**3GPP TSG RAN WG1 #106bis-e R1-21xxxxx**

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

**Agenda Item: 8.8**

**Source: Rapporteur (China Telecom)**

**Title: RAN1 agreements for Rel-17 NR coverage enhancements**

**Document for: Information**

1. Introduction

In RAN #90 e-meeting, a new Rel-17 work item on NR coverage enhancements was approved [1] and was revised in [2]. The objective of this work item is to specify enhancements for PUSCH, PUCCH and Msg3 PUSCH for both FR1 and FR2 as well as TDD and FDD.

The detailed objectives are as follows.

* *Specification of PUSCH enhancements [RAN1, RAN4]*
  + *Specify the following mechanisms for enhancements on PUSCH repetition type A [RAN1]*
    - *Increasing the maximum number of repetitions up to a number to be determined during the course of the work.*
    - *The number of repetitions counted on the basis of available UL slots.*
  + *Specify mechanism(s) to support TB processing over multi-slot PUSCH [RAN1]*
    - *TBS determined based on multiple slots and transmitted over multiple slots.*
  + *Specify mechanism(s) to enable joint channel estimation [RAN1, RAN4]*
    - *Mechanism(s) to enable joint channel estimation over multiple PUSCH transmissions, based on the conditions to keep power consistency and phase continuity to be investigated and specified if necessary by RAN4 [RAN1, RAN4]*
      * *Potential optimization of DMRS location/granularity in time domain is not precluded*
    - *Inter-slot frequency hopping with inter-slot bundling to enable joint channel estimation [RAN1]*
* *Specification of PUCCH enhancements [RAN1, RAN4]*
  + *Specify signaling mechanism to support dynamic PUCCH repetition factor indication [RAN1]*
  + *Specify mechanism to support DMRS bundling across PUCCH repetitions [RAN1, RAN4]*
    - *When applicable, based on similar mechanism(s) for enabling joint channel estimation for PUSCH*
* *Specify mechanism(s) to support Type A PUSCH repetitions for Msg3 [RAN1, RAN2]*

This contribution is a summary of RAN1 agreements till RAN1 #106b-e.

1. AI 8.8.1.1: Enhancements on PUSCH repetition type A

## 2.1 RAN1 #104-e

Agreements:

Select one of the following alternatives, considering the aspect whether or not the determination of all the available slots should be done prior to the first actual transmission of the repetitions (other alternatives are not precluded)

-        Alt1: Whether or not a slot is determined as available for UL transmissions depends on RRC configurations (at least tdd\_ul\_dl configuration, FFS: other RRC configurations) and does not depend on dynamic signaling (at least SFI, FFS: other dynamic signaling e.g. CI, PUSCH priority for URLLC).

-        Alt2: Whether or not a slot is determined as available for UL transmissions depends on RRC configurations (at least tdd\_ul\_dl configuration, FFS: other RRC configurations) and also depends on dynamic signaling (at least SFI, FFS: other dynamic signaling e.g. CI, PUSCH priority for URLLC).

Agreements:

The maximum number of repetitions for DG-PUSCH is also applicable to CG-PUSCH.

Agreements:

For defining available slots: a slot is determined as unavailable if at least one of the symbols indicated by TDRA for a PUSCH in the slot overlaps with the symbol not intended for UL transmissions

* FFS details

Agreements:

Rel-17 PUSCH repetition Type A supports the increase of maximum number of repetitions with repetition factors configured in a TDRA list with a row index indicated either by the configured grant configuration or by TDRA field in a DCI.

* FFS: increasing the maximum number of repetitions with repetition factor configured in *PUSCH-Config* and/or *ConfiguredGrantConfig*.

**Conclusion:**

Discuss further to select one of the following alternatives:

* Alt-a: The determination of all the available slots has to be done prior to the first actual transmission of the repetitions.
* Alt-b: The determination of all the available slots does not have to be done prior to the first actual transmission of the repetitions. The timeline requirement is per repetition basis.

## 2.2 RAN1 #105-e

Agreement:

* RV cycling is based on available slot for the Type A PUSCH repetition enhancement with repetitions counted based on available slot in Rel-17

Agreement:

* Down-selection in RAN1#106-e:
* Alt 1: The maximum number of repetitions supported by Rel-17 PUSCH repetition Type A is 32, irrespective of counting method,
* Alt 2: The maximum number of repetitions supported by Rel-17 PUSCH repetition Type A is: 32 for the counting based on physical slots; and 16 (i.e. no change from Rel-16) for the counting based on available slots.

**Conclusion:**

* The following agreement in RAN1#104-e is applied to all slots including special slots.

|  |
| --- |
| Agreements:  For defining available slots: a slot is determined as unavailable if at least one of the symbols indicated by TDRA for a PUSCH in the slot overlaps with the symbol not intended for UL transmissions.   * FFS details |

Agreement:

In addition to {1, 2, 3, 4, 7, 8, 12, 16} and {32}, the following additional value set for repetition factor is supported in Rel-17.

* {20, 24, 28}

Agreement:

* Each available slot identified by the UE is considered as a transmission occasion for PUSCH repetition.
  + RV is cycled across transmission occasions, irrespective of whether PUSCH transmission in the transmission occasion is further omitted or not.

Agreement:

* If PUSCH symbol in a slot overlaps with flexible symbol(s) with SSB transmission, the slot is determined as not available during the counting of repetitions. As there is no PUSCH in the slot, no PUSCH omission applies to the slot.

Agreement:

Select one from the following (further refinement of the alternatives can be further discussed), for the procedure of Rel-17 PUSCH repetition Type A (other alternatives are not precluded)

* Alt 1-B consisting of two steps
  + Step 1: Determine available slots for K repetitions based on RRC configuration(s) in addition to TDRA in the DCI scheduling the PUSCH, CG configuration or activation DCI
  + Step 2: The UE determines whether to drop a PUSCH repetition or not according to Rel-15/16 PUSCH dropping rules, but the PUSCH repetition is still counted in the K repetitions.
* Alt 1-B’ consisting of two steps
  + Step 1: Determine K repetitions based on available slots, where the available slot is the UL slot and flexible slot indicated by *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated*.
  + Step 2: The UE determines whether to drop a PUSCH repetition or not according to Rel-15/16 PUSCH dropping rules, but the PUSCH repetition is still counted in the K repetitions.
  + FFS: handling of dynamic signaling (e.g. UL CI, DCI for high priority channel), e.g., UE without CI capability
* Alt 2-A consisting of a single step
  + Step 1: Determine available slots for K repetitions based on RRC configuration(s) and dynamic signaling (e.g. SFI, UL CI, DCI for high priority channel) in addition to TDRA in the DCI scheduling the PUSCH, CG configuration or activation DCI
* Alt 2-B consisting of two steps
  + Step 1: Determine available slots for K repetitions based on RRC configuration(s) and dynamic SFI in addition to TDRA in the DCI scheduling the PUSCH, CG configuration or activation DCI
    - FFS timeline for the dynamic signalling
  + Step 2: The UE determines whether to drop a PUSCH repetition or not according to Rel-15/16 PUSCH dropping rules, but the PUSCH repetition is still counted in the K repetitions.

## 2.3 RAN1 #106-e

Agreement:

* For Rel-17 PUSCH repetition Type A without joint channel estimation, no new inter-slot frequency hopping mechanism is introduced.

Agreement

Take Option 1-B as an agreement for the procedure of Rel-17 PUSCH repetitions counted on the basis of available slots.

* Alt 1-B consisting of two steps
* Step 1: Determine available slots for K repetitions based on RRC configuration(s) in addition to TDRA in the DCI scheduling the PUSCH, CG configuration or activation DCI
* Step 2: The UE determines whether to drop a PUSCH repetition or not according to Rel-15/16 PUSCH dropping rules, but the PUSCH repetition is still counted in the K repetitions.
* FFS: Rel-17 PUSCH dropping rules are also applied if introduced in other WI(s)

Agreement

For PUSCH repetition Type A for Rel-17 CG-PUSCH, semi-static flexible symbol is considered as available.

Agreement

For PUSCH repetition Type A for Rel-17 DG-PUSCH, semi-static flexible symbol is considered as available.

Note: The applicability for Msg 3 is to be discussed in 8.8.3

Agreement

* 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.

Agreement

* For DG-PUSCH with counting based on the available slots, count of available slots continues until satisfying the conditions defined for DG-PUSCH repetition Type A in Rel-16.

Working Assumption

The maximum number of repetitions accounted for available slots supported by Rel-17 PUSCH repetition Type A is 32

## 2.4 RAN1 #106bis-e

Working Assumption is confirmed

Working Assumption

The maximum number of repetitions accounted for available slots supported by Rel-17 PUSCH repetition Type A is 32

**Conclusion:**

For CG-PUSCH repetitions counted on the basis of available slots, all the K transmission occasions including the 1st transmission occasion are determined on the basis of available slots.

Agreement

For CG-PUSCH repetition Type A with the counting based on available slots, the R16 existing restrictions as defined in Clause 6.1.2.3.1 of TS38.214 at least on the initial transmission of a transport block are applied, assuming the K repetitions of R17 determined based the rule of counting available slots.

Observation

* Whether or not the counting based on available slots is applicable only to unpaired spectrum is not discussed under AI 8.8.1.1 in RAN1#106bis-e. Discussions on how HD-FDD RedCap UEs support the available slot counting may take place in AI 8.8.1.1 in RAN1#107-e, depending on the progress of RedCap WI discussions.

Agreement

* For the *K* repetitions of DG-PUSCH, Step 1 of the previously agreed two-step procedure (i.e., Alt 1-B) determines the *K* earliest available slots no earlier than the slot which is determined by the slot offset *K2*.
  + No RAN1 spec impact is expected in terms of the relation with the slot which is determined by the slot offset *K2*.
  + Note: The available slot determination is to be specified.
* For the *K* repetitions of CG-PUSCH, Step 1 of the previously agreed two-step procedure (i.e., Alt 1-B) determines the *K* earliest available slots no earlier than the first slot which is determined by at least *ConfiguredGrantConfig*.
  + No RAN1 spec impact is expected in terms of the relation with the first slot which is determined by at least *ConfiguredGrantConfig*.
  + Note: The available slot determination is to be specified.

Agreement

* Only *tdd-UL-DL-ConfigurationCommon*, *tdd-UL-DL-ConfigurationDedicated* and *ssb-PositionsInBurst* are considered for the determination of available slots.
  + Any other RRC configuration is not considered for the determination of available slots.

Agreement

* The existing restriction “The UE is not expected to be configured with the time duration for the transmission of K repetitions larger than the time duration derived by the periodicity P” applies to both the counting based on physical slots and the counting based on available slots.
* The above “the time duration for the transmission of K repetitions” means the time duration between the start of the 1st slot of the K repetitions and the end of the last slot of the K repetitions for any instance of a CG period.

1. AI 8.8.1.2: TB processing over multi-slot PUSCH

## 3.1 RAN1 #104-e

Agreement:

* Consider one or two of the following options as starting points to design time domain resource determination of TBoMS
  + PUSCH repetition type A like TDRA, i.e., the number of allocated symbols is the same in each slot.
  + PUSCH repetition type B like TDRA, i.e., the number of allocated symbols in each slot can be different

Agreement:

* The same number of PRBs per symbol is allocated across slots for TBoMS transmission.

Agreements:

* Consecutive physical slots for UL transmission can be used for TBoMS for unpaired spectrum
  + To resolve in RAN1#104b-e whether to support non-consecutive physical slots for UL transmission for TBoMS for unpaired spectrum
* Consecutive physical slots for UL transmission can be used for TBoMS for paired spectrum and the SUL band
  + FFS if non-consecutive physical slots for UL transmission are also supported for paired spectrum and the SUL band

Agreements**:**

For TBoMS, the maximum supported TBS should not exceed legacy maximum supported TBS in Rel-15/16, for the same number of layers.

* FFS: Details and further constraints on the applicability of TBoMS.

Agreements:

One or two of the following approaches will be considered as a starting point to decide how *N*Info for TBoMS is calculated (aiming for down selection in RAN1 #104-bis-e):

* **Approach 1**: Based on all REs determined across the symbols or slots (FFS whether symbols or slots are used) over which the TBoMS transmission is allocated
* **Approach 2**: Based on the number of REs determined in the first L symbols over which the TBoMS transmission is allocated, scaled by K≥1.
  + FFS: the definition of K

Note: L is the number of symbols determined using the SLIV of PUSCH indicated via TDRA

FFS: impacts and further details if repetitions of TBoMS is supported.

FFS: whether the symbols over which the TBoMS transmission is allocated are the same or can be different from the symbols over which the TBoMS transmission is performed, and details on how to handle such scenarios.

Agreements:

One or two of the following options will be considered (aiming for down-selection in RAN1#104b-e) to calculate *NohPRB* for TBoMS:

* **Option 1**: *NohPRB* is assumed to be the same for all the slots over which the TBoMS transmission is allocated and can be configured by xOverhead as in Rel-15/16.
* **Option 2**: *NohPRB* is calculated depending on both xOverhead and the number of symbols or slots (FFS whether symbol or slot are used) over which the TBoMS transmission is allocated.
  + FFS: if either the number of symbols or the number of slots is used.
  + FFS: if xOverhead is separately configured from the one in Rel-15/16.

FFS: impacts and further details if repetitions of TBoMS is supported.

FFS: whether the symbols allocated over which the TBoMS transmission is allocated are the same or can be different from the symbols over which the TBoMS transmission is performed.

## 3.2 RAN1 #104bis-e

Agreement:

Non-consecutive physical slots for UL transmission can be used to transmit TBoMS at least for unpaired spectrum.

* How TBoMS is transmitted over non-consecutive physical slots for UL transmission for unpaired spectrum is to be discussed further.
* Whether and how non-consecutive physical slots for UL transmission can be used to transmit TBoMS for paired spectrum and SUL band as well, is to be discussed further.

Working Assumption

The concept of transmission occasion for TBoMS (TOT) is utilized for the purpose of discussion, where a TOT is constituted of time domain resources which may or may not span multiple slots

* FFS: details, whether multiple slots which constitute a TOT are consecutive or non-consecutive physical slots for UL transmissions
* FFS: other details.
* FFS: whether such concept will be specified or not.

Agreements**:**

For the definition of a single TBoMS, down select among the following options:

* **Option 1**: Only one TOT is determined for a TBoMS. The TB is transmitted on the TOT using a single RV.
  + FFS: whether and how the single RV is rate matched across the TOT, e.g., continuous rate-matching across the TOT, rate matched for each slot and so on.
* **Option 2**: Only one TOT is determined for a TBoMS. The TB is transmitted on the TOT using different RVs.
  + FFS: how RV index is refreshed within the TOT, e.g. after each slot boundary, at every jump between two non-contiguous resources, if any, and so on.
* **Option 3**: Multiple TOTs are determined for a TBoMS. The TB is transmitted on the multiple TOTs using a single RV.
  + FFS: how the single RV is rate matched across single or multiple TOTs, e.g., rate matched for each TOT, rate matched for all the TOTs, rate matched for each slot and so on.
* **Option 4**: Multiple TOTs are determined for a TBoMS. The TB is transmitted on the multiple TOTs using different RVs.
  + FFS: whether and how RV index is refreshed within one TOT, e.g. after each slot boundary, at every jump between two non-contiguous resources, if any, and so on.
* FFS: the exact TBS determination procedure.
* FFS: whether a single TBoMS can be repeated or not.
* FFS: other implications, e.g., power control, collision handling and so on.

## 3.3 RAN1 #105-e

Working assumption: 🡪 Agreement:

For TBS determination of TBoMS:

* *NohPRB* is configured by xOverhead and represents the overhead per slot.
* *NohPRB* is assumed to be the same for all the slots over which the TBoMS transmission is allocated.

Note: xOverhead configuration is as per Rel-15/16.

Agreement:

The following 2 options for time domain resource determination for TBoMS are considered for down-selection during RAN1 #105-e:

* Option 1: Time domain resource determination for TBoMS can be performed only via PUSCH repetition Type A like TDRA.
* Option 2: Time domain resource determination for TBoMS can be performed via PUSCH repetition Type A like TDRA or via PUSCH repetition Type B like TDRA.
  1. The use of PUSCH repetition Type B like TDRA for time domain resource determination is according to an additional UE capability for a TBoMS capable UE.
  2. FFS DMRS pattern for PUSCH repetition Type B like TDRA

**Working assumption**

A transmission occasion for TBoMS (TOT) is constituted of at least one slot or multiple consecutive physical slots for UL transmission

* FFS: whether the concept of TOT will be used for designing aspects related to signal generation, e.g., rate-matching, power control, etc.
* FFS: whether such concept will be specified or not.

Agreement:

* The structure of TBoMS will be according to only one of these two options (to be down-selected in RAN1#106-e)
  + Option 3, if a design based on single RV is adopted.
  + Option 4, if a design based on different RVs is adopted.
* FFS: other details, e.g., rate-matching, TBS determination, collision handling, etc.
* The single RV is not constrained to have only the same coded bits in each slot or in each TOT
* The concept of TOT as per the corresponding Working assumption is used to define Option 3 and Option 4 and may or may not be used to design other details, e.g., rate-matching, TBS determination, collision handling and so on.

Agreement:

Time domain resource determination for TBoMS can be performed only via PUSCH repetition Type A like TDRA.

* FFS: details
* FFS: whether or not optimizations for time domain resource determination are necessary for allocating resource in the S slots (for the unpaired spectrum case)

**Working assumption**

Allocating resources for TBoMS in the special slot in TDD is possible according to the agreed time domain resource determination for TBoMS.

Agreement:

The following three options for rate-matching for TBoMS are considered for down-selection during RAN1 #106-e, where only one option will be selected:

* Option a: Rate-matching is performed per slot;
* Option b: Rate matching is performed continuously across all the allocated slot(s) per TOT;
* Option c: Rate matching is performed continuously across all the allocated slots/TOTs for TBoMS

Note: “rate-matching is performed per X” means that the time unit for the bit selection and bit interleaving is X.

Note2: the above 3 options imply that the UL resource in the time unit may or may not be consecutive (depending on the given option)

Agreement:

Number of slots allocated for TBoMS is determined by using a row index of a TDRA list, configured via RRC.

* FFS: details.

Agreement:

The following approach is used to calculate NInfo for TBoMS:

* Approach 2: Based on the number of REs determined in the first L symbols over which the TBoMS transmission is allocated, scaled by K≥1.
  + FFS: the definition of K.

L is the number of symbols determined using the SLIV of PUSCH indicated via TDRA

FFS: impacts and further details if repetitions of TBoMS is supported.

FFS: whether the symbols over which the TBoMS transmission is allocated are the same or can be different from the symbols over which the TBoMS transmission is performed, and details on how to handle such scenarios.

## 3.4 RAN1 #106-e

Agreement

The number of slots allocated for TBoMS is counted based on the available slots for UL transmission.

* The determination of available slots for PUSCH repetition type A, as defined in AI 8.8.1.1, is reused.
* Note: Available slots for FDD or SUL could be revisited according to discussion in AI 8.8.1.1

Agreement

Allocating resources for TBoMS in the special slot in TDD is possible according to the agreed time domain resource determination for TBoMS.

* No further optimization to allocate resources for TBoMS in the special slot is supported.

Agreement

TBoMS is supported for both configured grant and dynamic grant.

Working Assumption

Single TBoMS structure of Option 3 is selected

* **Option 3**: Multiple TOTs are determined for a TBoMS. The TB is transmitted on the multiple TOTs using a single RV.
  + FFS: how the single RV is rate matched across single or multiple TOTs, e.g., rate matched for each TOT, rate matched for all the TOTs, rate matched for each slot and so on.

**Agreement**

To calculate for TBS determination, at least the scaling factor value =N is supported, where N is the number of allocated slots for a single TBoMS.

FFS: whether further values 1<K<N are supported.

FFS: details related to the indication of .

Note: No supporting the case K=1 for a single TBoMS.

**Agreement**

Repetitions of a single TBoMS are supported, where:

* The number of repetitions is denoted by M, i.e., the total number of allocated slots for TBoMS repetition is M\*N.
  + Note: M\*N is no more than the max number of repetitions agreed for repetition Type A enhancement in agenda 8.8.1.1
* Available slot determination is according to existing agreements.
* The number and location of allocated symbols within an allocated slot for TBoMS transmission are the same among all repeated single TBoMS.
* FFS other aspects of TBoMS repetitions, e.g.:
  + Details of time domain resource indication.
  + Supported values for the number of TBoMS repetitions.
  + How to indicate the number of TBoMS repetitions.
  + Interactions with frequency hopping and precoder cycling across the M groups of N allocated slots for each single TBoMS repetition.
  + Whether RV indices should be cycled across the M groups of N allocated slots for each single TBoMS repetition.
  + Details of TBoMS retransmissions.
  + Potential MAC layer impact, but should be decided by RAN2

Note: No additional dropping rule optimization will be introduced other than dropping rules for single TBoMS transmission.

**Conclusion**

Bit interleaving performed per ToT is precluded, and ToT will not be used in further discussion.

Agreement

The UE determines whether or not to drop a slot determined as available for TBoMS transmission according to Rel-15/16 PUSCH dropping rules, where the dropped slot is still counted in the N allocated slots for the single TBoMS transmission.

FFS: Rel-17 PUSCH dropping rules are also applied if introduced in other WI(s)

**Conclusion**

The N allocated slots for the single TBoMS are defined as the number of slots after available slot determination for a single TBoMS transmission, before dropping rules are applied.

Note: the number of final transmitted slots for the single TBoMS may be lower than N, depending on dropping rules for TBoMS transmission.

## 3.5 RAN1 #106bis-e

**Agreement**

* **For transmission power determination of TBoMS transmission in Rel-17, RAN1 to down-select one of the following two options:**
* **Option 1: The transmission power determination of TBoMS should be based on all the REs allocated in one available slot for the TBoMS transmission, excluding the overhead of reference signals**
* **Option 2: The transmission power determination of TBoMS should be based on all the REs allocated in the N available slots for the TBoMS transmission, excluding the overhead of reference signals.**
* **FFS: details on BPRE**

**Agreement**

**The number of MIMO layers (rank) for TBoMS transmission in Rel-17 is limited to 1.**

**Agreement**

**For a single TBoMS transmission and TBoMS repetitions in Rel-17, at least the legacy Rel-15/16 inter-slot frequency hopping framework used in PUSCH repetition Type A is supported.**

* **FFS: other frequency hopping schemes.**

**Agreement**

* The number *N* of allocated slots for TBoMS is indicated via a new column added to the TDRA table configured via *PUSCH-TimeDomainAllocationList*. The ~~existing~~column for configuring the number of repetitions in the TDRA for Rel-17 PUSCH repetition Type A, i.e., *numberOfRepetitions,*is used for indicating the number of repetitions *M* of a single TBoMS, when TBoMS transmission is enabled.
* FFS: supported values of *N* and *M.*
* FFS: how to enable the TBoMS transmission
* FFS: details of retransmission of TBoMS

**Agreement**

For the repetition of a single TBoMS transmission, redundancy versions (RVs) are cycled across the TBoMS repetitions. The legacy Rel-15/16 RV sequences and RV index indication are reused.

**Conclusion**

Values 1<K<N for the scaling factor to calculate N\_info for TBS determination for TBoMS transmission in Rel-17 are not supported.

**Agreement**

At least the following values are supported in Rel-17 for the number*N* of allocated slots for the single TBoMS:

* 

FFS: whether *N*=1 is also supported depends on how TBoMS transmission feature is enabled (or disabled)

FFS: other values, if any.

FFS: further constraints on N\*M

**Agreement**

The following values are supported in Rel-17 for the number*M*of repetitions of the single TBoMS:

* 

FFS: further constraints on N\*M, e.g., N\*M is a valid value according to agreements in AI 8.8.1.1

**Agreement**

BPRE for TBOMS is calculated as  where N is the number of slots allocated for a single TBOMS and  is the number of allocated REs in one allocated slot of a single TBOMS.

Note: How this equation or its equivalent is captured in the specification is left to the editor

**Agreement**

For a single TBoMS transmission and TBoMS repetitions in Rel-17, the legacy Rel-15/16 intra-slot frequency hopping framework used in PUSCH repetition Type A is supported.

* FFS: other frequency hopping schemes.

**Working Assumption**

**For TBoMS in Rel-17, the following is supported:**

* **Bit interleaving is performed per slot.**

·       **The index of the starting coded bit for each transmitted slot is predetermined prior to the start of the TBoMS transmission.**

* **Transmission is limited to one CB only.**
* **FFS: whether UCI multiplexing bits or cancellation/dropping of coded bits, if any, have to be known prior to the determination of the index of the starting coded bit for each transmitted slot or not**
* **FFS: Performance with UCI multiplexing on single and multiple slots of a single TBoMS**

**Note: How UCI multiplexing and cancellation/dropping of coded bits influence the sequence of coded bits transmitted in each slot of a single TBOMS is to be further discussed. Some knowledge on UCI to be multiplexed or cancellation/dropping of coded bits in each slot of a single TBOMS may be known prior to the start of a single TBOMS transmission. How this is to be handled is to be discussed further**.

**Agreement**

**For the bit selection for each transmitted slot for TBoMS, one of the following is to be down selected in RAN1 #107-e for determining the index of the starting coded bit in the circular buffer:**

* **Option B: the index of the starting coded bit in the circular buffer is the index continuous from the position of the last bit selected in the previous allocated slot.**
* **Option C: the index of the starting coded bit in the circular buffer is the index continuous from the position of the last bit selected in the previous allocated slot, regardless of whether UCI multiplexing occurred in the previous allocated slot or not.**

**FFS: whether the index of the starting coded bit for each transmitted slot is expressed as a multiple integer of the lifting size Zc**

**Note: Dropping/cancellation rules are not considered for the starting bit position determination in both Option B and Option C.**

**Agreement**

**For TBoMS transmission in Rel-17:**

* **TBoMS ~~transmission~~feature is enabled (or disabled) by configuring (or not) the number of allocated slots for a single TBoMS (N) in a row of the TDRA table.**
* **~~Dynamic switching between at least TboMS transmission and the legacy single-slot PUSCH transmission, by using a row in the TDRA table, is supported.~~**
  + **TBoMS transmission is enabled when N>1, where N is the number of allocated slots for a single TBoMS.**
  + **Single-slot PUSCH transmission is enabled when N=1.**
  + **Supported combinations of N and M that can be configured in the TDRA table, these combinations are constrained by retransmission are to be further discussed**

1. AI 8.8.1.3: Joint channel estimation for PUSCH

## 4.1 RAN1 #104-e

Agreements:

* Following potential use cases are considered for joint channel estimation for PUSCH:
  + Use case 1: back-to-back PUSCH transmissions within one slot.
  + Use case 2: non-back-to-back PUSCH transmissions within one slot.
  + Use case 3: back-to-back PUSCH transmissions across consecutive slots.
  + Use case 4: non-back-to-back PUSCH transmissions across consecutive slots.
  + Use case 5: PUSCH transmissions across non-consecutive slots.

Note: RAN1 assumes “back-to-back PUSCH transmission” has zero gap in-between adjacent PUSCH transmissions.

Agreements:

* For back-to-back PUSCH transmissions across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation at least for the following case:
  + Over back-to-back PUSCH transmissions (of the same TB) for repetition type A scheduled by dynamic grant or configured grant
  + FFS details (including possible other cases)

Agreements:

* For joint channel estimation, a time domain window is introduced to facilitate further discussion, during which UE is expected to maintain power consistency and phase continuity among PUSCH transmissions subject to power consistency and phase continuity requirements.
  + FFS: whether the window should be specified
  + FFS: the length of the time domain window is defined by a set of repetitions/slots/symbols
  + FFS: single or multiple time domain windows
* FFS: relation with UE capability
* FFS: the time domain window may or may not be configured.
* FFS: whether the term "time domain window" is used in the specification or replaced by other technical terms
* FFS: Whether the window is determined by the power consistency and phase continuity requirements and/or by other factors is to be decided.

Agreements:

* Companies are encouraged to study optimization of DMRS granularity in time domain with joint channel estimation, including:
  + Use cases
  + Simulations results
  + Enhanced schemes, e.g.,
    - Different DMRS density for different PUSCH transmissions
    - No DMRS for some PUSCH transmissions
  + If applicable, impact of dynamic changes, e.g., cancellation of a repetition and companies report the evaluation method.
* Companies are encouraged to study optimization of DMRS location in time domain with joint channel estimation, including:
  + Use cases
  + Simulations results
  + Enhanced schemes, e.g.,
    - DMRS equally spaced among PUSCH transmissions
    - DMRS located in special slots
    - Orphan symbol used for DMRS
  + If applicable, impact of dynamic changes, e.g., cancellation of a repetition and companies report the evaluation method.
* Note: the simulation assumptions for DM-RS in TR 38.830 are used as baseline for performance evaluation on optimization of DMRS location/granularity in time domain.
  + Take into account impairments such as frequency offset, and report corresponding parametrization together with the results. Further discuss impairment details.

**Working assumption:**

* For back-to-back PUSCH transmissions across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following case:
  + Over back-to-back PUSCH transmissions for one TB processed over multiple slots
    - It’s subject to UE capability

Agreements:

* For joint channel estimation.
  + Take into account the residual frequency error, e.g., +/- 0.1 ppm as upper bound.
  + Companies can report other values and frequency error model.

## 4.2 RAN1 #104bis-e

Agreements:

* For joint channel estimation, specify a time domain window during which a UE is expected to maintain power consistency and phase continuity among PUSCH transmissions subject to power consistency and phase continuity requirements.
  + FFS how the time domain window is determined (e.g., via explicit configuration and/or implicitly derived) and whether or not to have the possibility of enabling/disabling the time domain window
  + FFS the units the time domain window (e.g. repetitions, slots, and/or symbols)
    - FFS : association between the potential use case(s) and units of the time window
  + FFS: single or multiple time domain windows
* FFS: relation with UE capability
* FFS: whether the term "time domain window" is used in the specification or replaced by other technical terms
* FFS whether or not to further consider impacting of timing advance

**Agreements:**

* A new DMRS pattern equally spaced among PUSCH transmissions is not considered for joint channel estimation in Rel-17.

**Agreements:**

* For inter-slot frequency hopping with inter-slot bundling, down select on the following two options:
  + Option 1: The bundle size (time domain hopping interval) equals to the time domain window size.
  + Option 2: The bundle size (time domain hopping interval) can be different from the time domain window size.
    - FFS: Whether the bundle size (time domain hopping interval) is explicitly configured or implicitly determined.
    - FFS: Whether/How the bundle size (time domain hopping interval) is defined separately for FDD and TDD.
    - FFS: relation between the bundle size (time domain hopping interval) and the time domain window size

**Conclusion:**

* For optimization of DMRS granularity in time domain with joint channel estimation, the proponents are encouraged to provide more simulation results in next meeting

**Agreements:**

* For the time domain window for joint channel estimation, down select on the following two options:
  + Option 1: The unit of the time domain window is defined separately for the following PUSCH transmissions:
    - PUSCH repetition type A
    - PUSCH repetition type B, if agreed
    - TBoMS, if agreed
    - Different TB, if agreed
  + Option 2: The unit of the time domain window is the same for the following PUSCH transmission:
    - PUSCH repetition type A
    - PUSCH repetition type B, if agreed
    - TBoMS, if agreed
    - Different TB, if agreed

**Agreement:**

* For back-to-back PUSCH transmissions across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following cases:
  + Over back-to-back PUSCH transmissions (of the same TB) for repetition type B scheduled by dynamic grant or configured grant, if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A.
    - FFS: additional specification enhancements on top of that defined to support repetition Type A
    - Only for single layer transmissions
    - Subject to UE capability
  + FFS: Over back-to-back PUSCH transmissions with different TBs

## 4.3 RAN1 #105-e

Agreement**:**

* Joint channel estimation over non-back-to-back PUSCH transmissions within one slot is not supported.

Agreement:

* Definition of the maximum duration: a maximum time duration during which UE is able to maintain power consistency and phase continuity subject to power consistency and phase continuity requirements.
* FFS whether or not such a definition is necessary for RAN1 specifications.
  + Note: whether such a definition is to be specified in RAN4 specifications is up to RAN4.
* FFS the maximum duration may be reported by UE.
* Note: it is understood that for a UE, the maximum duration is no less than the time domain window duration

Agreement:Send LS to RAN4 asking the following questions

* For joint channel estimation, is there a maximum duration during which UE is able to maintain power consistency and phase continuity under certain tolerance level? If any, how long is it?
  + What factors determine the maximum duration?
  + Whether the maximum duration should be the same for different cases for both PUSCH and PUCCH?
  + Whether the maximum duration is dependent on the modulation order of transmission, e.g., QPSK, 16QAM, 64QAM?
  + Whether the maximum duration is dependent on UL waveform (DFT-s-OFDM vs. OFDM)?
  + Whether the maximum duration is band specific?
  + Besides the factors listed above, whether or not the maximum duration is further dependent on UE capabilities (e.g., multiple possible values for a given set of factor(s)), and if so, whether the UE should report such a duration

Draft LS to RAN4 is approved, with final LS in R1-2106212.

Agreement:

* Optimization of DMRS granularity in time domain for PUSCH is not considered for joint channel estimation in Rel-17.

Agreement:

* For back-to-back PUSCH transmissions within one slot, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following cases:
  + Over back-to-back PUSCH transmissions (of the same TB) for repetition type B scheduled by dynamic grant or configured grant, if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A with consecutive slots
    - FFS: additional specification enhancements on top of that defined to support repetition Type A
    - Only for single layer transmissions
    - Subject to UE capability
* Joint channel estimation over back-to-back PUSCH transmissions with different TBs within one slot is not supported.

**Working assumption:**

* For non-back-to-back PUSCH transmissions (at least for the case of the same TB) across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following cases:
  + Over non-back-to-back PUSCH transmissions (of the same TB) for repetition type A scheduled by dynamic grant or configured grant.
  + Over non-back-to-back PUSCH transmissions (of the same TB) for repetition type B scheduled by dynamic grant or configured grant, if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A.
    - FFS: additional specification enhancements on top of that defined to support repetition Type A
    - Only for single layer transmissions
    - Subject to UE capability
  + FFS: Over non-back-to-back PUSCH transmissions with different TBs
  + FFS: Over non-back-to-back PUSCH transmissions for TBoMS
  + For the non-back-to-back PUSCH transmissions, it is defined as at least when there is no UL transmission between the two successive PUSCH transmissions
  + Subject to UE capability with details FFS (e.g., separate vs. joint capability for type A & type B, w.r.t. OFF power requirements, etc.)
* FFS: Joint channel estimation over non-back-to-back PUSCH transmissions with other uplink transmissions between the two successive PUSCH transmissions across consecutive slot.

Agreement:

* Joint channel estimation for PUSCH transmissions is enabled or disabled via RRC configuration for a UE
  + FFS: whether additional dynamic signaling is needed to enable/disable joint channel estimation for PUSCH transmissions
  + Note: the enabling of such a feature is subject to certain prerequisites
  + FFS RRC parameter details (including explicit vs. implicit configuration)
* FFS For joint channel estimation for PUSCH, the time domain window is not explicitly enabled or disabled separately from joint channel estimation.

Note: Enabling/disabling of joint channel estimation for PUSCH transmissions means enabling/disabling of DMRS bundling for PUSCH transmissions under the condition of power consistency and phase continuity.

Agreement:

For joint channel estimation for PUSCH repetition type A of PUSCH repetitons of the same TB, down select one of the following alternatives for the time domain window.

* Alt 1: All the repetitions are covered by one single time domain window
  + The start of the window is the first PUSCH transmission
  + FFS: how to handle non-consecutive physical slots for UL transmission, e.g., due to DL/UL configuration for unpaired spectrum
  + FFS: frequency hopping and precoder cycling
* Alt 2: All the repetitions are covered by one or multiple time domain windows
  + For the start of each window,
    - The start of the first window is the first PUSCH transmission.
    - FFS: how to determine the start of other windows, e.g., whether multiple windows are consecutive or non-consecutive, whether the start of the window depends on DL/UL configuration for unpaired spectrum
  + For the length of each window,
    - FFS Each window consists of at least two adjacent physical slots for UL transmission.
    - The length of each window is no longer than the maximum duration.
    - FFS: how to determine the length of each window
    - FFS: whether the length of each window depends on DL/UL configuration for unpaired spectrum
  + FFS: how to handle non-consecutive physical slots for UL transmission, e.g., due to DL/UL configuration for unpaired spectrum.
  + FFS: frequency hopping and precoder cycling
* Other alternatives are not precluded.

## 4.4 RAN1 #106-e

**Confirm the following working assumption**

**Working assumption:**

* For non-back-to-back PUSCH transmissions (at least for the case of the same TB) across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following cases:
  + Over non-back-to-back PUSCH transmissions (of the same TB) for repetition type A scheduled by dynamic grant or configured grant.
  + Over non-back-to-back PUSCH transmissions (of the same TB) for repetition type B scheduled by dynamic grant or configured grant, if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A.
    - FFS: additional specification enhancements on top of that defined to support repetition Type A
    - Only for single layer transmissions
    - Subject to UE capability
  + FFS: Over non-back-to-back PUSCH transmissions with different TBs
  + FFS: Over non-back-to-back PUSCH transmissions for TBoMS
  + For the non-back-to-back PUSCH transmissions, it is defined as at least when there is no UL transmission between the two successive PUSCH transmissions
  + Subject to UE capability with details FFS (e.g., separate vs. joint capability for type A & type B, w.r.t. OFF power requirements, etc.)
* FFS: Joint channel estimation over non-back-to-back PUSCH transmissions with other uplink transmissions between the two successive PUSCH transmissions across consecutive slot.

Conclusion

* Optimization of DMRS location in time domain for PUSCH is not considered for joint channel estimation in Rel-17.

**Agreement**

* Joint channel estimation for PUSCH transmissions and the time domain window are jointly enabled or disabled via RRC configuration for a UE.
  + Note: Enabling/disabling of joint channel estimation for PUSCH transmissions means enabling/disabling of DMRS bundling for PUSCH transmissions under the condition of power consistency and phase continuity.

**Agreement**

**Make down-selection between the following two alternatives:**

* Alt 1: UE is not expected to receive TPC commands during the current time domain window.
* Alt 2: UE receives and accumulates TPC commands without taking effect during the current time domain window.

**Agreement**

* UE should not perform TA adjustment during the time domain window.
  + FFS: UE does not expect to receive TA command to indicate TA adjustment during the TDW.
  + FFS: UE ignores any TA command which indicates TA adjustment during the TDW.
  + FFS: UE performs TA adjustment after the TDW if it receives any TA command indicating TA adjustment during the TDW.

**Working assumption:**

For joint channel estimation for PUSCH repetition type A of PUSCH repetitions of the same TB, all the repetitions are covered by one or multiple consecutive/non-consecutive configured TDWs.

* Each configured TDW consists of one or multiple consecutive physical slots.
* The window length *L* of the configured TDW(s) can be explicitly configured with a single value.
  + FFS: The maximum value of *L*
  + FFS: Solutions to error propagation issue if *L* is longer than the maximum duration is to be discussed further.
  + FFS: The window length *L* is configured per UL BWP
* The start of the first configured TDW is the first PUSCH transmission
  + FFS: The first available slot/symbol, or the first physical slot/symbol for the first PUSCH transmission.
* The start of other configured TDWs can be implicitly determined prior to first repetition.
  + FFS: The configured TDWs are consecutive for paired spectrum/SUL band
  + FFS: The start of the configured TDWs for unpaired spectrum is implicitly determined based on semi-static DL/UL configuration.
* The end of the last configured TDW is the end of the last PUSCH transmission.
  + FFS: The end of the configured TDW is the last available slot/symbol, or the last physical slot/symbol for the last PUSCH transmission.
* Within one configured TDW, one or multiple actual TDWs can be implicitly determined:
  + The start of the first actual TDW is the first PUSCH transmission within the configured TDW.
    - FFS: The first available slot/symbol, or the first physical slot/symbol for the first PUSCH transmission.
  + After one actual TDW starts, UE is expected to maintain the power consistency and phase continuity until one of the following conditions is met, then the actual TDW is ended.
    - The actual TDW reaches the end of the last PUSCH transmission within the configured TDW.
      * FFS: The end of the actual TDW is the last available slot/symbol, or the last physical slot/symbol for the last PUSCH transmission.
    - An event occurs that violates power consistency and phase continuity
      * FFS: The events may include e.g., a DL slot based on DL/UL configuration for unpaired spectrum, the actual TDW reaches the maximum duration, DL reception/monitoring occasion for unpaired spectrum, high priority transmission, frequency hopping, precoder cycling.
      * FFS: The end of the actual TDW is the last available slot/symbol of the PUSCH transmission right before an event such that the power consistency and phase continuity are violated.
  + If the power consistency and phase continuity are violated due to an event, whether a new actual TDW is created is subject to UE capability of supporting restarting DMRS bundling.
    - If UE is capable of restarting DM-RS bundling, one new actual TDW is created after the event,
      * FFS: The start of the new actual TDW is the first available slot/symbol for PUSCH transmission after the event.
    - If UE is not capable of restarting DM-RS bundling, no new actual TDW is created until the end of the configured TDW.
    - FFS: UE capability of restarting DMRS bundling is applied only to dynamic event or not

Note 1: A ‘configured TDW’ refers to a time domain window whose length can be configured to ‘L’ and whose start and end is determined as described above.

Note 2: An ‘actual TDW’ refers to a time domain window during whose entire duration the DM-RS bundling is actually applied. An ‘actual TDW’ duration is always less than or equal to the ‘configure TDW’ duration.

Note 3: Whether the terms ‘configured TDW’ and ‘actual TDW’ are revised to other terms and if such terminology is used in specifications is to be further discussed.

## 4.5 RAN1 #106bis-e

**Agreement:**

* For PUSCH repetition type A counting based on physical slots
  + The start of the first configured TDW is the first physical slot for the first PUSCH transmission.
  + The end of the last configured TDW is the last physical slot for the last PUSCH transmission.
* For PUSCH repetition type A counting based on available slots
  + The start of the first configured TDW is the first available slot for the first PUSCH transmission.
  + The end of the last configured TDW is the last available slot for the last PUSCH transmission.
  + Note: The determination of available slots for PUSCH repetition Type A is defined in AI 8.8.1.1.

**Conclusion:**

* Joint channel estimation over PUSCH transmissions across non-consecutive slots is not supported in Rel-17.

**Agreement:**

Down-select one of the following options in this meeting:

**Option 1**:

* The maximum value of window length *L* of the configured TDW should not exceed the maximum duration, which is reported as UE capability as the duration where UE is able to maintain power consistency and phase continuity subject to power consistency and phase continuity requirements.

**Option 1’:**

* The maximum value of window length L of the configured TDW should not exceed the maximum duration, which is reported as UE capability as the duration where UE is able to maintain power consistency and phase continuity subject to power consistency and phase continuity requirements.
  + - ~~If L is not configured, the configured TDW length is equal to all repetitions~~
    - If L is not configured, default behavior should be defined, e.g., the configured TDW length is equal to all repetitions

**Option 3’**:

* Whether the window length *L* of the configured TDW can be longer than maximum duration is subject to UE capability.
  + If UE is capable of *L* being longer than maximum duration,
    - The maximum value of the window length *L* of the configured TDW is the duration of all repetitions.
      * FFS: whether *L* cannot be other values other than the duration of all repetitions, if it is longer than the maximum duration.
    - If *L* is longer than the maximum duration, UE does not expect dynamic events.
      * FFS: details of dynamic events

**Agreement**

* For DG-PUSCH, Type1 CG-PUSCH and Type2 CG-PUSCH, the window length L of the configured TDW is at least configured by RRC.
* FFS: For DG-PUSCH and Type2 CG-PUSCH, whether the window length *L* of the configured TDW can be indicated by DCI or indicated by TDRA table with one additional entry.

**Agreement**

* The window length L of the RRC configured TDW is configured separately for PUSCH and PUCCH.
  + For PUSCH, *L* is configured per BWP.
* FFS whether the window length L can be configured with each row in the TDRA table

**Agreement**

* For PUSCH repetition type A counting based on physical slots
  + The configured TDWs are consecutive, where the start of other configured TDWs is the first physical slot right after the last physical slot of a previous configured TDW.
* For PUSCH repetition type A counting based on available slots
  + The configured TDWs are determined based on available slots, where start of a configured TDWs is the ~~next~~ first available slot after the ~~conclusion~~ last available slot of a previous configured TDW.
  + Note: The determination of available slots for PUSCH repetition Type A is defined in AI 8.8.1.1.

**Working assumption:**

* The start of the first actual TDW is the first ~~available~~ symbol (at least determined by TDRA table) ~~in available slot~~ for the first PUSCH transmission in an available slot within the configured TDW.
* The end of the actual TDW is
  + the last ~~available~~ symbol (at least determined by TDRA table) ~~in available slot~~ for the last PUSCH transmission in an available slot within the configured TDW if the actual TDW reaches the end of the last PUSCH transmission within the configured TDW.
  + the last ~~available~~ symbol (at least determined by TDRA table) ~~in available slot~~ of the PUSCH transmission right before the event if an event occurs that violates power consistency and phase continuity, and the PUSCH transmission is in an available slot.
  + For UE capable of restarting DM-RS bundling, the start of the new actual TDW is the first ~~available~~ symbol (at least determined by TDRA table) ~~in available slot~~ for PUSCH transmission after the event violates power consistency and phase continuity, and the PUSCH transmission is in an available slot.

**Agreement**

* For back-to-back PUSCH transmissions across consecutive slots, support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following case:
  + Over back-to-back PUSCH transmissions for one TB processed over multiple slots
    - It’s subject to UE capability
    - if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A

**Agreement**

* For non-back-to-back PUSCH transmissions across consecutive slots (no uplink transmission in the middle of two PUSCH transmissions), support necessary design aspects (under the condition of power consistency and phase continuity) to enable joint channel estimation for the following case:
  + Over non-back-to-back PUSCH transmissions for one TB processed over multiple slots
    - It’s subject to UE capability
    - if it reuses only those joint channel estimation specification enhancements defined to support repetition Type A

**Agreement**

Down-select one of the following options:

* **Option 1:** If DM-RS bundling is supported, UE is mandatory to support restarting DM-RS bundling due to semi-static events. UE capability of restarting DMRS bundling is applied only to dynamic events.
* **Option 2:** UE capability of restarting DMRS bundling is applied to both semi-static events and dynamic events.

**Agreement**

* Support at least the following events that violate power consistency and phase continuity.
  + Dropping/cancellation based on Rel-15/16 collision rules.
  + FFS: Rel-17 collision rules.
  + DL slot or DL reception/monitoring based on semi-static DL/UL configuration for unpaired spectrum.
  + FFS: Other UL transmission in between PUSCH/PUCCH transmissions.
  + Gap between two PUSCH/PUCCH transmissions exceeds 13 symbols.
  + FFS: Transmission parameters need to be changed due to network-indicated operations, including: Tx power, UL beam/TPMI, and RB allocation.
  + FFS: TPC command.
  + FFS: TA adjustment.
  + FFS: The actual TDW reaches the maximum duration.
  + FFS: Frequency hopping.
  + FFS: Precoder cycling.
  + FFS: other events.
  + FFS: whether events are semi-static events or dynamic events.
  + FFS: the time duration of an event.

1. AI 8.8.2: PUCCH enhancements

## 5.1 RAN1 #104-e

Agreements: Down select from the following two options to support dynamic PUCCH repetition factor indication.

* Option 1 (without DCI enhancement): Enhance RRC signaling to allow configuration of PUCCH repetition factor per PUCCH resource. PUCCH repetition factor is implicitly indicated by DCI.
  + FFS details, e.g., via reusing the “PUCCH resource indicator” field (without increase # bits of it), starting CCE index (when applicable) of DCI, by PDCCH aggregation level, etc.
  + FFS: RRC signaling enhancement details
* Option 2 (with DCI enhancement): PUCCH repetition factor is explicitly indicated by DCI
  + e.g., introduce a new field or increase the number of bits of an existing field (e.g., PRI) in DCI for PUCCH repetition factor indication
  + FFS whether there is a need for RRC update

Agreements: Subject to the prerequisite of DMRS bundling for PUCCH repetitions, enhance inter-slot frequency hopping pattern for PUCCH repetitions with DMRS bundling.

* FFS: details in inter-slot frequency hopping pattern enhancement, e.g., additional frequency hopping patterns than Rel-16.
* Strive for common design for PUSCH/PUCCH with DMRS bundling as much as possible

Agreements:

Subject to the prerequisites of DMRS bundling for PUCCH repetitions, support enabling PUCCH repetitions with DMRS bundling via RRC configuration.

* FFS: the configuration is per UE or per PUCCH resource.
* FFS: whether additional dynamic signaling is needed to enable/disable PUCCH repetitions with DMRS bundling
* FFS: necessity of additional signaling/configuration of DMRS bundling duration/window and associated size

**Conclusion**: In Rel-17, deprioritize the study of DMRS pattern/location/granularity optimization for PUCCH coverage enhancement in AI 8.8.2. This conclusion could be revisited after the progress on the study of  DMRS pattern/location/granularity optimization for PUSCH coverage enhancement in AI 8.8.1.3.

**Conclusion**: For the study of enhancing inter-slot frequency hopping pattern for PUCCH repetitions with DMRS bundling, at least the following aspects can be considered:

* Performance tradeoff between maximizing # consecutive UL slots in one frequency hop (to achieve more DMRS bundling gain) and maximizing # hops (to achieve more diversity gain)
  + Note: the maximum # frequency hopping positions is still 2 as in Rel-15/16.
* Interaction between hopping boundary determination and TDD configuration

**Conclusion**: For the simulations to study the enhancement of inter-slot frequency hopping pattern for PUCCH repetitions with DMRS bundling, simulation assumptions in 38.830 are reused as a starting point.

Note: Additional simulation scenarios/assumptions are not precluded.

## 5.2 RAN1 #105-e

Agreement: For DMRS bundling for PUCCH repetitions, specify a time domain window during which a UE is expected to maintain power consistency and phase continuity among PUCCH repetitions subject to power consistency and phase continuity requirements.

* Strive for common design of the time domain window for PUSCH/PUCCH with DMRS bundling as much as possible.

Working assumption: In Rel-17, for a PUCCH with associated scheduling DCI, support the following for dynamic PUCCH repetition factor indication.

* Enhance RRC signaling to allow configuration of PUCCH repetition factor per PUCCH resource. Reuse Rel-16 PUCCH resource indication mechanism based on “PUCCH resource indicator” (PRI) field and starting CCE index (when applicable based on Rel-16 spec) of DCI to indicate a PUCCH resource and its associated repetition factor.
  + FFS: RRC signaling enhancement details

**Conclusion**: For PUCCH repetitions, the following use cases are deprioritized in RAN1 work on PUCCH DMRS bundling

* Use case 1: back-to-back PUCCH repetitions within one slot.
* Use case 2: non-back-to-back PUCCH repetitions within one slot.
  + Use case 2a: no uplink transmission in the middle of two PUCCH repetitions
  + Use case 2b: other uplink transmissions in the middle of two PUCCH repetitions

## 5.3 RAN1 #106-e

LS [R1-2108458](file:///C:\3gpp\Meetings\TSGR1\TSGR1_106-e\Docs\R1-2108458.zip) is endorsed.

**Confirm the following working assumption**

Working assumption:

In Rel-17, for a PUCCH with associated scheduling DCI, support the following for dynamic PUCCH repetition factor indication.

* Enhance RRC signaling to allow configuration of PUCCH repetition factor per PUCCH resource. Reuse Rel-16 PUCCH resource indication mechanism based on “PUCCH resource indicator” (PRI) field and starting CCE index (when applicable based on Rel-16 spec) of DCI to indicate a PUCCH resource and its associated repetition factor.
  + FFS: RRC signaling enhancement details

Agreement

* for a PUCCH resource, if both a new repetition parameter corresponding to Rel-17 dynamic PUCCH repetition factor indication and the Rel-15/16 nrofSlots are configured, the new repetition parameter overrides nrofSlots.

Agreement

* In Rel-17, reuse the Rel-16 PUCCH repetition factors 2, 4, 8.
* Do not support PUCCH repetition factor larger than 8 In Rel-17.

Agreement

* For DMRS bundling for PUCCH repetitions, RAN1 at least prioritize use cases 3 and 4a in R1-2104119.

Agreement

Dynamic PUCCH repetition factor indication for SR or P/SP-CSI on PUCCH is not supported in Rel-17.

## 5.4 RAN1 #106bis-e

LS R1-2110642 is endorsed.

**Agreement**

**Dynamic signaling to enable/disable DMRS bundling for PUCCH or PUSCH repetitions is not supported in Rel-17.**

**Agreement:**

**For the interaction between inter-slot frequency hopping and DMRS bundling for PUCCH/PUSCH repetitions, a UE perform the “hopping intervals determination”, “configured TDW determination”, and “actual TDW determination” in a sequential ordering. One option of the following options is to be selected.**

* **Option 1: “hopping intervals determination” -> “configured TDW determination” -> “actual TDW determination”**
* **Option 2: “configured TDW determination” -> “hopping intervals determination” -> “actual TDW determination”**
* **Option 4: “configured TDW determination” -> “actual TDW determination” and “hopping intervals determination”**

**Note: option 1~~,~~ and 2~~, and 3~~ assume a hopping interval can be different than an actual TDW. Option 4 assumes a hopping interval is the same as an actual TDW.**

**Agreement**

**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.**

**Note: it does not impact the discussion of slot level or sub-slot level repetition**

1. AI 8.8.3: Type A PUSCH repetitions for Msg3

## 6.1 RAN1 #104-e

**Agreements:**

* For indication of the number of repetitions for Msg3 initial transmission, down-select one option from the options below.
  + Option1: UL grant scheduling Msg3.
    - FFS details.
    - FFS fallbackRAR UL grant.
    - Note: Optimization specific for fallbackRAR UL grant in 2-step RACH is not considered in Rel-17 CovEnh WI, if supported.
  + Option2: DCI format 1\_0 with CRC scrambled by RA-RNTI
    - FFS details.
  + Option3: SIB1 only
* Any modifications of RAR UL grant or DCI format 1\_0 with CRC scrambled by RA-RNTI for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the RAR or DCI format 1\_0 with CRC scrambled by RA-RNTI respectively

**Agreements:**

* For indication of the number of repetitions for Msg3 re-transmission, down-select one option from the options below.

Option1: DCI format 0\_0 with CRC scrambled by TC-RNTI.

FFS details.

Any modifications of DCI format 0\_0 with CRC scrambled by TC-RNTI for indicating Msg3 repetitions shall not impact the legacy UE interpretation of the DCI format 0\_0 with CRC scrambled by TC-RNTI.

Option2: Can be determined based on the repetition number  for  Msg3 initial transmission

**Agreements:**

Support inter-slot frequency hopping for repetition of Msg3 initial and re-transmission.

FFS details, e.g., signaling etc.

**Agreements:**

For Msg3 PUSCH repetition, the following options are considered, aiming for down-selection in RAN1#104b-e:

* Option 1-1: For gNB scheduled Msg3 PUSCH repetition without UE request,
* A UE indicates to support of Msg3 PUSCH repetition via separate PRACH occasion or separate PRACH preamble in case of shared PRACH occasions.
* For a UE supporting Msg3 PUSCH repetition, gNB decides whether to schedule Msg3 PUSCH repetition or not. If scheduled, gNB decides the number of repetitions.
* FFS details if any.
* Option 1-2: For gNB scheduled Msg3 PUSCH repetition without UE request,
* gNB decides whether to schedule Msg3 PUSCH repetition or not. If scheduled, gNB decides the number of repetitions.
* For UE does not support Msg3 PUSCH repetition, UE transmits Msg3 PUSCH without repetition
* For UE does support Msg3 PUSCH repetition, UE transmits Msg3 PUSCH with repetition as indicated by gNB and UE uses, e.g., separate DMRS configuration or UCI multiplexing with Msg3 PUSCH (or other ways)
* Note: e.g., this can be for differentiation between UEs not supporting Msg3 PUSCH repetition and Rel-17 CE UEs supporting Msg3 PUSCH repetition or between RACH procedure with Msg3 PUSCH repetition and Msg3 PUSCH without repetition, etc.
* gNB blindly decodes Msg3 PUSCH with two different assumptions, w/ and w/o repetition.
* FFS details if any.
* Option 2-1: For UE triggered Msg3 PUSCH repetition with gNB indicating the number of repetitions,
* A UE can trigger RACH procedure with Msg3 PUSCH repetition via separate PRACH occasion or separate PRACH preamble in case of shared PRACH occasions.
* Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.
* If Msg3 PUSCH repetition is triggered by UE, gNB decides the number of repetitions for Msg3 PUSCH 3 (re)-transmission.
* FFS details if any.
* Option 2-2: For UE triggered Msg3 PUSCH repetition with gNB indicating the number of repetitions,
  + gNB decides whether to schedule Msg3 PUSCH repetition or not. If scheduled, gNB decides the number of repetitions.
  + If Msg3 PUSCH repetition is scheduled, UE transmits Msg3 PUSCH with or without repetition. If UE transmits Msg3 PUSCH repetition, the number of repetition follows the indication of gNB and UE uses e.g., separate DMRS configuration or UCI multiplexing with Msg3 PUSCH (or other ways)
* Whether a UE would trigger is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.
  + FFS details if any.
* Other options are not precluded.

## 6.2 RAN1 #104bis-e

Agreement: For Msg3 PUSCH repetition, support the following modified Option 2-1.

* Option 2-1: For UE requested Msg3 PUSCH repetition with gNB indicating the number of repetitions,
* A UE can request Msg3 PUSCH repetition via separate PRACH resources (FFS details, e.g., separate PRACH occasion or separate PRACH preamble in case of shared PRACH occasions after SSB association, etc.).
* Whether a UE would request ~~trigger~~ is based on some conditions, e.g., measured SS-RSRP threshold, which may or may not have spec impact.
* If Msg3 PUSCH repetition is requested triggered by UE, gNB decides whether to schedule Msg3 PUSCH repetition or not. If scheduled, gNB decides the number of repetitions for Msg3 PUSCH 3 (re)-transmission.
* FFS the UE capability of supporting Msg3 PUSCH repetition can be reported after initial access procedure as usual
* FFS details if any.

Agreements: For the determination of RV for Msg3 PUSCH repetition,

* RV of the first repetition is determined in the same way as legacy.
  + Use RV 0 for the first repetition of Msg3 PUSCH initial transmission.
  + Use a dynamically indicated RV id via DCI 0\_0 with CRC scrambled by TC-RNTI for the first repetition of Msg3 PUSCH re-transmission.
* FFS determination of the RV sequence.

Agreements: For indication of the number of repetitions for Msg3 initial transmission, Option 1 (i.e., using UL grant scheduling Msg3) is adopted.

* FFS additionally using MAC RAR for indication.

Agreements: For indication of the number of repetitions for Msg3 re-transmission, Option 1 (i.e., using DCI format 0\_0 with CRC scrambled by TC-RNTI) is adopted.

**Working assumption:**The number of repetitions is counted on the basis of available slots for Type A PUSCH repetitions for Msg3.

* FFS: the determination of available slots.

## 6.3 RAN1 #105-e

Agreement: A UE requests Msg3 PUSCH repetition at least when the RSRP of the downlink pathloss reference is lower than an RSRP threshold.

* FFS the determination of the RSRP threshold.

Agreement: For repetition indication of Msg3 re-transmission, select one options from the following two options.

* Option 1: Use the same mechanism as supported for Msg3 initial transmission.
* Option2: Use HARQ process number bit field in DCI format 0\_0 with CRC scrambled by TC-RNTI.

Agreement: Available slot for Msg3 PUSCH repetition doesn’t depend on dynamic SFI in DCI format 2-0.

Agreement: Available slot for Msg3 PUSCH repetition doesn’t depend on UL CI.

Agreement: Use a fixed RV sequence [0 2 3 1] for repetition of Msg3 initial and re-transmission.

* The RV cycling for Msg3 initial transmission follows the rule specified in the first row in Table 6.1.2.1-2 in TS38.214.
* The RV cycling for Msg3 re-transmission follows the rules specified in Table 6.1.2.1-2 in TS38.214.
* FFS: The RV cycling for Msg3 is based on transmission occasions on available slot.

Agreement:

* For requesting Msg3 PUSCH repetition, support the following:
  + Use separate preamble with shared RO configured by the same PRACH configuration index with legacy UEs.
    - FFS whether to introduce a PRACH mask to indicate a sub-set of ROs associated with a same SSB index within an SSB-RO mapping cycle for requesting Msg3 repetition for a UE.
    - FFS definition of shared RO (e.g., whether the shared RO can be an RO with preamble(s) for 4-step RACH only or with preambles for both 4-step RACH and 2-step RACH).
  + FFS whether or not to additionally support one (& only one) more option:
    - E.g., option 2: Use separate RO configured by a separate PRACH configuration index from legacy UEs
    - E.g., Option 3: Use separate RO, which include
      * the separate RO configured by a separate RACH configuration index from legacy UE, and
      * the remaining RO (if any) configured, by the same PRACH configuration index with legacy UEs, that cannot be used by legacy rules for PRACH transmission.

Agreement**:** Available slots for Msg3 PUSCH repetition do not depend on *tdd-UL-DL-ConfigurationDedicated*.

Agreement**:** Available slot for Msg3 PUSCH repetition depends on *TDD-UL-DL-Configcommon*.

* A slot is determined as available for Msg3 repetition only if the consecutive symbols allocated for Msg3 repetition in the slot are all available symbols.
  + UL symbols indicated by *TDD-UL-DL-Configcommon* are determined as available for Msg3 repetition.
  + FFS whether and how to use flexible symbols indicated by *TDD-UL-DL-Configcommon*.

Working assumption:

* Using an information field from the existing information fields in RAR UL grant for indication of the number of repetition of Msg3 initial transmission
  + Down-select only one from the following information fields in RAR UL grant for indication of the number of repetition of Msg3 initial transmission.
    - TDRA information field with introducing a new TDRA table including the repetition factors.
    - MCS information field
    - TPC information field
    - CSI request information field
    - FDRA information field
* The total size of RAR UL grant does not change.
* Position of all fields in the bit sequence of the RAR UL grant does not change, regardless of whether they are repurposed or not.
* FFS details, e.g., TDRA table selection, or whether/how to indicate which interpretation UE should use for the repurposed information field (legacy vs repurposed interpretation) etc.

**Conclusion:**

* Companies are encouraged to perform additional evaluations regarding intra-slot frequency hopping for Msg 3 with repetition. Aim to conclude whether or not to support this feature in RAN1#106-e (note: if supported, the intention is to not configure intra- and inter-slot frequency hopping simultaneously)

## 6.4 RAN1 #106-e

**Agreement**

Do NOT support fallback RAR UL grant in 2-step RACH for indicating Msg3 repetition.

**Agreement**

The separate preambles for requesting Msg3 repetition could be configured only in an RO configured with 4-step RACH preambles not for requesting Msg3 repetition.

**Working Assumption**

Down-select only one from the following methods for indication of the number of repetition of Msg3 initial transmission.

* Alt 1: If TDRA information field is chosen, introducing a new configurable TDRA table including the repetition factors.
  + The new TDRA table is configured by SIB1, with selecting one of the two options below.
    - Option 1: The new TDRA table includes separate new indication for K2, mapping type, SLIV and repetition factor.
    - Option 2: The new TDRA table includes legacy indication for K2, mapping type and SLIV from legacy TDRA table, and new indication for repetition factor.
  + If a new TDRA table is not configured, the legacy default TDRA table is used, and repetition factor K=1 is applied.
* Alt 2: If MCS information field is chosen, repurpose the MCS information field as follows.
  + X MSB bits of the MCS information field are used for repetition indication.
    - FFS the value of X.
    - FFS whether the X bits are directly used for indicating the repetition factor (i.e., the decimal value of X is equal to the repetition factor) or used for selecting one repetition factor from a predefined/SIB1 configured set.
* Alt 3: If TPC information field is chosen, repurpose the TPC information field by selecting one of the two options below.
  + Option 1: X LSB bits of the TPC information field are used for repetition indication.
    - FFS the value of X.
    - FFS whether the X bits are directly used for indicating the repetition factor (i.e., the decimal value of X is equal to the repetition factor) or used for selecting one repetition factor from a predefined/SIB1 configured set.
  + Option 2: A predefined TPC command table with including repetition factor K is introduced.
    - FFS details.

**Agreement**

Down-select one of the two options on how a UE should interpret the selected information field for indication of the number of repetitions.

* Option 1:
* When a UE requests Msg3 repetition, the new TDRA table or repurposed information field is applied. gNB schedules Msg3 with or without repetition for the UE requesting Msg3 repetition.
  + Repetition factor K=1 is included in the TDRA table or one entry/codepoint of the repurposed information field.
* When the UE doesn’t request Msg3 repetition (including legacy UE), the legacy TDRA table or legacy information field is applied. gNB schedules Msg3 without repetition for the UE not requesting Msg3 repetition.
* Option 2:
* When a UE requests Msg3 repetition, gNB schedules Msg3 with or without repetition by respectively using the new TDRA table or legacy TDRA table; or gNB schedules Msg3 with or without repetition by respectively using repurposed information field or legacy interpretation of information field. Whether the UE should apply the new or the legacy TDRA table, or apply repurposed or legacy interpretation of the information field, is indicated by gNB.
  + FFS details, e.g. implicit or explicit indication or predefined.
  + Repetition factor K=1 is NOT included in the TDRA table or one entry/codepoint of the repurposed information field.
* When the UE doesn't request Msg3 repetition (including legacy UE), gNB schedules Msg3 without repetition. The UE applies the legacy TDRA table, or the legacy interpretation of the information field.

**Agreement**

* Support at least repetition factor K = {2, 4} for Msg3 PUSCH repetition.
* FFS whether to support other values, e.g., 8.
* Note: K=1 is supported and how to support K=1 is FFS.

**Agreement**

* *The available slot of Msg3 PUSCH repetition is only determined by the tdd-UL-DL-ConfigurationCommon and ssb-PositionsInBurst, no other additional Rel-16 signals/signalings will be considered.*
* *If a symbol for Msg3 repetition in a slot overlaps with SSB transmission [FFS:N Gap symbols after SSB], the slot is determined as not available during the counting of repetitions. As there is no Msg3 repetition in the slot, no Msg3 repetition omission applies to the slot.*

**Agreement**

Do not support TBoMS for Msg3 in Rel-17 coverage enhancement WI.

## 6.5 RAN1 #106bis-e

LS [R1-2110585](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_106b-e/Inbox/R1-2110585.zip) is endorsed.

**Working Assumption**

**Down-select only one from the following methods for indication of the number of repetitions of Msg3 initial transmission.**

* **Alt 1: If TDRA information field is chosen, Option 2 is supported.** 
  + **The candidate values for repetition factor could be chosen from {[1], 2, 3, 4, 7, 8, [12], [16]}**
* **Alt 2: If MCS information field is chosen, repurpose the MCS information field as follows.**
  + **2 MSB bits of the MCS information field are used for selecting one repetition factor from a SIB1 configured set with 4 candidate values.**
    - **The set of candidate values for repetition factor could be chosen from {[1], 2, 3, 4, 7, 8, [12], [16]}**

**Note: Whether ‘1’ is included depends on the outcome of interpretation of the selected information field.**

**Agreement**

**Include the following into the reply LS to** [**R1-2108712**](file:///C:\3gpp\Meetings\TSGR1\TSGR1_106b-e\Docs\R1-2108712.zip)**(R2-2109195).**

**RAN1 thinks at least the number of preambles per SSB per RO for request of Msg3 repetition~~, i.e.,~~ *~~CB-PreamblesPerSSB~~*~~,~~ is needed. It’s up to RAN2 whether to indicate the start of preamble index for request of Msg3 repetition with shared RO.**

**Agreement**

**Include the following into the reply LS to** [**R1-2108712**](file:///C:\3gpp\Meetings\TSGR1\TSGR1_106b-e\Docs\R1-2108712.zip)**(R2-2109195).**

* **From RAN1 perspective, there is no need to separately configure the following legacy RACH parameters configured in *RACH-ConfigCommon* for requesting Msg3 PUSCH repetition with shared RO on a given UL carrier.**
* ***prach-ConfigurationIndex***
* ***msg1-FDM***
* ***msg1-FrequencyStart***
* ***zeroCorrelationZoneConfig***
* ***totalNumberOfRA-Preambles***
* ***ssb-perRACH-OccasionAndCB-PreamblesPerSSB***
* ***FFS: rsrp-ThresholdSSB***
* ***rsrp-ThresholdSSB-SUL***
* ***prach-RootSequenceIndex***
* ***msg1-SubcarrierSpacing***
* ***restrictedSetConfig***
* ***msg3-transformPrecoder***

**Conclusion**

**There is no consensus to additionally support intra-slot frequency hopping for Msg3 PUSCH with repetition in Rel-17.**

**Note: intra-slot FH is supported when a UE is scheduled Msg3 PUSCH without repetition.**

**Agreement**

Include the following into the reply LS to [R1-2108712](file:///C:\3gpp\Meetings\TSGR1\TSGR1_106b-e\Docs\R1-2108712.zip)(R2-2109195)

* From RAN1 perspective, it can be beneficial to separately configure *rsrp-ThreBsholdSS* for requesting Msg3 PUSCH repetition with shared RO on a given UL carrier.

**Agreement**

If UE is indicated with Msg3 PUSCH with repetition, the frequency hopping flag information field in UL RAR grant or DCI format 0\_0 with CRC scrambled by TC-RNTI is reused to enable/disable inter-slot frequency hopping.

**Agreement**

The Rel-15/16 Msg3 PUSCH collision handling rules are reused for transmission of Msg3 PUSCH repetition in an available slot.

* FFS whether collision with downlink symbols indicated by *tdd-UL-DL-ConfigurationDedicated* is an exceptional case, i.e., Msg3 PUSCH repetition cannot be canceled by downlink symbols indicated by *tdd-UL-DL-ConfigurationDedicated* in Rel-17.
* FFS: Rel-17 Msg3 PUSCH collision rules are also applied if introduced in other WI(s)

1. Reference
2. 3GPP RP-202928, “New WID on NR coverage enhancements”, China Telecom, RAN#90e, December 7th – 11th, 2020.
3. 3GPP RP-211566, “Revised WID on NR coverage enhancements”, China Telecom, RAN#92e, June 14th – 18th, 2021.