**3GPP TSG RAN WG1 #100bis-e R1-2002866**

e-Meeting, April 20th – 30th, 2020

Source: NTT DOCOMO, INC.

Title: Summary on Email discussion [100b-e-NR-UEFeatures-NRU-05]

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-05] Email discussion/approval on issues with capability signaling impacts on FGs related to DL operation for NR-U (dates TBD) – Hiroki (DCM)

* Discuss on component(s) of each FG that need to be reported and candidate values for the component(s)
* Discuss on reporting type of each FG
* Discuss on the need of xDD and/or FRx differentiation for each FG of per-UE type
* Note that discussed FGs in this email discussion are derived by outcome of high priority email discussion in FL proposal 2

In the email discussion [100b-e-NR-UEFeatures-NRU-02], following agreements were made.

**Agreements:**

* Not introducing the separate FGs for each length, i.e., FG 10-8 is kept for “Type B PDSCH length {3, 5, 6, 8, [9, 10,] 11, 12, 13} without DMRS shift due to CRS collision”
* FG10-16 and FG10-16a are combined into a single FG for “One-shot HARQ ACK feedback”
* FG10-14 is kept for “Non-numerical PDSCH to HARQ-ACK timing”
* FG10-17 is kept for “Multi-PUSCH UL grant”
* FG10-15 is kept for “Enhanced dynamic HARQ codebook”

**Agreements:**

* FG10-9c is kept for “Joint search space group switching across multiple cells”
* For FG10-9/9a/9b
  + Alt.1: merge them into a single FG
  + Alt.2: keep two separate FGs: one for explicit (10-9) and another for implicit (10-9a/9b)
  + Alt.3: keep two separate FGs: one for 10-9/9a and another for 10-9b
  + Alt.4: keep two separate FGs: one for based on PDCCH detection in first 3 symbols and another for others
  + Alt.5: keep three original FGs

**Agreements:**

* Remove 10-19c

**Agreements:**

* FG10-26 is kept for “CSI-RS based RLM for NR-U”
* A new FG for “CSI-RS based RRM for NR-U” is added
* Remove 10-19
* FG10-19a is kept for “[Support DL reception in a carrier with intra-cell guard-bands]”
* FG10-19b is kept for “[Support UL transmission with subset of RB sets passing LBT]”

**Agreements:**

* A new FG 10-9d for “Support Search space set group switching capability 2” is added
* FG 10-9/9a is merged and FG10-9b is kept

**Agreements:**

* Keep 10-31 with bracket

# **10-8: Type B PDSCH length {3, 5, 6, 8, [9, 10,] 11, 12, 13} without DMRS shift due to CRS collision**

Based on agreements and [1], FG10-8 can be defined as below.

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **( 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 10. NR-unlicensed | 10-8 | Type B PDSCH length {3, 5, 6, 8, [9, 10,] 11, 12, 13} without DMRS shift due to CRS collision | 1. Type B PDSCH length {3, 5, 6, 8, [9, 10,] 11, 12, 13} without DMRS shift due to CRS collision | TBD | Yes | N/A |  | FFS: Per UE or per band | N/A | N/A | N/A | Note length 9/10 with DMRS shift due to CRS collision are already covered by 14-3 | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| Company | Comment |
| NTT DOCOMO | We are OK to remove the bracket on PDSCH length [9, 10] for supporting them without DMRS shift due to CRS collision.  We think the type of all FGs in NR-U should be “per band” and whether a FG can be applied to licensed band as well can be discussed later. |
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Following feedbacks are provided in contributions for the RAN1#100bis-e meeting.

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| [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*** |

# **10-9, 10-9b and 10-9d: Search space set group switching**

Based on agreements and [1], FG10-9/9b/9d can be defined as below.

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| 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 or with implicit PDCCH decoding with DCI 2\_0 monitoring | 1. Two groups of search space sets  2. Monitor DCI 2\_0 with a search space set switching field  3. Support switching the search space set group with PDCCH decoding in group 1  4. Support a timer to switch back to original search space set group  5. 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  (TBD) | 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 |
| 10-9b | 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  (TBD) | 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 |
| 10-9d | Support Search space set group switching capability 2 | 1. Search space set group switching Capability-2: P=10/12/22 symbols for µ = 0/1/2 SCS | 10-9 or 10-9b  (TBD) | Yes | N/A |  | FFS: Per UE or per band | N/A | N/A |  |  | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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

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| [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. |

# **10-9c: Joint search space group switching across multiple cells**

Based on agreements and [1], FG10-9c can be defined as below.

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| 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 | 10-9c | 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 |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| Company | Comment |
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# **10-14: Non-numerical PDSCH to HARQ-ACK timing**

Based on agreements and [1], FG10-14 can be defined as below.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **( 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 10. NR-unlicensed | 10-14 | 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 | TBD  Need discussion for licensed use | Yes | N/A |  | Per band or per UE | N/A | N/A | N/A | If non-numerical K1 value is supported | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| Company | Comment |
| Huawei, HiSilicon | We suggest some update of the components descriptions as shown below, mostly to refer to the relevant RRC parameters for RAN2’s understanding*.*   |  |  |  | | --- | --- | --- | | 10-14 | Non-numerical PDSCH to HARQ-ACK timing | 1. 1. Support configuration of a value for dl-DataToUL-ACK indicating an inapplicable time to report HARQ ACK (*dl-DataToUL-ACK-r16* configured with value -1) | |
| NTT DOCOMO | Agree with the comment from Huawei.  We think the type of all FGs in NR-U should be “per band” and whether a FG can be applied to licensed band as well can be discussed later. |
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Following feedbacks on FG10-14/15/16/17 are provided in contributions for the RAN1#100bis-e meeting.

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| [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. |

# **10-15: Enhanced dynamic HARQ codebook**

Based on agreements and [1], FG10-15 can be defined as below.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **( 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 10. NR-unlicensed | 10-15 | 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 | TBD  Need discussion for licensed use | Yes | N/A |  | Per band or per UE | N/A | N/A | N/A | Enhanced dynamic HARQ codebook supporting grouping of HARQ ACK and triggering the retransmission of HARQ ACK in each groups | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | We suggest some update of the components descriptions as shown below, mostly to refer to the relevant RRC parameters for RAN2’s understanding.   |  |  |  | | --- | --- | --- | | 10-15 | Enhanced dynamic HARQ codebook | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1 (configuration of *nfi-TotalDAI-Included*)  2. Support of bit field in DCI 0\_1 for other group total DAI if configured. (configuration of *ul-TotalDAI-Included*)  3. Support the retransmission of HARQ ACK (pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16) | |
| NTT DOCOMO | Agree with the comment from Huawei.  We think the type of all FGs in NR-U should be “per band” and whether a FG can be applied to licensed band as well can be discussed later. |
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# **10-16: One-shot HARQ ACK feedback**

Based on agreements and [1], FG10-16 can be defined 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**  **( 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 | 10-16 | 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 2. 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 | TBD  Need discussion for licensed use | Yes | N/A |  | Per band or per UE | N/A | N/A | N/A | Upon triggering, UE reports A/N for all HARQ processes and all CCs in a PUCCH group. | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| --- | --- |
| Company | Comment |
| NTT DOCOMO | Agree with modification from Qualcomm as follow:   |  |  |  | | --- | --- | --- | | 10-16 | One-shot HARQ ACK feedback | 1. Support feedback of type 3 HARQ-ACK codebook, triggered by a DCI 1\_1 scheduling a PDSCH 2. Support feedback of type 3 HARQ-ACK codebook , triggered by a DCI 1\_1 without scheduling a PDSCH using a reserved FDRA value |   We think the type of all FGs in NR-U should be “per band” and whether a FG can be applied to licensed band as well can be discussed later. |
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# **10-17: Multi-PUSCH UL grant**

Based on agreements and [1], FG10-17 can be defined as below.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **( 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 10. NR-unlicensed | 10-17 | Multi-PUSCH UL grant | 1. Support of scheduling up to 8 PUSCH with a single DCI 0\_1 | TBD  Need discussion for licensed use | Yes | N/A |  | Per band or per UE | N/A | N/A | N/A |  | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We think the type of all FGs in NR-U should be “per band” and whether a FG can be applied to licensed band as well can be discussed later. |
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# **[10-19a/19b: wideband operation]**

Based on agreements and [1], FG10-19a/19b can be defined as below.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 | [10-19a] | [Support DL reception in a carrier with intra-cell guard-bands] | 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 |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| Company | Comment |
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# **10-26/26a: CSI-RS based measurement for NR-U**

Based on agreements and [1], FG10-26/26a can be defined as below.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 for NR-U | [CSI-RS based RLM for NR-U] | TBD | Yes | N/A |  | Per band | N/A | N/A |  |  | Optional with capability signalling |
| 10-26a | CSI-RS based RRM for NR-U | [CSI-RS based RRM for NR-U] | TBD | Yes | N/A |  | Per band | N/A | N/A |  |  | Optional with capability signalling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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

Based on agreements and [1], FG10-26/26a can be defined 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 (TBD) | Yes | N/A |  | [Per band] | N/A | N/A |  |  | Optional with capability signaling |

**Companies are encouraged to provide feedbacks focusing on signaling design aspects (e.g., components with candidate values for reporting, Type, Need of xDD/FRx differentiation).**

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| Company | Comment |
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# **Conclusion**

FL proposal

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (V2X WI only)”. | **Consequence if the feature is not supported by the UE** | **Type**  **( 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 10. NR-unlicensed | 10-8 | Type B PDSCH length {3, 5, 6, 8, [9, 10,] 11, 12, 13} without DMRS shift due to CRS collision | 1. Type B PDSCH length {3, 5, 6, 8, [9, 10,] 11, 12, 13} without DMRS shift due to CRS collision | TBD | Yes | N/A |  | Per band | N/A | N/A | N/A | Note length 9/10 with DMRS shift due to CRS collision are already covered by 14-3 | Optional with capability signalling |
| 10. NR-unlicensed | 10-9 | Search space set group switching with explicit DCI 2\_0 bit field trigger or with implicit PDCCH decoding with DCI 2\_0 monitoring | 1. Two groups of search space sets  2. Monitor DCI 2\_0 with a search space set switching field  3. Support switching the search space set group with PDCCH decoding in group 1  4. Support a timer to switch back to original search space set group  5. 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  (TBD) | 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. NR-unlicensed | 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  (TBD) | 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. NR-unlicensed | 10-9c | Joint search space group switching across multiple cells | 1. Configured with a group of cells and switch search space set group jointly over these cells | TBD | Yes | N/A |  | 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 |
| 10. NR-unlicensed | 10-9d | Support Search space set group switching capability 2 | 1. Search space set group switching Capability-2: P=10/12/22 symbols for µ = 0/1/2 SCS | 10-9 or 10-9b  (TBD) | Yes | N/A |  | FFS: Per UE or per band | N/A | N/A |  |  | Optional with capability signalling |
| 10. NR-unlicensed | 10-14 | Non-numerical PDSCH to HARQ-ACK timing | 1. Support configuration of a value for dl-DataToUL-ACK indicating an imapplicable time to report HARQ ACK | TBD  Need discussion for licensed use | Yes | N/A |  | Per band | N/A | N/A | N/A | If non-numerical K1 value is supported | Optional with capability signalling |
| 10. NR-unlicensed | 10-15 | Enhanced dynamic HARQ codebook | 1. Support of bit fields signalling PDSCH HARQ group index and NFI in DCI 1\_1 (configuration of *nfi-TotalDAI-Included*)  2. Support of bit field in DCI 0\_1 for other group total DAI if configured. (configuration of *ul-TotalDAI-Included*)  3. Support the retransmission of HARQ ACK (pdsch-HARQ-ACK-Codebook = enhancedDynamic-r16) | TBD  Need discussion for licensed use | Yes | N/A |  | Per band | N/A | N/A | N/A | Enhanced dynamic HARQ codebook supporting grouping of HARQ ACK and triggering the retransmission of HARQ ACK in each groups | Optional with capability signalling |
| 10. NR-unlicensed | 10-16 | One-shot HARQ ACK feedback | 1. Support feedback of type 3 HARQ-ACK codebook, triggered by a DCI 1\_1 scheduling a PDSCH 2. Support feedback of type 3 HARQ-ACK codebook , triggered by a DCI 1\_1 without scheduling a PDSCH using a reserved FDRA value | TBD  Need discussion for licensed use | Yes | N/A |  | Per band | N/A | N/A | N/A | Upon triggering, UE reports A/N for all HARQ processes and all CCs in a PUCCH group. | Optional with capability signalling |
| 10. NR-unlicensed | 10-17 | Multi-PUSCH UL grant | 1. Support of scheduling up to 8 PUSCH with a single DCI 0\_1 | TBD  Need discussion for licensed use | Yes | N/A |  | Per band | N/A | N/A | N/A |  | Optional with capability signalling |
| 10. NR-unlicensed | [10-19a] | [Support DL reception in a carrier with intra-cell guard-bands] | 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 (TBD) | 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. NR-unlicensed | [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 (TBD) | 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. NR-unlicensed | 10-26 | CSI-RS based RLM for NR-U | [CSI-RS based RLM for NR-U] | TBD | Yes | N/A |  | Per band | N/A | N/A |  |  | Optional with capability signalling |
| 10. NR-unlicensed | 10-26a | CSI-RS based RRM for NR-U | [CSI-RS based RRM for NR-U] | TBD | Yes | N/A |  | Per band | N/A | N/A |  |  | Optional with capability signalling |
| 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 (TBD) | Yes | N/A |  | [Per band] | N/A | N/A |  |  | Optional with capability signaling |

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| Company | Comment |
| Ericsson | Like discussed in our contribution, we would prefer to add FFS: Per band or Per UE to the following FGs:   * 10-8 (Additional Type B PDSCH lengths) * 10-16 (One-shot HARQ ACK feedback * 10-17 (Multi-PUSCH UL grant)   Given that we have redefined the basic FGs, the pre-requisites FGs column is now out of date. We think all pre-requisites should be removed and replaced with TBD. |
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# **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

[16] R1-2002863 Summary on Email discussion [100b-e-NR-UEFeatures-NRU-02] Moderator (NTT DOCOMO, INC.)