**3GPP TSG RAN WG1 #107-e R1-211xxxx**

**e-Meeting, November 11th – 19th, 2021**

**Agenda item:** 8.16.8

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

**Title:** [draft] Summary on UE features for NR coverage enhancement

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 8.16.8 regarding UE features for NR coverage enhancement and captures the following email discussion.

|  |
| --- |
| [107-e-R17-UE-features-CovEnh-01] Email discussion UE features for NR coverage enhancement – Shinya (DOCOMO) * 1st check point: November 15
* Final check point: November 19
 |

In the updated RAN1 UE features list for Rel-17 NR after RAN1 #106bis-e [1], there are following feature groups for NR coverage enhancement.

* 30-1 Increased maximum number of PUSCH Type A repetitions
* 30-1a Increased maximum number of Type 2 configured grant PUSCH Type A repetitions
* 30-2 PUSCH Type A repetitions based on available slots
* 30-2a Configured grant PUSCH Type A repetitions based on available slots
* 30-3 TB processing over multi-slot PUSCH
* 30-4 [The maximum duration for DM-RS bundling]
* 30-4a [DM-RS bundling for PUSCH repetition type A]
* 30-4b [DM-RS bundling for PUSCH repetition type B]
* 30-4c [DM-RS bundling for TB processing over multi-slot PUSCH]
* 30-4d [DMRS bunding for PUCCH repetitions]
* 30-4e [Inter-slot frequency hopping with inter-slot bundling for PUSCH]
* 30-4f [Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling]
* 30-4g [Restart DM-RS bundling after the events that violate power consistency and phase continuity]
* 30-5 Slot based dynamic PUCCH repetition indication
* 30-6 Msg3 repetition

The issues to be discussed are tagged and colour coded with High priority, Medium priority, or Low priority, considering RAN2 impact especially for capability signaling design.

In this round of the discussion, companies are requested to provide comments on the proposals and questions tagged FL1.

# **30-1 to 30-2a: Enhancements for PUSCH Type A repetitions**

In [1], FGs 30-1 to 30-2a 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 (Sidelink 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 |
|  30. NR\_cov\_enh | 30-1 | Increased maximum number of PUSCH Type A repetitions | K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions.The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a DCI. | [5-17] | Yes | N/A | UE does not support more than 16 repetitions. | [Per UE] | No | No | N/A |  | [Optional with capability signalling] |
|  30. NR\_cov\_enh | 30-1a | Increased maximum number of Type 2 configured grant PUSCH Type A repetitions | K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions.The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a Type 1 configured grant configuration. | [5-16], [30-1] | Yes | N/A | UE does not support more than 16 repetitions for Type 2configurecd grant PUSCH. | [Per UE] | No | No | N/A |  | [Optional with capability signalling] |
| 30. NR\_cov\_enh | 30-2 | PUSCH Type A repetitions based on available slots | Transmission occasions for K repetitions are determined on the basis of available slots. RV is cycled across transmission occasions. | [5-17] | Yes | N/A | UE does not support PUSCH repetitions counted on the basis of available slots. | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |
| 30. NR\_cov\_enh | 30-2a | Configurecd grant PUSCH Type A repetitions based on available slots | Transmission occasions for K repetitions for configured grant PUSCH are determined on the basis of available slots. RV is cycled across transmission occasions. | [5-14 or 5-16], [30-2] | Yes | N/A | UE does not support configured grant PUSCH repetitions counted on the basis of available slots. | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | Huawei, HiSilicon | **Whether the features are Mandatory or Optional**As enhanced features in Rel-17, considering UE capabilities and flexibility, all the UE features for coverage enhancement listed in [1] should be optional with capability signaling. Specifically, for FG 30-6 related to Msg3 repetition, the feature can realize optional based on whether to access via separate RACH resources without capability signaling. However, capability signaling after beyond the RACH procedure can help the gNB properly configure RACH resources for different purposes. Thus, FG 30-6 should be optional with capability signaling. ***Proposal 1:*** ***For FG 30-1 to FG 30-6,*** ***all the UE features should be optional with capability signaling.*****The need of FDD/TDD differentiation**For all the features, there seems no justification or evidence to support the need for FDD/TDD differentiation. The FDD/TDD differentiation is unnecessary.***Proposal 2: For FG 30-1 to FG 30-6, the FDD/TDD differentiation is unnecessary.*** |
|  |  | **The type of granularity**First of all, it should be noted that, there are certain reasons to define that the FG 30-4 is set per band. As previously described, the compensation leftover for frequency error and RF characteristics may be different for different bands. However, analyzing RF and determining the values of the maximum duration for all bands will result in very heavy workload and is unnecessary. Considering above, it is a good choice to define the UE feature of maximum duration, i.e. FG 30-4, based on the granularity of Per UE and with FR1/FR2 differentiation.For other features except for FG 30-4, there is no particular reason to apply other granularities. Per UE is sufficient.***Proposal 7: All the UE feature for NR coverage enhancement should be based on the granularity of Per UE.*****The structure of the features related to enhanced PUSCH repetition type A and TBoMS**In our view, only one FG for both CG and DG is sufficient. But we are also open to splitting that into CG and DG, or into type 1 CG, type 2 CG and DG, which enables more flexibility in supporting and reporting UE capabilities. The details of components and prerequisite feature groups are up to the structure. |
| [3] | ZTE | **Increased maximum number of PUSCH Type A repetitions**In [1], two separate UE feature groups (FG 30-1 and 30-1a) are introduced for dynamic grant (DG) and configured grant (CG) PUSCH respectively. In our view, there is no need two separate UE FGs as there is no complexity difference to support increased maximum number of repetitions between DG and CG PUSCH. This is similar as Rel-16 URLLC FG 11-5, where only one FG is introduced for dynamic PUSCH repetition indication for both DG and CG PUSCH. Based on above, we propose to merge FG 30-1 and FG 30-1a. In such case, the prerequisite FG should be updated correspondingly. Regarding the reporting type, we think per UE reporting is sufficient. ***Proposal 1:*** *Merge FG 30-1 and FG 30-1a with the following revisions.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | **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)** |
|  30. NR\_cov\_enh | 30-1 | Increased maximum number of PUSCH Type A repetitions | Support the number of repetitions K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 for PUSCH Type A repetitions ~~times repetitions~~.The number of repetitions is jointly coded with SLIV in TDRA list, by adding an additional column for the number of repetitions in the TDRA table. A row index of the TDRA list is indicated by a DCI or a Type 1 configured grant configuration. | ~~[5-17]~~One of {5-14, 5-16, 5-17} | ~~[~~Per UE~~]~~ |
|  ~~30. NR\_cov\_enh~~ | ~~30-1a~~ | ~~Increased maximum number of Type 2 configurecd grant PUSCH Type A repetitions~~ | ~~K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions.~~* ~~The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a Type 1 configured grant configuration.~~
 | ~~[5-16], [30-1]~~ | ~~[Per UE]~~ |

**Counting based on available slots**Similar as Proposal 1, we propose to merge FG 30-2 and FG 30-2a. The prerequisite FG is not needed as legacy FG is based on counting by physical slots. Regarding the reporting type, we think per UE reporting is sufficient. As for the ‘Need of FDD/TDD differentiation’, it depends on further discussion in AI 8.8.1.1.***Proposal 2:*** *Merge FG 30-2 and FG 30-2a with the following revisions.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | **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** |
|  30. NR\_cov\_enh | 30-2 | PUSCH Type A repetitions based on available slots | Transmission occasions for K repetitions are determined on the basis of available slots including both dynamic grant and configured grant PUSCH repetition type A. RV is cycled across transmission occasions. | ~~[5-17]~~ | ~~[~~Per UE~~]~~ | FFS |
| ~~30. NR\_cov\_enh~~ | ~~30-2a~~ | ~~Configurecd grant PUSCH Type A repetitions based on available slots~~ | ~~Transmission occasions for K repetitions for configured grant PUSCH are determined on the basis of available slots. RV is cycled across transmission occasions.~~ | ~~[5-14 or 5-16], [30-2]~~ | ~~[Per UE]~~ | FFS |

 |
| [5] | Nokia, Nokia Shanghai Bell | * **30-1, 30-1a, 30-2, 30-2a, 30-3, 30-4, 30-4a/b/c/d/e/f/g, 30-5, 30-6:**
	+ Confirm the FGs. Details to be finalized later.
* **30-1:**
	+ Move candidate values to notes column. No need to list the legacy values, hence only list values for K>16.
	+ Add FG11-6 (PUSCH repetition Type A) as pre-requisite
* **30-1a:**
	+ Similarly to FG30-1, move values to notes column and restrict range to K>16
* **30-2:**
	+ Add 30-1 as pre-requisite
* **30-2a:**
	+ Replace pre-requisite FG5-16 with FG30-1a
 |
| [6] | Intel Corporation | As listed in the Appendix, UE feature groups 30-1 and 30-1a are included for increased maximum number of repetitions for PUSCH repetition type A enhancement. Note that as agreed in RAN1#104-e meeting, the maximum number of repetitions for DG-PUSCH is also applicable to CG-PUSCH [3]. Following this agreement, it may be more appropriate to further divide the UE feature group for CG-PUSCH for the increased maximum number of repetitions. The same principle can also apply for the PUSCH repetition type A based on available slots.Based on the discussions above, Table 1 illustrates suggested update for UE feature groups for PUSCH repetition type A enhancement. Table 1. UE feature groups for PUSCH repetition type A enhancement

|  |  |  |
| --- | --- | --- |
| **Index** | **Feature group** | **Components** |
| 30-1 | Increased maximum number of PUSCH Type A repetitions for DG-PUSCH | K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 ~~times~~ repetitions.~~The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a DCI.~~ |
| 30-1a | Increased maximum number of ~~Type 2 configurecd grant~~ PUSCH Type A repetitions for CG-PUSCH | K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 ~~times~~ repetitions.~~The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a Type 1 configured grant configuration.~~ |
| 30-2 | PUSCH Type A repetitions based on available slots for DG-PUSCH | Transmission occasions for K repetitions are determined on the basis of available slots. ~~RV is cycled across transmission occasions~~. |
| 30-2a | ~~Configurecd grant~~ PUSCH Type A repetitions based on available slots for CG-PUSCH | Transmission occasions for K repetitions for configured grant PUSCH are determined on the basis of available slots. ~~RV is cycled across transmission occasions.~~ |

**Proposal 1*** *For PUSCH repetition type A enhancement, divide UE feature groups into DG-PUSCH and CG-PUSCH.*
* *Consider Table 1 as a starting point for discussion of feature groups for PUSCH repetition type A enhancement.*
 |
| [7] | Samsung | Current FGs for enhanced PUSCH repetition Type A are separated for dynamic grant (DG, FG 30-1/30-2) and for configured grant (CG, FG 30-1a/30-2a). It is the approach taken in Rel-15 for PUSCH repetition, e.g., FG 5-16/5-17. On the other hand, in Rel-16, a single capability (FG 11-5) consists of DG and CG. In our view, the Rel-16 approach simplifies the capability signalling. Even for UE implementation perspective, we do not see the value of differentiating DG and CG from UE capability.In this regard, we are fine with moderator’s latest proposal 2-1 from RAN1#106bis-e by removing the FFS [1].**Proposal 1: Combine DG and CG into a single feature group, i.e., merge FGs 30-1 and 30-1a and merge FGs 30-2 and 30-2a.**

|  |  |  |
| --- | --- | --- |
| **Index** | **Feature group** | **Components** |
| 30-1 | Increased maximum number of PUSCH Type A repetitions | 1. K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions for DG-PUSCH. The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a DCI.2. K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions for Type 2 CG-PUSCH. The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a Type 2 configured grant configuration. |
| ~~30-1a~~ | ~~Increased maximum number of Type 2 configurecd grant PUSCH Type A repetitions~~ | ~~K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions.~~~~The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a Type 1 configured grant configuration.~~ |
| 30-2 | PUSCH Type A repetitions based on available slots | 1. Transmission occasions for K repetitions for DG-PUSCH are determined on the basis of available slots. RV is cycled across transmission occasions.2. Transmission occasions for K repetitions for CG-PUSCH are determined on the basis of available slots. RV is cycled across transmission occasions. |
| ~~30-2a~~ | ~~Configurecd grant PUSCH Type A repetitions based on available slots~~ | ~~Transmission occasions for K repetitions for configured grant PUSCH are determined on the basis of available slots. RV is cycled across transmission occasions.~~ |

All Rel-17 FGs should be “Optional with capability signaling”. We may need to decide which FG is the basic FG for Rel-17 Coverage Enhancement.**Proposal 6: Set “Optional with capability signaling” for all feature groups under Rel-17 Coverage Enhancement.** |
| [8] | Apple | Currently, there is no consensus whether Rel-15 FG design principle or Rel-16 FG design principle should be adopted. Considering how to support 32 repetitions for type 1 CG PUSCH is still open, different solutions could be adopted for type 1 and type 2 CG PUSCH. Thus, merge or separate the FGs can be discussed later after the progress on AI 8.8.1.1.**Proposal 1: Merging or splitting the FGs for repetition enhancement is depending on the progress on type 1 CG PUSCH repetition.**All the UL coverage enhancement features are based on existing specification and implementation. Thus, whether support the enhanced features should leave the choice to UE implementation. **Proposal 4: UL enhancement features groups are optional with UE capability.** |
| [9] | Ericsson | For Type A PUSCH repetition, a set of UE features discussed so far are summarized and updated in Table 1. There were no updates to the features to the feature list in RAN1#106bis, and so the changes are shown with respect to the features as listed in [5]. The main updates proposed are:**30-1:** The Rel-15 repetition factor of PUSCH repetition is configured in a semi-static way. While in Rel-16, it can be dynamically indicated by DCI 0\_1 or DCI 0\_2. Based on the agreement in RAN1#106e that DCI format 0\_1 and DCI format 0\_2 support Rel-17 PUSCH repetition Type A with the increased maximum repetition numbers configured in TDRA lists, we think Rel-17 PUSCH repetition Type A with increased maximum repetition numbers is based on Rel-16 PUSCH repetition Type A, which is [11-6].**30-1a:** 2 Typos are corrected. And given [30-1] already includes [11-6] which is for both CG Type 2 PUSCH and DG PUSCH, we should remove [5-16].**30-2:** Time domain resource allocation of Rel-17 PUSCH repetition based on available slots is configured in the same way as PUSCH repetition with increased number of repetitions. Therefore, its prerequisite feature group is Rel-16 PUSCH repetition with dynamic indication of number of repetitions [11-6].**30-2a:** Since whether Type 1 CG-PUSCH will support repetitions counting on the basis of available slots is still open, no agreement has been made yet. So we should remove [5-14] (Type 1 configured PUSCH repetitions over multiple slots) at this stage unless RAN1 agrees on enhancing CG Type 1 PUSCH repetition to support repetition factors counted based on available slot, and clarify that Type 2 is supported in the feature group name. And given [30-2] already includes [11-6] which is for both CG Type 2 PUSCH and DG PUSCH, we should also remove [5-16].Table 1: Capabilities for PUSCH Repetition Type A Enhancement

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | Feature group | Components | Prerequisite feature groups | Comments |
| 30-1 | Increased maximum number of PUSCH Type A repetitions | K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions.The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a DCI. | ~~[5-17]~~ [11-6] |  |
| 30-1a | Increased maximum number of Type 2 configure~~c~~d grant PUSCH Type A repetitions | K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions.The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a Type ~~1~~2 configured grant configuration. | ~~[5-16],~~ [30-1] |  |
| 30-2 | PUSCH Type A repetitions based on available slots | Transmission occasions for K repetitions are determined on the basis of available slots. RV is cycled across transmission occasions. | ~~[5-17]~~ [11-6] |  |
| 30-2a | Type 2 configured grant PUSCH Type A repetitions based on available slots | Transmission occasions for K repetitions for configured grant Type 2 PUSCH are determined on the basis of available slots. RV is cycled across transmission occasions. | ~~[5-14 or 5-16],~~ [30-2] |  |

1. UE features for PUSCH Repetition Type A Enhancement are defined according to Table 1.
 |
| [10] | NTT DOCOMO, INC. | At the RAN1#106 bis-e meeting, the structure of FGs 30-1 to 30-2a was discussed and 4 options were summarized by FL [2]. Regarding the increased maximum number of PUSCH Type A repetitions, RRC parameter “*numberOfRepetitions-r17* “ will be introduced in TDRA table and the parameter is common for DG-PUSCH and Type 2 CG-PUSCH. Therefore, FG 30-1 for DG-PUSCH and FG 30-1a for Type 2 CG-PUSCH should be merged. Regarding the PUSCH Type A repetitions based on available slots, it was agreed that a single RRC parameter “*AvailableSlotCounting”* is applied for both DG-PUSCH and CG-PUSCH. Therefore, FG 30-2 for DG-PUSCH and FG 30-2a for CG-PUSCH should be merged as well.**Proposal 1: FGs 30-1 and 30-1a should be merged, and FGs 30-2 and 30-2a should be merged. (Option 1).**It was also discussed that the FGs are supported per UE or per band. The merged FGs 30-1 and 30-2 are related to the PUSCH Type A repetitions, so that they are not band specific features. Therefore merged FGs 30-1 and 30-2 can be per UE.**Proposal 2: Merged FGs 30-1 and 30-2 can be supported per UE.**Regarding optional or mandatory with capability signaling, the FGs should be supported as optional feature with capability signaling, because it has not been agreed that any CovEnh feature is mandatory to support.**Proposal 3: All CovEnh features should be supported as optional feature with capability signaling.** |
| [11] | Sharp | In RAN1#106bis-e, companies had different views on whether to have a single feature group or separate feature groups for DG-PUSCH and CG-PUSCH, for each of the increased maximum number of PUSCH Type A repetitions and the PUSCH Type A repetitions based on available slots. After several rounds of discussions, FL provided the following proposal. Considering that the majority was in favor of it, we are fine with it.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **[FL4] High priority proposal 2-1:*** FG 30-1a is merged into FG 30-1 as follows
* FG 30-2a is merged into FG 30-2 as follows

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 30. NR\_cov\_enh | 30-1 | Increased maximum number of PUSCH Type A repetitions | 1. K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions for DG-PUSCH. The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a DCI.
2. K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions for Type 2 CG PUSCH. The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a Type 2 configured grant configuration.

FFS whether/how to separate FG 30-1 into multiple FGs | [5-16], [5-17] | Yes | N/A | UE does not support more than 16 repetitions. | [Per UE] | No | No | N/A |  | [Optional with capability signalling] |
| 30. NR\_cov\_enh | 30-2 | PUSCH Type A repetitions based on available slots | 1. Transmission occasions for K repetitions for DG-PUSCH are determined on the basis of available slots. RV is cycled across transmission occasions.
2. Transmission occasions for K repetitions for CG-PUSCH are determined on the basis of available slots. RV is cycled across transmission occasions.

FFS whether/how to separate FG 30-2 into multiple FGs | [5-14 or 5-16], [5-17] | Yes | N/A | UE does not support PUSCH repetitions counted on the basis of available slots. | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |

 |

***Proposal 1: FG 30-1a is merged into FG 30-1, and FG 30-2a is merged into FG 30-2.*** |
| [12] | Qualcomm Incorporated | **General remark applicable to all features for NR coverage enhancement****Proposal 1:** Unless otherwise stated, the type for a UE feature should be at least per band (if not with finer granularity type), given the potential UE testing differentiation among licensed, unlicensed, and NTN band.**On PUSCH Type A repetition enhancements**On the question of UE supporting PUSCH Type A repetition enhancements, we prefer to have separate capabilities for CG and DG cases. We have the following proposal:**Proposal 2:** Ensure UE capabilities for PUSCH Type A repetitions are separately indicated for CG and DG scenarios:* + - Split 30-1 and 30-1a into 3 separate FGs: 1st one for DG, 2nd one for type 1 CG, 3rd one for type 2 CG
		- Split 30-2 and 30-2a into 3 separate FGs: 1st one for DG, 2nd one for type 1 CG, 3rd one for type 2 CG

**Additional comments and suggested changes to the UE features table:****Proposal 11:** Additional comments and suggested changes to the UE features table for coverage enhancement are included in the following table, with changes marked in red.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 30. NR\_cov\_enh | 30-1 | Increased maximum number of PUSCH Type A repetitions | K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions.The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a DCI. | [5-17] | Yes | N/A | UE does not support more than 16 repetitions.In some cases repetitions are limited to 8 (legacy type 1 CG PUSCH) | ~~[Per UE]~~ Per Band | ~~No~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
|  30. NR\_cov\_enh | 30-1a | Increased maximum number of Type 2 configured grant PUSCH Type A repetitionsIs this for Type 1 or Type 2? Please add 30-2b for the other type. | K = 1, 2, 3, 4, 7, 8, 12, 16, 20, 24, 28, 32 times repetitions.The number of repetitions is jointly coded with SLIV in TDRA list. A row index of the TDRA list is indicated by a Type 1 configured grant configuration.The above text mentions Type 1, but feature group description points to Type 2. Needs clarification. | [5-16], ~~[30-1]~~Dependence on [30-1] is not necessary. | Yes | N/A | UE does not support more than 16 repetitions for Type 2 configurecd grant PUSCH.In some cases repetitions are limited to 8 (legacy type 1 CG PUSCH) | ~~[Per UE]~~ Per Band | ~~No~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
|  30. NR\_cov\_enh | 30-2 | PUSCH Type A repetitions based on available slots | Transmission occasions for K repetitions for PUSCH scheduled by DCI are determined on the basis of available slots. RV is cycled across transmission occasions. | [5-17] | Yes | N/A | UE does not support PUSCH repetitions counted on the basis of available slots. | ~~[Per UE]~~ Per Band | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
| 30. NR\_cov\_enh | 30-2a | Configured grant PUSCH Type A repetitions based on available slots | Transmission occasions for K repetitions for configured grant PUSCH are determined on the basis of available slots. RV is cycled across transmission occasions. | [5-14 or 5-16], ~~[30-2]~~Dependence on [30-2] is not necessary. | Yes | N/A | UE does not support configured grant PUSCH repetitions counted on the basis of available slots. | ~~[Per UE]~~ Per Band | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |

 |
| [13] | MediaTek Inc. | Proposal 1: For enhancement of PUSCH Type A repetitions, separated FGs for DG, CG Type 2 and CG Type 1 (if supported).Proposal 7: All UE features are per band.Proposal 9: All UE features are optional with capability signalling |

## **Discussion**

**[FL1] High priority question 2-1:**

* **Companies are encouraged to provide views on whether/how to separate/merge FGs 30-1 to 30-2a, e.g.,**
	+ Option 1: [Huawei, HiSilicon], Intel
		- Keep current structure, i.e.,
			* FGs 30-1 for DG, 30-1a for type 2 CG (and potentially will include type 1 CG)
			* FGs 30-2 for DG, 30-2a for type 2 CG (and potentially will include type 1 CG)
	+ Option 2: Huawei, HiSilicon, ZTE, Samsung, DOCOMO, Sharp
		- Merge FGs 30-1 and 30-1a into an FG
		- Merge FGs 30-2 and 30-2a into an FG
	+ Option 3: [Huawei, HiSilicon], Qualcomm, MediaTek
		- Split 30-1 and 30-1a into 3 separate FGs: 1st one for DG, 2nd one for type 1 CG, 3rd one for type 2 CG
		- Split 30-2 and 30-2a into 3 separate FGs: 1st one for DG, 2nd one for type 1 CG, 3rd one for type 2 CG
	+ Option 4: Apple
		- Wait for progress on AI 8.8.1.1

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We support Option2. Single RRC parameter is used for DG and CG at least for FGs 30-2 and 30-2a, so that it’s better to follow RAN2 guidance as in R1-2001513 (Avoid defining functionality that has no RRC configuration but is dependent on capability bits.).  |
| Panasonic | We support Option 2. |
| QC | Support Option 3. Separation between CG and DG would be good. Development and commercialization of DG and CG features are not in sync.  |
| Intel | We support Option 1. We prefer to differentiate DG and CG for both increased maximum number of repetitions and counting based on available slots. In our view, CG-PUSCH is already optional w/ capability signaling. It would be more preferrable to differentiate these two cases.  |
| ZTE | Support Option 2. CG type 1 should also be included in the merged FG for FGs 30-1 and 30-1a. |
| Apple | We are ok with option 1 and option 3. Which one is selected is up to the progress of AI8.8.1.1. |

**Medium priority proposal 2-2:**

* **The column for “Mandatory/Optional” in FGs 30-1 to 30-2a is confirmed as “Optional with capability signaling”**

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We support the FL proposal. |
| Panasonic | We are fine with Proposal 2-2. |
| QC | Support |
| Intel | We are fine with FL proposal.  |
| ZTE | Fine |
| Apple | Support |

**Medium priority question 2-3:**

* **Companies are encouraged to provide views on whether the type of FGs 30-1 to 30-2a should be per UE or per band**
	+ Per UE: Huawei, HiSilicon, ZTE, DOCOMO
		- FDD/TDD differentiation is not necessary: Huawei, HiSilicon
	+ Per band: Qualcomm, MediaTek

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We support per UE since they are not band specific features. |
| Panasonic | We support “per UE”. |
| QC | Urge companies to think about testing and certification of features implemented by a UE. Suggest going with “per band”.  |
| Intel | We support per UE.  |
| ZTE | Per UE is sufficient.  |
| Apple | We support per band. |

**Low priority question 2-4:**

* **Companies are encouraged to provide views on whether/how to revise the sentence in “Consequence if the feature is not supported by the UE”, e.g.,**
	+ **Add “In some cases repetitions are limited to 8 (legacy type 1 CG PUSCH)” in FGs 30-1 and/or 30-1a**

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

**Low priority question 2-5:**

* **Companies are encouraged to provide views on whether/how to revise the prerequisite feature groups for FGs 30-1 to 30-2a**

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

**Low priority question 2-6:**

* **Companies are encouraged to provide views on whether/how to revise any other contents in FGs 30-1 to 30-2a which do not have capability signaling impacts**

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

# **30-3: TB processing over multi-slot PUSCH**

In [1], FG 30-3 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 (Sidelink 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 |
| 30. NR\_cov\_enh | 30-3 | TB processing over multi-slot PUSCH | Support of TB processing over multi-slot PUSCH in RRC connected mode. | [11-6] | Yes | N/A | UE does not support TB processing over multi-slot PUSCH. | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | Huawei, HiSilicon | **Whether the features are Mandatory or Optional**As enhanced features in Rel-17, considering UE capabilities and flexibility, all the UE features for coverage enhancement listed in [1] should be optional with capability signaling. Specifically, for FG 30-6 related to Msg3 repetition, the feature can realize optional based on whether to access via separate RACH resources without capability signaling. However, capability signaling after beyond the RACH procedure can help the gNB properly configure RACH resources for different purposes. Thus, FG 30-6 should be optional with capability signaling. ***Proposal 1: For FG 30-1 to FG 30-6, all the UE features should be optional with capability signaling.*****The need of FDD/TDD differentiation**For all the features, there seems no justification or evidence to support the need for FDD/TDD differentiation. The FDD/TDD differentiation is unnecessary.***Proposal 2: For FG 30-1 to FG 30-6, the FDD/TDD differentiation is unnecessary.*****The type of granularity**First of all, it should be noted that, there are certain reasons to define that the FG 30-4 is set per band. As previously described, the compensation leftover for frequency error and RF characteristics may be different for different bands. However, analyzing RF and determining the values of the maximum duration for all bands will result in very heavy workload and is unnecessary. Considering above, it is a good choice to define the UE feature of maximum duration, i.e. FG 30-4, based on the granularity of Per UE and with FR1/FR2 differentiation.For other features except for FG 30-4, there is no particular reason to apply other granularities. Per UE is sufficient.***Proposal 7: All the UE feature for NR coverage enhancement should be based on the granularity of Per UE.*****The structure of the features related to enhanced PUSCH repetition type A and TBoMS**In our view, only one FG for both CG and DG is sufficient. But we are also open to splitting that into CG and DG, or into type 1 CG, type 2 CG and DG, which enables more flexibility in supporting and reporting UE capabilities. The details of components and prerequisite feature groups are up to the structure. |
| [3] | ZTE | For UE FG 30-3 for TBoMS, we basically agree with that one FG is sufficient based on the agreements so far. More components could be added once all related functionalities are clear.However, we don’t think the prerequisite FG is needed as FG 11-6 is for single TB operation and TBoMS only borrows part of the features from FG 11-6, i.e., the time domain location, while not others e.g., RV design. Regarding the reporting type, we think per UE reporting is sufficient. As for the ‘Need of FDD/TDD differentiation’, it depends on further discussion in AI 8.8.1.2.As a result, we have the following proposal. ***Proposal 3:*** *For FG 30-3 for TBoMS, no prerequisite FG is needed and per UE reporting is sufficient.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | **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 |
| 30. NR\_cov\_enh | 30-3 | TB processing over multi-slot PUSCH | Support of TB processing over multi-slot PUSCH in RRC connected mode. | ~~[11-6]~~ | ~~[~~Per UE~~]~~ | FFS |

 |
| [4] | vivo | In RAN1#106e, it has been agreed that the number of slots for TBoMS is counted based on available slots for UL transmission, and the available slots are determined based on the mechanisms determined for type-A PUSCH repetition counted on available slots. Hence, feature 30-2, i.e., type-A PUSCH repetitions counted on available slots, should be considered as prerequisite feature for feature 30-3.On top of that, the candidate values of number of slots for a single TBoMS are being discussed in AI 8.8.1.2, and this should be captured in the component for feature 30-3.**Proposal 1: Feature 30-2 should be considered as prerequisite feature for feature 30-3. And value range of number of slots for a single TBoMS should be captured in the component for Feature 30-3.**The revised UE Feature 30-3 is provided in following table.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Mandatory/Optional |
| 30. NR\_cov\_enh | 30-3 | TB processing over multi-slot PUSCH | Support of TB processing over multi-slot PUSCH in RRC connected mode.Supported values for a single TBoMS include {2,4,8} | ~~[11-6]~~ 30-2 | [Optional with capability signalling] |

 |
| [5] | Nokia, Nokia Shanghai Bell | * **30-1, 30-1a, 30-2, 30-2a, 30-3, 30-4, 30-4a/b/c/d/e/f/g, 30-5, 30-6:**
	+ Confirm the FGs. Details to be finalized later.
 |
| [6] | Intel Corporation | As agreed in the RAN1#106-e meeting, TB processing over multiple slots (TBoMS) is supported for both configured grant and dynamic grant [4]. In this case, it is more appropriate to differentiate DG-PUSCH and CG-PUSCH for the UE feature group. Table 2 illustrates suggested update for UE feature groups for TBoMS. Table 2. UE feature groups for TBoMS

|  |  |  |
| --- | --- | --- |
| **Index** | **Feature group** | **Components** |
| 30-3 | TB processing over multi-slot PUSCH for DG-PUSCH | Support of TB processing over multi-slot PUSCH in RRC connected mode for DG-PUSCH. |
| 30-3a | TB processing over multi-slot PUSCH for CG-PUSCH | Support of TB processing over multi-slot PUSCH in RRC connected mode for CG-PUSCH. |

**Proposal 2*** *For TBoMS, divide UE feature groups into DG-PUSCH and CG-PUSCH.*
* *Consider Table 2 as a starting point for discussion of feature groups for TBoMS.*
 |
| [7] | Samsung | In RAN1#106bis-e, it was discussed whether/how to separate FG 30-3, e.g., split based on DG and CG. Similarly with the above discussion for PUSCH repetition Type A enhancement, we do not see the need to split current FG 30-3.Another discussion point raised in previous RAN1 meeting was whether/how to include the capability for the repetition of TB processing over multi-slot PUSCH. In our view, if a UE supports TBoMS and PUSCH repetition Type A respectively, it means the UE also supports the repetition of TBoMS. That is, no need to introduce a separate capability for the repetition of TBoMS. **Proposal 2: FG 30-3 is kept as “TB processing over multi-slot PUSCH”**All Rel-17 FGs should be “Optional with capability signaling”. We may need to decide which FG is the basic FG for Rel-17 Coverage Enhancement.**Proposal 6: Set “Optional with capability signaling” for all feature groups under Rel-17 Coverage Enhancement.** |
| [8] | Apple | All the UL coverage enhancement features are based on existing specification and implementation. Thus, whether support the enhanced features should leave the choice to UE implementation. **Proposal 4: UL enhancement features groups are optional with UE capability.** |
| [9] | Ericsson | The current status of features for TBoMS from [1] are captured in Table 2 (where the yellow shaded cell indicates an area identified by the moderator as for further discussion) as well as our suggested changes. Our rationale is as follows:**30-3:** The transmission of a single TBoMS is over at least two slots. This needs indication of the UE’s capability. [11-6] is the enhanced PUSCH repetition Type A in Rel-16 with the number of repetitions jointly coded with SLIV in TDRA table. Although TBoMS uses Type A-like resource allocation, it is a different type of UL transmission. We don’t see the need of a prerequisite feature beyond basic PUSCH transmission.**30-3a:** As agreed in RAN1#106e, TBoMS with repetition is supported, which can be considered as a sub-feature of TBoMS. PUSCH repetition Type A and Type B are already defined, and we do not see a need to require UEs to support TBoMS repetition if Type A and Type B can alternatively be supported.Table 2: Capabilities for Transport Block over Multi-slot PUSCH

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | Feature group | Components | Prerequisite feature groups | Comments |
| 30-3 | TB processing over multi-slot PUSCH | Support of TB processing over multi-slot PUSCH in RRC connected mode. | ~~[11-6]~~ |  |
| 30-3a | Repetition of TB processing over multi-slot PUSCH | Support of repetition of TB processing over multi-slot PUSCH in RRC connected mode. | [30-3] |  |

1. UE features for transport block over multi-slot PUSCH are defined according to Table 2.
 |
| [10] | NTT DOCOMO, INC. | At the RAN1#106 bis-e meeting, the structure of FGs 30-3 was discussed [1]. Regarding whether/how to separate FG 30-3, we do not think it needs to be split into multiple FGs for DG and type2 CG. As DG and type 2 CG are expected to have the same allocated slot indication mechanism, they can be merged into one FG. This follows the same structure of FG 11-6, where TDRA-based repetition factor indication FG covers both DG and type 2 CG. **Proposal 4: FGs 30-3 does not need to be split into multiple FGs for DG and type2 CG.**Regarding whether/how to include the capability for the repetition of TB processing over multi-slot PUSCH (TBoMS), we prefer introducing the capability as a separate FG. Under the assumption that the total number of allocated slots is the same, TBoMS itself provides better coverage performance than the repetition of TBoMS. Repetitions of TBoMS is just supported for relieving UE burden. Because of this, it should be up to UE if UE supports repetitions of TBoMS regardless of the capability of TBoMS or/and repetitions.**Proposal 5: Repetitions of TBoMS should be captured as capability.**Regarding optional or mandatory with capability signaling, the FGs should be supported as optional feature with capability signaling, because it has not been agreed that any CovEnh feature is mandatory to support.**Proposal 3: All CovEnh features should be supported as optional feature with capability signaling.** |
| [11] | Sharp | In RAN1#106bis-e, companies had different views on whether to have a single feature group or separate feature groups for DG-PUSCH and CG-PUSCH, for TBoMS. In our view, we need some more discussions in AI 8.8.1.2, for example it is not clear if the physical slot based counting is applicable to TBoMS. If only the available slot based counting is applicable to TBoMS, whether to merged or separated should follow the conclusion on whether to merged or separated between FG 30-2 and FG 30-2a. In the last meeting, FL suggested agreeing the FG30-3 with adding “FFS whether/how to separate FG 30-3 into multiple FGs”. To go with that proposal is also fine to us.***Proposal 2: For whether to have a single FG or separate FGs for DG-PUSCH with TBoMS and CG-PUSCH with TBoMS, it is suggested waiting the progress of the discussions in AI 8.8.1.2.*** |
| [12] | Qualcomm Incorporated | **General remark applicable to all features for NR coverage enhancement****Proposal 1:** Unless otherwise stated, the type for a UE feature should be at least per band (if not with finer granularity type), given the potential UE testing differentiation among licensed, unlicensed, and NTN band.**On TBOMS****Proposal 7:** Ensure UE capabilities for TB Processing over multiple slots are separately indicated for CG and DG scenarios:* + - Split 30-3 into 3 separate FGs: 1st one for DG, 2nd one for type 1 CG, 3rd one for type 2 CG

**Proposal 8:** To better align with R15 UE capability on supporting PUSCH repetitions, introduce a separate capability for TBoMS repetition. **Proposal 9:** Consider the following additional feature for TBOMS:* Maximum concurrent TBOMS transmissions supported by a UE across all carriers when operating in UL-CA.

**Additional comments and suggested changes to the UE features table:****Proposal 11:** Additional comments and suggested changes to the UE features table for coverage enhancement are included in the following table, with changes marked in red.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 30. NR\_cov\_enh | 30-3 | TB processing over multi-slot PUSCH | Support of TB processing over multi-slot PUSCH in RRC connected mode. | [11-6] | Yes | N/A | UE does not support TB processing over multi-slot PUSCH. | ~~[Per UE]~~ Per Band | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |

 |
| [13] | MediaTek Inc. | Proposal 2: For TBoMS, separated FGs for DG, CG Type 2 and CG Type 1 (if supported).Proposal 7: All UE features are per band.Proposal 9: All UE features are optional with capability signalling |

## **Discussion**

**[FL1] High priority question 3-1:**

* **Companies are encouraged to provide views on whether/how to separate FG 30-3, e.g.,**
	+ Option 1: Huawei, HiSilicon, ZTE, Samsung, DOCOMO
		- Keep current structure
	+ Option 2: [Huawei, HiSilicon], Qualcomm, MediaTek
		- Split 30-3 into 3 separate FGs: 1st one for DG, 2nd one for type 1 CG, 3rd one for type 2 CG
	+ Option 3: [Huawei, HiSilicon], Intel
		- Split 30-3 into 2 separate FGs: 1st one for DG, 2nd one for CG
	+ Option 4: Sharp
		- Wait for progress on AI 8.8.1.2

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We prefer not to split FG. Since single RRC parameter is used for indicating the number of allocated slots for TBoMS, only one FG fits the RAN2 guidance as in R1-2001513. Changing how UE interprets RRC parameter in TDRA table according to capability bits is against RAN2 guidance: avoid defining functionality that has no RRC configuration but is dependent on capability bits. |
| Panasonic | We support Option 1. TBoMS is not required to be split between DG and CG. |
| QC | Support Option 2. Separation between CG and DG would be good. Development and commercialization of DG and CG features are not in sync.  |
| Intel | We support Option 3. We prefer to differentiate DG and CG for TBoMS. In our view, CG-PUSCH is optional w/ capability signaling. It would be more preferrable to differentiate these two cases.  |
| ZTE | Support Option 1. There is no much different handling of DG and CG.  |
| Apple | We are ok with option 2 and option3. |

**[FL1] High priority question 3-2:**

* **Companies are encouraged to provide views on whether to add an FG for the repetition of TB processing over multi-slot PUSCH**
	+ Support: Ericsson, DOCOMO, Qualcomm
	+ Not support: Samsung

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We prefer to add a FG for the repetition of TBoMS. This feature requires a unique RV assignment: RV cycling where each RV index is assigned over consecutive multiple slots. It is not necessary to mandate supporting the repetition of TB processing over multi-slot PUSCH when UE has capability of repetitions and TBoMS. |
| QC | Useful to have. Helps establish a clear lineage to R15 features. |
| Intel | We are fine to add a FG for TBoMS repetition.  |
| ZTE | Fine to add.  |
| Apple | Ok to add a FG for TBoMS repetition. |

**[FL1] High priority question 3-3:**

* **Companies are encouraged to provide views on whethe to add an FG for the maximum concurrent TBoMS transmissions supported by a UE across all carriers when operating in UL-CA**
	+ Support: Qualcomm

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We are not sure why we need this FG. |
| Qualcomm | TBOMS requires additional state maintenance across slots. A bound on how many concurrent TBOMS transmissions a UE may have to handle is useful to scope the size of this overhead. |
| Intel | It is not clear to us why we need this FG. Need further discussion.  |
| ZTE | Ok to discuss the difference compared to legacy PUSCH repetition type A in CA operation.  |
| Apple | The motivation to introduce this FG is not clear, TBoMS is introduced as a coverage enhancement technique. If UE already has the coverage issue why it is configured with UL CA. |

**Medium priority proposal 3-4:**

* **“Mandatory/Optional” in FG 30-3 is confirmed as “Optional with capability signaling”**

|  |  |
| --- | --- |
| Company | Comment |
| Panasonic | We are fine with Proposal 3-4. |
| QC | Support |
| Intel | We support.  |
| Apple | Support |

**Medium priority question 3-5:**

* **Companies are encouraged to provide views on whether the type of FG 30-3 should be per UE or per band**
	+ Per UE: Huawei, HiSilicon, ZTE
		- FDD/TDD differentiation
			* Not necessary: Huawei, HiSilicon
			* FFS: ZTE
	+ Per band: Qualcomm, MediaTek

|  |  |
| --- | --- |
| Company | Comment |
| Panasonic | We support “per UE”. |
| QC | Due to testing differentiation between licensed, unlicensed and NTN bands, we prefer to go with “per band” capability. |
| Intel | Per UE.  |
| ZTE | Per UE is sufficient.  |
| Apple | We support per band. |

**Low priority question 3-6:**

* **Companies are encouraged to provide views on whether/how to revise the prerequisite feature groups for FG 30-3**

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

**Low priority question 3-7:**

* **Companies are encouraged to provide views on whether/how to revise any other contents in FG 30-3 which do not have capability signaling impacts**

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

# **30-4 to 30-4g: [DM-RS bundling]**

In [1], FGs 30-4 to 30-4g 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 (Sidelink 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 |
| 30. NR\_cov\_enh | 30-4 | [The maximum duration for DM-RS bundling] | The maximum duration during which UE is able to maintain power consisitency and phase continuity to support DM-RS bundling for PUSCH/PUCCH |  | Yes | N/A | UE does not support DM-RS bundling for PUSCH/PUCCH | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |
|  30. NR\_cov\_enh | 30-4a | [DM-RS bundling for PUSCH repetition type A] | Support DM-RS bundling for PUSCH repetition type A | [30-4], [30-1] or [30-2] | Yes | N/A | UE does not Support DM-RS bundling for PUSCH repetition type A | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |
|  30. NR\_cov\_enh | 30-4b | [DM-RS bundling for PUSCH repetition type B] | Support DM-RS bundling for PUSCH repetition type B | [30-4], [11-5] [30-1] | Yes | N/A | UE does not Support DM-RS bundling for PUSCH repetition type B | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |
|  30. NR\_cov\_enh | 30-4c | [DM-RS bundling for TB processing over multi-slot PUSCH] | Support DM-RS bundling for TB processing over multi-slot PUSCH | [30-4], [30-3] | Yes | N/A | UE does not Support DM-RS bundling for TB processing over multi-slot PUSCH | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |
| 30. NR\_cov\_enh | 30-4d | [DMRS bunding for PUCCH repetitions] | Support DM-RS bundling for PUCCH repetitions | [30-4], [4-23] | Yes | N/A | UE does not support DMRS bunding for PUCCH repetitions | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |
| 30. NR\_cov\_enh | 30-4e | [Inter-slot frequency hopping with inter-slot bundling for PUSCH] | Support inter-slot frequency hopping with inter-slot bundling for PUSCH | [30-4a] or [30-4b] or [30-4c] | Yes | N/A | UE does not support inter-slot frequency hopping with inter-slot bundling for PUSCH | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |
| 30. NR\_cov\_enh | 30-4f | [Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling] | Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling | [30-4d] | Yes | N/A | UE does not support Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |
| 30. NR\_cov\_enh | 30-4g | [Restart DM-RS bundling after the events that violate power consistency and phase continuity] | Support restarting DM-RS bundling after the events that violate power consistency and phase continuity | [30-4] | Yes | N/A | UE does not support restarting DM-RS bundling after the events that violate power consistency and phase continuity | [Per UE] | FFS | No | N/A |  | [Optional with capability signalling] |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | Huawei, HiSilicon | **Whether the features are Mandatory or Optional**As enhanced features in Rel-17, considering UE capabilities and flexibility, all the UE features for coverage enhancement listed in [1] should be optional with capability signaling. Specifically, for FG 30-6 related to Msg3 repetition, the feature can realize optional based on whether to access via separate RACH resources without capability signaling. However, capability signaling after beyond the RACH procedure can help the gNB properly configure RACH resources for different purposes. Thus, FG 30-6 should be optional with capability signaling. ***Proposal 1: For FG 30-1 to FG 30-6, all the UE features should be optional with capability signaling.*****The need of FDD/TDD differentiation**For all the features, there seems no justification or evidence to support the need for FDD/TDD differentiation. The FDD/TDD differentiation is unnecessary.***Proposal 2: For FG 30-1 to FG 30-6, the FDD/TDD differentiation is unnecessary.*****The structure of UE features about DMRS bundling**On the basis of the agreements reached in AI 8.8.1.3, whether DMRS bundling for repetition type B and TBoMS and so on are supported, should depend on the respective UE capabilities. The structure of FG 30-4a to FG 30-4c should be kept. The capabilities of DMRS bundling for back-to-back case and non-back-to-back case may be different, because the gap between transmissions of non-back-to-back case brings in other uncertainties that may affect power consistency and phase continuity. Actually, according to the RAN4’s input, compared to the non-back-to-back transmissions with the gap consist of unscheduled symbols, it is more difficult for the UE to maintain power consistency and phase continuity when there are other UL signals/channels inserted in the gap between transmissions, even with same setting. Thus, it is preferable that different use cases have separate FGs. At least the feature for non-back-to-back with other UL signals/channels inserted in the gap between repetitions with same setting should be separate.Besides, in generally, it is reasonable to set the features for PUCCH and PUSCH separately.***Proposal 3: The structure of UE features about DMRS bundling should be as follows:**** ***DMRS bundling for each type of transmission, e.g. repetition type A, repetition type B, TBoMS, should have separate FG.***
* ***Introduce additional FGs for non-back-to-back with the gap consists of unscheduled symbols and non-back-to-back with other UL signals/channels inserted in the gap between repetitions with same setting, separately.***
* ***DMRS bundling for PUSCH and PUCCH should have separate FG.***

**The value of maximum duration**The values of the maximum duration are related to the phase continuity and power consistency tolerance, which is under discussion in RAN4 now. The tolerance may be related to modulation order. Thus, whether and how to report different value of the maximum duration for DMRS bundling for different modulation orders is up to RAN4. For the back-to-back transmissions and non-back-to-back transmissions, although a single value of maximum duration may be sufficient, it is safer to wait for RAN4’s input.***Proposal 4: For FG 30-4, whether and how to report different value of the maximum duration for DMRS bundling for (a) different modulation orders (b)*** ***back-to-back and non-back-to-back, is up to RAN4.*****The need of FR1/FR2 differentiation for features related to DMRS bundling** For a given tolerance, the CFOs of different operating frequency are different, which may cause the “compensation leftover for frequency error” be different. And UE’s implementation on different FR range to maintain the phase continuity could be different. Thus, the differentiation of FR1/FR2 for the feature of maximum duration is necessary.***Proposal 5: For FG 30-4, FR1/FR2 differentiation is necessary.***For FG 30-4x, as previously described, the RF characteristics on different FR range are different, so the capabilities to support DMRS bundling on different FRs may be different for the same UE. The differentiation of FR1/FR2 is necessary for the features related to supporting DMRS bundling.***Proposal 6:******For FG 30-4x, FR1/FR2 differentiation is necessary.*****The type of granularity**First of all, it should be noted that, there are certain reasons to define that the FG 30-4 is set per band. As previously described, the compensation leftover for frequency error and RF characteristics may be different for different bands. However, analyzing RF and determining the values of the maximum duration for all bands will result in very heavy workload and is unnecessary. Considering above, it is a good choice to define the UE feature of maximum duration, i.e. FG 30-4, based on the granularity of Per UE and with FR1/FR2 differentiation.For other features except for FG 30-4, there is no particular reason to apply other granularities. Per UE is sufficient.***Proposal 7: All the UE feature for NR coverage enhancement should be based on the granularity of Per UE.*** |
| [3] | ZTE | Regarding DMRS bundling among PUSCH/PUCCH transmissions, the current FG list is a good starting point. However, we may not be able to further refine these FGs before more input from RAN4, or we can also decide some of the UE FGs could be left for RAN4, i.e., regarding as RAN4 FGs. For instance, RAN4 is still discussing whether the UE should report a maximum duration and the potential factors may have impact on the duration. ***Proposal 4:*** *RAN1 further revisits the FGs related to DM-RS bundling among PUSCH/PUCCH transmissions based on further input from RAN4 or leave some of UE FGs as RAN4 FGs.* If a maximum duration can be reported by UE, it would imply the UE supports DM-RS bundling at least for one of PUSCH repetition type A, repetition type B and TBoMS once the UE reports a value for maximum duration. Therefore, at least one of FG 30-4a, 30-4b and 30-4c should be merged into FG 30-4 if it is agreed by RAN4. In addition, RAN4 has agreed the maximum duration should be the same for different cases for both PUSCH and PUCCH. Therefore, we don’t think a separate FG 30-4d for DMRS bundling for PUCCH is needed. ***Proposal 5:*** *If RAN 4 would agree a maximum duration can be reported by UE (i.e. confirming FG 30-4), at least one of FG 30-4a, 30-4b and 30-4c should be merged into FG 30-4, and a separate FG 30-4d for DMRS bundling for PUCCH is not needed.*  |
| [4] | vivo | For DMRS bundling related features, it depends on detailed RAN4 FR requirements on power consistency, phase continuity, and it may be FR specific or band specific, may be not per UE feature. In [2], RAN4 replied that the maximum duration (feature 30-4) maybe per band or per FR dependent, and Feature 30-4 is considered as prerequisite for other DMRS bundling features. Hence, whether features 30-4 and 30-4(a)-(g) are per band features, or need to be different for FR1/FR2, needs to be confirmed by RAN4.**Proposal 2: Whether feature 30-4 and 30-4(a-g) is per ‘band/UE’, or ‘need of FR1/FR2 differentiation’ should be confirmed by RAN4.**The suggested revision DMRS bundling related UE features are provided in following table.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Index | Feature group | Components | Prerequisite feature groups | Consequence if the feature is not supported by the UE | Type | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation |
| 30-4a | [DM-RS bundling for PUSCH repetition type A] | Support DM-RS bundling for PUSCH repetition type A | [30-4], [30-1] or [30-2] | UE does not Support DM-RS bundling for PUSCH repetition type A | ~~[Per UE]~~[Per band] | FFS | ~~No~~[YES] |
| 30-4b | [DM-RS bundling for PUSCH repetition type B] | Support DM-RS bundling for PUSCH repetition type B | [30-4], [11-5] [30-1] | UE does not Support DM-RS bundling for PUSCH repetition type B | ~~[Per UE]~~[Per band] | FFS | ~~No~~[YES] |
| 30-4c | [DM-RS bundling for TB processing over multi-slot PUSCH] | Support DM-RS bundling for TB processing over multi-slot PUSCH | [30-4], [30-3] | UE does not Support DM-RS bundling for TB processing over multi-slot PUSCH | ~~[Per UE]~~[Per band] | FFS | ~~No~~[YES] |
| 30-4d | [DMRS bunding for PUCCH repetitions] | Support DM-RS bundling for PUCCH repetitions | [30-4], [4-23] | UE does not support DMRS bunding for PUCCH repetitions | ~~[Per UE]~~[Per band] | FFS | ~~No~~[YES] |
| 30-4e | [Inter-slot frequency hopping with inter-slot bundling for PUSCH] | Support inter-slot frequency hopping with inter-slot bundling for PUSCH | [30-4a] or [30-4b] or [30-4c] | UE does not support inter-slot frequency hopping with inter-slot bundling for PUSCH | ~~[Per UE]~~[Per band] | FFS | ~~No~~[YES] |
| 30-4f | [Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling] | Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling | [30-4d] | UE does not support Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling | ~~[Per UE]~~[Per band] | FFS | ~~No~~[YES] |
| 30-4g | [Restart DM-RS bundling after the events that violate power consistency and phase continuity] | Support restarting DM-RS bundling after the events that violate power consistency and phase continuity | [30-4] | UE does not support restarting DM-RS bundling after the events that violate power consistency and phase continuity | ~~[Per UE]~~[Per band] | FFS | ~~No~~[YES] |

 |
| [5] | Nokia, Nokia Shanghai Bell | * **30-1, 30-1a, 30-2, 30-2a, 30-3, 30-4, 30-4a/b/c/d/e/f/g, 30-5, 30-6:**
	+ Confirm the FGs. Details to be finalized later.
 |
| [6] | Intel Corporation | In the previous RAN1 meetings [3][4][5], the following use cases were agreed to be supported for joint channel estimation of PUSCH:* back-to-back PUSCH transmissions (of the same TB) for repetition type A and B scheduled by dynamic grant or configured grant
* back-to-back PUSCH transmissions for TB processing over multiple slots
* non-back-to-back PUSCH transmissions across consecutive slots (of the same TB) for repetition type A and type B scheduled by dynamic grant or configured grant.

Considering different use cases as mentioned above, it is more appropriate to divide the UE feature groups for back to back PUSCH transmission and non-back to back PUSCH transmission. At the RAN1#106-e meeting, it was agreed that for DMRS bundling for PUCCH repetitions, RAN1 at least prioritize use cases 3 and 4a in R1-2104119 [4]. Hence, the same principle can also apply for DMRS bundling for PUCCH repetitions, i.e., UE feature groups can be divided into back to back PUCCH transmission and non-back to back PUCCH transmission. Note that in RAN4 reply LS [6], certain conditions need to be met in order to maintain phase continuity in case of other UL signals/channels in the gap between repetitions as follows:

|  |
| --- |
| RAN4 has agreed for the case of other signals/channels in the gap between repetitions, it is not considered for UE to transmit other channels in the gap with different settings.For the case of other UL signals/channels in the gap between repetitions with same settings, as communicated in R4-2105417, RAN4 has further refined the conditions when phase continuity can be met as follows:* Signals/channels with repetitions and other UL signals/channels in the gap have the same:
	+ PAPR and average power, e.g., PUSCH/PUCCH part of repetitions and SRS has same PAPR and average power.
	+ Allocated number and locations of PRBs transmitted
	+ Antenna port settings
 |

Hence, addition UE feature group may need to be added for the case when other UL signals/channels are inserted in the gap between repetitions with same setting. **Proposal 3*** *For UE features for DMRS bundling, consider back to back PUSCH/PUCCH transmission and non-back to back PUSCH/PUCCH transmission.*
* *For non-back to back PUSCH/PUCCH transmissions, add UE feature group for the case when other UL signals/channels are inserted in the gap between repetitions with same setting.*
 |
| [7] | Samsung | It is understood that FGs 30-4/30-4a/30-4b/30-4c/30-4d/30-4e/30-4f/30-4g are within square bracket because the corresponding agreement is still working assumption or FFS. It can be further addressed based on RAN1 progress. FG 30-4a/30-4b/30-4c/30-4d define specific DM-RS bundling capability combined with PUSCH Type A repetition, PUSCH Type B repetition, PUSCH TBoMS, and PUCCH, respectively. Similar with above discussion on FG 30-1/30-1a, a single capability for DM-RS bundling would be enough. For example, if a UE supports DM-RS bundling and PUSCH TBoMS respectively, it means the UE also supports DM-RS bundling for TBoMS. **Proposal 3: Merge FGs 30-4b, 30-4c, and 30-4d into FG 30-4a.**

|  |  |  |
| --- | --- | --- |
| 30-4a | [DM-RS bundling ~~for PUSCH repetition type A~~] | Support DM-RS bundling for PUSCH ~~repetition type A~~ and PUCCH |
| ~~30-4b~~ | ~~[DM-RS bundling for PUSCH repetition type B]~~ | ~~Support DM-RS bundling for PUSCH repetition type B~~ |
| ~~30-4c~~ | ~~[DM-RS bundling for TB processing over multi-slot PUSCH]~~ | ~~Support DM-RS bundling for TB processing over multi-slot PUSCH~~ |
| ~~30-4d~~ | ~~[DMRS bunding for PUCCH repetitions]~~ | ~~Support DM-RS bundling for PUCCH repetitions~~ |

In case of frequency hopping with DM-RS bundling (FG 30-4e/30-4f), there would be no functional difference between PUSCH and PUCCH. Note that RAN1 agreement states “*to strive for common design for PUSCH/PUCCH with DMRS bundling as much as possible*”. Therefore, FG 30-4e and 30-4f can be consolidated. **Proposal 4: Merge FG 30-4f into FG 30-4e.**

|  |  |  |
| --- | --- | --- |
| 30-4e | [Inter-slot frequency hopping with inter-slot bundling for PUSCH/PUCCH] | Support inter-slot frequency hopping with inter-slot bundling for PUSCH and PUCCH |
| ~~30-4f~~ | ~~[Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling]~~ | ~~Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling~~ |

All Rel-17 FGs should be “Optional with capability signaling”. We may need to decide which FG is the basic FG for Rel-17 Coverage Enhancement.**Proposal 6: Set “Optional with capability signaling” for all feature groups under Rel-17 Coverage Enhancement.** |
| [8] | Apple | For FG30-4g, it’s not clear any technical reason to support this FG. Whatever the event is semi-static signaling triggered or dynamic signaling triggered, after the event the transmissions will continue, there is no timeline issues. The transmission power and phase continuity will be kept again in the new actual time domain window.**Proposal 2: Remove the FG 30-4g restarting DMRS bundling after the events that violate power consistency and phase continuity.**All the UL coverage enhancement features are based on existing specification and implementation. Thus, whether support the enhanced features should leave the choice to UE implementation. **Proposal 4: UL enhancement features groups are optional with UE capability.** |
| [9] | Ericsson | Largely due to the need for further input from RAN4, there was little progress on features for joint channel estimation in RAN1#106bis. Therefore, the described in the Table 3 below are those based on the initial UE feature discussion in [5]. Given the discussion in RAN1#106bis and further investigation, we have updated our views on 30-4f and 30-4g, as discussed further below. Our rationale for each of the features is as follows:**30-4, 30-4a, & 30-4d:** A basic UE feature supporting joint channel estimation should be defined jointly for PUCCH and PUSCH, given the RAN1#104 agreement to strive for a common design for PUSCH/PUCCH with DMRS bundling as much as possible. So we think 30-4, 30-4a and 30-4d can be merged into 30-4. DMRS bundling for PUSCH will be supported for Rel-15, -16, and -17 PUSCH repetition Type A and B as well as TBoMS. We note that 11-6, PUSCH Repetition Type A, depends on one of 5-16 and 5-17. Since prerequisites are what is required to configure a feature, and not what can be configured with a feature, this dependency on 5-16 and 5-17 means that 11-6 is not technically a prerequisite. Therefore, the prerequisites are 5-14, 5-16, 5-17, 11-5, or 30-3. As suggested (tentatively) by the moderator, the Rel-15 feature for PUCCH repetition (4-23, ‘Repetitions for PUCCH format 1, 3, and 4 over multiple slots with K = 2, 4, 8’), seems needed for PUCCH bundling for slots format 1/3/4. Similarly, the new Rel-17 feature 25-2, “Repetitions for PUCCH format 0, and 2 over multiple slots with K = 2, 4, 8” is needed for formats 0/2. The values for the time domain window size are still being discussed in RAN4, and so the candidate values are t.b.d. **30-4b**: The working assumption confirmed in RAN1#106 identifies support for PUSCH repetition type B in a UE configured joint channel estimation as an additional UE capability. Therefore, in addition to the basic support of DMRS bundling, the UE will also need to support PUSCH repetition Type B, i.e. Rel-16 feature 11-5. We suggest clarifying the wording of 30-4b to be “Support DM-RS bundling when configured for PUSCH repetition type B” because DM-RS bundling does not change when configured for PUSCH repetition Type B, since the agreement is that it reuses only those joint channel estimation specification enhancements defined to support repetition Type A.**30-4c:** Similar to 30-4b, our understanding is that DM-RS bundling for TBoMS is not any different than for Type A repetition, so it is not specifically for TBoMS, but the support is for DM-RS bundling when TBoMS is configured. Suggest: “Support DM-RS bundling when configured for TB processing over multi-slot PUSCH”.**30-4e**: As discussed in [2] and [3], new inter-slot frequency hopping patterns provide notable gains for both PUSCH joint channel estimation and for TBoMS. PUSCH Type A scheduling (2-16) is assumed as a baseline for both of these features and so should be a prerequisite. Lastly, especially since UEs in a cell not supporting JCE or TBoMS should be able to hop with UEs configured for JCE and/or TBoMS, and since enhanced frequency hopping patterns can have gains for UEs not configured for JCE and/or TBoMS, 2-16 should be a sufficient prerequisite for PUSCH inter-slot frequency hopping, and e.g. 30-4 and 30-3 should not be prerequisites.**30-4f:** After simulating PUCCH frequency hopping according to a new pattern designed originally for joint channel estimation, we find that the pattern is beneficial for PUCCH as well as for PUSCH, as can be seen in our contribution [4]. Since the new pattern can be supported for both PUCCH and PUSCH, we suggest that it is merged with 30-4e, but that 30-4e is clarified that PUCCH is supported as well by the new hopping pattern. PUCCH repetition 4-23 can be a starting point for a prerequisite for enhanced inter-slot frequency hopping for PUCCH.**30-4g:** Agree with moderator’s approach, but suggest to rephrase somewhat. As agreed in RAN1#106, there is a UE capability for when a configured time domain window is split into multiple actual windows and DMRS bundling is restarted in the new window. Since whether the terminology ‘actual window’ and ‘configured window’ is used in specifications is FFS, describing the capability more directly as is done in 30-4g seems appropriate. The phrase ‘restarting DM-RS bundling’ seems a bit imprecise, and the event timing could be more clear. We suggest clarifying with the component description with “Support ~~restarting~~ bundling of PUCCH and PUSCH DM-RS remaining in a bundling window after ~~the~~ an event that ~~violate~~ causes power consistency and phase continuity not to be maintained.”. This is in line with the description of events in the current draft of 38.214 section 6.1.7.**30-4h:** The working assumption confirmed in RAN1#106 requires that non-back-to-back PUSCH transmissions be a UE capability. RAN4 has indicated that it is possible to support phase continuity and power consistency for non-back-to-back transmission only where the gap is 13 symbols or less (in R4-2114991), but is still discussing whether continuity/consistency with DL slots between the bundled PUSCH repetitions is feasible. Furthermore, RAN4 has indicated that continuity/consistency can be maintained for back-to-back slots if the UE transmits other channels or signals between bundled PUSCHs, however the conditions are quite restrictive, and RAN4 is asking RAN1 about the consequences if bundling cannot be maintained in these cases. Furthermore, for PUCCH, RAN1 has agreed in RAN1#106 to prioritize the use case where UE does not transmit between the bundled PUCCHs. Therefore, the capability for non-back-to-back operation here only includes the case where UE does not transmit PUSCH or PUCCH in adjoining slots. The intention is that if support for additional non-back-to-back operation is agreed, e.g. for bundling across DL slots or where UE transmits other channels/signals between PUSCH/PUCCH repetitions, then additional capabilities can be defined.Table 3: Capabilities for PUSCH and PUCCH Joint Channel Estimation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | Feature group | Components | Prerequisite feature groups | Comments |
| 30-4 | ~~[The maximum duration for DM-RS bundling]~~DMRS bundling | 1) DMRS bundling for PUSCH2) DMRS bundling for PUCCH3) Maximum window duration during which UE is able to maintain power consistency and phase continuity to support DM-RS bundling for PUSCH/PUCCH | 1: [5-14, 5-16, 5-17, 11-5, or 30-3]2: 4-23 or 25-2 | Component-3: Candidate values T.B.D. |
| ~~30-4a~~ | ~~[DM-RS bundling for PUSCH repetition type A]~~ | ~~Support DM-RS bundling for PUSCH repetition type A~~ | ~~[30-4], [30-1] or [30-2]~~ |  |
| 30-4b | [DM-RS bundling for PUSCH repetition type B]  | Support DM-RS bundling when configured for PUSCH repetition type B | [30-4], [11-5] ~~[30-1]~~ |  |
| 30-4c | [DM-RS bundling for TB processing over multi-slot PUSCH] | Support DM-RS bundling when configured for TB processing over multi-slot PUSCH | [30-4], [30-3] |  |
| ~~30-4d~~ | ~~[DMRS bunding for PUCCH repetitions]~~ | ~~Support DM-RS bundling for PUCCH repetitions~~ | ~~[30-4], [4-23]~~ |  |
| 30-4e | [Enhanced Inter-slot frequency hopping ~~with inter-slot bundling~~ for PUSCH and PUCCH] | Support enhanced inter-slot frequency hopping pattern ~~with inter-slot bundling~~ for PUSCH and PUCCH | ~~[30-4a] or [30-4b] or [30-4c]~~2-16, [4-23] |  |
| ~~30-4f~~ | ~~[Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling]~~ | ~~Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling~~ | ~~[30-4d]~~ |  |
| 30-4g | [Restart DM-RS bundling after the events that violate power consistency and phase continuity] | Support ~~restarting~~ bundling of PUCCH and PUSCH DM-RS remaining in a bundling window after ~~the~~ an event that ~~violate~~ causes power consistency and phase continuity not to be maintained. | [30-4] |  |
| 30-4h | DMRS bundling for discontinuous transmission between adjoining slots | Support for DMRS bundling when UE does not transmit between bundled PUSCH/PUCCH repetitions in adjoining slots | 30-4 |  |

1. UE features for PUSCH and PUCCH joint channel estimation are defined according to Table 3
 |
| [10] | NTT DOCOMO, INC. | At the RAN1#106 bis-e meeting, the following points were discussed* + whether UE can report different values of maximum duration for DMRS bundling for (a) different modulation orders, (b) back-to-back and non-back-to-back transmissions
	+ whether/how to revise the structure for FGs 30-4 and 30-4x.

Since the feedback from RAN4 about the maximum duration values has not been given yet, we prefer deferring the discussion about whether to support different maximum duration values.**Proposal 6: Defer the discussion about whether to support different maximum duration values until RAN4 gives the feedback about the maximum duration values.** As for the structure for FGs 30-4 and 30-4x, we think it is better to merge FGs 30-4a, 30-4b, and 30-4c. Joint channel estimation of PUSCH repetition type B and TBoMS is supported on the condition to reuse the design of joint channel estimation for PUSCH repetition type A. Accordingly, the capability of DM-RS bundling for PUSCH transmissions can be merged into one capability. **Proposal 7: Merge FGs 30-4a, 30-4b, and 30-4c into the same FG, since the common DM-RS bundling mechanism is used for PUSCH repetition type A, B, and TBoMS.** Regarding optional or mandatory with capability signaling, the FGs should be supported as optional feature with capability signaling, because it has not been agreed that any CovEnh feature is mandatory to support.**Proposal 3: All CovEnh features should be supported as optional feature with capability signaling.** |
| [11] | Sharp | For the support of DM-RS bundling for PUSCH repetition type A, we do not see the need to limit its use to the Rel-17 PUSCH repetition type A. It should also be applicable to Rel-15/16 PUSCH repetition Type A. Therefore, in our view the prerequisite feature groups for FG 30-4a are not only FG 30-1 and FG 30-2 but also FG 5-14, FG 5-16 and FG 5-17.***Proposal 3: The Prerequisite feature groups for FG 30-4a should be FG 30-4 and at least one of FG 5-14, FG 5-16, FG 5-17, FG 30-1 and FG 30-2.*** |
| [12] | Qualcomm Incorporated | **General remark applicable to all features for NR coverage enhancement****Proposal 1:** Unless otherwise stated, the type for a UE feature should be at least per band (if not with finer granularity type), given the potential UE testing differentiation among licensed, unlicensed, and NTN band.**On DMRS bundling for PUSCH/PUCCH repetitions**We have the following proposals on UE capability reporting for PUSCH/PUCCH DMRS bundling.**Proposal 3:** UE can report different values of maximum duration for DMRS bundling for (a) different modulation orders, (b) back-to-back and non-back-to-back transmissions **Proposal 4:** On UE features 30-4a to 30-4d: split these features into two components, one for back-to-back transmissions and another for non-back-to-back transmissions.**Proposal 5:** On UE features 30-4 to 30-4g: all features on DMRS Bundling (PUSCH and PUCCH) to be indicated at the per FS level. This is required due potential impact of operations such as uplink tx switching, uplink full power transmission, and interactions with other features such as UE’s MIMO coherence capability.**Proposal 6**: On UE feature 30-4 for maximum duration for DMRS bundling, UE may report different values for (a) different modulation orders, (b) back-to-back and non-back-to-back transmissions. Consider splitting this into multiple components.**Additional comments and suggested changes to the UE features table:****Proposal 11:** Additional comments and suggested changes to the UE features table for coverage enhancement are included in the following table, with changes marked in red.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 30. NR\_cov\_enh | 30-4 | ~~[~~The maximum duration for DM-RS bundling~~]~~ | The maximum duration during which UE is able to maintain power consistency and phase continuity to support DM-RS bundling for PUSCH/PUCCH. Max duration is only applicable to modulation order not higher than QPSK. For other modulation orders, DMRS bundling is not supported. TBD:(a) whether another row for pi/2 BPSK is required. (b) Candidate values (c) whether different values for back to back and non back to back transmissions are reported. |  | Yes | N/A | UE does not support DM-RS bundling for PUSCH/PUCCH | ~~[Per UE]~~ Per FS | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
|  30. NR\_cov\_enh | 30-4a | [DM-RS bundling for PUSCH repetition type A with back-to-back transmission] | Support DM-RS bundling for PUSCH repetition type A. This is applicable for back-to-back transmissions. | [30-4], ~~[30-1] or [30-2]~~ | Yes | N/A | UE does not Support DM-RS bundling for PUSCH repetition type A with back-to-back transmission | ~~[Per UE]~~ Per FS | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
| 30. NR\_cov\_enh | 30-4h | DMRS-bundling for PUSCH Repetition Type A with non-back-to-back transmission | Support DM-RS bundling for PUSCH repetition type A. This is applicable for non-back-to-back transmissions. | [30-4] | Yes | N/A | UE does not Support DM-RS bundling for PUSCH repetition type A with non-back-to-back transmission | Per FS | N/A | N/A | N/A |  | Optional with capability signalling |
|  30. NR\_cov\_enh | 30-4b | [DM-RS bundling for PUSCH repetition type B with back-to-back transmission] | Support DM-RS bundling for PUSCH repetition type B. This is applicable for back-to-back transmissions. | [30-4], [11-5] ~~[30-1]~~ | Yes | N/A | UE does not Support DM-RS bundling for PUSCH repetition type B with back-to-back transmission | [Per UE] Per FS | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
| 30. NR\_cov\_enh | 30-4i | DMRS-bundling for PUSCH Repetition Type B with non-back-to-back transmission | Support DM-RS bundling for PUSCH repetition type B. This is applicable for non-back-to-back transmissions. |  | Yes | N/A | UE does not Support DM-RS bundling for PUSCH repetition type B with non-back-to-back transmission | Per FS | N/A | N/A | N/A |  | Optional with capability signalling |
|  30. NR\_cov\_enh | 30-4c | ~~[~~DM-RS bundling for TB processing over multi-slot PUSCH with back-to-back transmissions~~]~~ | Support DM-RS bundling for TB processing over multi-slot PUSCH. This is applicable only for back-to-back transmissions. | [30-4], [30-3],[30-4a] | Yes | N/A | UE does not Support DM-RS bundling for TB processing over multi-slot PUSCH with back-to-back transmissions | ~~[Per UE]~~ Per FS | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
| 30. NR\_cov\_enh | 30-4j | DM-RS bundling for TB processing over multi-slot PUSCH with non-back-to-back transmission | Support DM-RS bundling for TB processing over multi-slot PUSCH. This is applicable only for non-back-to-back transmissions. | [30-4], [30-3],[30-4h] | Yes | N/A | UE does not Support DM-RS bundling for TB processing over multi-slot PUSCH with non-back-to-back transmissions | Per FS | N/A | N/A | N/A |  | Optional with capability signalling |
| 30. NR\_cov\_enh | 30-4d | ~~[~~DMRS bunding for PUCCH repetitions with back-to-back transmissions~~]~~ | Support DM-RS bundling for PUCCH repetitions with back-to-back transmissions | [30-4], [4-23] | Yes | N/A | UE does not support DMRS bunding for PUCCH repetitions with back-to-back transmissions | ~~[Per UE]~~ Per FS | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
| 30. NR\_cov\_enh | 30-4k | DMRS bunding for PUCCH repetitions with non-back-to-back transmissions | Support DM-RS bundling for PUCCH repetitions with non-back-to-back transmissions | [30-4], [4-23] | Yes | N/A | UE does not support DMRS bunding for PUCCH repetitions with non-back-to-back transmissions | Per FS | N/A |  N/A | N/A |  | Optional with capability signalling |
| 30. NR\_cov\_enh | 30-4e | ~~[~~Inter-slot frequency hopping with inter-slot DMRS bundling for PUSCH~~]~~ | Support inter-slot frequency hopping with inter-slot bundling for PUSCH | [30-4a] or [30-4b] or [30-4c] | Yes | N/A | UE does not support inter-slot frequency hopping with inter-slot bundling for PUSCH | ~~[Per UE]~~ Per FS | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
| 30. NR\_cov\_enh | 30-4f | ~~[~~Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling~~]~~Unclear why this says “enhanced” but not 30-4e. | Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling | [30-4d] | Yes | N/A | UE does not support Enhanced inter-slot frequency hopping for PUCCH repetitions with DMRS bundling | ~~[Per UE]~~ Per FS | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |
| 30. NR\_cov\_enh | 30-4g | ~~[~~Restart DM-RS bundling after the events that violate power consistency and phase continuity within a configured TDW~~]~~ | Support restarting DM-RS bundling after the events that violate power consistency and phase continuity | [30-4] | Yes | N/A | UE does not support restarting DM-RS bundling after the events that violate power consistency and phase continuity within a configured TDW | ~~[Per UE]~~ Per FS | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |

 |
| [13] | MediaTek Inc. | Proposal 3: For DMRS bundling, separated FGs for PUSCH and PUCCH enhancements.Proposal 4: For DMRS bundling, separated FGs for B2B transmissions across the consecutive slots, non-B2B transmissions across the consecutive slots w/o other uplink transmissions, and B2B transmission within one slot. Proposal 5: For DMRS bundling, separated FGs for Type A and Type B repetitions.Proposal 7: All UE features are per band.Proposal 8: For DMRS bundling, the maximum duration is differentiated at least for FR1/FR2. Proposal 9: All UE features are optional with capability signalling |

## **Discussion**

**[FL1] High priority question 4-1:**

* **Companies are encouraged to provide views on whether UE can report different values of maximum duration for DMRS bundling for**
	+ **(a) different modulation orders**
		- Yes: Qualcomm
		- Wait for RAN4 reply: Huawei, HiSilicon, DOCOMO
	+ **(b) back-to-back and non-back-to-back transmissions**
		- Yes: Qualcomm
		- Wait for RAN4 reply: Huawei, HiSilicon, DOCOMO

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | Since the current majority view in RAN4 assumes the maximum duration is not dependent on modulation order, we should not decide to support (a) until RAN4 reaches the agreement that modulation order affects the maximum duration. The same thing goes for (b) |
| Qualcomm | On (a) Can we just directly limit DMRS bundling to modulation orders QPSK or lower? It might help sidestep the first question. RAN4 is not even looking at other modulation orders. From a RAN1 standpoint, its not clear why we’ll ever have 16-QAM or higher modulation order paired with PUSCH repetitions.On (b) this will definitely be needed as a UE Tx needs to get into a “standby” mode before resuming transmissions, and its likely that, depending on the exact implementation, this may cause a small phase jitter. This then impacts overall capability to support bundling. |
| Intel | We are fine to wait for RAN4 reply.  |
| ZTE | Ok to wait for RAN4 reply.  |
| Apple | We prefer to wait for RAN4 reply |

**[FL1] High priority question 4-2:**

* **Companies are encouraged to provide views on whether/how to revise the structure for FGs 30-4 and 30-4x, e.g.,**
	+ **Q1: Whether to wait for RAN4 input before discussing the structure**
		- Yes: ZTE
		- No:
	+ **Q2: Whether to split to back-to-back transmission and non-back-to-back transmission**
		- Yes: Huawei, HiSilicon, Intel, Ericsson, Qualcomm, MediaTek
			* **Q2a: For non-back-to-back transmission, whether to add an FG for the case when other UL signals/channels are inserted in the gap between repetitions with same setting**
				+ Yes: Huawei, HiSilicon, Intel
				+ No:
		- No:
	+ **Q3: Whether to merge some of FGs 30-4 to 30-4d**
		- Merge FGs 30-4b, 30-4c and 30-4d into FG 30-4a: Samsung
		- Merge FGs 30-4b, 30-4c into FG 30-4a: DOCOMO
		- Merge FGs 30-4a and 30-4d into FG 30-4: Ericsson, [ZTE]
		- Keep current structure: Huawei, HiSilicon, Qualcomm, MediaTek
	+ **Q4: Whether to merge FG 30-4f into FG 30-4e**
		- Yes: Samsung, Ericsson
		- No: Qualcomm, MediaTek
	+ **Q5: Whether to remove FG 30-4g from the UE feature list**
		- Yes: Apple
		- No: Ericsson, Qualcomm

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | Q2: Yes.Q2a: We should wait for the RAN1 discussion.Q3: We prefer to merge all FG of DMRS-bundling for PUSCH. Since single RRC parameter is used for PUSCH DMRS-bundling enabling/disabling indication. Applying DMRS bundling according to repetition types based on capability bits is against RAN2 guidance in R1-2001513: avoid defining functionality that has no RRC configuration but is dependent on capability bits.Q4: No. Q5: No. It should be up to UE if UE restarts DMRS bundling within configured TDW, because restarting TDW according to dynamic events could be burden for UE.  |
| Panasonic | Q3: We support Samsung’s view. DMRS bundling is not required to split among functions.Q4: We support to merge FG 30-4f into FG 30-4e.Q5: We support UE capability of restarting DMRS bundling to be applied for both semi-static events and dynamic events. |
| QC | Q1: We can proceed forward.Q2: Yes, a split is necessary. Q2a: We never agreed to support any uplink transmissions in the middle.Q3: Keep the current structure.Q4: Don’t mergeQ5: Don’t delete |
| Intel | Q2: Yes.Q2a: Yes. this is based on RAN4 feedback on the uplink transmission in the middle with same setting. Q3: we are okay to merge DMRS bundling for PUSCH. In the agreement, DMRS bundling for PUSCH repetition type B/TBoMS reuses the design for PUSCH repetition type A. Q4: We support to merge FG 30-4f into FG 30-4e. The main benefit of inter-slot frequency hopping with inter-slot bundling is to apply DMRS bundling. Q5: No. This is aligned with current agreements.  |
| ZTE | In general, we prefer to reserve more time for the discussion on other UE FGs in this meeting since DMRS bundling related FGs are highly related to RAN4 further discussion.  |
| Apple | Q2: yesQ2a: RAN4 has no indication to support this case.Q3: Keep the current structure.Q4: Don’t mergeQ5: Prefer to remove. If UE can re-start the transmission, everything should be ready from hardware, such as the transmission power preparation, transmission timeline. There is no issues to keep the phase continuity and power consistency in new window. |

**Medium priority question 4-3:**

* **The column for “Mandatory/Optional” in FGs 30-4 and 30-4x is confirmed as “Optional with capability signaling”**

|  |  |
| --- | --- |
| Company | Comment |
| Panasonic | We are fine with Proposal 4-3. |
| QC | Yes, this is fine. |
| Intel | Support. |
| Apple | Support |

**Medium priority question 4-4:**

* **Companies are encouraged to provide views on whether the type of FGs 30-4 and 30-4x should be per UE, per band, or per FS**
	+ Per UE: Huawei, HiSilicon
		- FR1/FR2 differentiation is necessary: Huawei, HiSilicon
	+ Per band: vivo (should be confirmed by RAN4), MediaTek
	+ Per FS: Qualcomm

|  |  |
| --- | --- |
| Company | Comment |
| Panasonic | We support “per band”. |
| QC | It is important that for features related to DMRS bundling we choose per FS type. DMRS bundling relies heavily on careful RF architecture and implementation. Due to shared components across bands and due to RF impact of transmissions in one band on the other band, it is not guaranteed that what a UE reports as being capable in a band in non-CA mode is also possible in inter-band CA mode. RAN4 in fact clearly identifies this in their LS back to RAN1:From the R4-2103393, “Reply LS on PUCCH and PUSCH repetition”, RAN4 (Qualcomm), 3GPP TSG-RAN WG4 Meeting #98-e, 24 Jan – 5 Feb 2021* Question 1: Under what conditions UE can keep phase continuity cross PUCCH or PUSCH repetitions
* RAN4 Answer for question 1: If the following conditions are met
	+ No change on transmission power level of its own CC, i.e., no change on the power control parameters specified in TS 38.213, and also when own CC is not impacted by other concurrent CC(s) that are configured for inter-band CA or DC for same UE with dynamic power sharing and no change in any configured CC s that are part of configured intra-band uplink CA or DC.
 |
|  |  |

**Low priority question 4-5:**

* **Companies are encouraged to provide views on whether/how to revise the prerequisite feature groups for FGs 30-4 and 30-4x**

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

**Low priority question 4-6:**

* **Companies are encouraged to provide views on whether/how to revise any other contents in FGs 30-4 and 30-4x which do not have capability signaling impacts**

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

# **30-5: Slot based dynamic PUCCH repetition indication**

In [1], FG 30-5 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 (Sidelink 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 |
| 30. NR\_cov\_enh | 30-5 | Slot based dynamic PUCCH repetition indication | Support dynamic PUCCH repetition indication | [4-23] | Yes | N/A | UE does not support Dynamic PUCCH repetition indication | [Per UE] | FFS | No | N/A |  | Optional with capability signalling |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | Huawei, HiSilicon | **The need of FDD/TDD differentiation**For all the features, there seems no justification or evidence to support the need for FDD/TDD differentiation. The FDD/TDD differentiation is unnecessary.***Proposal 2: For FG 30-1 to FG 30-6, the FDD/TDD differentiation is unnecessary.*****The type of granularity**First of all, it should be noted that, there are certain reasons to define that the FG 30-4 is set per band. As previously described, the compensation leftover for frequency error and RF characteristics may be different for different bands. However, analyzing RF and determining the values of the maximum duration for all bands will result in very heavy workload and is unnecessary. Considering above, it is a good choice to define the UE feature of maximum duration, i.e. FG 30-4, based on the granularity of Per UE and with FR1/FR2 differentiation.For other features except for FG 30-4, there is no particular reason to apply other granularities. Per UE is sufficient.***Proposal 7: All the UE feature for NR coverage enhancement should be based on the granularity of Per UE.*** |
| [3] | ZTE | We agree that one single FG is sufficient. We also confirm that the prerequisite FG 4-23 is needed and per UE reporting is sufficient. We don’t identify any differentiation for FDD/TDD and FR1/FR2 is needed. Therefore, we have the following proposal. ***Proposal 6:*** *Adopt the following revisions for FG 30-5 for dynamic PUCCH repetition indication.*

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | **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 |
| 30. NR\_cov\_enh | 30-5 | Slot based dynamic PUCCH repetition indication | Support dynamic PUCCH repetition indication | 4-23 | Per UE | No | No |

 |
| [5] | Nokia, Nokia Shanghai Bell | * **30-1, 30-1a, 30-2, 30-2a, 30-3, 30-4, 30-4a/b/c/d/e/f/g, 30-5, 30-6:**
	+ Confirm the FGs. Details to be finalized later.
 |
| [9] | Ericsson | The current status of features for PUCCH repetition enhancement from [1] are captured in Table 4 (where the yellow shaded cells indicate an area identified by the moderator as for further discussion), as well as our suggested changes. Our rationale is as follows:In RAN1#106bis, there was discussion on what the prerequisite feature should be for slot based dynamic PUCCH repetition indication. While the Rel-15 feature for PUCCH repetition (4-23, ‘Repetitions for PUCCH format 1, 3, and 4 over multiple slots with K = 2, 4, 8’), we are not sure whether it is needed for dynamic PUCCH repetition factor indication, as these could be duplicate functionality. Dynamic PUCCH repetition in our understanding is implemented as configuring a repetition factor for a PUCCH resource, while 4-23 is configured per PUCCH format. Configuring per PUCCH resource can have the same behavior without additional DCI overhead, as configuring per PUCCH format. Therefore, we would like to discuss further whether 4-23 is really needed as a prerequisite, and suggest the square brackets around 4-23 be kept for now.Regarding the 30-5 feature description for dynamic PUCCH repetition indication, since dynamic PUCCH repetition is implemented by configuring a repetition factor per PUCCH resource, it can be supported together e.g. with repetition of PUCCH formats 0 and 2, so 30-5 is a general mechanism that supports PUCCH formats 0, 1, 2, 3, and 4. We think it is more clear to identify the supported PUCCH formats directly, rather than describing the feature only as dynamic PUCCH repetition indication. The related agreements supporting this line of thinking are:Agreement: Support sub-slot based PUCCH repetition for HARQ-ACK based on the Rel-16 PUCCH procedure for slot-based PUCCH applied to sub-slot based PUCCH* Note: the intention is to take the Rel-16 slot-based PUCCH by replacing with “sub-slot” appropriately, without further optimization unless necessary
* FFS whether or not there is any restriction for the applicability of sub-slot based PUCCH repetition for HARQ-ACK
* Dynamic repetition indication is supported also for sub-slot based PUCCH in Rel-17
	+ FFS: if the method to be specified in Cov. Enh WI for slot-based PUCCH repetition can be directly applied to sub-slot PUCCH or if changes are needed

**Agreement:**Support PUCCH repetition for PUCCH formats 0 and 2 at least for sub-slot based PUCCH repetition. * FFS: Support for slot-based PUCCH repetition

**Agreement**Support slot-based PUCCH repetition for PUCCH Format 0 and Format 2 also for single TRP operation. * The support is subject to independent UE capability indication

**Conclusion**The dynamic repetition indication solution for slot-based PUCCH repetition from the RAN1#105-e working assumption from Cov. Enh. WI can be directly applied for dynamic repetition indication for sub-slot based PUCCH repetition.**Agreement** For sub-slot based PUCCH repetition for HARQ-ACK, semi-static configured PUCCH repetition (i.e. using *nrofSlots*) and dynamic repetition factor based operation is supported. * Sub-slot based PUCCH repetition based on semi-static configuration (i.e. using *nrofSlots*) and based on dynamic indication is subject to separate UE capabilities

Table 4: Capabilities for PUCCH Repetition Enhancement

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | Feature group | Components | Prerequisite feature groups | Comments |
| 30-5 | Slot based dynamic PUCCH repetition indication | ~~Support dynamic PUCCH repetition indication~~Support for configuring a repetition factor per PUCCH resource for slot based PUCCH formats 0, 1, 2, 3, and 4 | [4-23] |  |

1. UE features for PUCCH repetition enhancement are defined according to Table 4
 |
| [10] | NTT DOCOMO, INC. | Regarding the prerequisite feature group, FGs for slot based PUCCH repetitions (FG 4-23) can be the prerequisite feature group, since to support FG 30-5, it is assumed that the UE supports slot based PUCCH repetitions, although the parent IE for the RRC parameters are different, e.g. *PUCCH format* for FG 4-23, and *PUCCH Resource* for FG 30-5. **Proposal 8: FG 4-23 can be kept as prerequisite feature group.** It was also discussed that the FGs are supported per UE or per band and FDD/TDD differentiation is necessary or not. The FG 30-5 is related to the PUCCH repetitions, so that they are specific for band or duplexing, therefore the FG can be supported per UE and no FDD/TDD differentiation is necessary.**Proposal 9: FG 30-5 can be supported per UE and no FDD/TDD differentiation is necessary.**Regarding optional or mandatory with capability signaling, the FGs should be supported as optional feature with capability signaling, because it has not been agreed that any CovEnh feature is mandatory to support.**Proposal 3: All CovEnh features should be supported as optional feature with capability signaling.** |
| [12] | Qualcomm Incorporated | **General remark applicable to all features for NR coverage enhancement****Proposal 1:** Unless otherwise stated, the type for a UE feature should be at least per band (if not with finer granularity type), given the potential UE testing differentiation among licensed, unlicensed, and NTN band.**On dynamic indication of PUCCH repetition****Proposal 10:** Ensure UE capabilities for dynamic indication of PUCCH repetition separately indicated at least per frequency band.**Additional comments and suggested changes to the UE features table:****Proposal 11:** Additional comments and suggested changes to the UE features table for coverage enhancement are included in the following table, with changes marked in red.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 30. NR\_cov\_enh | 30-5 | Dynamic PUCCH repetition indication | Support dynamic PUCCH repetition indication | [4-23] | Yes | N/A | UE does not support Dynamic PUCCH repetition indication | ~~[Per UE]~~ Per band | ~~FFS~~ N/A | ~~No~~ N/A | N/A |  | ~~[~~Optional with capability signalling~~]~~ |

 |
| [13] | MediaTek Inc. | Proposal 6: For dynamic PUCCH repetition indication, UE capability for repetition of PUCCH format 3 and 4 are defined in FGs for Rel’17 CovEnh. UE capability for support repetition of PUCCH format 0 and 2 should be defined in FGs for Rel’17 URLLC. Proposal 7: All UE features are per band. |

## **Discussion**

**[FL1] High priority question 5-1:**

* **Companies are encouraged to provide views on whether FG 30-5 is for dynamic PUCCH repetition indication for PUCCH formats 0/1/2/3/4 or for PUCCH formats 1/3/4 and FG 25-2 is for PUCCH formats 0/2**
	+ FG 30-5 is for PUCCH formats 0/1/2/3/4: Ericsson
	+ FG 30-5 is for PUCCH formats 1/3/4 and FG 25-2 is for PUCCH formats 0/2: MediaTek

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | At the RAN1#106bis-e meeting, we had following agreement, so that we support that the FG 30-5 is for PUCCH formats 0/1/2/3/4.Support dynamic PUCCH repetition factor indication for all PUCCH formats including format 0, 1, 2, 3, 4 with a unified mechanism as agreed in RAN1#106e under agenda 8.8.2. |
| Intel | We share similar view as NTT DOCOMO that this is for all PUCCH formats based on the agreement.  |
| ZTE | Share similar view as NTT DOCOMO and Intel. |

**Medium priority question 5-2:**

* **Companies are encouraged to provide views on whether the type of FG 30-5 should be per UE or per band**
	+ Per UE: Huawei, HiSilicon, ZTE, DOCOMO
		- FDD/TDD differentiation is not necessary: Huawei, HiSilicon, ZTE, DOCOMO
	+ Per band: Qualcomm, MediaTek

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | We support per UE since they are not band specific features. |
| Intel | Per UE |
| ZTE | Per UE is sufficient.  |

**Low priority question 5-3:**

* **Companies are encouraged to provide views on whether/how to revise the prerequisite feature groups for FG 30-5**

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

**Low priority question 5-4:**

* **Companies are encouraged to provide views on whether/how to revise any other contents in FG 30-5 which do not have capability signaling impacts**

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

# **30-6: Msg3 repetition**

In [1], FG 30-6 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 (Sidelink 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 |
| 30. NR\_cov\_enh | 30-6 | Msg3 repetition | Support of Msg3 repetition for Msg3 initial transmission and re-transmission in RRC connected mode.  |  | Yes | N/A | UE does not support Msg3 repetition for Msg3 initial transmission and re-transmission in RRC connected mode. | [Per UE] | No | No | N/A  |  | [Optional with capability signalling] |

Following feedbacks are provided in contributions for the RAN1#107-e meeting.

|  |  |  |
| --- | --- | --- |
| [2] | Huawei, HiSilicon | **Whether the features are Mandatory or Optional**As enhanced features in Rel-17, considering UE capabilities and flexibility, all the UE features for coverage enhancement listed in [1] should be optional with capability signaling. Specifically, for FG 30-6 related to Msg3 repetition, the feature can realize optional based on whether to access via separate RACH resources without capability signaling. However, capability signaling after beyond the RACH procedure can help the gNB properly configure RACH resources for different purposes. Thus, FG 30-6 should be optional with capability signaling. ***Proposal 1: For FG 30-1 to FG 30-6, all the UE features should be optional with capability signaling.*****The need of FDD/TDD differentiation**For all the features, there seems no justification or evidence to support the need for FDD/TDD differentiation. The FDD/TDD differentiation is unnecessary.***Proposal 2: For FG 30-1 to FG 30-6, the FDD/TDD differentiation is unnecessary.*****The type of granularity**First of all, it should be noted that, there are certain reasons to define that the FG 30-4 is set per band. As previously described, the compensation leftover for frequency error and RF characteristics may be different for different bands. However, analyzing RF and determining the values of the maximum duration for all bands will result in very heavy workload and is unnecessary. Considering above, it is a good choice to define the UE feature of maximum duration, i.e. FG 30-4, based on the granularity of Per UE and with FR1/FR2 differentiation.For other features except for FG 30-4, there is no particular reason to apply other granularities. Per UE is sufficient.***Proposal 7: All the UE feature for NR coverage enhancement should be based on the granularity of Per UE.*** |
| [3] | ZTE | As whether to introduce FG 30-6, it has been discussed once in AI 8.8.3. Below our view on the necessity of this FG is provided. * If a UE requests Msg3 repetition, it implicitly means the UE reports its capability. However, gNB would not know how many of UEs in the cell is capable of Msg3 repetition. Because, only those Msg3 capable UEs in poor coverage will make a request. Allowing UE to report its capability of Msg3 repetition after initial access could let gNB know this information (i.e., how many of UEs in the cell is capable of Msg3 repetition), then gNB can know the maximum number of separate PRACH resources needed. In addition, NW generally has the knowledge of channel variation of a UE (e.g., moving) by various means (e.g., mobility management). Therefore, knowing the number of UEs needed Msg3 repetition (by request) and the total number of UEs supporting Msg3 repetition (by capability reporting after initial access) would certainly help NW find a more appropriate PRACH configuration based on it’s monitoring. In this sense, reporting the capability after initial access is beneficial in general including CBRA case.
* For CFRA case, it allows gNB can configure less separate PRACH resources for CE UEs. Because, in CFRA case, even if UE uses legacy PRACH resource for transmission, gNB can still schedule Msg3 with or without repetition based on gNB's measurement, since gNB would know whether the UE has the capability or not, thanks to the capability reporting after initial access.
* Theoretically, if a UE requests Msg3 repetition and the RACH procedure is successfully completed, NW can know UE’s capability of supporting Msg3 repetition. While, the RACH procedure with Msg3 repetition may also fail, and if UE accesses to the NW without requesting Msg3 repetition later, capability reporting after initial access is also needed in such case.

Regarding the reporting type, we think per UE reporting is sufficient. In addition, it may or may not need to differentiate FDD or TDD based on further discussion of HD FDD UEs regarding how to handle SSB and Msg3 PUSCH transmission in RedCap WI. At this moment, we prefer to leave this open. ***Proposal 7:*** *Adopt the following revisions for FG 30-6 for Msg3 PUSCH repetition.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | **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 |
| 30. NR\_cov\_enh | 30-6 | Msg3 repetition | Support of Msg3 repetition for Msg3 initial transmission and re-transmission in RRC connected mode.  |  | ~~[~~Per UE~~]~~ | ~~No~~ FFS |

 |
| [4] | vivo | For msg3 repetition related features 30-6, whether the capability reporting is needed depends on RAN2 further discussions, according to RAN2 agreements as follows.

|  |
| --- |
| Agreements1. Msg3 repetition is applicable to all cases that trigger 4-step CBRA procedure (can come back if we identify that some specific case should not be covered)
2. A separate RSRP threshold is introduced for requesting Msg3 repetition
3. Extension of ra-ResponseWindow and ra-ContentionResolutionTimer are not needed for Msg3 repetition.
4. RAN2 confirms enhancing MAC RAR for indicating MSG3 repetition is not supported.
5. Postpone the discussion on UE capability (i.e. whether explicit UE capability is needed for indicating the support of Msg3 repetition).
 |

Hence, whether Features 30-6 is ‘Optional with capability signaling’ or ‘Optional without capability signaling’ can be up to RAN2 discussion.**Proposal 3: Whether Features 30-6 is ‘Optional with capability signaling’ or ‘Optional without capability signaling’ can be up to RAN2 discussion.** |
| [5] | Nokia, Nokia Shanghai Bell | * **30-1, 30-1a, 30-2, 30-2a, 30-3, 30-4, 30-4a/b/c/d/e/f/g, 30-5, 30-6:**
	+ Confirm the FGs. Details to be finalized later.
 |
| [6] | Intel Corporation | For Msg3 PUSCH repetition, it is supported for RRC IDLE/INACTIVE mode UEs and can also be supported for RRC CONNECTED mode UEs. Table 3 illustrates suggested update for UE feature groups for Msg3 PUSCH repetition. Table 3. UE feature group for Msg3 PUSCH repetition

|  |  |  |
| --- | --- | --- |
| **Index** | **Feature group** | **Components** |
| 30-6 | Msg3 repetition | Support of Msg3 repetition for Msg3 initial transmission and re-transmission ~~in RRC connected mode~~.  |

**Proposal 4*** *For UE features for Msg3 PUSCH repetition, support Msg3 repetition for initial transmission and re-transmission in RRC idle/inactive and connected mode.*
 |
| [7] | Samsung | Regarding FG 30-6 (Msg3 repetition), company views have been divided at RAN1#106bis-e [1]. We are still of the opinion that FG 30-6 is not needed because a UE can implicitly indicate its capability via PRACH transmission thanks to the RACH resource partition for msg3 repetition. **Proposal 5: Remove FG 30-6 from the UE feature for Rel-17 Coverage Enhancement.**

|  |  |  |
| --- | --- | --- |
| ~~30-6~~ | ~~Msg3 repetition~~ | ~~Support of Msg3 repetition for Msg3 initial transmission and re-transmission in RRC connected mode.~~  |

 |
| [8] | Apple | This feature group is not needed, if the UE support msg3 repetition, it will select the corresponding preamble to perform the random access process, and gNB would know whether UE supports this feature after preamble detection. The necessity of introducing this FG is not clear.**Proposal 3: Remove the FG 30-6 Msg3 repetition.** |
| [9] | Ericsson | For Type A PUSCH repetition for Msg3, a set of UE features discussed so far are summarized and updated in Table 5. There were no updates to the features to the feature list in RAN1#106bis, and so the changes are shown with respect to the features as listed in [5]. It was agreed in RAN1#105e that a UE requests Msg3 PUSCH repetition at least when the RSRP of the downlink pathloss reference is lower than an RSRP threshold. So only if UE is capable of Msg3 repetition and its RSRP is below the threshold, will it request Msg3 repetition with specific preamble. The gNB can’t distinguish between a UE that doesn’t request Msg3 repetition because it is incapable of Msg3 repetition and a UE that has higher RSRP. Therefore, UEs should report their capability for Msg3 repetition after random access. Msg3 repetition can be used both in RRC Idle and RRC connected mode, so we suggest to remove the words “~~in RRC connected mode~~”. Furthermore, since in RAN1 specification, PUSCH scheduled by RAR is used for Msg3 in CBRA and a PUSCH scheduled by RAR in CFRA. Thus, we propose to use term “PUSCH scheduled by RAR” instead for Msg3 initial transmission and the PUSCH transmission scheduled by RAR in CFRA.Table 5: Capabilities for Type A PUSCH repetition for Msg3

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | Feature group | Components | Prerequisite feature groups | Comments |
| 30-6 | ~~Msg3~~ repetition of PUSCH scheduled by RAR or Msg3 retransmission scheduled by DCI. | Support of ~~Msg3~~ repetition of PUSCH scheduled by RAR ~~for Msg3 initial transmission~~ and Msg3 re-transmission scheduled by DCI ~~in RRC connected mode~~.  |  |  |

1. UE features for Type A PUSCH repetition for Msg3 are defined according to Table 5
 |
| [10] | NTT DOCOMO, INC. | At the RAN1#106 bis-e meeting, whether to introduce capability for Msg3 repetitions in RRC connected mode, FG 30-6, was discussed. This capability report is beneficial when UE capable of Msg3 repetition does not request Msg3 repetitions due to high RSRP of the downlink path loss reference. In that case, the capability report is necessary for the network to trigger the handover with Msg3 repetitions. Albeit RAN2 is discussing this point, we think FG 30-6 should be introduced for further coverage enhancements in RRC connected mode.**Proposal 10: For UE features of Msg3 PUSCH repetitions, support Msg3 repetition for initial transmission and re-transmission in RRC connected mode.** Regarding optional or mandatory with capability signaling, the FGs should be supported as optional feature with capability signaling, because it has not been agreed that any CovEnh feature is mandatory to support.**Proposal 3: All CovEnh features should be supported as optional feature with capability signaling.** |
| [11] | Sharp | Msg3 repetitions can be applicable to all cases that trigger 4-step CBRA procedure. If the capability signaling is not supported for msg3 repetition, network will confuse when providing CBRA resource for a connected mode UE. For example, when the network triggers the handover or PSCell addition, the network needs to decide what resource (CBRA with/without msg3 repetition request resource or CFRA) should be provided to the UE. If the capability signaling is not supported, the network decision will be complicated, or the network needs to allocate CBRA with msg3 repetition request resource all the time. The same thing happens for scheduling BFR resource.In other situation, the network may configure two BWPs (e.g., one with CBRA resource without msg3 repetition request resource, and another with CBRA with/without msg3 repetition request resource). If the network wants to distribute UEs in the two BWPs, the capability signaling is necessary. Therefore, we should confirm that the capability signaling for msg3 repetition is supported.***Proposal 4: Confirm that a capability signaling for msg3 repetition (FG 30-6) is supported.*** |
| [12] | Qualcomm Incorporated | **General remark applicable to all features for NR coverage enhancement****Proposal 1:** Unless otherwise stated, the type for a UE feature should be at least per band (if not with finer granularity type), given the potential UE testing differentiation among licensed, unlicensed, and NTN band.**Additional comments and suggested changes to the UE features table:****Proposal 11:** Additional comments and suggested changes to the UE features table for coverage enhancement are included in the following table, with changes marked in red.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 30. NR\_cov\_enh | 30-6 | ~~Msg3 repetition~~[This feature group seems unnecessary since UE capability of msg3 repetition is implicitly indicated by UE RACH transmission. Indication of msg3 repetition is not necessary after initial access.] | Support of Msg3 repetition for Msg3 initial transmission and re-transmission in RRC connected mode.  |  |  YesNo, gNB doesn’t not need to know this via UE capability reporting. | N/A | UE does not support Msg3 repetition for Msg3 initial transmission and re-transmission in RRC connected mode. | ~~[Per UE]~~ Per band | ~~No~~ N/A | ~~No~~ N/A | N/A  |  | ~~[Optional with capability signalling]~~Optional without capability signalling |

 |
| [13] | MediaTek Inc. | Proposal 7: All UE features are per band.Proposal 9: All UE features are optional with capability signalling |

## **Discussion**

**[FL1] High priority question 6-1:**

* **Companies are encouraged to provide views on whether FG 30-6 is necessary or not**
	+ Necessary: ZTE, Nokia, NSB, Intel, Ericsson, DOCOMO, Sharp
		- Support for RRC idle/inactive modes in addition to connected mode: Intel. Ericsson
	+ Not necessary: Samsung, Apple, Qualcomm
	+ Up to RAN2: vivo

|  |  |
| --- | --- |
| Company | Comment |
| NTT DOCOMO | Since UE capable of Msg3 repetition does not always request Msg3 repetitions due to high RSRP, the capability report after RRC connection is necessary for network to know whether UE supports Msg3 repetitions. This information is useful when the network manages handover of UEs. |
| Panasonic | Msg.3 repetition related feature can be up to RAN2 discussion. |
| Intel | We think it is necessary to have FG 30-6 |
| ZTE | Share similar view as NTT DOCOMO.  |

**Medium priority question 6-2:**

* **Companies are encouraged to provide views on** **whether capability signaling is necessary for FG 30-6, i.e., whether to support as optional with capability signaling or optional without capability signaling**
	+ Optional with capability signaling: Huawei, HiSilicon, ZTE, DOCOMO, MediaTek
	+ Optional without capability signaling: Qualcomm
	+ Up to RAN2: vivo

|  |  |
| --- | --- |
| Company | Comment |
| Panasonic | Msg.3 repetition related feature can be up to RAN2 discussion. On the other hand, we see argument that for the handover case capability is necessary. Therefore, we are fine to signal it. |
| ZTE | Reporting the capability to network could help NW to configure more appropriate PRACH resources. |
|  |  |

**Medium priority question 6-3:**

* **Companies are encouraged to provide views on whether the type of FG 30-6 should be per UE or per band**
	+ Per UE: Huawei, HiSilicon, ZTE
		- FDD/TDD differentiation
			* Not necessary: Huawei, HiSilicon
			* FFS: ZTE
	+ Per band: Qualcomm, MediaTek

|  |  |
| --- | --- |
| Company | Comment |
| ZTE | Per UE reporting is sufficient.  |
|  |  |
|  |  |

**Low priority question 6-4:**

* **Companies are encouraged to provide views on whether/how to revise any other contents in FG 30-6 which do not have capability signaling impacts**

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

# **Conclusions**

TBD

# **References**

[1] R1-2110587 Updated RAN1 UE features list for Rel-17 NR after RAN1 #106bis-e Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2110794 Rel-17 UE features for NR coverage enhancement Huawei, HiSilicon

[3] R1-2110927 Discussion on UE features for NR coverage enhancement ZTE

[4] R1-2111056 Discussion on UE features for NR coverage enhancement vivo

[5] R1-2111159 On UE features for NR coverage enhancement Nokia, Nokia Shanghai Bell

[6] R1-2111532 Discussion on UE features for NR coverage enhancement Intel Corporation

[7] R1-2111776 UE features for NR coverage enhancement Samsung

[8] R1-2111912 Views on Rel-17 Coverage Enhancement UE Features Apple

[9] R1-2112041 UE Features for NR Coverage Enhancement Ericsson

[10] R1-2112140 Discussion on Rel.17 UE features for NR coverage enhancement NTT DOCOMO, INC.

[11] R1-2112168 UE feature for Rel-17 coverage enhancement Sharp

[12] R1-2112253 UE Features for Coverage Enhancements Qualcomm Incorporated

[13] R1-2112319 Discussion on UE features for NR Coverage Enhancement MediaTek Inc.