means that low priority transmissions (including HARQ-ACK) may be dropped due to sudden arrival of high priority traffic. These features can be used to request the dropped HARQ-ACK without retransmission of corresponding DL traffic which is of great importance for efficient operation of NR. Lastly, extensive efforts were made during Rel-16 NR-U to develop these features (including NNK1). Limiting the outcome of efforts to only one use case and create artificial restrictions, result in spending specification efforts to develop new features with similar functionalities, resulting in fragmentation of the spec and additional, unecssary UE capability signaling.
 |
| Moderator | Thank you very much for the inputs!Based on the inputs so far, majority prefers to not extend the applicability of FGs to licensed bands.Therefore, updated FL proposal is provided according to the majority view. |
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### **Updated FL proposal 1:**

* **The FG10-9/9b/9c/9d/15/16/20a are only applicable to unlicensed bands, and the note “the signaling is per band but is only expected for a band where shared spectrum channel access must be used” is added for the FGs.**

Companies are encouraged to check above FL proposal 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 |
| LG Electronics | Support FL proposal. |
| Ericsson | Respectfully, we must object to the FL proposalBased on the technical motivation that we provided above, we have demonstrated that the FGs provide useful – indeed beneficial – funtionality for licensed operation. In our view it is not enough for the majority to simply claim only that the FGs are not needed, or there is no strong motivation.We humbly request that this proposal is discussed further on-line in a GTW before a conclusion is drawn. |
| Nokia, NSB | In our understanding FGs 10-9/b/c/d should not be extended to licensed operation as they are tightly related to COT information and it is not very clear how to apply them to licensed band operation. As for 10-15/16/20a we can be open for application to licensed band, but no strong position at this point.  |
| Moderator | We can continue discussion on above updated FL proposal 1. |
| Qualcomm | We share the same view as Ericsson. In our view, these set of features are developed in NR-U but can work nicely in licensed band as well. They are already per band, so a party does not want to implement can skip the features. For companies implemented the feature in unlicensed band, the extra effort to support them in licensed band might be small. We should not rule out the feature for licensed band just because they were not developed in licensed band discussion in the beginning. |
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1. Basic FG(s) for particular NR-U deployment scenarios

Following proposals are made in contributions.

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| [2] | **Regarding basic FG definition**, the following FGs are listed as candidate basic FGs in [3] and our view is provided below:

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| --- | --- | --- |
| **FG** | **Description** | **Our view** |
| 10-1 | UL channel access for dynamic channel access mode  | It should be basic FG for standalone and LAA DL+UL scenario with LBE since LBT is mandatory for UL transmission. |
| 10-1a | UL channel access for semi-static channel access mode | It should be basic FG for standalone and LAA DL+UL scenario with FBE since LBT is mandatory for UL transmission.  |
| 10-2 | SSB-based RRM for dynamic channel access mode | It should be basic FG for standalone scenario with LBE since it is needed for mobility measurement. |
| 10-2a | SSB-based RRM for semi-static channel access mode | It should be basic FG for standalone scenario with FBE since it is needed for mobility measurement. |
| 10-2b | MIB reading on unlicensed cell | It should be basic FG for standalone scenario since it is needed for initial access. |
| 10-2c | SSB-based RLM for dynamic channel access mode | It should be basic FG at least for standalone scenario with LBE since it is needed for link reliability. |
| 10-2d | SSB-based RLM for semi-static channel access mode | It should be basic FG at least for standalone scenario since it is needed for link reliability. |
| 10-2e | SIB1 reception on unlicensed cell | It should be basic FG for standalone scenario since it is needed for initial access. |
| 10-2f | Support monitoring of extended RAR window | It should be basic FG for standalone scenario with LBE since it is needed for initial access. |
| 10-27 | Wideband PRACH | Not necessary as a basic FG since legacy PRACH still works |
| 10-29 | Support available RB set indicator field in DCI 2\_0 | Not necessary as a basic FG since it still works without it. |
| 10-30 | Support channel occupancy duration indicator field in DCI 2\_0 | Not necessary as a basic FG since it still works without it. |

Based on the above analysis, the following proposal is made:***Proposal 2.3: FG 10-1, 10-1a, 10-2, 10-2a, 10-2b, 10-2c, 10-2d, 10-2e and 10-2f should be basic FGs for at least one particular scenario.*** |
| [3] | In our view, Alt.1 is clear as the table is defined with the intention that the basic FGs would be defined with tightly related functionality, and the basic FGs would try to avoid overlapping functionality as much as possible. It would be easier to build the relationship between the basic FGs and other optional FGs in terms of prerequisite condition. ***Proposal 1:*** * The following table is defined in specification to capture the basic FGs required for a certain NR-U deployment scenario.

|  |  |
| --- | --- |
| Basic FGs | Deployment scenarios |
| A-1 (SCell) | A-2 (SCell) | A-2 (SCell) | C (Standalone),D (Standalone + SUL) | C (Standalone),D (Standalone + SUL) | B (EN-DC),E (NR-NR DC) | B (EN-DC),E (NR-NR DC) |
| DL only | DL+ULLBE | DL+ULFBE | DL+ULLBE | DL+ULFBE | DL+ULLBE | DL+ULFBE |
| 10-1: UL channel access for dynamic channel access mode  |  | X |  | X |  | X |  |
| 10-1a: UL channel access for semi-static channel access mode |  |  | X |  | X |  | X |
| 10-2: SSB based RRM for dynamic channel access mode | X | X |  | X |  | X |  |
| 10-2a: SSB based RRM for semi-static channel access mode | X | X | X |  | X |  | X |
| 10-2b: MIB reading on unlicensed cell |  |  |  | X | X | X | X |
| 10-2c: SSB-based RLM for dynamic channel access mode |  |  |  | X |  | X |  |
| 10-2d: SSB-based RLM for semi-static channel access mode |  |  |  |  | X |  | X |
| 10-2e: SIB1 reception |  |  |  | X | X |  |  |

 |
| [4] | According to NR-U WID, Rel-16 NR-U aims to support the following deployment scenarios. Based on the NR-U target deployment scenarios, we provide our views on which feature groups should be mandatory for a particular deployment scenario in Table 1. * Scenario A: Carrier aggregation between licensed band NR (PCell) and NR-U (SCell).
	+ NR-U SCell may have both DL and UL, or DL-only.
	+ In this scenario, NR PCell is connected to 5G-CN.
* Scenario B: Dual connectivity between licensed band LTE (PCell) and NR-U (PSCell)
	+ In this scenario, LTE PCell connected to EPC as higher priority than PCell connected to 5G-CN.
* Scenario C: Stand-alone NR-U
	+ In this scenario, NR-U is connected to 5G-CN.
* Scenario D: A stand-alone NR cell in unlicensed band and UL in licensed band (single cell architecture).
	+ In this scenario, NR-U is connected to 5G-CN.
* Scenario E: Dual connectivity between licensed band NR and NR-U.
	+ In this scenario, PCell is connected to 5G-CN.

MIB reading should basic FG for SA/DC deployment scenarios. RACH related FGs should be basic FGs for SA/DC deployment scenarios. RAR windows are extended to 40ms to cope with the transmission timing uncertainty caused by LBT. We think it should be supported by UE that plans to support NR-U SA and DC deployments. On the other hand, for UE that only supports NR-U CA operation, then it is not necessary, because RAR is transmitted in SpCell (PCell or PSCell) only.PRB interlaced mapping for PUSCH should be basic FGs for CA with UL and SA/DC deployment scenarios. PRB interlaced mapping for PUCCH should be basic FGs for SA/DC deployment scenarios. In our opinion, monitoring DCI 2\_0 to acquire COT structure in both time (*CO duration*) and frequency (*availableRB-Sets-r16*) dimensions is beneficial to UE in terms of AGC adjustment, COT detection, skipping of PDCCH monitoring and CSI-RS reception, etc. Therefore, we suggest to make FG10-29 and 10-30 as basic FGs for all NR-U deployment scenarios. **Table 1: Proposed basic feature groups for NR-U deployment scenarios**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Scenario A with DL-only in LBE | Scenario A with DL-only in FBE | Scenario A with both DL and UL in LBE | Scenario A with both DL and UL in FBE | Scenario B in LBE | Scenario B in FBE | Scenario C | Scenario D | Scenario E in LBE | Scenario E in FBE |
| 10-1 (LBT LBE) |  |  | X |  | X |  | X |  | X |  |
| 10-1a (LBT FBE) |  |  |  | X |  | X | X |  |  | X |
| 10-2 (SSB RRM for LBE) | X |  | X |  | X |  | X | X | X |  |
| 10-2a (SSB RRM for FBE) |  | X |  | X |  | X |  |  |  | X |
| 10-2b (MIB) |  |  |  |  | X | X | X | X | X | X |
| 10-2c (SSB RLM for LBE) |  |  |  |  | X |  | X | X | X |  |
| 10-2d (SSB RLM for FBE) |  |  |  |  |  | X | X | X |  | X |
| 10-2e (SIB1) |  |  |  |  | X | X | X | X | X | X |
| 10-2f (ext. RAR) |  |  |  |  |  |  | X | X | X | X |
| 10-3 (interlaced PUSCH) |  |  | X | X | X | X | X |  | X | X |
| 10-3a (interlaced PUCCH) |  |  |  |  | X | X | X |  | X | X |
| 10-27 (wide PRACH) |  |  |  |  | X | X | X |  | X | X |
| 10-29 (DCI 2\_0: RB set) | X | X | X | X | X | X | X | X | X | X |
| 10-30 (DCI 2\_0: COT duration) | X | X | X | X | X | X | X | X | X | X |

**Proposal 1: Adopt the proposed basic feature groups in Table 1 to TS38.306 specification for NR-U deployment scenarios.**  |
| [6] | As discussed in [5], one particular aspect of NR-U feature groups is that there are several dimensions that influence if a certain FG should be considered as “basic”, i.e. mandatory, or not:1. Scenario (e.g. carrier aggregation with licensed carrier, dual connectivity, stand-alone, stand-alone with UL on licensed band)
2. Access mode (dynamic or semi-static)
3. UL carrier (not present, unlicensed, licensed)

This implies a non-trivial mapping of which FGs apply for each scenario, and it is our understanding that such relationship would become clearer if captured directly into one of more tables in TS 38.306. The technical recommendation on the exact mapping should be defined by RAN1. Example definitions of tables and potential mapping of FGs can be found in [2, 3, 4]. **Proposal: The mapping between basic feature groups for NR-U and the different operating scenarios is to be captured explicitly in TS 38.306, e.g. by means of one or more tables.**The targeted scenarios listed in the WID [3] are as follows:* Scenario A: Carrier aggregation between licensed band NR (PCell) and NR-U (SCell).
	+ NR-U SCell may have both DL and UL, or DL-only.
	+ In this scenario, NR PCell is connected to 5G-CN.
* Scenario B: Dual connectivity between licensed band LTE (PCell) and NR-U (PSCell)
	+ In this scenario, LTE PCell connected to EPC as higher priority than PCell connected to 5G-CN.
* Scenario C: Stand-alone NR-U
	+ In this scenario, NR-U is connected to 5G-CN.
* Scenario D: A stand-alone NR cell in unlicensed band and UL in licensed band (single cell architecture).
	+ In this scenario, NR-U is connected to 5G-CN.
* Scenario E: Dual connectivity between licensed band NR and NR-U.
	+ In this scenario, PCell is connected to 5G-CN.

Table 1 and 2 below provides our proposed mapping for the basic FGs to the NR-U deployment scenarios for dynamic and semi-static channel access modes, respectively. In the tables, ‘O’ indicates the FG can be optional for the corresponding scenario, while ‘M’ indicates the FG should be mandatory for the corresponding scenario.**Table 1: Proposed mapping for the basic FGs to the NR-U deployment scenarios assuming dynamic channel access mode**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Index** | **FG** | **Scen. A (DL-only)** | **Scen. A (UL+DL)** | **Scen. B** | **Scen. C** | **Scen. D** | **Scen. E** |
| 10-1 | UL channel access for dynamic channel access mode  | N/A | M | M | M | N/A | M |
| 10-2 | SSB-based RRM for dynamic channel access mode | M | M | M | M | M | M |
| 10-2b | MIB reading on unlicensed cell | N/A | N/A | M | M | M | M |
| 10-2c | SSB-based RLM for dynamic channel access mode | N/A | N/A | M | M | M | M |
| 10-2e | SIB1 reception on unlicensed cell | N/A | N/A | M | M | M | M |
| 10-2f | Support monitoring of extended RAR window | N/A | N/A | M | M | M | M |
| 10-30 | Support channel occupancy duration indicator field in DCI 2\_0 | M | M | M | M | M | M |
| 10-31 | Support of CSI-RS measurements for CSI reporting and tracking without COT duration from DCI 2\_0 | M | M | M | M | M | M |

**Table 2: Proposed mapping for the basic FGs to the NR-U deployment scenarios assuming semi-static channel access mode**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Index** | **FG** | **Scen. A (DL-only)** | **Scen. A (UL+DL)** | **Scen. B** | **Scen. C** | **Scen. D** | **Scen. E** |
| 10-1a | UL channel access for semi-static channel access mode | N/A | M | M | M | N/A | M |
| 10-2a | SSB-based RRM for semi-static channel access mode | M | M | M | M | M | M |
| 10-2b | MIB reading on unlicensed cell | N/A | N/A | M | M | M | M |
| 10-2d | SSB-based RLM for semi-static channel access mode | N/A | N/A | M | M | M | M |
| 10-2e | SIB1 reception on unlicensed cell | N/A | N/A | M | M | M | M |
| 10-2f | Support monitoring of extended RAR window | N/A | N/A | M | M | M | M |
| 10-30 | Support channel occupancy duration indicator field in DCI 2\_0 | M | M | M | M | M | M |
| 10-31 | Support of CSI-RS measurements for CSI reporting and tracking without COT duration from DCI 2\_0 | M | M | M | M | M | M |

 |
| [7] | Our understanding is that it is still an open issue as to which FGs can be part of basic operation. In our view, the following FGs make sense to be part of a basic operation for a particular scenario:* FG 10-1, -1a, -2, -2a, -2b, -2c, -2d, -2e

Regarding FG 10-2f on support for monitoring of extended RAR window, although RAN2 has indicated in an LS to RAN1 that there should be no UE capability defined for this (see [2]), in our view this recommendation is only valid for stand-alone and DC operation. For LAA operation, this should not be defined as basic capability.**Only the following FGs are part of basic operation for a particular scenario: 10-1, -1a, -2, -2a, -2b, -2c, -2d, -2e. For FG 10-2f, it can be part of basic operation only for stand-alone and DC scenarios; it should not be part of basic operation for LAA scenarios.**In contrast to the above FGs, the following FGs should be listed only as “Optional with capability signaling,” and not be part of basic operation for a particular scenario. These features can be "nice to have," but are not critical for basic operation of NR-U* FG 10-27, -29, -30

**Remove the text "This FG may be part of basic operation for a particular scenario," for the following FGs: 10-27, -29, -30.**In the prior meeting, the FL made the following proposal during an email discussion (see [4]) on scenarios to which the basic FGs would be mapped:FL proposal* **Decide classification of NR-U deployment scenarios for the purpose of defining basic FGs as below**
	+ **Scenario A with DL-only**
	+ **Scenario A with both DL and UL in LBE**
	+ **Scenario A with both DL and UL in FBE**
	+ **Scenario B in LBE**
	+ **Scenario B in FBE**
	+ **Scenario C in LBE**
	+ **Scenario C in FBE**
	+ **Scenario D in LBE**
	+ **Scenario D in FBE**
	+ **Scenario E in LBE**
	+ **Scenario E in FBE**

The following recommendation was made at the conclusion of the email discussion.

|  |  |
| --- | --- |
| Moderator (NTT DOCOMO) | Based on the feedbacks so far, we can start listing up basic FGs according to classification in FL proposal. Merging some scenarios as suggested by Ericsson can also be discussed in parallel (based on how basic FGs in scenarios are common). |

Based on the FL recommendation, we propose a mapping of scenarios to basic FGs in Table 1 assuming that our Proposal 1 and Proposal 2 above are adopted for the basic FGs. In this table, we provide more descriptive names for the scenarios, but still preserve the agreed scenario lettering according to the WID. For convenience, the descriptions of the basic FGs are contained in Table 2.In Table 1 we assume that Scenarios B and E are grouped, since both apply to dual connectivity and it is not envisioned that there is a differentiation of functionality between the two scenarios. As can be seen from Table 1, the mapping of basic FGs is identical for scenarios C and D since both have a PCell in unlicensed. In scenario D, the SUL does not require any of the basic FGs, since it operates in a licensed band.**Support the mapping of basic FGs to deployment scenarios as shown in Table 1 in which Scenarios B and E are merged. In addition, consider merging scenarios C and D.****Table 1: Mapping of basic FGs to deployment scenarios**

|  |  |
| --- | --- |
| BasicFG | Type of cell operating in band with shared spectrum channel accessandChannel Access Mode (Dynamic or Semi-static) |
| A | A | A | C | C | D | D | B,E | B,E |
| SCell(DL Only) | SCell(DL/UL)Dynamic | SCell(DL/UL)Semi-static | PCell(DL/UL)Dynamic | PCell(DL/UL)Semi-static | PCell(DL/UL)+SUL in licensed bandDynamic | PCell(DL/UL)+SUL in licensed bandSemi-static | PSCell(DL/UL)Dynamic | PSCell(DL/UL)Semi-static |
| 10-1 |  | X |  | X |  | X |  | X |  |
| 10-1a |  |  | X |  | X |  | X |  | X |
| 10-2 | X | X |  | X |  | X |  | X |  |
| 10-2a |  |  | X |  | X |  | X |  | X |
| 10-2b |  |  |  | X | X | X | X | X | X |
| 10-2c |  |  |  | X |  | X |  | X |  |
| 10-2d |  |  |  |  | X |  | X |  | X |
| 10-2e |  |  |  | X | X | X | X |  |  |
| 10-2f |  |  |  | X | X | X | X | X | X |

**Table 2: Description of basic FGs**

|  |  |  |
| --- | --- | --- |
| **Index** | **Feature group** | **Components** |
| 10-1 | UL channel access for dynamic channel access mode  | 1. Type 1 channel access and contention window size adjustment2. Type 2A channel access3. Type 2B channel access4. Type 2C channel access5. 20MHz LBT bandwidth6. CP extension up to 1 symbol for PUSCH/PUCCH transmission |
| 10-1a | UL channel access for semi-static channel access mode | 1. Type 2C channel access2. Single sensing slot of 9us channel access3. 20MHz LBT bandwidth4. CP extension up to 1 symbol for PUSCH/PUCCH transmission |
| 10-2 | SSB-based RRM for dynamic channel access mode | 1. SSB-based RRM with Q for dynamic channel access mode |
| 10-2a | SSB-based RRM for semi-static channel access mode | 1. SSB-based RRM with Q for semi-static channel access mode, when SMTC window is no longer than the fixed frame period |
| 10-2b | MIB reading on unlicensed cell | 1. MIB reading on unlicensed cell for PCell and PSCell |
| 10-2c | SSB-based RLM for dynamic channel access mode | 1. SSB-based RLM with Q for dynamic channel access mode |
| 10-2d | SSB-based RLM for semi-static channel access mode | 1. SSB-based RLM with Q for semi-static channel access mode, when DRS window is no longer than the fixed frame period |
| 10-2e | SIB1 reception on unlicensed cell | 1. SIB1 reception on unlicensed cell for PCell |
| 10-2f | Support monitoring of extended RAR window | 1. Support of RAR extension from 10ms to 40ms by decoding of the 2-bit SFN indication in DCI 1\_0 |

~As discussed above, this feature, while "nice to have" is not required for basic NR-U operation. Hence, we propose **For FG 10-27, remove the following text from the Notes column: "This FG may be part of basic operation for a particular scenario"**~As discussed above, this feature, while "nice to have" is not required for basic NR-U operation. Hence, we propose **For FG 10-29, remove the following text from the Notes column: "This FG may be part of basic operation for a particular scenario"**~As discussed above, this feature, while "nice to have" is not required for basic NR-U operation. Hence, we propose **For FG 10-30, remove the following text from the Notes column: "This FG may be part of basic operation for a particular scenario"** |
| [8] | The following FGs were marked as “This FG may be a part of basic operation for a particular scenario”. The same note may be included in the definition of FG 10-31.

|  |  |  |
| --- | --- | --- |
| 10-1 | UL channel access for dynamic channel access mode  | 1. Type 1 channel access and contention window size adjustment2. Type 2A channel access3. Type 2B channel access4. Type 2C channel access5. 20MHz LBT bandwidth6. CP extension up to 1 symbol for PUSCH/PUCCH transmission |
| 10-1a | UL channel access for semi-static channel access mode | 1. Type 2C channel access2. Single sensing slot of 9us channel access3. 20MHz LBT bandwidth4. CP extension up to 1 symbol for PUSCH/PUCCH transmission |
| 10-2 | SSB-based RRM for dynamic channel access mode | 1. SSB-based RRM with Q for dynamic channel access mode |
| 10-2a | SSB-based RRM for semi-static channel access mode | 1. SSB-based RRM with Q for semi-static channel access mode, when SMTC window is no longer than the fixed frame period |
| 10-2b | MIB reading on unlicensed cell | 1. MIB reading on unlicensed cell for PCell and PSCell |
| 10-2c | SSB-based RLM for dynamic channel access mode | 1. SSB-based RLM with Q for dynamic channel access mode |
| 10-2d | SSB-based RLM for semi-static channel access mode | 1. SSB-based RLM with Q for semi-static channel access mode, when DRS window is no longer than the fixed frame period |
| 10-2e | SIB1 reception on unlicensed cell | 1. SIB1 reception on unlicensed cell for PCell |
| 10-2f | Support monitoring of extended RAR window | 1. Support of RAR extension from 10ms to 40ms by decoding of the 2-bit SFN indication in DCI 1\_0 |
| 10-27 | Wideband PRACH | 1. Enhanced PRACH design for NR-U by adopting a single long ZC sequence, with ZC sequence = 1151 for 15kHz and ZC sequence = 571 for 30kHz
 |
| 10-29 | Support available RB set indicator field in DCI 2\_0 | 1. Support monitoring DCI 2\_0 to read availableRB-Sets-r16
 |
| 10-30 | Support channel occupancy duration indicator field in DCI 2\_0 | 1. Support monitoring DCI 2\_0 to read COT duration
 |

Table 1 – Status of possible basic FGs for NR-U [1]It is relatively straightforward to map most of the FGs above to the NR-U deployment scenarios, with a differentiation based on dynamic vs. semi-static channel access mode. However, it is not obvious that FGs 10-29, 10-30, and 10-31 qualify as basic FGs that must be supported for a scenario.RAN2 informed RAN1 that FG 10-2f does not require a UE capability bit, as clarified in the LS [2] from RAN2 quoted below. Therefore, there is no need to discuss FG10-2f as basic FG.*RAN2 has further discussed the two LSB bits of the SFN specified in DCI format 1\_0 related to the random access procedure in unlicensed spectrum and for 2-step RACH:**RAN2 agreed that the gNB signals the SFN bits to the UE only if there is a risk of ambiguity, i.e. if the random access response window or the MSGB response window is larger than 10 ms. The RAR window is configured by ra-ResponseWindow or ra-ResponseWindow-r16 and the MSGB response window is configured by msgB-ResponseWindow-r16.**No UE capability it required and all NR-U capable and 2step RA UEs should support extended RAR*Mapping of the basic FGs to the NR-U scenarios is proposed as follows:

|  |  |  |
| --- | --- | --- |
|  | Dynamic channel access mode | Semi-static channel access mode |
| Scenario A: CA between licensed band NR (PCell) and NR-U (SCell)NR-U SCell may have both DL and UL, or DL-only | 10-1, 10-2, 10-2cIf it is allowed that a UE does not support UL in unlicensed band: 10-2, 10-2c | 10-1a, 10-2a, 10-2dIf it is allowed that a UE does not support UL in unlicensed band: 10-2a, 10-2d |
| Scenario B: DC between licensed band LTE (PCell) and NR-U (PSCell) | 10-1, 10-2, 10-2b, 10-2c, 10-27 | 10-1a, 10-2a, 10-2b, 10-2d, 10-27 |
| Scenario C: stand-alone NR-U | 10-1, 10-2, 10-2b, 10-2c, 10-2e, 10-27 | 10-1a, 10-2a, 10-2b, 10-2d, 10-2e, 10-27 |
| Scenario D: stand-alone NR cell in unlicensed band and SUL in licensed band | 10-1, 10-2, 10-2b, 10-2c, 10-2e, 10-27 | 10-1a, 10-2a, 10-2b, 10-2d, 10-2e, 10-27 |
| Scenario E: DC between licensed band NR and NR-U | 10-1, 10-2, 10-2b, 10-2c, 10-27 | 10-1a, 10-2a, 10-2b, 10-2d, 10-27 |

Table 2 - NR-U basic FGs mapping to NR-U deployment scenarios**Proposal 1: FG 10-2f does not need to be a basic FG because RAN2 indicated no capability bit is needed.****Proposal 2: FG 10-29, 10-30 and 10-31 may not need to be defined as basic FGs.****Proposal 3: NR-U basic FGs are mapped to NR-U deployment scenarios as in Table 2.** |

Based on the above contributions, it is agreed to discuss following point in the email discussion [9].

**Discussion point #4**

* **How to define basic FG(s) for each of particular NR-U deployment scenarios based on completed FGs**

## 2.1 Proposal and discussion

Based on contribution and above inputs during preparation phase discussion, following proposals are made.

### **FL proposal 2**

* **Decide classification of NR-U deployment scenarios for the purpose of defining basic FGs first**
1. **SCell (DL-Only) in band for shared spectrum channel access (maps to Scenario A)**
2. **SCell (DL + UL) in band for shared spectrum channel access (maps to Scenario A)**
	1. **For dynamic channel access mode**
	2. **For semi-static channel access mode**
3. **PCell (DL + UL) in band for shared spectrum channel access (maps to Scenario C)**
	1. **For dynamic channel access mode**
	2. **For semi-static channel access mode**
4. **PCell (DL + UL) in band for shared spectrum channel access + SUL in licensed band (maps to Scenario D)**
	1. **For dynamic channel access mode**
	2. **For semi-static channel access mode**
5. **PSCell (DL + UL) in band for shared spectrum channel access (maps to Scenarios B,E)**
	1. **For dynamic channel access mode**
	2. **For semi-static channel access mode**

Companies are encouraged to check above FL proposal 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 |
| Qualcomm | The list is good for us. |
|  |  |
|  |  |
|  |  |

### **FL proposal 3**

* **Decide basic FGs for each of NR-U deployment scenarios**

|  |  |  |  |
| --- | --- | --- | --- |
|  | FG | Components | Scenario where the FG is required as part of basic FGs (index is based on FL proposal 2) |
| 10-1 | UL channel access for dynamic channel access mode  | 1. Type 1 channel access and contention window size adjustment2. Type 2A channel access3. Type 2B channel access4. Type 2C channel access5. 20MHz LBT bandwidth6. CP extension up to 1 symbol for PUSCH/PUCCH transmission | 2a, 3a, 4a, 5a |
| 10-1a | UL channel access for semi-static channel access mode | 1. Type 2C channel access2. Single sensing slot of 9us channel access3. 20MHz LBT bandwidth4. CP extension up to 1 symbol for PUSCH/PUCCH transmission | 2b, 3b, 4b,5b |
| 10-2 | SSB-based RRM for dynamic channel access mode | 1. SSB-based RRM with Q for dynamic channel access mode | 1, 2a, 3a, 4a, 5a |
| 10-2a | SSB-based RRM for semi-static channel access mode | 1. SSB-based RRM with Q for semi-static channel access mode, when SMTC window is no longer than the fixed frame period | 2b, 3b, 4b,5b |
| 10-2b | MIB reading on unlicensed cell | 1. MIB reading on unlicensed cell for PCell and PSCell | 3a, 3b, 4a, 4b, 5a, 5b |
| 10-2c | SSB-based RLM for dynamic channel access mode | 1. SSB-based RLM with Q for dynamic channel access mode | 3a, 4a, 5a |
| 10-2d | SSB-based RLM for semi-static channel access mode | 1. SSB-based RLM with Q for semi-static channel access mode, when DRS window is no longer than the fixed frame period | 3b, 4b,5b |
| 10-2e | SIB1 reception on unlicensed cell | 1. SIB1 reception on unlicensed cell for PCell | 3a, 3b, 4a, 4b, 5a, 5b |
| 10-2f | Support monitoring of extended RAR window | 1. Support of RAR extension from 10ms to 40ms by decoding of the 2-bit SFN indication in DCI 1\_0 | 3a, 3b, 4a, 4b, 5a, 5b |
| 10-27 | Wideband PRACH | 1. Enhanced PRACH design for NR-U by adopting a single long ZC sequence, with ZC sequence = 1151 for 15kHz and ZC sequence = 571 for 30kHz
 |  |
| 10-29 | Support available RB set indicator field in DCI 2\_0 | 1. Support monitoring DCI 2\_0 to read availableRB-Sets-r16
 |  |
| 10-30 | Support channel occupancy duration indicator field in DCI 2\_0 | 1. Support monitoring DCI 2\_0 to read COT duration
 |  |
|  |  |  |  |

Companies are encouraged to check above FL proposal 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 |
| Qualcomm | Why 10-2a is not for scenario 1?Given this table, it is quite straight-forward which FG is needed to support which scenario. Then is it really necessary to have this table in the spec in the beginning? |
|  |  |
|  |  |
|  |  |

1. Conclusion

Reference

[1] R1-2006462 Updated RAN1 UE features list for Rel-16 NR Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2005361 Remaining issues on Rel-16 UE features vivo

[3] R1-2005423 Discussion on NR Rel-16 UE Features ZTE

[4] R1-2005781 Views on Rel-16 UE features MediaTek Inc.

[5] R1-2005814 Remaining details of Rel-16 NR UE features Huawei, HiSilicon

[6] R1-2006677 Remaining aspects of Rel-16 UE features Nokia, Nokia Shanghai Bell

[7] R1-2006874 Remaining details of Rel-16 NR UE features Ericsson

[8] R1-2006409

[9] R1-2006709 Summary on UE features for NR-U Moderator (NTT DOCOMO, INC.)

Appendix: UE features list for NR-U in [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****( 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 |
| 10. NR-unlicensed | 10-1 | UL channel access for dynamic channel access mode  | 1. Type 1 channel access and contention window size adjustment2. Type 2A channel access3. Type 2B channel access4. Type 2C channel access5. 20MHz LBT bandwidth6. CP extension up to 1 symbol for PUSCH/PUCCH transmission |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-1a | UL channel access for semi-static channel access mode | 1. Type 2C channel access2. Single sensing slot of 9us channel access3. 20MHz LBT bandwidth4. CP extension up to 1 symbol for PUSCH/PUCCH transmission |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-2 | SSB-based RRM for dynamic channel access mode | 1. SSB-based RRM with Q for dynamic channel access mode |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Q indicates the value of RAN1 parameter $N\_{SSB}^{QCL}$ | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-2a | SSB-based RRM for semi-static channel access mode | 1. SSB-based RRM with Q for semi-static channel access mode, when SMTC window is no longer than the fixed frame period |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Q indicates the value of RAN1 parameter $N\_{SSB}^{QCL}$ | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-2b | MIB reading on unlicensed cell | 1. MIB reading on unlicensed cell for PCell and PSCell |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-2c | SSB-based RLM for dynamic channel access mode | 1. SSB-based RLM with Q for dynamic channel access mode |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Q indicates the value of RAN1 parameter $N\_{SSB}^{QCL}$ | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-2d | SSB-based RLM for semi-static channel access mode | 1. SSB-based RLM with Q for semi-static channel access mode, when DRS window is no longer than the fixed frame period |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Q indicates the value of RAN1 parameter $N\_{SSB}^{QCL}$ | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-2e | SIB1 reception on unlicensed cell | 1. SIB1 reception on unlicensed cell for PCell |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-2f | Support monitoring of extended RAR window | 1. Support of RAR extension from 10ms to 40ms by decoding of the 2-bit SFN indication in DCI 1\_0 |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-2g | SSB-based BFD/CBD for dynamic channel access mode | SSB-based BFD/CBD with Q for dynamic channel access mode |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Q indicates the value of RAN1 parameter $N\_{SSB}^{QCL}$ | Optional with capability signaling |
| 10. NR-unlicensed | 10-2h | SSB-based BFD/CBD for semi-static channel access mode | SSB-based BFD/CBD with Q for semi-static channel access mode |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Q indicates the value of RAN1 parameter $N\_{SSB}^{QCL}$ | Optional with capability signaling |
| 10. NR-unlicensed | 10-2i | CSI-RS-based BFD/CBD for NR-U | CSI-RS-based BFD/CBD for NR-U |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signaling |
| 10. NR-unlicensed | 10-7 | UL channel access for 10 MHz SCell  | 1. 10 MHz LBT bandwidth
 | one of {10-1, 10-1a} | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signaling |
| 10. NR-unlicensed | 10-10 | RSSI and channel occupancy measurement and reporting | 1. RSSI measurement
2. Channel occupancy reporting
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A | the signaling is per band but is only expected for a band where shared spectrum channel access must be used | Optional with capability signaling |
| 10. NR-unlicensed | 10-11 | SRS starting position at any OFDM symbol in a slot | 1. Support transmitting SRS starting in all symbols (0,…,13) of a slot
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signaling |
| 10. NR-unlicensed | 10-20 | Support search space set configuration with freqMonitorLocation-r16 | 1. Maximum number of frequency domain locations for a search space set configuration with freqMonitorLocations-r16 |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Candidate values of component 1: {1, 2, ,3, 4, 5}the signaling is per band but is only expected for a band where shared spectrum channel access must be used | Optional with capability signaling |
| 10. NR-unlicensed | 10-20a | Support coreset configuration with rb-Offset | 1. Support coreset configuration with rb-Offset  |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signaling |
| 10. NR-unlicensed | 10-23 | CGI reading on unlicensed cell for ANR functionality | 1. Support acquisition of relevant information from a neighbouring NR unlicensed cell in an unlicensed carrier by reading the RMSI of the neighbouring unlicensed cell and reporting the acquired information to the network |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Support reading RMSI from an unlicensed cell for ANR | Optional with capability signaling |
| 10. NR-unlicensed | 10-25 | Enable configured UL transmissions when SFI field in DCI 2\_0 is configured but DCI 2\_0 is not detected | 1. Support configuration of enableConfiguredUL-r16 and enable transmission of higher-layer configured UL \*SRS, PUCCH, CG-PUSCH etc) when SFI field in DCI 2\_0 is configured but DCI 2\_0 is not detected |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signaling |
| 10. NR-unlicensed | 10-27 | Wideband PRACH | 1. Enhanced PRACH design for NR-U by adopting a single long ZC sequence, with ZC sequence = 1151 for 15kHz and ZC sequence = 571 for 30kHz
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-29 | Support available RB set indicator field in DCI 2\_0 | 1. Support monitoring DCI 2\_0 to read availableRB-Sets-r16
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-30 | Support channel occupancy duration indicator field in DCI 2\_0 | 1. Support monitoring DCI 2\_0 to read COT duration
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalingThis FG may be a part of basic operation for a particular scenario |
| 10. NR-unlicensed | 10-8 | Type B PDSCH length {3, 5, 6, 8, 9, 10, 11, 12, 13} without DMRS shift due to CRS collision | 1. Type B PDSCH length {3, 5, 6, 8, 9, 10, 11, 12, 13} without DMRS shift due to CRS collision
 | 5-6a | Yes | N/A |  | Per band | N/A | N/A | N/A | Note length 9/10 with DMRS shift due to CRS collision are already covered by 14-2 | Optional with capability signalling |
| 10. NR-unlicensed | 10-9 | Search space set group switching with DCI 2\_0 monitoring | 1. Two groups of search space sets2. Monitor DCI 2\_0 with a search space set switching field 3. Support switching the search space set group with PDCCH decoding in group 1 4. Support a timer to switch back to original search space set group5. Monitor DCI 2\_0 for channel occupancy time and use the end of channel occupancy time to switch back to the original search space set group |  | Yes | N/A |  | Per band  | N/A | N/A | N/A | Being configured with two groups of search spaces, and switch between them. Some search space sets can be configured in both groups. | Optional with capability signalling |
| 10. NR-unlicensed | 10-9b | Search space set group switching with implicit PDCCH decoding without DCI 2\_0 monitoring | 1. Two groups of search space sets2. Support switching the search space set group with PDCCH decoding in group 1 3. Support a timer to switch back to original search space set group |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Being configured with two groups of search spaces, and switch between them. Some search space sets can be configured in both groups. | Optional with capability signalling |
| 10. NR-unlicensed | 10-9c | Joint search space group switching across multiple cells | 1. Configured with a group of cells and switch search space set group jointly over these cells
 | one of {10-9, 10-9b} | Yes | N/A |  | Per BC | N/A | N/A | N/A | Without this capability, the UE will switch search space set groups for different cells independently | Optional with capability signalling |
| 10. NR-unlicensed | 10-9d | Support Search space set group switching capability 2 | 1. Search space set group switching Capability-2: P=10/12/22 symbols for µ = 0/1/2 SCS
 | one of {10-9, 10-9b} | Yes | N/A |  | Per band | N/A | N/A | N/A | Without this capability, the UE supports search space set group switching capability-1: P=25/25/25 symbols for µ=0/1/2 | Optional with capability signalling |
| 10. NR-unlicensed | 10-14 | Non-numerical PDSCH to HARQ-ACK timing | 1. Support configuration of a value for dl-DataToUL-ACK indicating an inapplicable time to report HARQ ACK
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A | If non-numerical K1 value is supportedthe signaling is per band but is only expected for a band where shared spectrum channel access must be used | Optional with capability signalling |
| 10. NR-unlicensed | 10-15 | Enhanced dynamic HARQ codebook | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1 (configuration of nfi-TotalDAI-Included)2. Support of bit field in DCI 0\_1 for other group total DAI if configured. (configuration of ul-TotalDAI-Included)3. Support the retransmission of HARQ ACK (pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16) |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Enhanced dynamic HARQ codebook supporting grouping of HARQ ACK and triggering the retransmission of HARQ ACK in each groups | Optional with capability signalling |
| 10. NR-unlicensed | 10-16 | One-shot HARQ ACK feedback | 1. Support feedback of type 3 HARQ-ACK codebook, triggered by a DCI 1\_1 scheduling a PDSCH
2. Support feedback of type 3 HARQ-ACK codebook , triggered by a DCI 1\_1 without scheduling a PDSCH using a reserved FDRA value
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Upon triggering, UE reports A/N for all HARQ processes and all CCs in a PUCCH group.  | Optional with capability signalling |
| 10. NR-unlicensed | 10-17 | Multi-PUSCH UL grant | 1. Support of scheduling up to 8 PUSCH with a single DCI 0\_1  |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 10. NR-unlicensed | [10-19a] | DL wideband carrier operation mode 1 | Support of DL wideband carrier operation mode 1: single carrier wideband operation when LBT is successful in all LBT sub-bands of [BWP/carrier] |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  These FGs 10-19a/b/c/d/e/f are examples on what RAN1 ask RAN2 to reserve capability bits in LS R1-2004965 | Optional with capability signalling |
| 10. NR-unlicensed | [10-19b] | DL wideband carrier operation mode 2 | Support of DL wideband carrier operation mode 2: single wideband carrier when LBT is successful in a subset of the LBT sub-bands which are contiguous |  | Yes | N/A |  | Per band | N/A | N/A | N/A | These FGs 10-19a/b/c/d/e/f are examples on what RAN1 ask RAN2 to reserve capability bits in LS R1-2004965 | Optional with capability signalling |
| 10. NR-unlicensed | [10-19c] | DL wideband carrier operation mode 3 | Support of DL wideband carrier operation mode 3: single wideband carrier when LBT is successful in a subset of the LBT sub-bands which are non-contiguous |  | Yes | N/A |  | Per band | N/A | N/A | N/A | These FGs 10-19a/b/c/d/e/f are examples on what RAN1 ask RAN2 to reserve capability bits in LS R1-2004965 | Optional with capability signalling |
| 10. NR-unlicensed | [10-19d] | UL wideband carrier operation mode 1 | Support of UL wideband carrier operation mode 1: UE transmits only if LBT passes for all LBT sub-bands of BWP |  | Yes | N/A |  | Per band | N/A | N/A | N/A | These FGs 10-19a/b/c/d/e/f are examples on what RAN1 ask RAN2 to reserve capability bits in LS R1-2004965 | Optional with capability signalling |
| 10. NR-unlicensed | [10-19e] | UL wideband carrier operation mode 2A | Support of UL wideband carrier operation mode 2A: UE transmits if LBT passes for single scheduled LBT sub-band |  | Yes | N/A |  | Per band | N/A | N/A | N/A | These FGs 10-19a/b/c/d/e/f are examples on what RAN1 ask RAN2 to reserve capability bits in LS R1-2004965 | Optional with capability signalling |
| 10. NR-unlicensed | [10-19f] | UL wideband carrier operation mode 2B | Support of UL wideband carrier operation mode 2B: UE transmits if LBT passes for scheduled multiple contiguous LBT sub-bands |  | Yes | N/A |  | Per band | N/A | N/A | N/A | These FGs 10-19a/b/c/d/e/f are examples on what RAN1 ask RAN2 to reserve capability bits in LS R1-2004965 | Optional with capability signalling |
| 10. NR-unlicensed | 10-26 | CSI-RS based RLM for NR-U | CSI-RS based RLM for NR-U |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 10. NR-unlicensed | 10-26a | CSI-RS based RRM for NR-U | CSI-RS based RRM for NR-U |  | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 10. NR-unlicensed | 10-31 | Support of P/SP-CSI-RS reception with CSI-RS-ValidationWith-DCI-r16 configured | 1. Validate P/SP-CSI-RS reception when receiving a DCI granting a PDSCH over the same set of symbols2. Validate P/SP-CSI-RS reception when receiving a DCI triggering a A-CSI-RS over the same set of symbols |  | Yes | N/A |  | Per band | N/A | N/A |  | If UE does not signal capability for FG 10-31, the UE cannot be configured with CSI-RS-ValidationWith-DCI-r16.If none of the RRC parameters CO-DurationPerCell-r16, SlotFormatIndicator, and CSI-RS-ValidationWith-DCI-r16 is configured on a cell with shared spectrum access, and P/SP CSI-RS is configured, for reception/cancellation of SP/P CSI-RS the behavior in 11.1 of TS38.213 applies as per agreement.the signaling is per band but is only expected for a band where shared spectrum channel access must be used | Optional with capability signaling |
| 10. NR-unlicensed | 10-3 | PRB interlace mapping for PUSCH | 1. PRB interlace frequency domain resource allocation for PUSCH |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Support of PRB interlace PUSCH | Optional with capability signalling |
| 10. NR-unlicensed | 10-3a | PRB interlace mapping for PUCCH | 1. PRB interlace frequency domain resource allocation for PUCCH format 0 and format 1
2. PRB interlace frequency domain resource allocation for PUCCH format 2
3. PRB interlace frequency domain resource allocation for PUCCH format 3
 |  | Yes | N/A |  | Per band | N/A | N/A | N/A | Support of PRB interlace PUCCH format 0/1 | Optional with capability signalling |
| 10. NR-unlicensed | 10-12 | OCC for PRB interlace mapping for PF2 and PF3 | 1. OCC22. OCC4 | 10-3a | Yes | N/A |  | Per band | N/A | N/A | N/A | UE OCC capability for EPF2/EFP3 | Optional with capability signalling |
| 10. NR-unlicensed | 10-13a | Extended CP range of more than one symbol for CG-PUSCH | 1. UE supports generating a CP extension of length longer than 1 symbol for Configured Grant PUSCH transmission
 | One or both of {5-19, 5-20} | Yes | N/A |  | Per band | N/A | N/A | N/A | How long a UE can generate the CP extension beyond 1 symbol for CG-PUSCH | Optional with capability signalling |
| 10. NR-unlicensed | 10-18 | Configured grant with retransmission in CG resources  | 1. Support retransmission in CG resources2. Support configured grant retransmission timer3. Support DFI monitoring4. Support CG-UCI in CG-PUSCH | One or both of {5-19, 5-20} | Yes | N/A |  | Per band | N/A | N/A | N/A | Support configured grant with retransmission in configured grant resource | Optional with capability signalling |
| 10. NR-unlicensed | 10-21a | Support using ED threshold given by gNB for UL to DL COT sharing | 1. Use ULtoDL-CO-SharingED-Threshold-r16 for Type 1 channel access for scheduled UL to share COT with gNB for DL2. Use ULtoDL-CO-SharingED-Threshold-r16 for Type 1 channel access for CG-PUSCH to share COT with gNB for DL3. Indicate in CG-UCI the COT sharing information | 10-1 | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 10. NR-unlicensed | 10-21b | Support UL to DL COT sharing | 1. Support Type 1 LBT for scheduled UL to share COT with gNB for DL without ULtoDL-CO-SharingED-Threshold-r162. Support Type 1 LBT for CG-PUSCH to share COT with gNB for DL without ULtoDL-CO-SharingED-Threshold-r163. Indicate in CG-UCI the COT sharing information | 10-1 | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signaling |
| 10. NR-unlicensed | 10-24 | CG-UCI multiplexing with HARQ ACK | 1. Support multiplexing CG-UCI with HARQ ACK | 10-18 | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 10. NR-unlicensed | 10-28 | Configured grant with Rel-16 enhanced resource configuration | 1. Support configuration of resources with cg-nrofSlots-r16 and cg-nrofPUSCH-InSlot-r16, | One or both of {5-19, 5-20} | Yes | N/A |  | Per band | N/A | N/A | N/A | the signaling is per band but is only expected for a band where shared spectrum channel access must be used | Optional with capability signalling |