**3GPP TSG RAN WG1 #114 R1-230nnnn**

**Toulouse, France, August 21st – August 25th, 2023**

**Agenda item:** 9.16.16

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

**Title:** [draft] Summary on UE features for TEIs

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 9.16.16 regarding UE features for TEIs.

According to the initial UE features lists from endorsed TEI proponents [1, 2], there are following feature groups for TEI18.

* FGs for HARQ multiplexing for PDSCH scheduling after UL grant on PUSCH
	+ 55-4a Multiplexing Type-1 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH
	+ 55-4b Multiplexing Type-2 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH
	+ 55-4c Multiplexing Type-3 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH
	+ 55-5 Determining a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant
	+ 55-6 Determining different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant
* FGs for pathloss RS updates for Type 1 CG-PUSCH
	+ 55-x Enable MAC CE based pathloss RS updates for Type 1 CG-PUSCH

# **FGs for HARQ multiplexing** **for PDSCH scheduling after UL grant on PUSCH**

In [1], FGs for HARQ multiplexing for PDSCH scheduling after UL grant on PUSCH are captured as below.

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| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (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 |
| 55. TEI18 | 55-4a | Multiplexing Type-1 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-1 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-11, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-1 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4b | Multiplexing Type-2 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-2 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-10, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-2 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4c | Multiplexing Type-3 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-3 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission | 4-1, 10-16, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-3 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-5 | Determining a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining a different PUCCH resource in a slot from the PUCCH resource indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | 4-1, 4-10 | Yes | N/A | UE does not support to determine a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-6 | Determining different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining different codebook size in a PUCCH slot from the size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | 4-1, 4-10 | Yes | N/A | UE does not support to determine different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |

Following inputs are provided in contributions for the RAN1#114 meeting.

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| [1] | Huawei, HiSilicon, Ericsson, China Unicom | In RAN1#113, following agreement is reached.

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| **Agreement**If UCI multiplexing of different priorities is not enabled, the restriction on scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions except the first repetition* UE generates Type-1 HARQ-ACK codebook according to the existing specification with the modification of setting the actual ‘ACK/NACK’ value corresponding to PDSCH(s) scheduled after the UL grant.
* UE generates Type-2/3 HARQ-ACK codebook according to the existing specification.
	+ For Type-2 CB, UL DAI is used for generating HARQ CB.
* This feature is subject to separate UE capabilities for type-1, type-2, and type-3 codebooks.
* RRC parameter(s) to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on a PUSCH repetition except the first repetition are introduced in Rel-18.
* Note: the number of PUSCH repetitions can be scheduled/configured by gNB.
* Note: same principle of current specification which UL DAI in UL grant is applied to each PUSCH repetition is reused.
* The timeline specified in TS 38.213 Clause 9.2.5 are satisfied, i.e. $T\_{proc,1}^{mux}$between the last PDSCH and PUCCH, $T\_{proc,2}^{mux}$ between the last PDCCH among UL grant /DL grant(s) and the earliest PUCCH or PUSCH
* Additional UE capabilities are introduced to support the following functions (UE will be configured by gNB to use the following features via RRC)
	+ HARQ-ACK codebook size change on a PUCCH slot
	+ PUCCH resource change on a PUCCH slot
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Based on the agreement, Type-1/2/3 HARQ-ACK codebook can be generated containing HARQ-ACK information associated with PDSCH(s) scheduled after a UL grant. The codebook is then multiplexed on a repetition of a PUSCH transmission other than the first repetition, where the repetitions are scheduled by the UL grant. To support this functionality, several UE features should be introduced.**UE features for supporting Type-1/2/3 HARQ codebook generation**In order to include more HARQ-ACK information arriving after a UL grant, new UE behaviors for HARQ-ACK codebook generation are required to be implemented and corresponding UE capabilities should be defined. Referring to FG 55-4a/b/c in the Appendix, individual UE features are introduced for Type-1/2/3 codebook generation respectively. To support these UE features, UE requires UCI multiplexing on PUSCH (FG 4-1), HARQ-ACK codebook generation (FG 4-11/4-10/10-16) and PUSCH repetition FGs as prerequisite features. Since both Type-A and Type-B PUSCH repetitions are supported and the number of PUSCH repetitions can be scheduled or configured by the gNB, at least one of the FGs from {5-17, 11-5, 11-6} should be supported as well.**UE feature for determining a different PUCCH resource**Due to accumulation of HARQ-ACK information bits after a UL grant, the increasing HARQ-ACK payload size might result in PUCCH resource changing, i.e. a different PUCCH resource from the one only includes HARQ-ACK associated with the PDSCH reception(s) scheduled before the UL grant might be determined. To support such behavior, a new UE feature should be specified, which is FG 55-5 in the Appendix. Since all three types of HARQ codebook generation are applicable for dynamic PDSCH scheduling, the prerequisite of FG 55-5 is at least one of {4-10, 4-11, 10-16}.**UE feature for determining different HARQ-ACK codebook size**Similar as FG 55-5, codebook sizes can be different before and after the UL grant, if more HARQ-ACK information are included. A specific UE feature is defined as FG 55-6 in the Appendix.***Proposal 1: Endorse UE feature list in the Appendix to support the multiplexing of HARQ-ACK codebook on a repetition of a PUSCH transmission, other than the first repetition, where the codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant which schedules the PUSCH transmission.***

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| **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (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** |
| 55. TEI18 | 55-4a | Multiplexing Type-1 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-1 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-11, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-1 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4b | Multiplexing Type-2 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-2 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-10, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-2 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4c | Multiplexing Type-3 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-3 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission | 4-1, 10-16, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-3 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-5 | Determining a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining a different PUCCH resource in a slot from the PUCCH resource indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | 4-1, 4-10 | Yes | N/A | UE does not support to determine a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-6 | Determining different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining different codebook size in a PUCCH slot from the size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | 4-1, 4-10 | Yes | N/A | UE does not support to determine different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |

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| [3] | Nokia, Nokia Shanghai Bell | RAN1#113 made the following agreement for HARQ-ACK multiplexing on PUSCH with repetitions:

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| **Agreement**If UCI multiplexing of different priorities is not enabled, the restriction on scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions except the first repetition* UE generates Type-1 HARQ-ACK codebook according to the existing specification with the modification of setting the actual ‘ACK/NACK’ value corresponding to PDSCH(s) scheduled after the UL grant.
* UE generates Type-2/3 HARQ-ACK codebook according to the existing specification.
	+ For Type-2 CB, UL DAI is used for generating HARQ CB.
* This feature is subject to separate UE capabilities for type-1, type-2, and type-3 codebooks.
* RRC parameter(s) to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on a PUSCH repetition except the first repetition are introduced in Rel-18.
* Note: the number of PUSCH repetitions can be scheduled/configured by gNB.
* Note: same principle of current specification which UL DAI in UL grant is applied to each PUSCH repetition is reused.
* The timeline specified in TS 38.213 Clause 9.2.5 are satisfied, i.e. $T\_{proc,1}^{mux}$between the last PDSCH and PUCCH, $T\_{proc,2}^{mux}$ between the last PDCCH among UL grant /DL grant(s) and the earliest PUCCH or PUSCH
* Additional UE capabilities are introduced to support the following functions (UE will be configured by gNB to use the following features via RRC)
	+ HARQ-ACK codebook size change on a PUCCH slot
	+ PUCCH resource change on a PUCCH slot
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**Proposal 1: To facilitate the RAN1#113 agreement on Enhancement for HARQ multiplexing on PUSCH with repetitions, the following new FG should be introduced**

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| Index | Feature group | Components | Prerequisite feature groups |
| 55-4 | Enhanced HARQ-ACK on PUSCH multiplexing timeline for PUSCH with repetitions | Support multiplexing a HARQ-ACK on PUSCH with repetitions when the DCI scheduling the PDSCH to be ACKed is received after the DCI scheduling the PUSCH on which the HARQ-ACK is to be multiplexed on  | At least one of {5-17, 10-40, 11-5, 11-6, 23-3-1, 23-3-1-2, 23-3-1-1, 23-3-1-3 ,30-3} |

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| [4] | ZTE | In RAN1#113, the TEI on HARQ multiplexing on PUSCH was approved with reaching the following agreements.

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| **Agreement*** If UCI multiplexing of different priorities is not enabled, the restriction on scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions except the first repetition
* UE generates Type-1 HARQ-ACK codebook according to the existing specification with the modification of setting the actual ‘ACK/NACK’ value corresponding to PDSCH(s) scheduled after the UL grant.
* UE generates Type-2/3 HARQ-ACK codebook according to the existing specification.
	+ For Type-2 CB, UL DAI is used for generating HARQ CB.
* This feature is subject to separate UE capabilities for type-1, type-2, and type-3 codebooks.
* RRC parameter(s) to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on a PUSCH repetition except the first repetition are introduced in Rel-18.
* Note: the number of PUSCH repetitions can be scheduled/configured by gNB.
* Note: same principle of current specification which UL DAI in UL grant is applied to each PUSCH repetition is reused.
* The timeline specified in TS 38.213 Clause 9.2.5 are satisfied, i.e. between the last PDSCH and PUCCH, between the last PDCCH among UL grant /DL grant(s) and the earliest PUCCH or PUSCH

* Additional UE capabilities are introduced to support the following functions (UE will be configured by gNB to use the following features via RRC)
	+ HARQ-ACK codebook size change on a PUCCH slot
	+ PUCCH resource change on a PUCCH slot
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According to the agreements, our views on the required UE FGs are summarized below.* Introduce three separate UE FGs for type-1, type-2, and type-3 codebooks, and the prerequisite UE FGs are FG 4-11, 4-10 and FG 10-16 respectively.
	+ Set the FG for Rel-15 DG PUSCH repetition (FG 5-17) as the prerequisite as the new function is for DG PUSCH repetition only.
	+ The reporting granularity for the UE FGs for type-1, type-2, and type-3 codebooks could be the same as the prerequisite FG, i.e., per UE, per UE and per band, respectively.
	+ Though the targeting scenario is mainly for TDD, we are ok to also apply this to FDD, and no need to do any differentiation.
	+ Add some notes in the FGs to clarify for reusing the legacy timeline and same principle for handling across PUSCH repetitions.
* Introduce two separate UE FGs for HARQ-ACK codebook size change on a PUCCH slot and PUCCH resource change on a PUCCH slot,
	+ Per UE reporting is sufficient.
	+ No need any FR or TDD/FDD differentiation.

With above, we have the following proposal. ***Proposal 1: Introduce the following UE FGs for the TEI on HARQ multiplexing on PUSCH***

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| 55. TEI18 | 55-x1 | Scheduling PDSCH after UL grant for the case of PUSCH with repetitions except the first repetition for Type 1 HARQ-ACK codebook | 1. If UCI multiplexing of different priorities is not enabled, support scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions except the first repetition for Type 1 HARQ-ACK codebook
2. UE generates Type-1 HARQ-ACK codebook according to the existing specification with the modification of setting the actual ‘ACK/NACK’ value corresponding to PDSCH(s) scheduled after the UL grant.
 | FG 4-11, FG 5-17 | Yes | N/A | Scheduling PDSCH after UL grant is not supported for the case of PUSCH with repetitions except the first repetition for Type 1 HARQ-ACK codebook | Per UE | N/A | N/A | N/A | Note1: same principle of current specification which UL DAI in UL grant is applied to each PUSCH repetition is reused.Note 2: The timeline specified in TS 38.213 Clause 9.2.5 are satisfied, i.e. $T\_{proc,1}^{mux}$between the last PDSCH and PUCCH, $T\_{proc,2}^{mux}$ between the last PDCCH among UL grant /DL grant(s) and the earliest PUCCH or PUSCH | Optional with capability signalling |
| 55. TEI18 | 55-x2 | Scheduling PDSCH after UL grant for the case of PUSCH with repetitions except the first repetition for Type 2 HARQ-ACK codebook | 1. If UCI multiplexing of different priorities is not enabled, support scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions except the first repetition for Type 2 HARQ-ACK codebook
2. UE generates Type-2 HARQ-ACK codebook according to the existing specification, and UL DAI is used for generating HARQ CB.
 | FG 4-10, FG 5-17 | Yes | N/A | Scheduling PDSCH after UL grant is not supported for the case of PUSCH with repetitions except the first repetition for Type 2 HARQ-ACK codebook | Per UE | N/A | N/A | N/A | Note1: same principle of current specification which UL DAI in UL grant is applied to each PUSCH repetition is reused.Note 2: The timeline specified in TS 38.213 Clause 9.2.5 are satisfied, i.e. $T\_{proc,1}^{mux}$between the last PDSCH and PUCCH, $T\_{proc,2}^{mux}$ between the last PDCCH among UL grant /DL grant(s) and the earliest PUCCH or PUSCH | Optional with capability signalling |
| 55. TEI18 | 55-x3 | Scheduling PDSCH after UL grant for the case of PUSCH with repetitions except the first repetition for Type 3 HARQ-ACK codebook | 1. If UCI multiplexing of different priorities is not enabled, support scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions except the first repetition for Type 3 HARQ-ACK codebook
2. UE generates Type-2 HARQ-ACK codebook according to the existing specification, and UL DAI is used for generating HARQ CB.
 | FG 10-16, FG 5-17 | Yes | N/A | Scheduling PDSCH after UL grant is not supported for the case of PUSCH with repetitions except the first repetition for Type 3 HARQ-ACK codebook | Per band | N/A | N/A | N/A | Note1: same principle of current specification which UL DAI in UL grant is applied to each PUSCH repetition is reused.Note 2: The timeline specified in TS 38.213 Clause 9.2.5 are satisfied, i.e. $T\_{proc,1}^{mux}$between the last PDSCH and PUCCH, $T\_{proc,2}^{mux}$ between the last PDCCH among UL grant /DL grant(s) and the earliest PUCCH or PUSCH | Optional with capability signalling |
| 55. TEI18 | 55-x4 | HARQ-ACK codebook size change on a PUCCH slot for scheduling PDSCH after UL grant for the case of PUSCH with repetitions except the first repetition | Support HARQ-ACK codebook size change on a PUCCH slot for scheduling PDSCH after UL grant for the case of PUSCH with repetitions except the first repetition | 55-x1 or 55-x2 or 55-x3 | Yes | N/A | HARQ-ACK codebook size change is not supported on a PUCCH slot for scheduling PDSCH after UL grant for the case of PUSCH with repetitions except the first repetition | Per UE | N/A | N/A | N/A |  | Optional with capability signalling |
| 55. TEI18 | 55-x5 | PUCCH resource change on a PUCCH slot for scheduling PDSCH after UL grant for the case of PUSCH with repetitions except the first repetition | Support PUCCH resource change on a PUCCH slot for scheduling PDSCH after UL grant for the case of PUSCH with repetitions except the first repetition | 55-x1 or 55-x2 or 55-x3 | Yes | N/A | PUCCH resource change is not supported on a PUCCH slot for scheduling PDSCH after UL grant for the case of PUSCH with repetitions except the first repetition | Per UE | N/A | N/A | N/A |  | Optional with capability signalling |

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## **Discussion**

### **Proposal 2-1:**

* + **Introduce following FGs for** **HARQ multiplexing for PDSCH scheduling after UL grant on PUSCH**

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| 55. TEI18 | 55-4a | Multiplexing Type-1 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-1 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-11, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-1 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4b | Multiplexing Type-2 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-2 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-10, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-2 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4c | Multiplexing Type-3 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-3 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission | 4-1, 10-16, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-3 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4d | Determining a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining a different PUCCH resource in a slot from the PUCCH resource indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | 4-1, 4-10 | Yes | N/A | UE does not support to determine a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4e | Determining different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining different codebook size in a PUCCH slot from the size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | 4-1, 4-10 | Yes | N/A | UE does not support to determine different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |

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| --- | --- |
| Company | Comment |
| Moderator | Most companies propose the above five FGs are necessary based on the agreement in RAN1#113, while Nokia/NSB propose a single FG.

|  |
| --- |
| **Agreement**If UCI multiplexing of different priorities is not enabled, the restriction on scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions except the first repetition* UE generates Type-1 HARQ-ACK codebook according to the existing specification with the modification of setting the actual ‘ACK/NACK’ value corresponding to PDSCH(s) scheduled after the UL grant.
* UE generates Type-2/3 HARQ-ACK codebook according to the existing specification.
	+ For Type-2 CB, UL DAI is used for generating HARQ CB.
* This feature is subject to separate UE capabilities for type-1, type-2, and type-3 codebooks.
* RRC parameter(s) to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on a PUSCH repetition except the first repetition are introduced in Rel-18.
* Note: the number of PUSCH repetitions can be scheduled/configured by gNB.
* Note: same principle of current specification which UL DAI in UL grant is applied to each PUSCH repetition is reused.
* The timeline specified in TS 38.213 Clause 9.2.5 are satisfied, i.e. $T\_{proc,1}^{mux}$between the last PDSCH and PUCCH, $T\_{proc,2}^{mux}$ between the last PDCCH among UL grant /DL grant(s) and the earliest PUCCH or PUSCH
* Additional UE capabilities are introduced to support the following functions (UE will be configured by gNB to use the following features via RRC)
	+ HARQ-ACK codebook size change on a PUCCH slot
	+ PUCCH resource change on a PUCCH slot
 |

Regarding the prerequisite FGs and reporting type, companies have different view, and hence, to be discussed after the FG structure is concluded. |
|  |  |
|  |  |

### **(pending) Question 2-2:**

* + **Companies are encouraged to provide views on which FGs should be included as prerequisite FGs of FG 55-4a/4b/4c/4d/4e.**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | Summary of companies view* General (Nokia/NSB)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Index** | **Feature group** | **Type** | **Mandatory/Optional** | **Supported by** |
| 5-17 | PUSCH repetitions over multiple slots | Per UE | Mandatory with capability signalling | Nokia/NSB |
| 10-40 | PUSCH repetitions over multiple slots for unlicensed spectrum | Per band | Optional with capability signaling | Nokia/NSB |
| 11-5 | PUSCH repetition Type B | Per FS | Optional with capability signaling | Nokia/NSB |
| 11-6 | PUSCH repetition Type A | Per UE | Optional with capability signaling | Nokia/NSB |
| 23-3-1 | Multi-TRP PUSCH repetition (type A) -codebook based | Per FS | Optional with capability signaling | Nokia/NSB |
| 23-3-1-2 | Multi-TRP PUSCH repetition (type A) - non-codebook based | Per FS | Optional with capability signaling | Nokia/NSB |
| 23-3-1-1 | Multi-TRP PUSCH repetition (type B) - codebook based | Per FSPC | Optional with capability signaling | Nokia/NSB |
| 23-3-1-3 | Multi-TRP PUSCH repetition (type B) – non-codebook based | Per FSPC | Optional with capability signaling | Nokia/NSB |
| 30-3 | TB processing over multi-slot PUSCH | Per band | Optional with capability signaling | Nokia/NSB |

* 55-4a

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Index** | **Feature group** | **Type** | **Mandatory/Optional** | **Supported by** |
| 4-1 | Basic UL control channel | n/a | Mandatory without capability signalling | HW/HiSi, E///, CU |
| 4-11 | Semi-static HARQ-ACK codebook | Per UE | Mandatory with capability signalling | HW/HiSi, E///, CU, ZTE |
| 5-17 | PUSCH repetitions over multiple slots | Per UE | Mandatory with capability signalling | HW/HiSi, E///, CU, ZTE |
| 11-5 | PUSCH repetition Type B | Per FS | Optional with capability signaling | HW/HiSi, E///, CU |
| 11-6 | PUSCH repetition Type A | Per UE | Optional with capability signaling | HW/HiSi, E///, CU |

* 55-4b

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Index** | **Feature group** | **Type** | **Mandatory/Optional** | **Supported by** |
| 4-1 | Basic UL control channel | n/a | Mandatory without capability signalling | HW/HiSi, E///, CU |
| 4-10 | Dynamic HARQ-ACK codebook | Per UE | Mandatory with capability signaling which shall be set to '1' | HW/HiSi, E///, CU, ZTE |
| 5-17 | PUSCH repetitions over multiple slots | Per UE | Mandatory with capability signalling | HW/HiSi, E///, CU, ZTE |
| 11-5 | PUSCH repetition Type B | Per FS | Optional with capability signaling | HW/HiSi, E///, CU |
| 11-6 | PUSCH repetition Type A | Per UE | Optional with capability signaling | HW/HiSi, E///, CU |

* 55-4c

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Index** | **Feature group** | **Type** | **Mandatory/Optional** | **Supported by** |
| 4-1 | Basic UL control channel | n/a | Mandatory without capability signalling | HW/HiSi, E///, CU |
| 10-16 | One-shot HARQ ACK feedback | Per band | Optional with capability signaling | HW/HiSi, E///, CU, ZTE |
| 5-17 | PUSCH repetitions over multiple slots | Per UE | Mandatory with capability signalling | HW/HiSi, E///, CU, ZTE |
| 11-5 | PUSCH repetition Type B | Per FS | Optional with capability signaling | HW/HiSi, E///, CU |
| 11-6 | PUSCH repetition Type A | Per UE | Optional with capability signaling | HW/HiSi, E///, CU |

* 55-4d

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Index** | **Feature group** | **Type** | **Mandatory/Optional** | **Supported by** |
| 4-10 | Dynamic HARQ-ACK codebook | Per UE | Mandatory with capability signaling which shall be set to '1' | HW/HiSi, E///, CU |
| 4-11 | Semi-static HARQ-ACK codebook | Per UE | Mandatory with capability signalling | HW/HiSi, E///, CU |
| 10-16 | One-shot HARQ ACK feedback | Per band | Optional with capability signaling | HW/HiSi, E///, CU |
| 55-4a or 55-4b or 55-4c |  | FFS | Optional with capability signaling | ZTE |

* 55-4e

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Index** | **Feature group** | **Type** | **Mandatory/Optional** | **Supported by** |
| 4-1 | Basic UL control channel | n/a | Mandatory without capability signalling | HW/HiSi, E///, CU |
| 4-10 | Dynamic HARQ-ACK codebook | Per UE | Mandatory with capability signaling which shall be set to '1' | HW/HiSi, E///, CU |
| 55-4a or 55-4b or 55-4c |  | FFS | Optional with capability signaling | ZTE |

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### **(pending) Question 2-3:**

* + **Companies are encouraged to provide views on the reporting type of FG 55-4a/4b/4c/4d/4e.**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | Summary of companies view* 55-4a
	+ Per UE: Nokia/NSB, ZTE
	+ Per Band: HW/HiSi, E///, CU
* 55-4b
	+ Per UE: Nokia/NSB, ZTE
	+ Per Band: HW/HiSi, E///, CU
* 55-4c
	+ Per UE: Nokia/NSB
	+ Per Band: HW/HiSi, E///, CU, ZTE
* 55-4d
	+ Per UE: Nokia/NSB, ZTE
	+ Per Band: HW/HiSi, E///, CU
* 55-4e
	+ Per UE: Nokia/NSB, ZTE
	+ Per Band: HW/HiSi, E///, CU

Note that if “per band” is used, it should be clarified whether the support of these FGs are reported based on PUCCH band or PUSCH band or PDSCH band. |
|  |  |
|  |  |

# **FGs for pathloss RS updates for Type 1 CG-PUSCH**

In [2], FGs for pathloss RS for Type 1 CG-PUSCH 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 |
| 55. TEI18 | 55-x | Enable MAC CE based pathloss RS updates for Type 1 CG-PUSCH | Support configuration of *enablePL-RS-UpdateForType1CG-PUSCH-SRS-r18* | 16-1e | Yes  | N/A | MAC CE based pathloss RS updates for Type 1 CG-PUSCH is not supported | Per UE | No | No |  |  | Optional with capability signalling |

Following inputs are provided in contributions for the RAN1#114 meeting.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [2] | xiaomi | In Rel-16, the UE feature of MAC CE based pathloss RS updates for PUSCH/SRS was introduced only for Type 2 CG and dynamic grant PUSCH, but not for Type 1 CG PUSCH.

| ***maxNumberPathlossRS-update-r16***Indicates the maximum number of configured pathloss reference RSs for PUSCH/PUCCH/SRS by RRC that the UE can support for MAC-CE based pathloss reference RS update. | UE | No | No | No |
| --- | --- | --- | --- | --- |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16-1e | Pathloss reference RS activation via MAC CE | 1. The maximum number of configured pathloss reference RSs for PUSCH/PUCCH/SRS by RRC for MAC-CE based pathloss reference RS update | 8-3 | *maxNumberPathlossRS-Update-r16* | *Phy-ParametersCommon* | No | No | Candidate values for component (1): {4, 8, 16, 32, 64} | Optional with capability signaling |

According to the agreement in RAN1-113 meeting, MAC CE based pathloss RS updated for Type 1 CG PUSCH will be supported. Hence, we propose to support the corresponding UE capability in Table 1.**Agreement**Rel-18 TEI proposal on pathloss RS for Type 1 CG-PUSCH is agreed. Relevant TP for clause 7.1.1 in TS 38.213 is endorsed in principle* Note: Corresponding UE capability and RRC configuration will be introduced and discussed in future meetings.

|  |
| --- |
| 7.1.1 UE behaviour……**<Unchanged parts are omitted>**- For a PUSCH transmission configured by *ConfiguredGrantConfig,* if *rrc-ConfiguredUplinkGrant* is included in *ConfiguredGrantConfig*, * if the UE is provided [*enablePL-RS-UpdateForType1CG-PUSCH-SRS*]*,* the UE determines a RS resource index *qd* from the value of *PUSCH-PathlossReferenceRS-Id* that is mapped to the *sri-PUSCH-PowerControlId* indicated by the *srs-ResourceIndicator* value included in *rrc-ConfiguredUplinkGrant*
* if the UE is not provided [*enablePL-RS-UpdateForType1CG-PUSCH-SRS*]*,* a RS resource index *qd* is provided by a value of *pathlossReferenceIndex* included in *rrc-ConfiguredUplinkGrant* where the RS resource is either on serving cell *c* or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*
* ……

**<Unchanged parts are omitted>** |

Table 1, Proposed FG for pathloss RS for Type 1 CG-PUSCH

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 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 |
| 55. TEI18 | 55-x | Enable MAC CE based pathloss RS updates for Type 1 CG-PUSCH | Support configuration of *enablePL-RS-UpdateForType1CG-PUSCH-SRS-r18* | 16-1e | Yes  | N/A | MAC CE based pathloss RS updates for Type 1 CG-PUSCH is not supported | Per UE | No | No |  |  | Optional with capability signalling |

***Proposal 1: capture the UE capability in Table 1 for pathloss RS for Type 1 CG-PUSCH.*** |
| [3] | Nokia, Nokia Shanghai Bell | RAN1#113 made the following agreement for updating the Type 1 CG-PUSCH PL-RS based on the PL-RS updated for the SRS:

|  |
| --- |
| **Agreement**Rel-18 TEI proposal on pathloss RS for Type 1 CG-PUSCH is agreed. Relevant TP for clause 7.1.1 in TS 38.213 is endorsed in principle* Note: Corresponding UE capability and RRC configuration will be introduced and discussed in future meetings.

7.1.1 UE behaviour……**<Unchanged parts are omitted>**- For a PUSCH transmission configured by *ConfiguredGrantConfig,* if *rrc-ConfiguredUplinkGrant* is included in *ConfiguredGrantConfig*, * if the UE is provided [*enablePL-RS-UpdateForType1CG-PUSCH-SRS*]*,* the UE determines a RS resource index *qd* from the value of *PUSCH-PathlossReferenceRS-Id* that is mapped to the *sri-PUSCH-PowerControlId* indicated by the *srs-ResourceIndicator* value included in *rrc-ConfiguredUplinkGrant*
* if the UE is not provided [*enablePL-RS-UpdateForType1CG-PUSCH-SRS*]*,* a RS resource index *qd* is provided by a value of *pathlossReferenceIndex* included in *rrc-ConfiguredUplinkGrant* where the RS resource is either on serving cell *c* or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*

……**<Unchanged parts are omitted>** |

**Proposal 2: To facilitate the RAN1#113 agreement on pathloss RS for type 1 CG-PUSCH, the following new FG should be introduced**

|  |  |  |  |
| --- | --- | --- | --- |
| Index | Feature group | Components | Prerequisite feature groups |
| 55-5 | Pathloss RS update for Type 1 Configured UL grant | Support determining the Type 1 CG-PUSCH PL-RS from the *sri-PUSCH-PowerControlId* | 5-19 |

 |

## **Discussion**

### **Proposal 3-1:**

* + **Introduce FG 55-5 for** **pathloss RS updates for Type 1 CG-PUSCH**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55. TEI18 | 55-5 | Enable MAC CE based pathloss RS updates for Type 1 CG-PUSCH | Support configuration of *enablePL-RS-UpdateForType1CG-PUSCH-SRS-r18* | 5-19, [16-1e] | Yes  | N/A | MAC CE based pathloss RS updates for Type 1 CG-PUSCH is not supported | Per UE | No | No |  |  | Optional with capability signalling |

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | Companies are generally fine to introduce FG 55-5, while companies may have different view on whether to include 16-1e as the prerequisite FG, and hence, to be discussed after the FG structure is concluded. Note that FG 5-19 would be necessary as the prerequisite FG since FG 5-19 is the basic FG for type 1 CG. |
|  |  |
|  |  |

### **(pending) Question 3-2:**

* + **Companies are encouraged to provide view on which FGs should be included as prerequisite FGs of FG 55-5.**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | Summary of companies view

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Index** | **Feature group** | **Type** | **Mandatory/Optional** | **Supported by** |
| 16-1e | Pathloss reference RS activation via MAC CE | Per UE | Optional with capability signalling | xiaomi |

 |
|  |  |
|  |  |

# **Conclusions**

To be updated

# **References**

[1] R1-2306528 UE features for endorsed Rel-18 TEI on HARQ multiplexing Huawei, HiSilicon, Ericsson, China Unicom

[2] R1-2307367 UE features for endorsed Rel-18 TEI on pathloss RS for Type 1 CG-PUSCH xiaomi

[3] R1-2306598 On UE features for TEI18 Nokia, Nokia Shanghai Bell

[4] R1-2306994 Discussion on UE feature for Rel-18 TEI ZTE