**3GPP TSG RAN WG1 #100bis-e R1-20xxxxx**

e-Meeting, April 20th – 30th, 2020

Source: NTT DOCOMO, INC.

Title: Summary on Email discussion [100b-e-NR-UEFeatures-NRU-02]

Agenda Item: 7.2.11.2

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

# **Introduction**

This contribution summarizes the following email discussion in AI 7.2.11.2 regarding UE features for NR-U.

[100b-e-NR-UEFeatures-NRU-02] Email discussion/approval on feature groups structure related to DL operation for NR-U (20th-24th April) – (DCM, Hiroki)

* Discuss on whether or not “Support fixed frame period of 5ms and 10ms” and “Support fixed frame periods shorter than 5ms” can be separate capabilities.
* Discuss whether or not the capability FG10-8 are separate for each length or some groups are formed to signal the capability together
* Discuss whether or not 10-9/9a/9b/9c can be combined into a single FG
* Discuss whether or not 10-14/10-15/10-16/10-16a/10-17 can be combined into a single FG
  + If no, whether or not 10-15 can be further split under other group DAI/NFI configured or not
* Discuss whether or not 10-19/10-19a/10-19b/10-19c are needed
* Discuss whether or not 10-26 is needed
* Discuss whether or not 10-31 is needed

# **10-1 to 10-2b: Possible basic feature groups for operating in unlicensed band and their related feature group**

In [1], FGs 10-1 to 10-2b are captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 10. NR-unlicensed | 10-1 | UE stand-alone (DL and UL) operation in shared spectrum under dynamic channel access mode | 1. Type 1 channel access  2. Type 2A channel access  3. Type 2B channel access (FFS if move this to separate feature)  4. Type 2C channel access  5. 20MHz LBT bandwidth  6. Contention window adjustment  7. CP extension up to 1 symbol for PUSCH/PUCCH transmission  8. SSB/MIB/RMSI reception with Q  9. SSB RRM with Q in DMTC  10. SSB-RLM with Q in DMTC window  11. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0 |  |  | N/A |  | Per band | N/A | N/A |  | This can be a basic feature group for operating in unlicensed band with both DL and UL transmission support under dynamic channel access | Optional with capability signalling |
| 10-1a | UE DL only operation in shared spectrum under dynamic channel access mode | 1. SSB RRM with Q in DMTC | 6-5 |  | N/A |  | Per band | N/A | N/A |  | This can be a basic feature group for operating in unlicensed band with DL only operation | Optional with capability signalling |
| 10-2 | UE stand-alone (DL and UL) operation in shared spectrum under semi-static channel access mode | 1. Type 2C channel access  2. Single sensing slot of 9us channel access  3. 20MHz LBT bandwidth  4. SSB/MIB/RMSI reception with Q  5. SSB RRM with Q in DMTC  6. SSB-RLM with Q in DMTC window  7. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0  8. Support fixed frame period of 5ms and 10ms |  |  | N/A |  | Per band | N/A | N/A |  | This can be a basic feature group for operating in unlicensed band.  Support of channel access mechanism for FBE operation, including fixed frame period, Cat 2 LBT, Cat 1 LBT | Optional with capability signalling |
| 10-2a | UE DL only operation in shared spectrum under semi-static channel access mode | 1. SSB RRM with Q in DMTC  2. Support fixed frame period of 5ms and 10ms | 6-5 |  | N/A |  | Per band | N/A | N/A |  | This can be a basic feature group for operating in unlicensed band with DL only operation | Optional with capability signalling |
| 10-2b | UE stand-alone (DL and UL) operation in shared spectrum under semi-static channel access mode | 1. Support fixed frame periods shorter than 5ms | 10-2 or 10-2a |  | N/A |  | Per band | N/A | N/A |  |  | Optional with capability signalling |

Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | ZTE, Sanechips | For NR-U, depending on different use scenarios, there could be multiple basic feature groups defined for UE to support LBE mode (DL+UL), FBE mode (DL+UL), LBE mode (DL only) and FBE mode (DL only), respectively. The different operation modes can be regarded as different sub-features for the NR-U feature.  Each basic feature group includes multiple components that are essential for the UE to support the sub-feature. Other optional feature groups can use one or multiple of the above basic feature groups as prerequisite. One thing could be further discussed is that whether or not to include more components to the basic feature group, for example the supported enhancements on HARQ, configured grant, SRS and CORESET/SS. Those enhancements are used to compensate the potential loss of LBT failure in terms of efficiency and reliability, it may be useful to make these function as mandatory, at least for LBE mode.  ***Proposal 1:***   * ***Multiple basic feature groups can be defined for NR-U, corresponding to different operation modes.***   + ***Further discuss whether the enhancements on CORESET/SS, SRS, HARQ, CG can be merged into the basic feature group(s).*** |
| [3] | vivo | In current table, different basic feature groups (i.e. 10-1, 10-1a, 10-2, 10-2a) are defined to support standalone and CA DL only scenario for LBE and FBE respectively. However, the scenario regarding CA DL+UL operation in unlicensed band is missing. Under this scenario, initial access related features are not needed as components in this basic feature group compared to standalone scenario. Therefore, the following should be added as separate basic feature groups: a) UE DL and UL operation in shared spectrum under dynamic channel access mode; b) UE DL and UL operation in shared spectrum under semi-static channel access mode.  Proposal 3: Add the following two basic feature groups to NRU UE feature table.   |  |  |  |  | | --- | --- | --- | --- | | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | | 10-1b | UE DL and UL operation in shared spectrum under dynamic channel access mode | 1. Type 1 channel access  2. Type 2A channel access  3. Type 2B channel access (FFS if move this to separate feature)  4. Type 2C channel access  5. 20MHz LBT bandwidth  6. Contention window adjustment  7. CP extension up to 1 symbol for PUSCH/PUCCH transmission  8. SSB RRM with Q in DMTC | 6-5 | | 10-2c | UE DL and UL operation in shared spectrum under semi-static channel access mode | 1. Type 2C channel access  2. Single sensing slot of 9us channel access  3. 20MHz LBT bandwidth  4. SSB RRM with Q in DMTC  5. Support fixed frame period of 5ms and 10ms | 6-5 |   On **10-2a** (*UE DL only operation in shared spectrum under semi-static channel access mode*), we don’t see much difference with different FFP period for LAA DL only scenario. In LAA DL only case, UE only performed reception in shared spectrum and shorter FFP period doesn’t bring more complexity. Therefore, the component “Support fixed frame period of 5ms and 10ms” is not needed.  Proposal 4: Remove component “Support fixed frame period of 5ms and 10ms” from 10-2a. |
| [4] | OPPO | **FG 10-1, 10-1a, 10-2, 10-2a**: SSB RRM with Q in DMTC, in NRU we should replace DMTC with SMTC. Moreover, SSB RLM with Q in DMTC, in NRU we should replace DMTC with discovery burst transmission window. Another point is that Type 2B channel access should not be a basic component. NRU can perfectly runs its function without having to implement Type 2B channel access.   |  |  |  | | --- | --- | --- | | 10-1 | UE stand-alone (DL and UL) operation in shared spectrum under dynamic channel access mode | 1. Type 1 channel access  2. Type 2A channel access  3. ~~Type 2B channel access (FFS if move this to separate feature)~~  4. Type 2C channel access  5. 20MHz LBT bandwidth  6. Contention window adjustment  7. CP extension up to 1 symbol for PUSCH/PUCCH transmission  8. SSB/MIB/RMSI reception with Q  9. SSB RRM with Q in ~~DMTC~~ SMTC  10. SSB-RLM with Q in ~~DMTC~~ discovery burst transmission window  11. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0 | | 10-1a | UE DL only operation in shared spectrum under dynamic channel access mode | 1. SSB RRM with Q in ~~DMTC~~ SMTC | | 10-2 | UE stand-alone (DL and UL) operation in shared spectrum under semi-static channel access mode | 1. Type 2C channel access  2. Single sensing slot of 9us channel access  3. 20MHz LBT bandwidth  4. SSB/MIB/RMSI reception with Q  5. SSB RRM with Q in ~~DMTC~~ SMTC  6. SSB-RLM with Q in ~~DMTC~~ discovery burst transmission window  7. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0  8. Support fixed frame period of 5ms and 10ms | | 10-2a | UE DL only operation in shared spectrum under semi-static channel access mode | 1. SSB RRM with Q in ~~DMTC~~ SMTC  2. Support fixed frame period of 5ms and 10ms |   **Proposal 1: Remove Type 2B channel access from basic feature group 10-1.** |
| [5] | MediaTek Inc. | According to NR-U WID, Rel-16 NR-U aims to support the following deployment scenarios. However, with the current UE feature structure, it may not be feasible for UE to indicate its support for the deployments highlighted in yellow without excessive support of NR-U features. Scenario A specifies the carrier aggregation where NR-U serves as a secondary cell (SCell). In this scenario, UE should not be mandated to support procedures such as MIB/RMSI acquisition, RACH, and RLM in an unlicensed cell. In Scenario D where NR-R stand-alone operation is targeted but only DL is in unlicensed and UL is in licensed band. In this case, UE should support initial access procedures but does not have to support uplink features such as channel access procedures or interlaced resource mapping. Therefore, the corresponding basic feature groups should be defined for it. Alternatively, we can discuss whether this scenario should be supported.   * 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.   **Proposal 2: The NR-U UE feature list should make it possible that UE can indicate which NR-U deployment scenarios it is capable of supporting without excessive support of other NR-U features.**  **Proposal 3: UE should not be mandated to support MIB/RMSI acquisition, RACH, and RLM when it only plans to support Scenario A specified in NR-U WID.**  **Proposal 4: Add basic feature groups (10-1c and 10-2d added to the table below) for carrier aggregation between NR licensed (PCell) and NR-U (SCell) where the NR-U SCell have both DL and UL.**  **Proposal 5: Add basic feature groups (10-1b and 10-2c added to the table below) for Scenario D or discuss whether Scenario D should be supported.**   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 10-1b | UE stand-alone (DL only) operation in shared spectrum under dynamic channel access mode | 1. SSB/MIB/RMSI reception with *SSB-PositionQCL-Relationship*  2. SSB RRM with *SSB-PositionQCL-Relationship* in DMTC  3. SSB-RLM with *SSB-PositionQCL-Relationship* in DMTC window  4. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0  5. Support monitoring DCI 2\_0 to read availableRB-Sets-r16  6. Support monitoring DCI 2\_0 to read CO duration |  |  | N/A |  | Per band | N/A | N/A |  | This can be a basic feature group for the Scenario D in NR-U WID | Optional with capability signalling | | 10-1c | UE DL and UL operation in shared spectrum under dynamic channel access mode | 1. Type 1 channel access  2. Type 2A channel access  3. Type 2B channel access (FFS if move this to separate feature)  4. Type 2C channel access  5. 20MHz LBT bandwidth  6. Contention window adjustment  7. CP extension up to 1 symbol for PUSCH/PUCCH transmission  8. SSB RRM with *SSB-PositionQCL-Relationship* in DMTC  9. Support monitoring DCI 2\_0 to read availableRB-Sets-r16  10. Support monitoring DCI 2\_0 to read CO duration | 6-5 and 6-6 |  | N/A |  | Per band | N/A | N/A |  | This can be a basic feature group for operating in an unlicensed SCell with both DL and UL | Optional with capability signalling | | 10-2c | UE stand-alone (DL only) operation in shared spectrum under semi-static channel access mode | 1. Type 2C channel access  2. Single sensing slot of 9us channel access  3. 20MHz LBT bandwidth  4. SSB/MIB/RMSI reception with Q  5. SSB RRM with Q in DMTC  6. SSB-RLM with Q in DMTC window  7. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0  8. FFS: Support fixed frame period of 5ms and 10ms  9. Support monitoring DCI 2\_0 to read availableRB-Sets-r16  10. Support monitoring DCI 2\_0 to read CO duration  11. Invalidate RACH occasions that partially or fully fall within the idle period of a fixed frame period |  |  |  |  |  |  |  |  | This can be a basic feature group for the Scenario D in NR-U WID | Optional with capability signalling | | 10-2d | UE DL and UL operation in shared spectrum under semi-static channel access mode | 1. Type 2C channel access  2. Single sensing slot of 9us channel access  3. 20MHz LBT bandwidth  4. SSB RRM with Q =8 in DMTC  5. UL transmission conditioned on the detection of DL transmission in the same fixed frame period  6. FFS: Support fixed frame period of 5ms and 10ms | 6-5 and 6-6 |  |  |  |  |  |  |  | This can be a basic feature group for operating in an unlicensed SCell with both DL and UL | Optional with capability signalling |   With the introduction of discovery burst transmission windows, the number of SSB positions that UE has to monitor for measurements and PBCH reading is increased dramatically especially for small Q values. In addition, PCI collision is no new issue in NR-U. LTE-LAA has the same issue. However, it is resolved by eNB without mandating UE to read and report CGI.  **Proposal 6: For a UE that only supports NR-U as SCell (i.e. CA deployments in unlicensed operation), the UE is not required to read PBCH of an unlicensed cell.**  HARQ procedures are essential for stand-alone operation. However, they are missing from the basic feature groups for stand-alone.  **Proposal 10: Add the following HARQ components to the basic feature groups for stand-alone operation 10-1 and 10-2.**   * **Non-numerical PDSCH to HARQ-ACK timing** * **Enhanced dynamic HARQ-ACK codebook**   For FBE feature group 10-2b, it is not clear why FFP smaller than 5ms needs to be single out. So far we only have an agreement saying no SSB and corresponding PDSCH rate matching is required when an SSB falls within an idle period. But this does not evoke us that much difference between handling an FFP smaller than 5ms and handling an FFP not smaller than 5ms.  **Proposal 11: Discuss whether we need 10-2b.** |
| [7] | Intel Corporation | It is proposed to clarify that the basic feature groups including 10-1, 10-1a, 10-2, and 10-2a are targeting unlicensed band in the FR1 regime in order to avoid unnecessary capability signaling to licensed band or FR2. Therefore, it is proposed to put the restriction of FR1 unlicensed band in the note of the basic feature groups as shown below:  **Proposal 1: Put the restriction of FR1 unlicensed band in the note of 10-1, 10-1a, 10-2, and 10-2a.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Type** | **Note** | **Mandatory/Optional** | | 10-1 | UE stand-alone (DL and UL) operation in shared spectrum under dynamic channel access mode | 1. Type 1 channel access  2. Type 2A channel access  3. Type 2B channel access (FFS if move this to separate feature)  4. Type 2C channel access  5. 20MHz LBT bandwidth  6. Contention window adjustment  7. CP extension up to 1 symbol for PUSCH/PUCCH transmission  8. SSB/MIB/RMSI reception with Q  9. SSB RRM with Q in DMTC  10. SSB-RLM with Q in DMTC window  11. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0 |  | Per band | This can be a basic feature group for operating only in FR1 unlicensed band with both DL and UL transmission support under dynamic channel access | Optional with capability signalling | | 10-1a | UE DL only operation in shared spectrum under dynamic channel access mode | 1. SSB RRM with Q in DMTC | 6-5 | Per band | This can be a basic feature group for operating only in FR1 unlicensed band with DL only operation | Optional with capability signalling | | 10-2 | UE stand-alone (DL and UL) operation in shared spectrum under semi-static channel access mode | 1. Type 2C channel access  2. Single sensing slot of 9us channel access  3. 20MHz LBT bandwidth  4. SSB/MIB/RMSI reception with Q  5. SSB RRM with Q in DMTC  6. SSB-RLM with Q in DMTC window  7. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0  8. Support fixed frame period of 5ms and 10ms |  | Per band | This can be a basic feature group for operating only in FR1 unlicensed band with DL only operation | Optional with capability signalling | | 10-2a | UE DL only operation in shared spectrum under semi-static channel access mode | 1. SSB RRM with Q in DMTC  2. Support fixed frame period of 5ms and 10ms | 6-5 | Per band | This can be a basic feature group for operating only in FR1 unlicensed band with DL only operation | Optional with capability signalling |   It is OK to have 10-2 and 10-2a for both stand-alone operation and DL only operation. However, current table has different feature groups for stand-alone operation depending on the fixed frame period length. We do not have clear motivation to define additional feature groups for supporting small fixed frame period length. And this differentiation is only applied for stand-alone operation and not applied for DL only operation, which does not look desirable either.  **Proposal 2: Remove 10-2b and change the 8th bullet of 10-2.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | Index | Feature group | Components | Prerequisite feature groups | **Type** | Note | Mandatory/Optional | | 10-2 | UE stand-alone (DL and UL) operation in shared spectrum under semi-static channel access mode | 1. Type 2C channel access  2. Single sensing slot of 9us channel access  3. 20MHz LBT bandwidth  4. SSB/MIB/RMSI reception with Q  5. SSB RRM with Q in DMTC  6. SSB-RLM with Q in DMTC window  7. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0 |  | Per band | This can be a basic feature group for operating in unlicensed band.  Support of channel access mechanism for FBE operation, including fixed frame period, Cat 2 LBT, Cat 1 LBT | Optional with capability signalling | | 10-2a | UE DL only operation in shared spectrum under semi-static channel access mode | 1. SSB RRM with Q in DMTC  2. Support fixed frame period of 5ms and 10ms | 6-5 | Per band | This can be a basic feature group for operating in unlicensed band with DL only operation | Optional with capability signalling | |  |  |  |  |  |  |  | |
| [8] | Ericsson | We observe that in the most recent UE features list [R1-2001484] there has been an attempt to define feature groups based on some (but not all) deployment scenarios for both LBE and FBE with some components repeated in multiple feature groups. We refer to this as “deployment based grouping.” For example, 10-1 is currently defined for standalone (Scenario C) for LBE, and 10-1a is for DL only LAA operation (one of the 2 possible deployments in Scenario A).  There are several problems with deployment based grouping, namely:   * It is not consistent with the grouping approach used in Rel-15. As NR evolves, a consistent approach should be used across releases.   + In Rel-15, the Notes column in TR38.822 was used to provide information on which deployment scenarios a particular feature group is applicable to when needed, and this same approach can be used in Rel-16 if needed. * Not all deployment scenarios are covered, e.g., dual connectivity is missing   + It becomes unmanageable to define basic feature groups for all possible deployment scenarios   + The structure will unnecessarily restrict the ability to signal support for a different deployment scenario in the future that may need a different combination of components * The basic feature groups have overlapping functionality   + This can complicate IODT testing in that there would likely need to be a partitioning of components different from the defined feature groups which is undesirable * It becomes very hard to define prerequisites in a logical way   + If basic FGs are defined only for a subset of scenarios (as in [R1-2001484] currently), what pre-requisite should be defined for a FG-x if the UE implementation is targeted for a deployment for which a basic FG is not defined?   + IODT testing becomes complicated if multiple pre-requisites corresponding to different deployments are needed to capture the pre-requisite components   To alleviate these problems, it is better to define basic feature groups with components that have tightly related functionality. The goal of this grouping is that for any given deployment scenario, the pre-requisites can be defined as a subset of the basic feature groups, and those feature groups by design should have non-overlapping functionality. This is the approach that was used in Rel-15 and is closer to the approach that was used in the prior version of the UE feature list [R1-2000390] in contrast to the deployment-based grouping approach in the current version [R1-2001484]. The Notes column in TR 38.822 can be used to indicate which functionality is necessary for a particular deployment scenario if needed.  Based on this we make the following proposals that should be used as general principles:   1. Define basic feature groups with components that have tightly related functionality 2. Define basic feature groups that have non-overlapping functionality as much as possible   Based on these general principles, we propose to replace the 5 basic FGs 10-1, 10-1a, 10-2, 10-2a, and 10-2c in [R1-2001484] by the following 5 basic feature groups. We note that FGs 10-2, 10-3, and 10-4 in this proposal very much follow the structure used in Rel-15 for FGs 1-1 and 1-3 related to initial access, RRM, RLM, and RMSI reception (see Appendix of [R1-2001484]).   1. Replace FGs 10-1, 10-1a, 10-2, 10-2a, and 10-2c in by the 5 basic feature groups shown in the table below  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 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 | | 10. NR-unlicensed | 10-1 | UL channel access for dynamic channel access mode | 1. Type 1 channel access  2. Type 2A channel access  3. Type 2B channel access (FFS whether or not this should be defined as a separate FG)  4. Type 2C channel access  5. 20MHz LBT bandwidth  6. Contention window adjustment  7. CP extension up to 1 symbol for PUSCH/PUCCH transmission |  |  | N/A |  | Per band | N/A | N/A |  | Basic feature group | Optional with capability signaling | | 10-1a | UL channel access for semi-static channel access mode | 1. Type 2C channel access  2. Single sensing slot of 9us channel access  3. 20MHz LBT bandwidth |  |  | N/A |  | Per band | N/A | N/A |  | Basic feature group | Optional with capability signaling | | 10-2 | SSB reception (including reading MIB) and SSB-based RRM | 1. SSB reception with Q  2. SSB RRM with Q |  |  | N/A |  | Per band | N/A | N/A |  | Basic feature group | Optional with capability signaling | | 10-3 | SSB-based RLM | 1. SSB RLM with Q |  |  | N/A |  | Per band | N/A | N/A |  | Basic feature group | Optional with capability signaling | | 10-4 | SIB1 reception | 1. SIB1 reception with Q |  |  | N/A |  | Per band | N/A | N/A |  | Basic feature group  Note: SIB1 reception for ANR (FG 10-23) remains as a separate FG with 10-4 as a pre-requisite | Optional with capability signaling |   With the basic feature groups defined as above, all of the deployment scenarios captured in the WID are covered with combinations of the basic feature groups. The deployment scenarios can be summarized as follows:   1. SCell (DL only) in unlicensed band    1. Maps to Scenario A with DL only, i.e., LAA – DL Only    2. Required Basic FGs: 10-2 2. SCell (DL + UL) in unlicensed band    1. Maps to Scenario A with DL + UL, i.e., LAA – DL + UL    2. Required Basic FGs:       1. LBE: 10-1 + 10-2       2. FBE: 10-1a + 10-2 3. PSCell in unlicensed band    1. Maps to Scenario B and E, i.e., ENDC and NR-NR DC    2. Required Basic FGs: 10-1 + 10-2 + 10-3 4. PCell in unlicensed band    1. Maps to Scenario C and D, i.e., Standalone and Standalone + SUL    2. Required Basic FGs:       1. LBE: 10-1 + 10-2 + 10-3 + 10-4       2. FBE: 10-1a + 10-2 + 10-3 + 10-4   In this way, the deployment scenarios are described based on different combinations of the basic feature groups. Moreover, the basic feature groups have non-overlapping functionality as much as possible, thus simplifying IODT testing.  As a general principle, feature group A should be listed as a pre-requisite for feature group B only if feature group B cannot *functionally* operate without feature group A.  For operation in shared spectrum, a UE should indeed support UL LBT. However, the **functionality** of feature groups, for example one-shot-HARQ (10-16), that have nothing to do with UL LBT operation should not have the feature group with UL LBT as a prerequisite. This means that it is technically incorrect to include 10-1 or 10-2 as a pre-requisite for 10-16 (numbering as per the latest draft in [R1-2001484]). It should be noted that feature group 10-16 being listed as part of feature “10. NR-unlicensed” in TR 38.822 makes it amply clear that this feature was developed for operation in unlicensed spectrum. There is no further need to artificially link functionally unrelated feature groups together to attempt to indicate the intended scenario for a feature. This type of pre-requisite definition has the same issues as the deployment based grouping discussed in the previous section.  We have previously commented that adding pre-requisite features for a feature group should have technical justifications with respect to the functionality being tested for the feature group. Hence, we reiterate the following proposal.   1. We propose the following:  * A feature group A should be listed as a pre-requisite for another feature group, B, only if feature group B cannot functionally operate without feature group A. * The basic feature groups related to UL channel access should be removed as pre-requisites from the following feature groups (as per the latest draft in [R1-2001484]) since these feature groups do not require UL LBT to operate:   + 10-3, -3a, -3b, -3c, -9, -9a, -9b, -9c, -10, -11, -14, -15, -16, -16a, -17, -18a, -19a, -19c, -20, -20a, -23, -24, -26, -27, -28, -29, -30, -31   For supporting the semi-static channel access mode, the main additional functionalities that are useful to be implemented in the UE are   1. RACH validation to take into account idle periods in the fixed frame period 2. Sensing in a single slot of 9 us   It should be noted that the system can operate in FBE even without these two functionalities with appropriate configuration of RACH occasions and with the use of a short LBT over 25 μs that also meets the requirements of sensing in a single slot of 9 μs. Therefore, there is no necessity to define multiple feature groups individually for dynamic and semi-static channel access modes. Only a basic feature group for dynamic channel access and one for semi-static channel access as in Proposal 3 are needed.  Furthermore, for semi-static channel access mode, support of fixed frame period of 5 and 10 ms is listed. It is not clear why a limitation to a fixed frame period of 5 and 10 ms needs to be included in the feature group definition considering the functionalities listed above for which there isn’t any significant complexity difference between for the different fixed frame periods. Finally, the current structure doesn’t allow signaling of support for fixed frame periods that are less than 5 and 10 ms unless the UE also supports UL which seems like a very strange restriction.   1. Remove values for fixed frame period from the definition of feature groups related to semi-static channel access   Component 11 is “Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0” in our view, it is not critical if NR-U capable UEs do not support the extended RAR window. Collisions do not happen frequently, and if there is a collision, a UE can retry to access the channel again. It is true that the gNB does not know the UE’s capability if the RACH procedure is initiated by the IDLE/INACTIVE UE. However, if support of extended RAR is a separate FG with its own an capability bit, this can be used to collect statistics on UE capabilities, and the gNB may decide based on the penetration and use case whether to configure the extended RAR window or not. If considered useful, this can be implemented in the initial phase. Otherwise, UEs may also be upgraded with this capability if enhancements are considered needed.   1. Introduce a separate FG for support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0 |
| [12] | Nokia, Nokia Shanghai Bell | * 10-1/10-1a/10-2/10-2a: Missing clear relationship with 10-30 (COT duration). It should be a pre-requisite at least for 10-1/10-1a. * 10-1, components 8, 9, 10: remove “with Q” or clarify the text so that it becomes self-contained. * 10-1a: remove “with Q” or clarify the text so that it becomes self-contained. * 10-2:   + Components 4, 5, 6: remove “with Q” or clarify the text so that it becomes self-contained.   + Component 8: add 2ms support * 10-2a:   + Component 1: remove “with Q” or clarify the text so that it becomes self-contained.   + Component 2: add 2ms support * 10-2b: it is unclear why this component would be needed. |
| [13] | Qualcomm Incorporated | |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 10-1 | UE stand-alone (DL and UL) operation in shared spectrum under dynamic channel access mode | 1. Type 1 channel access  2. Type 2A channel access  3. Type 2B channel access (FFS if move this to separate feature)  4. Type 2C channel access  5. 20MHz LBT bandwidth  6. Contention window adjustment  7. CP extension up to 1 symbol for PUSCH/PUCCH transmission  8. SSB/MIB/RMSI reception with Q  9. SSB RRM with Q in DMTC  10. SSB-RLM with Q in DMTC window  11. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0 |  |  | N/A |  | Per band | N/A | N/A |  | This is a basic feature group for operating in unlicensed band with both DL and UL transmission support under dynamic channel access | Optional with capability signalling | | 10-1a | UE DL only operation in shared spectrum under dynamic channel access mode | 1. SSB RRM with Q in DMTC | 6-5 |  | N/A |  | Per band | N/A | N/A |  | This is a basic feature group for operating in unlicensed band with DL only operation under CA mode | Optional with capability signalling | | 10-2 | UE stand-alone (DL and UL) operation in shared spectrum under semi-static channel access mode | 1. Type 2C channel access  2. Single sensing slot of 9us channel access  3. 20MHz LBT bandwidth  4. SSB/MIB/RMSI reception with Q  5. SSB RRM with Q in DMTC  6. SSB-RLM with Q in DMTC window  7. Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0  8. Support fixed frame period of 5ms and 10ms |  |  | N/A |  | Per band | N/A | N/A |  | This is a basic feature group for operating in unlicensed band. | Optional with capability signalling | | 10-2a | UE DL only operation in shared spectrum under semi-static channel access mode | 1. SSB RRM with Q in DMTC  2. Support fixed frame period of 5ms and 10ms | 6-5 |  | N/A |  | Per band | N/A | N/A |  | This is a basic feature group for operating in unlicensed band with DL only operation | Optional with capability signalling | | 10-2b | UE operation in shared spectrum under semi-static channel access mode with shorter fixed frame periods | 1. Support fixed frame periods shorter than 5ms | 10-2 or 10-2a |  | N/A |  | Per band | N/A | N/A |  |  | Optional with capability signalling |   10-2b: An alternative solution is to merge this back to 10-2 and 10-2a where introducing a component on supported fixed frame period lengths with {5ms, 10ms} as one value and {1ms, 2ms, 2.5ms, 4ms, 5ms, 10ms} as another value |
| [14] | Huawei, HiSilicon | It cannot be excluded that certain UEs may only support one of the above scenarios, e.g. Scenario A (licensed-assisted access) with DL-only. Therefore some UEs may not support uplink on unlicensed band. So any FG that only contains UL components should not be a basic feature group according to approach 1.  The discussion on UE feature groups for NR-U is considering defining basic feature groups for the following FGs associated with NR-U operation scenarios: 10-1, 10-1a, 10-2, 10-2a, 10-2b (see Table 1 below). Previously FGs 10-1 and 10-2 were only about UL capabilities, but in the latest version [R1-2001484] DL components were added and certain DL components are repeated in several of those FGs, i.e. SSB RRM with Q in DMTC. This means approach 2 is taken as basis for the proposed definition of basic FGs in [R1-2001484], as this is not consistent with approach 1. However it is unclear if there would be separate capability signaling for the components within FG 10-1 and 10-2, or if all components of FG 10-1 and 10-2 would also need to be individual FGs of their own.  Alternatively FG10-1a could be considered a prerequisite of FG10-1, and FG10-2a a prerequisite of FG10-2. The earlier version clearly separating the UL and DL components into different FGs allowed a UE to clearly report those capabilities separately for signaling support for various operation scenarios. With the latest grouping in [R1-2001484], how would a UE signal support for scenario B with dual-connectivity? Would the UE have to support standalone DL and UL in order to support scenario B? If so, why should such constraint be introduced?  For DL only operation with SCell in unlicensed band, there are now 2 FGs: one for LBE and one for FBE. If those 2 FGs (10-1a and 10-2a) are considered as basic FGs, then it is clear that it should not be expected that a UE has to report support for both FGs if the UE signals support for band n46. So again, FGs 10-1a and 10-2a as defined in [R1-2001484] can only be considered as basic FGs according to approach 2 in [RP-200502]. If the minimum required for operation on band n46 is considered, according to the current list, it should be SSB RRM with Q in DMTC, and support for FBE comes with one additional capability (support fixed frame period of 5ms and 10ms).  ***Observation 1:***   * ***According to the definition of basic feature group of approach 1 in RP-200502, only a FG10-1a with SSB RRM with Q in DMTC as a single component may qualify as a basic FG for NR-U.*** * ***FGs 10-1, 10-1a, 10-2, 10-2a, 10-2b in R1-2001484 are defined according to the definition of basic feature group of approach 2 in RP-200502.***   ***Proposal 1:***   * ***RAN1 needs to clearly indicate whether separate capability signaling for each component is expected for FGs 10-1 and 10-2 in R1-2001484.*** * ***RAN1 needs to clarify why certain components are included in multiple NR-U FGs in R1-2001484.***   **Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0**  FG10-27 is kept as a separate FG for wideband PRACH (same as RB-interlaced PUSCH and PUCCH), so it is unclear why “*Support of RAR extension from 10ms to [40ms] by decoding of the 2-bit SFN indication in DCI 1\_0*” was included as a component of FG10-1 and FG10-2. This functionality is for 2-step RACH, so it should be a separate FG because support of 2-step RACH is not a prerequisite for FG10-1 or FG10-2. |
| [15] | TCL Communication | We believe that for NR-Unlicensed, similar to V2X, for the UEs able to interoperate with the network over the shared spectrum using NR-U as standardized in 3GPP Rel-16, the 3GPP should define a set of features which are mandatory for the NR-U capable UEs. This base group of features defines the minimum functionalities which 3GPP deems necessary for unlicensed operation.  Without such baseline future interoperability testing will prove difficult and the market will require another level of alignment between vendors.  **Proposal 1:**  There is a base group of UE features defined among the NR-Unlicensed capabilities which are defined to be mandatory if a UE indicates its capability to operate over shared spectrum. These features shall be group in UE feature 10-1 or 10-2.  We believe that NR-U Rel-16 provides for shared spectrum usage what NR Rel-15 provides for Uu opeatrion. For this reason, we believe that it will be useful to define the basic features which may provide certain quality of communication. For this reason, we believe that 10-3 (PRB interlace mapping for PUSCH) should be part of basic feature set which are mandatory for UEs indicating being capable of Rel-16 NR-U operation.  For feature 10-25 (Enable configured UL transmission out of COT), we understand the description of this feature as to support CG UL transmissions where UE initiates the COT. If this understanding is correct, and when this feature is not supported, UE will not initiate channel access to make a CG UL transmission. From our perspective, this is very performance inefficient for configured grant operation and this behaviour should be supported as mandatory or among the basic feature groups.  Feature 10-16 (One-shot HARQ ACK feedback) is a very important feature. Without this feature, system efficiency is very low due to loss of feedback for many DL packets. For this reason, this should be added as one of the mandatory features to UEs capable of Rel-16 NR-U operation.  Similarly, 10-19 (number of LBT bandwidths), this is more of a fundamental feature compared to carrier aggregation. One aspect is related to per band nature, and one other aspect is related to UE processing capability. Independent of the representation, from our perspective, given NR supports upto 100 MHz BW, the basic feature set for NR-U should be the support of BW larger than 20 MHz. This also means that feature 10-29 (support available RB set indicator field in DCI 2\_0) should be supported as mandatory NR-U Rel-16 feature as this signaling in the DCI largely facilitates the effective usage of wideband carrier over the shared spectrum. The feature 10-30 (Support channel occupancy duration indicator field in DCI 2\_0) also provides very basic functionliaty about the channel occupancy representation and utilization over the shared spectrum and thus should be mandatory.  From our understanding, following the strategy of making the basic features as components in 10-1 and 10-2, we believe that the best way to ensure meaningful NR-U operation is to add 10-3, 10-25, 10-19, 10-29 and 10-30 as components in the basic features groups of 10-1 and 1-2.  **Proposal 2:**  Add 10-3, 10-25, 10-19, 10-29, 10-30 and 10-16 as components in 10-1 and 10-2. |

## 2.1 Discussion 1

**Companies are encouraged to provide views on whether or not “Support fixed frame period of 5ms and 10ms” and “Support fixed frame periods shorter than 5ms” can be separate capabilities.**

**Introducing the separated FGs supported by:**

**Objected (i.e., not introducing the separate FGs) by: NTT DOCOMO, Huawei, HiSilicon, vivo, OPPO**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We don’t see any strong motivation to introduce the separate FGs. At least for NR-U SA scenario in FBE operation, all FFPs should be supported by the UE. |
| Huawei, HiSilicon | We prefer to keep them together because those different FFP don’t seem to have much implementation difference at the UE. |
| vivo | Not very clear on the motivation of separate FG here. |
| Nokia, NSB | We prefer to keep them together. |
| Qualcomm | We prefer to separate them. The motivation is an observation that if the FFP is 5ms or 10ms, the entire SSB sweep will be contained in one LBT hypothesis. The UE can assume the SSBs are either all transmitted or none of them are transmitted. This is simpler than UE needs to perform more hypothesis testing on when the LBT will pass for RLM/RRM purpose.  An alternative to have separate FG is to have two values for the component on FFP supported, with one being {5ms, 10ms} and the other being all values. |

# **10-8: Type B PDSCH length**

In [1], FG 10-8 is captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 10. NR-unlicensed | 10-8 | Type B PDSCH length | Length 3, 5, 6, 8, 11, 12, 13  FFS the capability are separate for each length or some groups are formed to signal the capability together |  | Yes | N/A |  | FFS: Per UE or per band | N/A | N/A |  | Support of additional length (other than 2/4/7) for type B PDSCH.  Note length 9/10 are already covered by 14-3 | Optional with capability signalling |

Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | ZTE, Sanechips | * TypeB PDSCH length: including FG 10-8   In general, the above enhancements on PDSCH could be beneficial to licensed spectrum in terms of enhanced flexibility and reliability. On the other hand, it may introduce implementation complexity for NR UEs. Probably they can be considered as optional features to be applied to NR licensed spectrum. |
| [5] | MediaTek Inc. | Proposal 1: NR-U features can only be extended to licensed operation when uses cases and benefits are well justified. |
| [7] | Intel Corporation | We support that some of feature groups are used for licensed use, including 10-8 and 10-11. And also some of HARQ features seem beneficial for licensed use as well including enhanced dynamic HARQ codebook, one-shot HARQ ACK, and multi-PUSCH UL grant.  **Proposal 5:**   * **Let 10-8/10-11/10-14/10-15/10-16/10-16a/10-17 be used for licensed band** |
| [8] | Ericsson | Regarding the FFS, it is beneficial (and simpler) that if any new Type B mapping lengths are supported, then all are supported. Having separate capabilities for each new length results in too fine grained capability signalling and is hard to manage in the network. Since the PDSCH mapping lengths are generally useful, regardless of the band, in our view this feature should be per UE.   1. Support only single capability bit for all new PDSCH mapping lengths (3,5,6,8,11,12,13). FG 10-8 should be per UE. |
| [9] | Samsung | NR-U functions have been introduced to handle inherit problem of unlicensed band such as LBT failure and regulation. Hence, in our view, except FG-8 and FG-11 which are general function for licensed band, applicability of NR-U feature groups should be restricted to unlicensed band. If some of NR-U feature groups are identified to be beneficial for licensed band operation, we will be able to make an agreement for each.  **Proposal 2: UE features for NR-U should be used only for unlicensed band.** |
| [12] | Nokia, Nokia Shanghai Bell | * 10-8: Preference to have length 9/10 included in this feature for clarity. However, if length 9/10 is assumed to be covered by 14-3 then it needs to be added as a pre-requisite. |
| [13] | Qualcomm Incorporated | For supported type B PDSCH lengths, we propose to have two components: {3, 5, 6, 8, 11} supported and {12, 13} supported |
| [14] | Huawei, HiSilicon | |  |  |  | | --- | --- | --- | | Functionality | FGs | Need for licensed band operation | | Type B PDSCH length | 10-8 Type B PDSCH length  14-2 PDSCH Type B mapping of length 9 and 10 OFDM symbols | Per UE  FG10-8 and FG14-2 could be “per UE”. At least FG14-2 is applicable to licensed and unlicensed bands in FR1. |   ***Proposal 2: The following FGs could be extended to licensed bands, i.e. reported “per UE”:***   * ***10-8 Type B PDSCH length*** |

## 3.1 Discussion 2

**Companies are encouraged to provide views on whether or not the capability FG10-8 are separate for each length or some groups are formed to signal the capability together.**

**Introducing the separated FGs for each length supported by:**

**Objected (i.e., not introducing the separate FGs for each length and forming some group(s)) by: NTT DOCOMO, Huawei, HiSilicon**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We prefer not introducing the separate FGs for each length or forming some group(s), i.e., only a single capability bit for all new PDSCH lengths is enough |
| Huawei, HiSilicon | It is not clear why different components should be defined for different PDSCH lengths |
| Nokia, NSB | We do not see a need to separate the FG for each length. |
| Qualcomm | We prefer to separate to {3, 5, 6, 8, 11} and {12, 13} |

# **10-9 to 10-9c: Search space set group switching**

In [1], FGs 10-9 to 10-9c are captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 10. NR-unlicensed | 10-9 | Search space set group switching with explicit DCI 2\_0 bit field trigger | 1. Two groups of search space sets  2. Monitor DCI 2\_0 with a search space set switching field  3. Support a timer to switch back to original search space set group  4. 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 | 10-1, 10-1a, 10-2, or 10-2a  Need discussion for licensed use | Yes | N/A |  | FFS: Per UE or per band or per BC | 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 |
| 10-9a | Search space set group switching with implicit PDCCH decoding with DCI 2\_0 monitoring | 1. Two groups of search space sets  2. 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  4. 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 | 10-1, 10-1a, 10-2, or 10-2a  Need discussion for licensed use | Yes | N/A |  | FFS: Per UE or per band | 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 |
| 10-9b | Search space set group switching with implicit PDCCH decoding without DCI 2\_0 monitoring | 1. Two groups of search space sets  2. 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 | 10-1, 10-1a, 10-2, or 10-2a  Need discussion for licensed use | Yes | N/A |  | FFS: Per UE or per band | 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 |
| 10-9c | 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 | 10-9, 10-9a, or 10-9b | Yes | N/A |  | FFS: Per UE or per band | N/A | N/A |  | Without this capability, the UE will switch search space set groups for different cells independently | Optional with capability signalling |

Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | ZTE, Sanechips | * CORESET/SS: including FG 10-9/9a/9b/9c, 10-20/20a.   In general, the above enhancements on CORESET/SS could be beneficial to licensed spectrum in terms of enhanced flexibility and reliability. On the other hand, it may introduce implementation complexity for NR UEs. Probably they can be considered as optional features to be applied to NR licensed spectrum. |
| [3] | Vivo | For search space set (SS) group switching related features (10-9, 10-9a, 10-9b), 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. Thus, these UE features could be extended to licensed use.  Proposal 1: Interlace UL related features (10-3, 10-3a, 10-3b, 10-3c) should be limited to unlicensed band only and SS group switching related features (10-9, 10-9a, 10-9b) could be extended to licensed use. |
| [5] | MediaTek Inc. | Proposal 1: NR-U features can only be extended to licensed operation when uses cases and benefits are well justified. |
| [6] | LG Electronics | On the type for this feature group (and including FG 10-9a), one FFS point is between per UE and per band. In our view, per band (i.e., unlicensed band only) would be more desirable since switching behaviour based on channel occupancy time indicated by DCI format 2\_0 (which corresponds to 4th component in FG 10-9 and FG 10-9a) is only applicable to unlicensed band.  **Proposal #1: Per band (i.e., unlicensed band only) as type for FG 10-9 and FG 10-9a.** |
| [7] | Intel Corporation | However, do not see any motivation to let the features for search space set group switching and search space/CORESET configuration in wideband to be used for licensed band. Those features were introduced to overcome the limitation of unlicensed band and we do not see any benefits when used for licensed operation.  **Proposal 6:**   * **Do not open 10-9/10-9a/10-9b/10-20/10-20a for licensed use.** |
| [8] | Ericsson | There is no need to split the search space switching capability into 4 separate feature groups. This complicates managing of different UEs with different capabilities in the network due to too fine grained capability signalling. In our view, this feature is useful for UE power saving, regardless of the operating band. Hence this feature should be per UE.   1. Merge FG 10-9, 10-9a, 10-9b, and 10-9c into a single FG. The merged FG should be per UE. |
| [9] | Samsung | NR-U functions have been introduced to handle inherit problem of unlicensed band such as LBT failure and regulation. Hence, in our view, except FG-8 and FG-11 which are general function for licensed band, applicability of NR-U feature groups should be restricted to unlicensed band. If some of NR-U feature groups are identified to be beneficial for licensed band operation, we will be able to make an agreement for each.  **Proposal 2: UE features for NR-U should be used only for unlicensed band.** |
| [12] | Nokia, Nokia Shanghai Bell | * 10-9/10-9a/9b 10-9b should be baseline and required for UEs implementing 10-9 or 10-9a. |
| [14] | Huawei, HiSilicon | |  |  |  | | --- | --- | --- | | Functionality | FGs | Need for licensed band operation | | Search space set group switching | 10-9 Search space set group switching with explicit DCI 2\_0 bit field trigger  10-9a Search space set group switching with implicit PDCCH decoding with DCI 2\_0 monitoring  10-9 b Search space set group switching with implicit PDCCH decoding without DCI 2\_0 monitoring  10-9 c Joint search space group switching across multiple cells | Per band  It is unclear what benefit could be obtained for operation on a licensed carrier since the monitoring periodicity of PDCCH search spaces would generally not need to change frequently nor depend on implicit rules. | |
| [14] | Huawei, HiSilicon | **FG 10-9/9a/9b/9c (Search space set group switching)**  FG10-9b (implicit switching without DCI 2\_0 decoding) should be a prerequisite of 10-9/9a/9c. |

## 4.1 Discussion 3

**Companies are encouraged to provide views on whether or not 10-9/9a/9b/9c can be combined into a single FG.**

**Combining them into a single FG supported by: NTT DOCOMO, vivo**

**Objected (i.e., keeping them as separated FGs) by: OPPO**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We prefer to combine 10-9/9a/9b/9c into a single FG. As an alternative, it is fine to keep them as separate FGs if 10-19b is a prerequisite of 10/9/9a/9c since 10-19b does not require for UE to monitor DCI format 2\_0 (i.e., like default behavior). |
| Huawei, HiSilicon | 10-9a and 10-9b could be grouped in one FG focusing on implicit switching without differentiating details of timer or COT duration, because timer-based switching is the basic functionality for 10-9 and 10-9a FGs. |
| vivo | Prefer combining them into a single FG |
| OPPO | We support separate FG. The UE who supports any of 10-9, 10-9a, 10-9b can claim to support search space group switching function, why shall we mandate the UE to implement all. |
| Nokia, NSB | We are OK to combine them into a single FG. |
| Qualcomm | We are fine to keep them separate. |

# **10-14 to 10-17: HARQ enhancements**

In [1], FGs 10-14 to 10-17 are captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 10. NR-unlicensed | 10-14 | Non-numerical PDSCH to HARQ-ACK timing | 1. Support configuration of a value for dl-DataToUL-ACK indicating an imapplicable time to report HARQ ACK | 10-1 or 10-2  Need discussion for licensed use | Yes | N/A |  | Per band or per UE | N/A | N/A |  | If non-numerical K1 value is supported | Optional with capability signalling |
| 10-15 | Enhanced dynamic HARQ codebook | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1  2. Support of bit field in DCI 0\_1 for other group total DAI if configured.  3. Support the retransmission of HARQ ACK  FFS if need to further split under other group DAI/NFI configured or not | 10-1 or 10-2  Need discussion for licensed use | Yes | N/A |  | Per band or per UE | 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 |
| 10-16 | One-shot HARQ ACK feedback | 1. Support feedback of HARQ-ACK codebook containing all configured HARQ processes for all configured CCs, triggered by a DCI 1\_1 scheduling a PDSCH | 10-1 or 10-2  Need discussion for licensed use | Yes | N/A |  | Per band or per UE | 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 |
| 10-16a | One-shot HARQ ACK feedback trigger with empty DCI 1\_1 | 1. Support feedback of HARQ-ACK codebook containing all configured HARQ processes for all configured CCs with a DCI 1\_1 without scheduling a PDSCH using a reserved FDRA value | 10-16  Need discussion for licensed use | Yes | N/a |  | Per band or per UE | N/A | N/A |  |  | Optional with capability signalling |
| 10-17 | Multi-PUSCH UL grant | 1. Support of scheduling up to 8 PUSCH with a single DCI 0\_1 | 10-1 or 10-2 Need discussion for licensed use | Yes | N/A |  | Per band or per UE | N/A | N/A |  |  | Optional with capability signalling |

Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | ZTE, Sanechips | There has been various enhancements made in NR-U WI on different aspects based on Rel-15 NR design. For the enhancements on the same aspect, it may not be a good way to split the features into too many small pieces and make all of them as optional. It would be hard for network to implement and utilize a meaningful Rel-16 functionality if different UEs support drastically different combinations of feature groups for one aspect.  For example for the interlace structure, currently there are 4 optional feature groups defined for PUSCH and each of the PUCCH formats respectively, which implies one UE may support interlaced PUSCH but not support interlaced PUCCH, or vice versa. This is not necessary, as in the RRC signalling there is only one parameter to just indicate whether the interlaced structure is enabled or not. Therefore, it would be better to merge them into one feature group. Similar principle can be applied to the enhancements on HARQ and configured grant.  ***Proposal 2:***   * ***To avoid implementation complexity, the enhancements on the same aspect should be combined into one feature group, including the following:***   + ***Interlaced structure: combine 10-3, 10-3a, 10-3b, and 10-3c***   + ***HARQ enhancement: combine 10-14, 10-15, 10-16, 10-16a, and 10-17***   + ***Configured grant: combine 10-18 and 10-28*** * HARQ enhancements: including FG 10-14 ~ 10-17.   In general, the above enhancements on HARQ could be beneficial to licensed spectrum in terms of enhanced flexibility and reliability. On the other hand, it may introduce implementation complexity for NR UEs. Probably they can be considered as optional features to be applied to NR licensed spectrum. |
| [3] | vivo | For other UE features, the extension to licensed band could be considered if the benefit is identified in certain licensed scenario.  Proposal 2: For UE features that are not agreed to be extended to licensed use, update “per band” to “per unlicensed band”. |
| [4] | OPPO | **FG 10-15**: In NRU the enhanced dynamic HARQ-ACK codebook may be realized by DCI 1\_1 that contains NFI for two groups or 1 group. Moreover, the DAI in DCI 0\_1 can indicate for two groups or one group. All these can be configurable at the network side, if the UE supports each of these individual features. Thus, one FG that aggregates multiple sub-FGs seems too restricted, it should be allowed that a UE only implements one configuration, which does not refrain the UE from supporting enhanced dynamic HARQ-ACK codebook. For this reason, two FGs are indeed needed for the UE to report if it can support enhanced dynamic HARQ-ACK codebook with UL-TotalDAI-Included-r16 or without UL-TotalDAI-Included-r16.   |  |  |  | | --- | --- | --- | | ~~10-15~~ | ~~Enhanced dynamic HARQ codebook~~ | ~~1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1~~  ~~2. Support of bit field in DCI 0\_1 for other group total DAI if configured.~~  ~~3. Support the retransmission of HARQ ACK~~  ~~FFS if need to further split under other group DAI/NFI configured or not~~ | | 10-15 | Enhanced dynamic HARQ codebook | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1 for scheduled group  2. Support of bit field in DCI 0\_1 for total DAI of scheduled group  3. Support the retransmission of HARQ ACK | | 10-15a | Enhanced dynamic HARQ codebook with DAI/NFI for the other group | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1 for non-scheduled group  2. Support of bit field in DCI 0\_1 for total DAI of non-scheduled group |   **Proposal 4: Split feature group 10-15 enhanced dynamic HARQ codebook into two cases: enhanced dynamic HARQ codebook with or without reading DAI/NFI for non-scheduled group.** |
| [5] | MediaTek Inc. | Proposal 1: NR-U features can only be extended to licensed operation when uses cases and benefits are well justified. |
| [6] | LG Electronics | One correction is necessary for 2nd component since total DAI field for other PDSCH group can be configured to DCI format 1\_1 in addition to DCI format 0\_1.  **Proposal #3: Modify 2nd component of FG 10-15 as follows.**   |  |  |  | | --- | --- | --- | | 10-15 | Enhanced dynamic HARQ codebook | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1  2. Support of bit field in DCI 0\_1 and DCI 1\_1 for other group total DAI if configured.  3. Support the retransmission of HARQ ACK  FFS if need to further split under other group DAI/NFI configured or not | |
| [7] | Intel Corporation | We support that some of feature groups are used for licensed use, including 10-8 and 10-11. And also some of HARQ features seem beneficial for licensed use as well including enhanced dynamic HARQ codebook, one-shot HARQ ACK, and multi-PUSCH UL grant.  **Proposal 5:**  **Let 10-8/10-11/10-14/10-15/10-16/10-16a/10-17 be used for licensed band** |
| [8] | Ericsson | The word “inapplicable” is misspelled in the description of the component.  Multi-PUSCH UL grants should be per UE instead of per band. Firstly, the functionality will be very useful in any band where PDCCH capacity can be constrained. Secondly, it is functionality that once implemented is fundamentally not related to the band of operation.   1. FG 10-17 should be per UE |
| [9] | Samsung | NR-U functions have been introduced to handle inherit problem of unlicensed band such as LBT failure and regulation. Hence, in our view, except FG-8 and FG-11 which are general function for licensed band, applicability of NR-U feature groups should be restricted to unlicensed band. If some of NR-U feature groups are identified to be beneficial for licensed band operation, we will be able to make an agreement for each.  **Proposal 2: UE features for NR-U should be used only for unlicensed band.** |
| [12] | Nokia, Nokia Shanghai Bell | * 10-14: fix typo “imapplicable time -> inapplicable time”. It is OK to support it for licensed use as well. * 10-15: Remove “FFS if need to further split under other group DAI/NFI configured or not” * 10-16 and 10-16a: to be merged into a single feature * 10-17: It is OK to support it for licensed use as well. |
| [13] | Qualcomm Incorporated | |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 10-14 | Non-numerical PDSCH to HARQ-ACK timing | 1. Support configuration of a value for dl-DataToUL-ACK indicating an imapplicable time to report HARQ ACK | 10-1 or 10-2  Need discussion for licensed use | Yes | N/A |  | Per band | N/A | N/A |  | If non-numerical K1 value is supported | Optional with capability signalling | | 10-15 | Enhanced dynamic HARQ codebook | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1  2. Support of bit field in DCI 0\_1 for other group total DAI if configured.  3. Support the retransmission of HARQ ACK  FFS if need to further split under other group DAI/NFI configured or not | 10-1 or 10-2  Need discussion for licensed use | Yes | N/A |  | Per band | 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 | | 10-16 | One-shot HARQ ACK feedback | 1. Support feedback of type 3 HARQ-ACK codebook, triggered by a DCI 1\_1 scheduling a PDSCH | 10-1 or 10-2  Need discussion for licensed use | Yes | N/A |  | Per band | 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 | | 10-16a | One-shot HARQ ACK feedback trigger with empty DCI 1\_1 | 1. Support feedback of type 3 HARQ-ACK codebook triggered by a DCI 1\_1 without scheduling a PDSCH using a reserved FDRA value | 10-16  Need discussion for licensed use | Yes | N/a |  | Per band | N/A | N/A |  |  | Optional with capability signalling | | 10-17 | Multi-PUSCH UL grant | 1. Support of scheduling up to 8 PUSCH with a single DCI 0\_1 | 10-1 or 10-2 Need discussion for licensed use | Yes | N/A |  | Per band | N/A | N/A |  |  | Optional with capability signalling | |
| [14] | Huawei, HiSilicon | |  |  |  | | --- | --- | --- | | Functionality | FGs | Need for licensed band operation | | HARQ enhancements | 10-14 Non-numerical PDSCH to HARQ-ACK timing  10-15 Enhanced dynamic HARQ codebook  10-16 One-shot HARQ ACK feedback  10-16a One-shot HARQ ACK feedback trigger with empty DCI 1\_1 | TBD Per band or Per UE  FGs 10-14/15/16/16a each offer their own trade-offs between overhead, latency and scheduling flexibility, so they should all be considered together to either be allowed for both licensed and unlicensed bands, or just for unlicensed bands. | | Multi-PUSCH UL grant | 10-17 Multi-PUSCH UL grant | Per UE  This feature is beneficial for reducing control overhead on licensed bands. To avoid additional complexity, we suggest no further optimization for this feature in Rel-16, so it should be limited to time-consecutive PUSCHs even on licensed bands.. |   ***Proposal 2: The following FGs could be extended to licensed bands, i.e. reported “per UE”:***   * ***10-17 Multi-PUSCH UL grant***   **FG 10-16a (One-shot HARQ ACK feedback trigger with empty DCI 1\_1)**  FG10-16 does not need to be a prerequisite for FG10-16a. Otherwise it would make more sense to merge the two FGs into a single FG. |

## 5.1 Discussion 4

**Companies are encouraged to provide views on whether or not 10-14/10-15/10-16/10-16a/10-17 can be combined into a single FG.**

**Combining them into a single FG supported by: NTT DOCOMO (at least for 10-16 and 10-16a), Huawei, HiSilicon (group some of them)**

**Objected (i.e., keeping them as separated FGs) by: OPPO (10-16 and 10-16a can be combined)**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | At least 10-16 and 10-16a should be combined into a single FG |
| Huawei, HiSilicon | We would support at least grouping 10-14 and 10-15, and grouping 10-14 with 10-16 and 10-16a, so reduce the number of NR-U HARQ FGs from 4 to 2. Further grouping to just 1 FG is also ok since one-shot feedback can complement enhanced Type-2 codebook operation. |
| vivo | 10-16 and 10-16a could be combined into a single FG |
| OPPO | We don’t think 10-17 should be combined, but maybe 10-16 and 10-16a can be combined to be a single FG |
| Nokia, NSB | At last 10-16 and 10-16a can be combined into a single FG. |
| Qualcomm | We are fine to combine 10-16 and 10-16a. Others should be kept separate |

## 5.2 Discussion 5

**If 10-14/10-15/10-16/10-16a/10-17 are not combined, companies are encouraged to provide views on whether or not 10-15 can be further split under other group DAI/NFI configured.**

**Further splitting 10-15 supported by: OPPO, MedaiTek**

**Objected (i.e., not splitting 10-15) by: NTT DOCOMO, Huawei, HiSilicon**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We prefer not splitting 10-15 |
| Huawei, HiSilicon | We prefer not further splitting 10-15 |
| OPPO | We support the splitting, the function can be realized with or without two groups NFI/T-DAI |
| Qualcomm | We prefer not to split. Don’t see a strong reason why a UE can implement one but not the other |
| MediaTek | We support the splitting. Otherwise, UE has to implement two different configurations of HARQ-ACK codebook generation for the non-scheduled group depending on whether other group DAI/NFI is configured. It should be allowed that a UE only implements one default configuration if the UE supports enhanced dynamic HARQ-ACK codebook. |

# **[10-19] to [10-19c]: Number of LBT bandwidth and its related feature groups**

In [1], FGs 10-19 to 10-19c are captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 10. NR-unlicensed | 10-19 | Number of LBT bandwidth  FFS if this is needed | Number of ED measurements the UE is able to perform simultaneously  [Whether the UE in WB operating mode can support nx20MHz measurement | 10-1 or 10-2 | Yes | N/A |  | Per band | N/A | N/A |  | This is the number of LBT bandwidth a UE can perform separate ED check on simultaneously | Optional with capability signalling |
| 10-19a | Support DL reception with subset of RB sets | 1. When DL BWP has multiple RB sets, support using the available RB set bitmap in DCI 2\_0 to validate the periodic CSI-RS transmission if the CSI-RS is over multiple RB-sets | 10-1 or 10-2 | Yes | N/A |  | Per band | N/A | N/A |  | Without this capability, UE will assume all RB sets in the DL BWP are all transmitted or none of them are transmitted | Optional with capability signalling |
| 10-19b | Support UL transmission with subset of RB sets passing LBT | 1. When UL BWP has multiple RB sets, support transmission of UL signal or channels when LBT passes for only the RB sets the UL signals or channels are located | 10-1 or 10-2 | Yes | N/A |  | Per band | N/A | N/A |  | Without this capability, UE will transmit UL when all RB sets in the UL BWP pass LBT | Optional with capability signalling |
| [10-19c] | Support intra-cell guard band(s) for DL carrier BW > 20MHz | Support DL frequency domain resource allocation type 0 with PRG partially overlapped with Type-2 intra-cell gard band between two adjacent LBT RB sets where CCA is clear on only one of RB sets as defined by RAN4, and rate matching around the guard bands either at RB level (in case of wideband precoding) or at PRG level (in case of precoding granularity of 2 or 4 RBs) according to the information provided by DCI Format 2\_0 available RB set bitmap and RRC intra-cell guard band configurations | 10-1a | Yes | N/A |  | [Per band] | N/A | N/A |  |  | Optional with capability signalling |

Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

|  |  |  |
| --- | --- | --- |
| [3] | vivo | On **10-19a** (*Support DL reception with subset of RB sets*), it seems only related with CSI-RS from component description but not aligned with the feature name or description part. It should be clarified what’s the intention for this UE feature.  **Proposal 5: Clarify the intention of 10-19a.** |
| [4] | OPPO | **FG 10-19**: Our initial understanding of this FG is the capability of simultaneously performing multiple LBT within the same CC. A typical use case is that an active UL BWP contains more than one LBT subbands. When the scheduled resources are spreading over multiple LBT subbands, the UE needs the capability of performing simultaneous LBT. Therefore, this feature is not tightly related to CA.  **Proposal 5: Keep feature group 10-19 to support nx20MHz measurement simultaneously.** |
| [5] | MediaTek Inc. | For 10-19c, the description of the component is lack of the support of agreements. It is not clear what the use cases and benefits of this proposal while it require to specify new UE behaviour. We should discuss it first under the NR-U agenda item before we can agree to this feature.  **Proposal 12: FG 10-19c, discuss it under the NR-U agenda item.** |
| [6] | LG Electronics | In our view, FG 10-19 is not needed, with the following understandings.   * This feature group is related to UE capability on how many 20 MHz LBT bandwidths UE can perform energy detection based channel access procedure at the same time. * The number of LBT bandwidths supported by a UE would be determined based on the UE’s capability on supported carrier BW. In other words, if a UE indicates the support of 80 MHz carrier BW, then the UE should support up to 4 LBT bandwidths.   **Proposal #4: Remove FG 10-19 from NR-U UE feature list.**  The necessity of this feature group should be first discussed in RAN1. To be specific, our opinion is that this is not needed since rate-matching pattern supported in Rel-15 seems to work also for the case of type-1/2 intra-cell guard band.  **Proposal #5: Remove FG 10-19c from NR-U UE feature list.** |
| [7] | Intel Corporation | In the context of 10-19b, in previous meetings RAN1 has made the agreements listed below on the UL wideband operation. From them, it is straightforward that a UE will transmit UL channels using the RB sets that overlap with the resource allocation for the UL transmission. From this perspective, the UE only perform the transmission based on the LBT outcomes of the RB sets of interest. Since LBT operation is performed per RB set (LBT BW), we do not see any motivation to define the feature group of 10-19b.   |  | | --- | | Agreement:   * For UL transmissions in a serving cell with carrier bandwidth greater than the LBT bandwidth, for the case where UE performs CCA before UL transmission, UE transmits on the UL only if CCA is successful at UE in all LBT bandwidths that overlap with the resource allocation for the UL transmission * The UE is not expected to receive resource allocations in discontiguous LBT bandwidths within a wideband carrier   + This does not preclude such resource allocation in discontiguous LBT bandwidths being supported by specifications managed by RAN1 in Rel-16. |   As for 0-19c, we do not have enough justification to support it due to the lack of discussion. Therefore, there is need to discuss further whether this is really needed. Also, it is not clear on the reason that the prerequisite is only 10-1a (only for DL-only operation under dynamic channel access mode).  **Proposal 4:**   * **Remove 10-19b.** * **Discuss more on the necessity of 10-19c.** |
| [8] | Ericsson | Regarding the FFS, this feature group is needed, as it is important for the network to know the UE capability to enable proper UL scheduling.   1. Keep FG 10-19; FFS can be deleted   It seems that this capability is more general and applies not only to CSI-RS but also PDSCH. We suggest to add a second component to this feature group. It can be further discussed if this is a separate capability, or whether it should be merged with 10-19c   1. Add a component to FG 10-19a for reception of PDSCH over a subset of RB sets as follows  |  |  |  |  | | --- | --- | --- | --- | | 10-19a | Support DL reception with subset of RB sets | 1. When DL BWP has multiple RB sets, support using the available RB set bitmap in DCI 2\_0 to validate the periodic CSI-RS transmission if the CSI-RS is over multiple RB-sets  2. When DL BWP has multiple RB sets, support PDSCH reception on a subset of RB sets | Without this capability, UE will assume all RB sets in the DL BWP are all transmitted or none of them are transmitted |   It should be clarified which signals/channels to which this FG applies. It is already specified that PUSCH is only transmitted if LBT is successful on all scheduled RB sets. Hence it seems that this capability is related to SRS only.   1. Clarify to which signals/channels to which FG-19b applies, e.g., SRS only.   In principle we agree that FG 10-19c is needed, either as a separate FG or merged with 10-19a; however, several aspects need to be clarified. It is not clear what Type-2 intra-cell guard bands are. Also, our understanding of the available RB-set bitmap is that it indicates to the UE which RB sets for which the UE can skip PDCCH monitoring. PDSCH reception is controlled by the scheduling DCI, so there is not a dependence on decoding DCI 2\_0. It should also be clarified what is the gNB/UE assumption if the capability is not supported. Shall the UE be scheduled only if LBT is successful in all RB sets as mentioned in FG 10-19a?   1. FG 10-19c is needed (or can be merged with 10-19a); clarify FG description. |
| [9] | Samsung | During the email discussion, following feature groups (10-19c, 10-22, and 10-31) have been added without discussion in NR-U WI. These features would affect not only UE behaviour but also gNB implementation so that sufficient discussion should be proceeded before the introduction. Hence, we propose to remove above feature groups in UE feature list for NR-U at this stage.  **Proposal 1: Remove FG 10-19c, 10-22, and 10-31 in UE feature list for NR-U.** |
| [10] | Apple | As detailed in our companion paper [2], we believe the FG 10-19c should be added for Type 0 resource allocation to provide flexibility at the UE to avoid processing increased number of PRG(s) due to puncturing by Type-2 CC guard band. More specifically, UE behavior can be different depending on the precoding granularity configurations. If PRG size is one of two values {2,4}, the overlapped PRG should be not used. On the other hand, for wideband configuration, RB-level rate-matching is still possible without increasing complexity.  **Proposal 1:**   * *For DL wideband operation and Type-0 RA, UE feature FG 10-19c should be introduced as optional feature to allow rate-matching around the overlapped PRG level with Type-2 intra-CC guard band in case of PRG = 2/4 or overlapped RB(s) with Type-2 intra-CC guard band for the case of wideband precoding.* |
| [11] | Sharp | FG 10-19 specifies the number of ED measurements the UE is able to perform simultaneously. We see that it is not necessary since the number of ED measurements should be implicitly determined by the supported channel bandwidth. If the UE supports 80 MHz channel bandwidth, the UE is required to support 4 ED measurements.  **Proposal 1: FG 10-19 is not necessary since the number of ED measurements is determined by the supported channel bandwidth.**  The functionality of FG 10-19a coincides with FG 10-29. Both FG indicates RB-set indicator interpretation in DCI format 2\_0. Thus, we propose to delete FG 10-19a from the list.  **Proposal 2: FG 10-19a is deleted from the list since the functionality coincides with FG 10-29.** |
| [12] | Nokia, Nokia Shanghai Bell | * 10-19: Numbers need to be more clear, otherwise we need to assume maximum is supported always. Is this applicable for all LBT types with ED measurement equally? * 10-19b: Feature is not needed as it is not fundamentally different single-RB set operation. * 10-19c: Feature is under discussion in R16 NR-U maintenance. |
| [13] | Qualcomm Incorporated | |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  |  |  |  |  |  |  |  |  |  |  |  | | 10-19a | Support DL reception with subset of RB sets | 1. When DL BWP has multiple RB sets, support using the available RB set bitmap in DCI 2\_0 to validate the periodic CSI-RS transmission if the CSI-RS is over multiple RB-sets | 10-1 or 10-2 | Yes | N/A |  | Per band | N/A | N/A |  | Without this capability, UE will assume all RB sets in the DL BWP are all transmitted or none of them are transmitted | Optional with capability signalling | | 10-19b | Support UL transmission with subset of RB sets passing LBT | 1. When UL BWP has multiple RB sets, support transmission of UL signal or channels when LBT passes for only the RB sets the UL signals or channels are located | 10-1 or 10-2 | Yes | N/A |  | Per band | N/A | N/A |  | Without this capability, UE will transmit UL when all RB sets in the UL BWP pass LBT | Optional with capability signalling | | [10-19c] | Suppport intra-cell guard band(s) for DL carrier BW > 20MHz | Support DL frequency domain resource allocation type 0 with PRG partially overlapped with Type-2 intra-cell gard band between two adjacent LBT RB sets where CCA is clear on only one of RB sets as defined by RAN4, and rate matching around the guard bands either at RB level (in case of wideband precoding) or at PRG level (in case of precoding granularity of 2 or 4 RBs) according to the information provided by DCI Format 2\_0 available RB set bitmap and RRC intra-cell guard band configurations | 10-19a | Yes | N/A |  | [Per band] | N/A | N/A |  |  | Optional with capability signalling |   10-19: We propose to remove this as the functionality is included in band combination capability, and 10-19a and 10-19b are introduced  10-19c: We are fine introducing this. However, should the prerequisite be 10-19a? Also the title may need some clarification. Might be better to describe this as “support partial PRG reception on the intra-cell guard band boundary |
| [14] | Huawei, HiSilicon | **FG 10-19 (Number of LBT bandwidth)**  There is no need to have a separate L1 feature group of 10-19. It can be derived implicitly from the supported channel combinations. If the carrier bandwidth is larger than 20 MHz, the UE should be capable to perform LBT on all LBT bandwidths in the carrier. It is proposed to delete FG10-19.  **FG10-19a (Support DL reception with subset of RB sets)**  The component should be clarified, it should be about the basic behavior in support of the configuration of intra-cell guard band where the UE assumes there is no data mapped to the intra-cell guard (which may happen with a PDSCH scheduled by DCI format 1\_0). Another component should be added to FG10-19a.  **FG10-19b (Support UL transmission with subset of RB sets passing LBT)**  Change “only” to “at least”, or delete “only” from the component description: *When UL BWP has multiple RB sets, support transmission of UL signal or channels when LBT passes for ~~only~~ the RB sets the UL signals or channels are located.*  **FG10-19c (Support DL reception with subset of RB sets and support intra-cell guard bands)**  We support removing the brackets of FG10-19c. |

## 6.1 Discussion 6

**Companies are encouraged to provide views on whether or not 10-19/10-19a/10-19b/10-19c are needed.**

**Keeping them (removing brackets) supported by:**

**Objected (i.e., removing them) by: NTT DOCOMO (for 10-19.** **10-19c can be merged to 10-19a)**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | 10-19 is not needed since it can be derived from CA combination capability. 10-19c can be merged to 10-19a for PDSCH reception on a subset of RB sets. |
| Huawei, HiSilicon | 10-19 does not need to be defined as a FG or as a component, because the number of supported LBT bandwidths can be derived implicitly from the supported channel combinations. If the carrier bandwidth is larger than 20 MHz, the UE should be capable to perform LBT on all LBT bandwidths in the carrier. We propose deleting FG10-19.  We can remove the brackets for 10-19c |
| vivo | Need more clarification on the motivation |
| OPPO | Respond to HW’s comment, could you please elaborate on the supported channel combinations? To our understanding the number of supported LBT bandwidth is needed.  We agree that 10-19 and 10-10b can be merged, and 10-19a/10-19c can be merged. |
| Nokia, NSB | 10-19b is not needed. 10-19c is under discussion in NR-U maintenance, so it might be better to wait for the conclusions there before considering merging it. |
| Qualcomm | 10-19 is not needed.  10-19a can be merged with 10-29 as a component  10-19b might be needed, if there is a UE vendor interested to implement a UE that transmit on one RB set conditioned on the LBT passing on all RB sets.  10-19c may need more discussion on the functionality. |

# **10-26: CSI-RS based RLM outside of discovery burst transmission window**

In [1], FG 10-26 is captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 10. NR-unlicensed | 10-26 | CSI-RS based RLM outside of discovery burst transmission window | Support RLM measurements using CSI-RS resources that are outside of discovery burst transmission window | 10-1 or 10-2 | Yes | N/A |  | Per band | N/A | N/A |  |  | Optional with capability signalling |

Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

|  |  |  |
| --- | --- | --- |
| [3] | vivo | On **10-26 (***CSI-RS based RLM outside of discovery burst transmission window*), we do not see the motivation for having this feature group as there is currently no new RLM behavior defined for unlicensed band. If new RAN1 agreement is made for RLM, this UE feature could be revisited.  **Proposal 7: Remove 10-26 currently and revisit it when any RLM enhancement is agreed for NRU.** |
| [5] | MediaTek Inc. | Without any agreements on “the initial signal” design and any guaranteed DL transmissions (e.g. (GC-) PDCCH) in the beginning of a COT, it is challenging to UE to adjust AGC and conduct periodic/semi-persistent DL reception. We hence propose the following.  **Proposal 9: Periodic/semi-persistent CSI-RS reception without SSB/PDCCH in the beginning of a COT should be UE capability. Support 10-26, 10-31 and 10-32.** |
| [8] | Ericsson | It is not clear why this feature group is needed as Rel-15 already includes RLM measurements based on CSI-RS. There should be no dependency on inside or outside the discovery burst transmission window (formerly DRS window) as CSI-RS is not constrained to be either inside or outside the window, in contrast to SS/PBCH blocks.   1. FG 10-26 should be removed; CSI-RS is not constrained to be either inside or outside the discovery burst transmission window. |

## 7.1 Discussion 7

**Companies are encouraged to provide views on whether or not 10-26 is needed.**

**Keeping it supported by:**

**Objected (i.e., removing it) by: NTT DOCOMO**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We think it may not be necessary, since the feature is already included in Rel-15 |
| vivo | Remove it. |
| OPPO | Support to remove |
| Qualcomm | Prefer to keep |

# **[10-31]: Support of CSI-RS measurements for CSI reporting and tracking without COT duration from DCI 2\_0**

In [1], FG 10-31 is captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 10. NR-unlicensed | [10-31] | Support of CSI-RS measurements for CSI reporting and tracking without COT duration from DCI 2\_0 | · Perform CSI measurements for reporting and tracking using CSI-RS resources that are not within a COT duration indicated by DCI 2\_0  · Note: This includes the cases when DCI 2\_0 is not configured and when DCI 2\_0 is configured but COT duration is not provided by either CO duration field or SFI. | 10-1a | Yes | N/A |  | [Per band] | N/A | N/A |  |  | Optional with capability signaling |

Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [5] | MediaTek Inc. | Without any agreements on “the initial signal” design and any guaranteed DL transmissions (e.g. (GC-) PDCCH) in the beginning of a COT, it is challenging to UE to adjust AGC and conduct periodic/semi-persistent DL reception. We hence propose the following.  **Proposal 9: Periodic/semi-persistent CSI-RS reception without SSB/PDCCH in the beginning of a COT should be UE capability. Support 10-26, 10-31 and 10-32.**   |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | 10. NR-unlicensed | [10-32] | CSI-RS based CBD outside discovery burst transmission windows | Support CBD (candidate beam detection) measurements using CSI-RS resources that are outside transmission windows | 10-1, 10-1a, 10-2, 10-2a, 10-1d, or 10-2e | Yes | N/A |  | [Per band] | N/A | N/A |  |  | Optional with capability signalling | |
| [6] | LG Electronics | We support this feature group to avoid significant burden of UE implementation to blindly detect CSI-RS for CSI reporting and tracking, as discussed in our companion paper [R1-2001933].  **Proposal #8: Support FG 10-31 for NR-U UE feature list.** |
| [8] | Ericsson | We don’t believe that such a feature group is needed or useful. It is well understood that in unlicensed spectrum, quality cannot be ensured and is always dependent on the number of other devices trying to access the carrier. It is also well understood that CSI-RS measurements for reporting and tracking are highly implementation dependent and rely on the UE admitting measurements into its averaging processes and tracking loops when the UE is able to ascertain reliably that the measurement is legitimate.  Consider the two extreme cases, the first where the gNB has excellent access to the channel, similar to licensed spectrum. It is clear that in these cases, the UE can rely on detecting the presence of other transmissions such as SSBs and PDCCHs in order to ensure that the CSI-RS measurements are reliable. In fact, this functionality is so fundamental to the UE that it does not make sense to define a capability for this. In the other extreme, if the gNB is unable to get access to the channel for long periods, it is well understood that not only do CSI-RS measurements get affected, but other core functions also will be affected. In this case, it is not expected that the UE is able to operate normally and would need some duration of transmissions from the gNB before it can measure CSI-RS reliably. In such a situation, a capability does not make sense since no UE would be able to report having the capability to measure CSI-RS under these conditions.  So, in summary, the proposed capability is not something that the UE can credibly report unless it is tied to some very specific set of conditions, e.g., some signals such as SSB are received with at least some periodicity or within some vicinity in time from the CSI-RS transmission occasion. These conditions will not only be very difficult to define, but this is the exact task that RAN4 will anyway undertake when defining requirements. Therefore, it is best to just leave it to RAN4 to define a reasonable test case for the UE to be able to measure CSI-RS when DCI 2\_0 is not configured or no pertinent information is received in DCI 2\_0.  We also note that there has not been any discussion that has taken place on this issue from a capability perspective thus far.   1. FG 10-31 should be removed |
| [9] | Samsung | During the email discussion, following feature groups (10-19c, 10-22, and 10-31) have been added without discussion in NR-U WI. These features would affect not only UE behaviour but also gNB implementation so that sufficient discussion should be proceeded before the introduction. Hence, we propose to remove above feature groups in UE feature list for NR-U at this stage.  **Proposal 1: Remove FG 10-19c, 10-22, and 10-31 in UE feature list for NR-U.** |
| [10] | Apple | As in Rel-15, NR-U supports DL transmissions that are semi-statically configuration by higher layers including periodic, semi-persistent CSI-RS transmission/reporting, CSI-IM and DL SPS transmission. However, it is possible that these semi-statically configured DL resources maybe actually not transmitted by gNB due to LBT failure. The monitoring and blind detection of P/SP-CSI-RS at each configured occasion causes unnecessary UE complexity and power consumption especially for the case of frequent detection and monitoring with a small period. Moreover, the uncertainty of CSI-IM resources makes it challenging for interference measurement. This motivates to introduce FG 10-31 to provides flexibility at UE side to implement CSI measurements based on periodic or semi-persistent CSI-RS/CSI-IM. The same analysis is also applicable for SPS PDSCH reception on unlicensed band and justify the need of FG 10-32.  Further details can be found in our paper [R1- 2002320].   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | [10-31] | Support of CSI-RS measurements for CSI reporting and tracking without COT duration from DCI 2\_0 | Perform CSI measurements for reporting and tracking using CSI-RS/CSI-IM resources that are not within a COT duration indicated by DCI 2\_0  Note: This includes the cases when DCI 2\_0 is not configured and when DCI 2\_0 is configured but COT duration is not provided by either CO duration field or SFI. | 10-1a | Per-band | Optional with capability signalling | | [10-32] | Support of SPS PDSCH reception without COT duration from DCI 2\_0 | Receiving SPS PDSCH that are not within a COT duration indicated by DCI 2\_0  Note: This includes the cases when DCI 2\_0 is not configured and when DCI 2\_0 is configured but COT duration is not provided by either CO duration field or SFI. | 10-1a | Per-band | Optional with capability signalling |   **Proposal 2:**   * *Add the FG 10-31 and FG 10-32 as optional UE features for CSI-RS measurement and SPS PDSCH reception without COT duration from DCI 2\_0.* |
| [12] | Nokia, Nokia Shanghai Bell | * 10-31: Feature is under discussion in R16 NR-U maintenance. |
| [14] | Huawei, HiSilicon | **FG10-31 (Support of CSI-RS measurements for CSI reporting and tracking without COT duration from DCI 2\_0)**  There is no agreement in Rel-16 for this UE behavior, so this FG requires more discussion and clarification first. |

## 8.1 Discussion 8

**Companies are encouraged to provide views on whether or not 10-31 is needed.**

**Keeping it (removing bracket) supported by:**

**Objected (i.e., removing it) by:**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | It depends on the outcome of email discussion #3 of DL agenda (CSI-RS measurements, incl. validity/presence of periodic/semi-persistent CSI-RS) |
| Huawei, HiSilicon | Agreement on the functionality is required first, based on the corresponding FL email discussion on NR-U DL signals and channels |
| vivo | Agree with docomo that this needs to be decided depending on outcome of CSI-RS validation rule. |
| OPPO | The spec is not ready for this issue. |
| Nokia, NSB | This depends on outcome of related discussion in NR-U maintenance, |
| Qualcomm | Need to clarify the functionality |

# **Conclusion**

TBD

# **References**

[1] R1-2001484 RAN1 UE features list for Rel-16 NR after RAN1#100-E Moderator (AT&T, NTT DOCOMO, INC.)

[2] R1-2001715 Discussion on the UE features for NR-U ZTE, Sanechips

[3] R1-2001720 Discussion on Rel-16 NRU UE features vivo

[4] R1-2001765 Discussion on UE feature for NRU OPPO

[5] R1-2001826 Views on Rel-16 UE features for NR-U MediaTek Inc.

[6] R1-2001941 Discussion on UE features for NR-U LG Electronics

[7] R1-2002016 UE features for NR-U Intel Corporation

[8] R1-2002037 UE features for NR-U Ericsson

[9] R1-2002151 UE features for NR-U Samsung

[10] R1-2002350 Discussions on NR-U UE features Apple

[11] R1-2002393 Discussion on UE feature for NR-U Sharp

[12] R1-2002480 On UE features NR Unlicensed Nokia, Nokia Shanghai Bell

[13] R1-2002563 Discussion on NR-U UE features Qualcomm Incorporated

[14] R1-2002589 Rel-16 UE features for NR-U Huawei, HiSilicon

[15] R1-2002683 UE Features for NR-U TCL Communications