3GPP TSG RAN WG1 #104-e R1-21xxxxx

e-Meeting, January 25th – February 5th, 2021

**Agenda item: 8.8.1.2**

**Source: Moderator (Nokia, Nokia Shanghai Bell)**

**Title: FL summary of TB processing over multi-slot PUSCH (AI 8.8.1.2)**

**Document for: Discussion and Decision**

# 1 Introduction

TB processing over multi-slot PUSCH was included as one of the enhancements, for both FR1 and FR2 as well as TDD and FDD, to be specified in the NR coverage enhancement work item approved in RAN1#90-e [1]:

* *Specification of PUSCH enhancements [RAN1, RAN4]*
  + *Specify mechanism(s) to support TB processing over multi-slot PUSCH [RAN1]*
    - *TBS determined based on multiple slots and transmitted over multiple slots.*

Section 2 summarizes the key aspects of TB processing over multi-slot PUSCH based on companies’ contributions submitted under AI 8.8.1.2 to RAN1#104-e [3]-[28].

All related proposals from different contributions, organized per aspect, are listed in Appendix A for reference.

# 2 Summary of Contributions on TB processing over multi-slot PUSCH

Contributions submitted under AI 8.8.1.2 discussed several aspects of TB processing over multi-slot PUSCH (referred to as TBoMS in this document, for simplicity). From FL’s perspective, laying down the bases for a constructive discussion is of utmost priority at this stage to ensure good progress is achieved. For this reason, a systematic categorization will be used in this document to summarize the content of all contributions. This is done according to both FL’s understanding and number of submitted proposals on the different aspects. The rationale of the categorization is given by the natural relationship of consequentiality which exists between different aspects. In the remainder of the document, aspects are thus categorized as follows:

* **Resource allocation aspects of TBoMS**
  + TDRA
  + FDRA
  + TBS determination
* **Basic design aspects of TBoMS**
  + Relationship between TBoMS and PUSCH repetitions
  + DM-RS
  + CB segmentation, Redundancy version, rate-matching and interleaving
  + Link adaptation
* **Advanced design aspects of TBoMS**
  + Frequency hopping
  + Transmission power determination
  + Rank of TBoMS transmission
  + Channel estimation
  + Retransmissions
* **Signaling and interaction with other signals/channels**
  + Multi-slot/single-slot activation/switch
  + UCI multiplexing, SRS/DL collisions/cancellations
  + Service-like prioritization of TBoMS

The categorization above will be used to identify a priority order for the discussions to be held for AI 8.8.1.2. In this context, sections 2.1 to 2.3 will focus on aspects related to resource allocation for TBoMS. Priority will be given to these, during RAN1 #104-e. Summary of all other aspects will be provided in Section 2.4. Should discussions for 2.1 to 2.3 progress fast, new sections for specific aspects, currently in 2.4, will be added.

Before proceeding, it is also worth observing that simulation assumptions have also been discussed in one contribution [23]. Its content is summarized separately from all the above in Section 2.5. It is also treated with lower priority, given the existence of baseline evaluation assumptions agreed during Rel-17 SI [2].

## 2.1 TDRA

Five major sub-aspects of TDRA have been discussed by companies in the submitted contributions:

1. Time domain resource indication
2. Indication of number of slots
3. Constraints on how slots can be used for TBoMS
4. How to handle S slots
5. Definition of transmission occasion

Summary, discussion and proposals on these sub-aspects are provided in the following different sub-sections, whose numbers are given in the list above.

### 2.1.1 Time domain resource indication

Most contributions acknowledged the fundamental nature of this aspect and discussed it in detail. Several options are considered in all contributions. A high-level summary of all options, including companies’ preferences based on the contributions, is as follows:

* **Option 1**. Repetition type A like or repetition type B like TDRA for TBoMS [11 companies]:
  + Type A like:
    - Intel [8], CATT [6], Samsung [18], China Telecom [12], Ericsson (first preference) [23], Apple [20], OPPO [4], vivo [7], ZTE [3];
  + Type B like:
    - Huawei [5], Nokia [28], CATT [6], Samsung [18], Ericsson (second preference) [23], vivo [7].
* **Option 2**. Indication via SLIV of a number of symbols L larger than 14 [4 companies]:
  + - Panasonic [15], CMCC [16], Samsung (symbols can be grouped) [18], vivo [7].
* **Option 3**. Multiple SLIV for slot-by-slot resource allocation [3 companies]:
  + - Panasonic [15], Fujitsu [11], vivo [7].
* **Option 4**. Different rules [3 companies]:
  + Multiple number of slots for multi-slot PUSCH and length L (value ranging from 1-13 symbols) for the last slot [1 company]:
    - Lenovo [14];
  + Multi-slot encoding with gaps [1 company]:
    - Sierra Wireless [19];
  + Time-domain window configuration wherein all valid PUSCH symbols are used for TBoMS [1 company]:
    - Nokia/NSB [28];
  + New PUSCH mapping type with L and S+L > 14; L valid symbols starting from the symbol with index S in the slot indicated by K2 are used for multi-slot TB transmission [1 company]:
    - Nokia/NSB [28].

A large majority of companies expressed preference for Option1, i.e., Repetition type A like or repetition type B like TDRA for multi-slot TB. The rationale of this option is its potential to reuse most if not all the existing signalling and indication framework. In this context, time domain resource indication would be supported by reinterpreting or adding possibly small modifications to Rel-16 PUSCH repetitions signalling structures.

Support for other approaches is non-negligible for Option 2 and Option 3, whose rationales are somehow aligned with the what is expressed for Option 1. Option 3, in particular, is described as an alternative which offers a larger flexibility which could be exploited by gNB to better adapt UL resource allocation to external factors/needs.

Option 4 includes all the approaches proposed by only 1 company. Different modifications to current specification would be needed to support them, however extents and degrees of such modifications may not be larger. From FL’s perspective, it may be premature to exclude them from the discussion at this stage.

#### 2.1.1.1 First round of discussions

Given the very early stage of the WI, FL’s recommendation is to have a first round of discussion among companies about the four options. The goal is to identify the preferred directions RAN1 should pursue for defining and specifying time domain resource indication for TBoMS. The number of considered options should be reduced. First FL’s proposals will be made at the end of the first round.

Companies are invited to express views on the Options provided above for defining and specifying time domain resource indication for TBoMS.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | We prefer Option 1. Given the limited TU and specification impact, existing mechanism on PUSCH repetition type A or B should be considered as a starting point. We slightly prefer time domain resource allocation mechanism based on PUSCH repetition type A, but we can defer this to the next discussion. |
| Sharp | We support Option 1. In our understanding, the motivations for this enhancement are exploiting more coding gain, reducing overhead (CRC or higher layer overhead) and PSD reduction. Therefore, TBS scaling for multi-slot PUSCH with reusing existing Rel-16 repetition type A or B should be supported. |
| Apple | We prefer Option 1, and mechanism of PUSCH repetition type A TDRA is applied. |
| China Telecom | Support option 1. Other options need more standardization efforts. |
| Qualcomm | Prefer Option 1 with no changes to TDRA.  We prefer to reuse the TDRA framework that is already in place for Type A repetitions. With TBS scaling handled by an independent scale factor parameter separate from number of repetitions, we see no need for any changes to TDRA. When coupled with RV cycling across repetitions, the gains of multi-slot TB processing are rather naturally realized.  This is a lightweight approach that is equally applicable across contiguous or non-contiguous slot repetitions. Note that any scheme that we adopt must be applicable to TDD slots patterns that do not have two back-to-back U slots.  Considerations of SLIV with L > 14 don’t seem well motivated and unnecessary from our point of view. The spec impact of this change could be rather large, and it may not be prudent to pursue this path given that better alternatives exist. This approach also clearly doesn’t help when we have TDD slot patterns that do not have two or more back-to-back U slots. |
| NTT DOCOMO | Our 1st preference is Option 2 and 2nd preference is Option 1.  Option 1 is a reasonable choice, because the signalling mechanism can be reused as repetition, and the option seems to be for TBoMS with non-consecutive slots However, as the number of nominal repetitions in type A is smaller than that of actual repetitions, it is better to apply the enhancement of PUSCH repetition type As discussed in 8.8.1.1 even in TBoMS. Also, Option 1 should not include only repetition type A but repetition type B, because symbol-level repetition is flexible, e.g. considering special slot for TBoMS  Option 2 is a good choice too, and the option seems to be for TBoMS with consecutive slots. This option makes it possible to assign TBoMS with large flexibility. We should consider whether or not to support more than one TDRA. |
| ZTE | Support Option 1 with repetition type A like TDRA for TBoMS.  For TBoMS, the issues listed in Section 2.1 and several issues in Section 2.3/2.4 could all use the corresponding mechanisms of PUSCH repetition type A as a starting point. For instance, we need to discuss the collision handling between TBoMS transmission and DL/flexible symbols/SFI, it would be a rather complicate topic and reusing the legacy mechanism is much preferred for moving forward. |
| WILUS | Support Option 1. Type-A PUSCH repetition and type-B PUSCH repetition can be reused to determine time domain resource allocations. If a new time domain indication rule (option 2/3/4) is necessary, clear motivations and gains should be justified. |
| CATT | We support Option 1 for simplicity. We do not see large advantage from other options when compared to Option1. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | Support Option-1 |
| NEC | Support option 1. |
| vivo | Option 1/2/3 can be further considered.  Type-A like resource allocation is restricted by same starting symbols(S) and number of symbols(L) in a slot, which may limit the flexibility for resource allocation. Type-B like repetition is more efficient in resource utilization.  For TDRA with L>14, it can be applied for TDD frame structure with slot format “…SU…”. Since type-B PUSCH repetition is an optional UE capability, UEs may not able to perform all behaviours for type-B like TDRA, such as segmentation within a slot, L>14 contiguous symbols seem easier to be implemented compared with resource allocation mechanism for type B repetition.  For Multi-SLIV, it has been supported in Rel-16 NRU, and it is also applicable for license band. While the PUSCH occasions indicated by multiple SLIVs is restricted to be contiguous transmission in current specification. For TBoMS, this restricted can be removed to support non-contiguous transmissions. |

### 2.1.2 Indication of number of slots

Observations on how numbers of slots for transmitting TBoMS should be indicated by gNB are provided in different forms in several contributions. Explicit proposals are made in 5 contributions. Several options are considered. A high-level summary of such options, including companies’ preferences based on the contributions, follows:

* **Option 1**. Indication of number of slots via RRC [2 companies]:
  + - CMCC [16], China Telecom [12];
* **Option 2**. Dynamically indicated via DCI [3 companies]
  + No preference on the max number:
    - China telecom [12], ZTE [3];
  + Up to maximum 8 slots:
    - Apple [20];
* **Option 3**. Indication should occur, details FFS [1 company]:
  + - Samsung [18].

Option 2 is slightly more popular, with [20] stating that a maximum number of slots for TB transmission could be 8, if the TB overhead for the re-transmission is considered. On the other hand, number of contributors is not large hence further observations on the situation may not be so relevant at this stage. The general understanding is that semi-static or dynamic indication solutions used in Rel-16 for other parameters can be used for this indicator as well. Further discussion is needed.

#### 2.1.2.1 First round of discussions

Given the very early stage of the WI, FL’s recommendation is to have a first round of discussion among companies about the three options. The goal is to identify the preferred directions RAN1 should pursue for defining and specifying indication of number of slots for TBoMS. The number of considered options should be reduced. First FL’s proposals will be made at the end of the first round.

Companies are invited to express views on the Options provided above for defining and specifying indication of number of slots for TBoMS.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | The number of slots can be configured as part of TDRA entries. Further, the existing time domain resource assignment field in the DCI can be used to indicate which row is used for TDRA. This can also enable dynamic switching from single slot and multiple slot based transmission for TB processing. |
| Sharp | If we go with Option 1 in 2.1.1, indication mechanism for Rel-16 repetition type A or B can be reused. |
| Apple | We prefer dynamic indication via DCI, if DCI size is the concern, it can be indicated via MAC CE. |
| China Telecom | Both semi-static configuration and dynamic indication can be supported. |
| Qualcomm | There is no need to indicate number of slots. We propose to reuse the existing TDRA framework in conjunction with a scale factor. The scale factor can be either indicated via DCI or provided as part of RRC configuration. |
| NTT DOCOMO | The difference between the indication of number of slot and repetition type A is not clear. Firstly it is better to clarify the difference |
| ZTE | Option 2.  The TBS to be scheduled and the channel condition could be dynamically changed. Using semi-static indication cannot accommodate the change of TBS and link adaption, and will make TBoMS not useful. Similar to dynamic repetition indication of PUSCH repetition type A, Option 2 with adding one column for the number of slots in the TDRA table can be considered. |
| WILUS | Agree with Sharp. If type-A or type-B PUSCH repetition is reused to determine the time domain allocation for TBoMS, then the number of slots can be indicated in TDRA table. |
| CATT | OK with Option 1 (like *pusch-AggregationFactor* for repetition) and Option 2 (like *numberOfRepetitions* in RRC configururation and dynamically indicated by DCI TDRA).  Not prefer Option 2 with dedicated DCI fields indicating the slot number. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | We believe this is also linked to the issue in 2.3.1  If the K factor in 2.3.1 is signalled, then this slot indication parameter is not required. |
| vivo | In our opinion, the number of slots for TBoMS can be derived, if the solution for TDRA for TBoMS is clear.  For option 1/2/3 in section 2.1.1, the number of slots can be determined together with the TDRA indication. For CG-TBoMS, the TDRA(number of slots) is indicated via RRC, for DG-TBoMS, the TDRA(number of slots) is indicated in DCI. |

### 2.1.3 Constraints on how slots can be used for TBoMS

Observations on how numbers of slots can be used for transmitting TBoMS are provided in different forms in several contributions. Explicit proposals are made in 3 contributions. Two options are considered up to now. A high-level summary of such options, including companies’ preferences based on the contributions, follows:

* **Option 1**. Both consecutive and non-consecutive UL slots can be used to transmit TBoMS [2 companies]:
  + - China Telecom [12], vivo [7];
* **Option 2**. Consecutive slot in paired, any available slot in unpaired spectrum (LGE) [1 company]
  + - LGE [9].

For the sake of completeness, it is worth mentioning that the rationale of the position expressed in [9], lies on the difference between paired and unpaired spectrum cases, where finding several U slots in the latter may not be so straightforward. It is argued that not allowing transmission on non-consecutive slot in this case may hinder the transmission of TBoMS.

#### 2.1.3.1 First round of discussions

Given the very early stage of the WI, FL’s recommendation is to have a first round of discussion among companies about the two options. Other options can be proposed, as well. The goal is to identify the preferred directions RAN1 should pursue for defining and specifying constraints, if any, on how slots can be used for TBoMS. First FL’s proposals will be made at the end of the first round.

Companies are invited to express views on the Options provided above for defining and specifying constraints, if any, on how slots can be used for TBoMS.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | Both consecutive and non-consecutive slots should be supported for TBoMS. In particular, for TDD system with semi-static UL/DL configuration, it is more desirable to consider the PUSCH to be transmitted based on the available UL slots, which is similar to enhancement on PUSCH repetition type A. |
| Sharp | Agree that “not allowing transmission on non-consecutive slot in this case may hinder the transmission of TBoMS”. |
| Apple | Option 1 is preferred, the validation of slot can be similar as the PUSCH repetition type A enhancement. |
| China Telecom | In our understanding, it does not restrict the operation to consecutive slots only. UEs operated in TDD spectrum can also benefit from TB processing over multi-slot PUSCH. |
| Qualcomm | Given the wide deployments of 5G NR in TDD bands, any solution we adopt must be applicable to non-contiguous slots as well. When transmitting across non-contiguous slots, RV cycling must be used to determine the exact transmission in each slot. |
| NTT DOCOMO | For non-consecutive slots, repetition may cover the performance, so that TBoMS with consecutive slots might be sufficient. |
| ZTE | Agree the intention of Option 2. As commented above, the time domain resource determination could follow that defined for PUSCH repetition type A. |
| CATT | Option 1 is preferred. We think Option 2 may be the final TDRA result due to the difference between TDD and FDD band, but not the restriction principle. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | Non-contiguous slots should be used. Otherwise, most TDD slot formats may not be covered. Option1 is supported. |
| NEC | We prefer consecutive slots. Non-consecutive UL slots transmission may have higher latency of this TB. Benefits of one TB over multiple slots are not clear. We may use legacy one TB one slot instead. |
| vivo | Option 1 preferred.  For paired spectrum, it can be up to NW implementation/scheduler to indicated contiguous or non-contiguous slots. |

### 2.1.4 How to handle S slots

Observations on how S slots should be handles in the context of TBoMS are provided in different forms in several contributions. The same explicit proposal is made in 2 contributions and worth reporting, given the relevance of this aspect in the context of TDRA for transmitting TBoMS. In particular, the following is proposed:

* **Option 1**. Available UL symbols in special slot can be used for TBoMS [2 companies]:
  + - China Telecom [12], NTT Docomo [25].
* **Option 2**. UL symbols in special slot cannot be used for TBoMS [-]:
  + - Added for completeness.

It is worth mentioning that the rationale of the position expressed in [12] is that PUSCH repetition Type A can be configured to use S slot, hence similar behavior could apply to TBoMS transmission (assuming a repetitions Type A like TDRA configuration and indication for TBoMS). The rationale of the position expressed in [25] is related to the larger performance claimed to be achievable if both S and U slots can be used for transmitting TBoMS. From FL’s perspective, this important aspect of TDRA for TBoMS deserves more discussion before commenting further. Option 2 has been added for completeness, to simplify the discussion.

#### 2.1.4.1 First round of discussions

Given the very early stage of the WI, FL’s recommendation is to have a first round of discussion among companies about the two options. Other options can be proposed, as well. The goal is to identify the preferred directions RAN1 should pursue for defining and specifying how to handle the S slots in the context of TBoMS. First FL’s proposals will be made at the end of the first round.

Companies are invited to express views on the Options provided above for defining and specifying constraints, if any, on how to handle S slots in the context of TBoMS.

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| --- | --- |
| Company | Comments |
| Intel | This depends on the discussion in 2.1.1, i.e., whether PUSCH repetition type A or B is considered as TDRA for TBoMS. We suggest to defer the discussion after we have better understanding on the TDRA for TBoMS. |
| Sharp | Repetition type B can be used if resource in S slots should be exploited. |
| Apple | We share the similar view as Intel. The discussion can be deferred. |
| China Telecom | Support option 1 no matter which option is supported in section 2.1.1. In our view, for coverage enhancement, one of the principles is to maximize the amount of time a UE can transmit continuously at maximum power. In this sense, it is necessary to include any UL resource in time domain for PUSCH transmission, especially for TDD. |
| Qualcomm | To the best of our understanding, TBoMS was not intend to couple S and U slots under s a single PUSCH transmission. It was intended to prevent unnecessary segmentation of the payload and to reduce MAC/PDCP/RLC header overhead. With this in mind, S slot handling shall be govered by whatever is currently permitted using TDRA for Type A PUSCH repetitions. In particular, if we don’t allow S+L > 14, this question does not arise. |
| NTT DOCOMO | As TDD is one of the target scenario for coverage enhancements, it is beneficial to utilize some UL symbols (2-4 symbols) in special slots together with UL slots which has large number of symbols (e.g. 14 symbols). Therefore, unless any problem is found in TBoMS with S slot, TBoMS should cover UL symbols in special slots. |
| ZTE | Option 1 at least when the available UL symbols in special slot can accommodate the indicated symbols for transmission in a slot, similar as PUSCH repetition type A. |
| WILUS | Flexible/UL symbols in S slots can be used for type-B PUSCH repetition. So, if option 1 in section 2.1.1 is supported, then flexible/UL symbols in S slots can be also used for TBoMS. |
| CATT | We support Option 1. We share similar views with China Telecom that utilization of ‘S’ slot is not limited to the outcome of 2.1.1. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | Option1, S slots should be considered for the TBoMS. |
| NEC | It depends on the previous question that whether type A and/or type B like repetition is used. |
| vivo | Option 1, special slots can be used for TBoMS to take full usage of the available symbols. |

### 2.1.5 Definition of transmission occasion

The concept of “transmission occasion” in the context of TBoMS appears implicitly or explicitly in slots different forms in several contributions. On the other hand, an explicit proposal in this sense is made in only 1 contribution, as follows:

* **Option 1**. A TB transmission occasion for TBoMS can be composed by multiple slots [1 company]:
  + - LGE [9].
* **Option 2**. A TB transmission occasion for TBoMS can be composed by one slot [-]:
  + - Added for completeness.

From FL’s perspective, this important aspect of TDRA for TBoMS deserves more discussion before commenting further. Its relevance for subsequent discussions on repetition of TBoMS over multiple transmission occasions and/or re-transmission (if applicable), justifies its presence in this section. Option 2 has been added for completeness, to simplify the discussion.

#### 2.1.5.1 First round of discussions

Given the very early stage of the WI, FL’s recommendation is to have a first round of discussion among companies about the two options. Other options can be proposed, as well. The goal is to identify the preferred directions RAN1 should pursue for defining a transmission occasion for TBoMS. First FL’s proposals will be made at the end of the first round.

Companies are invited to express views on the Options provided above for defining a transmission occasion for TBoMS.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | It is good to clarify the purpose of defining transmission occasions for TBoMS. Is this related to the cancellation/dropping for TBoMS? |
| Sharp | What is TB transmission occasion? If it means that RE mapping or DMRS mapping is done within the TB transmission occasion, those two should be separately discussed. In our view, change to RE mapping is not justified from coverage enhancement perspective. Instead of enhancing RE mapping, controlling RV for each TB transmission occasion will have less specification impacts. For DMRS mapping, we are fine to discuss. On the other hand, DMRS mapping optimization would be discussed in AI8.8.1.3. |
| Apple | Transmission occasion may not need if TBoMS joint operation with repetition is not supported. Maybe we need to determine first whether support TBoMS repetition. |
| China Telecom | We have the same question: what is the definition of TB transmission occasion? Is it related to whether the transmission in each slot can be self-decodable? |
| Qualcomm | Option 2. There is no compelling need to extend an occasion to more than 1 slot. |
| ZTE | Similar as above companies, the motivation to define a transmission occasion needs to be clarified. |
| WILUS | Not clear on intention of defining “transmission occasion”. |
| CATT | Similar confusion as above companies. |
| NEC | We should discuss this after we have clear procedure of TBoMS. |
| vivo | In our opinion, the multiple slots for TBoMS and transmission occasion for TBoMS have different meanings.  The multiple slots for TBoMS is composed of multiple transmission occasions derived by either Type-A/B repetition like TDRA indication or multi-SLIV TDRA indication, as discussed in section 2.1.1, which means the transmission occasion has finer granularity compared to the multiple slots for TBoMS. Collision handling, UCI multiplexing, can be performed per transmission occasion rather than per multiple slots. Otherwise, it may hinder the TBoMS transmission. |

## 2.2 FDRA

Two major sub-aspects of FDRA have been discussed by companies in the submitted contributions:

1. Maximum number of PRBs allocated for TBoMS transmission per symbol
2. Number of PRBs across the slots used for TBoMS

Summary, discussion and proposals on these sub-aspects are provided in the following different sub-sections, whose numbers are given in the list above.

### 2.2.1 Maximum number of PRBs allocated for TBoMS transmission per symbol

Several contributions acknowledged the fundamental nature of this aspect and discussed it in detail. Discussions on the major reason behind the performance increase observed in case of multi-slot TB transmissions as compared to their single-slot counterpart are carried out therein.

It is argued that TBoMS is beneficial in terms of PSD boosting, since it concentrates transmission power in a narrow frequency resource and frequency domain resource multiplexing. Moreover, there seems to be no need to occupy more frequency domain resource to achieve a lower code rate, given that the TB can be transmitted over multiple slots. It is finally observed that restricting the number of PRBs for the FDRA of TBoMS transmission may also reduce DCI size, which could positively impact the coverage of PDCCH as a by-product.

Several proposals are made in this regard. A high-level summary of all options, including companies’ preferences based on the contributions, follows:

* **Option 1**. FDRA for TBoMS is limited to a small number of PRBs [3 company]:
  + - Samsung [18], LGE [9], InterDigital [10];
* **Option 2**. Any number of PRBs can be allocated for TBoMS transmission [-]:
  + - Added for completeness.

Partially different technical understandings on why TBoMS is expected to bring gains as compared to single-slot counterpart have been provided in other contributions submitted to this AI, even if no proposal was added therein. From FL’s perspective, this important aspect of FDRA for TBoMS deserves more discussion before commenting further. Its relevance for subsequent discussions on TBS determination, link adaptation and (possibly) frequency hopping justifies its presence in this section. Option 2 has been added for completeness, to simplify the discussion.

#### 2.2.1.1 First round of discussions

Given the very early stage of the WI, FL’s recommendation is to have a first round of discussion among companies about the two options. Other options can be proposed, as well. The goal is to identify the preferred directions RAN1 should pursue for defining and specifying constraints, if any, on the maximum number of PRBs allocated for TBoMS. First FL’s proposals will be made at the end of the first round.

Companies are invited to express views on the Options provided above for constraints, if any, on the maximum number of PRBs allocated for TBoMS.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | Although we agree the principle, it is not clear to us whether we need to define the limit for number of PRBs in the specification.  BTW, for FDRA, our view is that we need to understand how to support frequency hopping and detailed frequency hopping pattern, e.g., intra-slot, inter-slot or inter-slot frequency hopping with inter-slot bundling. |
| Sharp | Restricting use cases for specific feature should be carefully discussed. If UE implementation complexity doesn’t change for TBoMS for large PRBs, then we see no need to specify such a restriction. |
| Apple | The restriction on the PRB number is not really necessary, gNB scheduler could handle this to guarantee the TBoMS gain. |
| Qualcomm | Option 1. We don’t think there are any performance gains once we have a reasonable number of PRBs ( greater than 32 PRBs, for example). Coding gains diminish and become negligible once TB size exceeds 1000 bits or so. |
| ZTE | Firstly, we think the maximum TBS for one HARQ process should be limited. Otherwise, it would be increased since it is based on more resources in multiple slots, and then it would exceed legacy gNB/UE HARQ buffer.  As for the options, we have no strong view, and would like to keep both options open for now. If we go with Option 1, we need carefully define the maximum number of RBs can be allocated. For Option 2, we may need other ways to limit the TBS. |
| WILUS | Since TBoMS is intended to coverage enhancements, the number of PRBs may be limited. But, this is up to gNB configuration. |
| CATT | We understand the motivation. However, we think the gNB can handle this well without explicit restriction on FDRA, just by implementation. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | Narrow banding operation is crucial to improve the link budgets and coverage. We agree with the motivation of Option-1. |
| NEC | Option 1. |
| vivo | It can be up to NW scheduler to limit the number of PRBs. |

### 2.2.2 Number of PRBs across slots used for TBoMS

Implicit assumptions on how PRBs should be allocated across slots for TBoMS seem to be present in most contributions submitted to this AI. Indeed, only one company provided an explicit proposal in this sense which, from FL’s perspective, seems aligned with the aforementioned assumptions. Given its relevance in the context of FDRA for TBoMS, a more explicit discussion on this aspect seems to be in order, for the sake of completeness and to avoid any ambiguity.

A high-level summary of all options, including companies’ preferences based on the contributions, where Option 2 has been added for completeness, follows:

* **Option 1**. The same PRB allocation is used across slots for TBoMS [1 company]:
  + - Ericsson [23];
* **Option 2**. Different PRB allocations can be used across slots for TBoMS [-]:
  + - Added for completeness.

From FL’s perspective, this important aspect of FDRA for TBoMS deserves more discussion before commenting further. Its relevance for subsequent discussions on TBS determination, link adaptation and (possibly) frequency hopping justifies its presence in this section.

#### 2.2.2.1 First round of discussions

Given the very early stage of the WI, FL’s recommendation is to have a first round of discussion among companies about the two options. Other options can be proposed, as well. The goal is to identify the preferred directions RAN1 should pursue for defining and specifying how to allocate PRBs across slots for TBoMS. First FL’s proposals will be made at the end of the first round.

Companies are invited to express views on the Options provided above for defining and specifying how to allocate PRBs across slots for TBoMS.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | In case of frequency hopping, different PRB allocation can be used across slots. Same PRB allocation is used without frequency hopping. |
| Sharp | Motivation is not clear for Option 2 in a case of without frequency hopping. |
| Apple | FDRA is applied to all the slots used for TBoMS if frequency hopping is not enabled. At least we don’t indicate the FDRA per slot. |
| China Telecom | Agree with Intel. |
| Qualcomm | Same comment as Intel. |
| NTT DOCOMO | We support Option 1, though we are open to both options. |
| ZTE | Agree with Intel. |
| WILUS | The same PRB allocation is used across slots without frequency hopping. In case of frequency hopping, the starting PRB can be different but the number of PRBs are not changed. |
| CATT | Agree with Intel. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | The same PRB allocation is used across slots. Frequency hopping need not be coupled with TBoMS. |
| NEC | Agree with Intel’s comments. |
| vivo | Agree with Intel. Same PRB allocation is used when frequency hopping is not enabled. |

## 2.3 TBS determination

TBS determination was discussed by many companies. Indeed, it is an aspect which will have to be discussed and properly defined, regardless of how other aspects of TBoMS are dealt with. Two major sub-aspects of TBS determination have been discussed by companies in the submitted contributions:

1. calculation
2. calculation

Summary, discussion and proposals on these sub-aspects are provided in the following different sub-sections, whose numbers are given in the list above.

### 2.3.1 calculation

Most contributions acknowledged the fundamental nature of this aspect and discussed it in detail. Several options are considered in all contributions. A high-level summary of all options, including companies’ preferences based on the contributions, is as follows:

* **Option 1**. Based on all REs in a set of slots allocated for PUSCH [8 companies]:
  + The set of slots is equal to the total number of slots allocated for PUSCH:
    - Samsung [18], Fujitsu [11], CMCC [16], Huawei [5], China Telecom [12], Nokia/NSB [28], CATT (Upper bound of TBS should be adjusted other than 156\*) [6];
  + The set of slots may or may not be equal to the total number of slots allocated for PUSCH:
    - Panasonic [15],
* **Option 2**. Based on the number of RE in one slot scaled by [8 companies]:
  + is equal to the total number of slots allocated for TBoMS transmission:
    - NEC [13], Fujitsu [11], LGE [9], Intel [8], WILUS [27], Huawei [5], IITH [21];
  + may or may not be equal to the total number of slots allocated for TBoMS transmission:
    - OPPO [4], Qualcomm (TBoMS implemented as a special case of PUSCH repetitions, i.e., scale a TB with repetitions and transmit the TB on each repetition with RV cycling) [22] , Sharp [24];
* **Option 3**. Based on average number of RE per slot scaled by the total number of slots allocated for TBoMS transmission [1 company]:
  + - CMCC [16];
* **Option 4**. Based on number of REs calculated slot-by-slot [1 company]:
  + - CMCC [16];

#### 2.3.1.1 First round of discussions

Given the very early stage of the WI, FL’s recommendation is to have a first round of discussion among companies about the four options. The goal is to identify the preferred directions RAN1 should pursue for defining and specifying how is calculated for TBoMS. The number of considered options should be reduced. First FL’s proposals will be made at the end of the first round.

Companies are invited to express views on the Options provided above for defining and specifying how is calculated for TBoMS.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | We prefer Option 2. Note that this highly depends on the discussion 2.1.1. For PUSCH repetition type A based TDRA, option 2 is a straightforward solution for TBS determination. |
| Sharp | In our contribution [24], it is proposed that the value K may not be equal to the total number of slots. If TB scaling is based on the total number of slots for TBoMS, there may be a gNB/UE ambiguity issue when the UE is configured with dynamic SFI. When the UE miss-detects dynamic SFI indication, resulting in different number of slots from the one assumed by the gNB, the gNB cannot decode the TB or needs multiple blind decoding. |
| Apple | We are ok with Option 1 and Option2. It’s not clear the difference between Option 1 and Option 4. Option 1 could use all the REs more efficiently with the cost of TDRA indication per slot. |
| China Telecom | Support option 1. |
| Qualcomm | Option 2. |
| NTT DOCOMO | We prefer Option 1. However, this TBS calculation depends on TDRA and FDRA, because some TDRA does not fit Option2. |
| ZTE | If repetition type A like TBoMS is adopted, it seems not much difference between these Options. Otherwise, Option 1 would be more accurate. Thus, Option 1 is slightly preferred. |
| WILUS | Option 2. For type A PUSCH based time domain resource allocation, K should be the number of slots. For type B PUSCH based time domain resource allocation, K should be the number of nominal repetitions. |
| CATT | We think the calculation highly related to TDRA method in Section 2.1.1. Option 1 seems more like a high-level description, where other options are some detailed calculations under different TDRA assumption.  We support Option 1 in principle. But we think this can be discussed later, after clear TDRA preference is shown in Section 2.1.1. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | Option 2 |
| NEC | It depends on type A or Type B repetition like TBoMS. For type A like TBoMS, option 1 and 2 are the same. |
| vivo | Since it is not clear which TDRA method would be adopted. It is hard to say which option is better.  If Type-A like TDRA is adopted, option 2 with K equals to the total number of slots for TBoMS, seems a simple solution.  While if TDRA other than type-A like method is considered, and the number of REs is not the same across the multiple slots, option 1 is more accurate for TBS calculation, and it is also applicable for type-A like TDRA for TBoMS. |

### 2.3.2 calculation

Most contributions discussed this aspect, which has a precise impact TBS determination and, as such, needs to be discussed carefully. Several options are considered in all contributions. A high-level summary of all options, including companies’ preferences based on the contributions, is as follows:

* **Option 1**. Same value of is assumed for all slots [1 company]:
  + - InterDigital [10];
* **Option 2**. is calculated depending on both *xOverhead* and the resources allocated for multi-slot TB transmission, expressed in number of actual PUSCH symbols/slots [1 company]:
  + - Nokia/NSB [28];
* **Option 3**. is calculated slot-by-slot [1 company]:
  + - CMCC [16];
* **Option 4**. FFS [1 company]:
  + - Samsung [18];

From FL’s perspective, this important aspect of TBS determination for TBoMS deserves more discussion before commenting further.

#### 2.3.2.1 First round of discussions

Given the very early stage of the WI, FL’s recommendation is to have a first round of discussion among companies about the four options. The goal is to identify the preferred directions RAN1 should pursue for defining and specifying how is calculated for TBoMS. The number of considered options should be reduced. First FL’s proposals will be made at the end of the first round.

Companies are invited to express views on the Options provided above for defining and specifying how is calculated for TBoMS.

|  |  |
| --- | --- |
| Company | Comments |
| Intel | We slightly prefer Option 1. |
| Sharp | Basically, is designed for optimizing TBS taking RB/RE level rate matching including CORESET or CSI-RS into account. For UL, given that no RB/RE level rate-matching specified, we don’t think necessity of optimizing in Rel-17 CE WI. |
| Apple | Option 1 is straightforward; we open for other options. |
| Qualcomm | Option 1 |
| ZTE | Option 1 is sufficient if repetition type A like TBoMS is adopted. |
| WILUS | We are open to discuss how to configure/apply *xOverhead*. Since *xOverhead* is configured in *PUSCH-ServingCellConfig,* we further discuss separate configuration of *xOvehead* for TBoMS is necessary and if configured it is per slot (i.e., is scaled by the number of slots) or per PUSCH transmission (i.e., is not scaled) |
| CATT | Similar to our answer in 2.3.1.1, we can discuss this later after TDRA method is concluded. |
| IITH, IITM, CEWIT, Reliance Jio, Tejas Networks | Option 1 |
| NEC | Option 1 |

## 2.4 Others

As discussed at the beginning of Section 2, aspects and topics related to several aspects of TBoMS have been prioritized in order to ensure that constructive discussions and effective progress can be achieved during RAN1 #104-e. In this context, priority has been given to the aspects and topics discussed in sections 2.1 to 2.4, which mostly focus on resource allocation for TBoMS and related matters. All other aspects are listed in this section, i.e, 2.4, where proposals made by companies in their contributions are reported and described in detail. No specific FL’s proposal or recommendation is formulated at this stage, since such aspects may not be handled during RAN1 #104-e. Should discussions for 2.1 to 2.4 progress fast, new sections for specific aspects, currently in 2.4, will be open for discussions and corresponding FL’s proposals and recommendations would be made.

### Relationship between TBoMS and PUSCH repetitions

The relationship between TBoMS and PUSCH repetitions was discussed in several contributions, which can be summarized as follows:

* Two companies (Samsung[18], Intel [8]) proposed that repetition is supported for TBoMS.
* One company (vivo [7]) proposed that repetition is not supported for TBoMS.
* One company (ZTE [3]) proposed to further discuss this aspect.

### DM-RS

DM-RS allocation was discussed in several contributions, which can be classified into the following sub-topics:

**DM-RS allocation for TBoMS in general**

* Two companies (Fujitsu [11], Ericsson [23]) proposed that the existing DM-RS specifications should be reused.
* One company (Huawei [5]) proposed that DM-RS positions can be determined per slot or the DM-RS determination mechanism of PUSCH repetition type B can be reused.
* One company (DOCOMO [25]) proposed that DM-RS configuration should be extended (e.g. 3 additional DM-RS positions) so that one PUSCH can have more than 14 OFDM symbols with uniform DM-RS symbol distribution.

**DM-RS allocation for TBoMS in case joint channel estimation is enabled**

* One company (Huawei [5]) proposed that DM-RS positions can be determined per L symbols where L is configurable.
* One company (Samsung [18]) proposed to further study time domain allocation of DM-RS considering joint channel estimation over multi-slot and transmissions (e.g. DM-RS allocation is determined per PUSCH transmission, or per slot).

### CB segmentation, redundancy version, rate-matching and interleaving

Concerning TB processing for mapping the TB on the resource that spans across multiple slots, the following sub-topics were discussed in several contributions:

**Codebook (CB) segmentation**

* One company (Ericsson [23]) proposed that CB segmentation is deprioritized for TBoMS and that RAN1 should decide a maximum TBS of TBoMS to avoid CB segmentation.
* One company (Apple [20]) proposed that both TB segmentation and CBG-based TB processing can be considered.
* Two companies (Samsung [18], ZTE [3]) proposed that the supported maximum TBS remains unchanged.

**Redundancy version (RV) if repetition of TBoMS is supported**

* One company (LGE [9]) proposed that the value of rvid applied to nth transmission occasion of the TB is determined based on the value “n mod 4”.
* One company (OPPO [4]) proposed that a single RV scheme can be used across all the repetition slots in case of TB size over multi-slot and PUSCH repetition is configured.
* One company (Intel [8]) proposed that the existing RV cycling pattern for PUSCH with repetition is reused for TBoMS with repetitions.

**Rate-matching and interleaving**

* One company (Samsung [18]) proposed to further study the operation of interleaving and rate-matching output for TBoMS.

### Link adaptation

One company (Ericsson [23]) proposed that the same MCS index can be used for multiple slots of multi-slot PUSCH.

### Frequency hopping

Frequency hopping (FH) aspects were discussed, and corresponding proposals were made, depending on whether joint channel estimation and repetition are supported for TBoMS:

* One company (Lenovo [14]) proposed that multi-slot frequency hopping and multi-slot DM-RS bundling for joint channel estimation for entire hop can be supported and the association between frequency hop duration and DM-RS bundle duration should be considered.
* One company (Intel [8]) proposed that inter-slot FH with inter-slot bundling is supported for TBoMS without repetition and that inter-slot FH and inter-repetition FH are supported for TBoMS with repetition.

### Transmission power determination

One company (ZTE [3]) proposed that the transmission power determination should be based on the multiple slots for TBoMS.

### Rank of TBoMS transmission

The rank of a TBoMS transmission (number of layers) was discussed in several contributions and can be summarized as follows:

* One company (Ericsson [23]) proposed that the same number of layers can be used for multiple slots of multi-slot PUSCH.
* One company (vivo [7]) proposed that TBoMS should be limited to single-layer transmission.

### Channel estimation

Discussions on whether joint channel estimation can be applied for TBoMS were carried out in several contributions. The following proposals were made:

* One company (InterDigital [10]) proposed to support joint channel estimation for the TBoMS.
* One company (vivo [7]) proposed that it is up to UE capability to ensure phase continuity for TBoMS.
* One company (Lenovo [14]) implicitly assumed joint channel estimation for TBoMS by proposing that multi-slot frequency hopping and multi-slot DM-RS bundling for joint channel estimation for entire hop can be supported.

### Retransmissions

Details of retransmission of a TBoMS were discussed in several contributions as follows.

* One company (CMCC [16]) proposed that per-slot retransmission should be considered for the retransmission of TBoMS.
* One company (InterDigital [10]) proposed to support enhanced retransmission mechanisms to avoid the retransmission of the entire multi-slot PUSCH.

### Collision handling

Details of collision handling between TBoMS PUSCH and PUCCH/SRS/DL symbols were discussed in several contributions. Corresponding proposals can be classified into the following sub-topics:

**UCI multiplexing on TBoMS PUSCH**

* One company (NEC [13]) proposed that UCI can be multiplexed on TBoMS PUSCH when PUCCH transmission overlaps with TBoMS PUSCH in at least one slot.
* One company (Intel [8]) proposed that when PUCCH and TBoMS are overlapped in time, if the timeline requirement is satisfied, the whole TBoMS PUSCH is cancelled and the PUCCH is transmitted in the overlapped slots.
* One company (vivo [7]) proposed that the number of symbols for UCI multiplexing is determined by the number of overlapping symbols in a slot or a configured PUSCH length that is not greater than 14 symbols.
* One company (vivo [7]) proposed that UCI multiplexing should be performed per PUSCH transmission occasion within a slot, and UCIs can be multiplexed more than once to different PUSCH occasions.
* One company (vivo [7]) proposed a limitation on the resource allocated for UCI multiplexing on later PUSCH occasions if there are UCI multiplexing on previous PUSCH occasions of TBoMS.
* One company (vivo [7]) proposed that HARQ-Ack multiplexing on TBoMS PUSCH can be allowed if HARQ-Ack for the scheduling DCI comes after the UL grant for the TBoMS PUSCH.
* One company (ZTE [3]) proposed to reuse the legacy collision handling mechanisms f or PUSCH repetition type A for TBoMS PUSCH by replacing a repetition by a PUSCH in one slot of a TBoMS.
* One company (Huawei [5]) proposed to further improve the current mechanisms of collision handling for PUSCH before applying them for TBoMS PUSCH.
* Three companies (CMCC [16], WILUS [27], ZTE [3]) proposed to further study the collision handling of PUCCH vs. TBoMS PUSCH, e.g. how to determine the number of REs for UCI multiplexing.

**SRS/DL symbols collision handling**

* One company (Intel [8]) proposed that TBoMS PUSCH is transmitted on the basis of available UL slots.
* Two companies (CMCC [16], Panasonic [15]) proposed to further study the collision handling of SRS vs. TBoMS PUSCH.

### TBoMS vs. single slot PUSCH transmission indication

The indication of TBoMS feature, i.e. indication on whether a PUSCH transmission should follow TBoMS or legacy PUSCH transmission, was discussed in several contributions. Corresponding proposals can be summarized as follows.

* Two companies (NEC [13], InterDigital [10]) proposed to support dynamic switching between TBoMS and single-slot PUSCH.
* One company (NEC [13]) proposed implicit indication based on RB/MCS allocation/indication.
* One company (Nokia [28]) proposed to further study details of indication method, including introducing a new field or reusing the available field in the scheduling DCI (or RRC parameter in case of configured grant configuration), e.g., some rows in the TDRA table are used to configure for multi-slot TB transmission.

### Service-like prioritization of TBoMS

One company (Intel [8]) proposed that TBoMS is treated as low priority uplink transmission.

## Simulation assumptions

One company (Ericsson [23]) discussed the relevance of specific simulation assumptions for performance evaluation of TBoMS transmission. Proposals were made as follows:

* Low data rate services should be considered for evaluations, such as VoIP or 30 kbps data for simulations.
* To keep comparable PDCCH overhead, Rel-15/16 PUSCH repetition (including RV cycling) can be used as baseline for performance evaluation.

From FL’s perspective, a set of baseline evaluation assumptions already exists for the WI, i.e., the ones agreed during Rel-17 SI and detailed in [2]. No explicit item in the WID seems to indicate that a revision to baseline evaluation assumptions is to be agreed during the WI. On the other hand, any company is welcome to propose and discuss results of evaluations carried out using assumptions like the ones above.

# 3 [CLOSED] Proposals for GTW

# 4 [CLOSED] Agreements

# References

1. RP-202928 New WID on NR coverage enhancements, China Telecom, RAN#90e, Dec. 2020
2. TR 38.830 Study on NR coverage enhancements, 3GPP RAN1 Technical Report, Dec. 2020
3. R1-2100096 Discussion on TB processing over multi-slot PUSCH, ZTE
4. R1-2100173 Supporting TB over multi-slot PUSCH, OPPO
5. R1-2100232 Discussion on TB processing over multi-slot PUSCH, Huawei, HiSilicon
6. R1-2100398 Discussion on TB processing over multi-slot PUSCH, CATT
7. R1-2100458 Discussion on PUSCH TB processing over multiple slots, vivo
8. R1-2100666 Discussion on TB processing over multi-slot PUSCH, Intel Corporation
9. R1-2100713 Discussions on TB processing over multi-slot PUSCH, LG Electronics
10. R1-2100732 TB processing over multi-slot PUSCH , InterDigital, Inc.
11. R1-2100743 Views on TB processing over multi-slot PUSCH, Fujitsu
12. R1-2100916 Discussion on TB processing over multi-slot PUSCH, China Telecom
13. R1-2100943 Discussion on TB processing over multi-slot PUSCH, NEC
14. R1-2101002 Enhancements for TB processing over multi-slot PUSCH, Lenovo, Motorola Mobility
15. R1-2101018 Discussion on TB processing over multi-slot PUSCH, Panasonic Corporation
16. R1-2101056 Discussion on TB processing over multi-slot PUSCH, CMCC
17. R1-2101128 Joint channel estimation for PUSCH, Xiaomi
18. R1-2101222 TB processing over multi-slot PUSCH , Samsung
19. R1-2101328 Design Considerations for TB processing over multi-slot PUSCH, Sierra Wireless
20. R1-2101396 Discussion on TB processing over multi-slot PUSCH, Apple
21. R1-2101406 On TB processing over multiple slots for PUSCH, Indian Institute of Tech (H)
22. R1-2101478 TB processing over multi-slot PUSCH , Qualcomm Incorporated
23. R1-2101521 TB Processing over Multi-Slot PUSCH, Ericsson
24. R1-2101546 TB processing over multi-slot PUSCH, Sharp
25. R1-2101642 TB processing over multi-slot PUSCH NTT, DOCOMO, INC.
26. R1-2101646 Discussion on TB processing over multi-slot PUSCH, MediaTek Inc.
27. R1-2101680 Discussion on TB processing over multi-slot PUSCH, WILUS Inc.
28. R1-2101711 Transport block processing for PUSCH coverage enhancements, Nokia, NSB

# Appendix A: Proposals from contributions aggregated by topic

## A.1 TDRA

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| **R1-2101222**  **TB processing over multi-slot PUSCH,**  **Samsung**  Proposal 1: Further study the time domain resource allocation methods for TB over multi-slot, at least including:   * Option 1: Indicating number of slot or repetition for one TB based on Type A and/or Type B PUSCH   + Number of occupied repetition/slots can be configured. * Option 2: Directly indicating a number of symbol L that can be larger than 14.   + A symbols group can be considered   **R1-2100743**  **Views on TB processing over multi-slot PUSCH,**  **Fujitsu**  Proposal 1: Further discuss which of the following mapping pattern to be supported,   1. Continuous mapping over multi-slot 2. Common TDRA for at least UL-only slots 3. Flexible mapping   **R1-2101002**  **Enhancements for TB processing over multi-slot PUSCH, Lenovo/Motorola**  Proposal 1: For one TB processing over multi-slot PUSCH in NR coverage enhancements in Rel-17, support time-domain resource allocation enhancement to indicate multiple number of slots for multi-slot PUSCH and length L (value ranging from 1-13 symbols) for the last slot to allow partial slot occupation at the end and avoid scheduling restriction to only multiples of 14 symbols  **R1-2101056**  **Discussion on TB Processing Over Multi-Slot PUSCH, CMCC**  Proposal 3: Both extending the allocated symbol length and indication of the slot number through RRC configuration similar as PUSCH repetition should be considered.  **R1-2100398**  **Discussion on TB Processing Over Multi-Slot PUSCH, CATT**  Proposal 3: For TB processing over multi-slot PUSCH, new time domain resource allocation method should be studied.  Proposal 4: For TB processing over multi-slot PUSCH, take repetition type A and type B as the starting point for time domain resource allocation.  **R1-2100713**  **Discussions on Tb processing over multi-slot PUSCH, LGE**  Proposal 1: For TB processing over multi-slot PUSCH, a TB transmission occasion can be composed by multiple slots.  Proposal 2: When a PUSCH TB is transmitted over multiple slots,   * A PUSCH TB is transmitted over multiple consecutive slots in paired spectrum. * A PUSCH TB is transmitted over multiple available slots in unpaired spectrum.   Proposal 4: To discuss the number of slots for a PUSCH TB mapping, the desired range of TB size should be considered.  **R1-2100666**  **Discussion on TB processing over multi-slot PUSCH, Intel Corporation**  Proposal 1:   * Same time domain resource allocation is applied to each slot for mPUSCH transmission. * SLIV for each slot, number of slots for an mPUSCH repetition, and number of repetitions can be configured as part of TDRA for mPUSCH transmission.   **R1-2101680**  **Discussion on TB processing over multi-slot PUSCH, WILUS**  Proposal 2: It should be clarified whether to include PUSCH repetition Type B in the WI scope or not for TB processing over multi-slot PUSCH.  **R1-2101018**  **Discussion on TB processing over multi-slot PUSCH, Panasonic**  Proposal 2: For the time-domain resource, following options should be considered.   * Option 1: Time-domain resource more than 14 OFDM symbols * Option 2: Multi-SLIV based   **R1-2100232**  **Discussion on TB processing over multi-slot PUSCH, Huawei, HiSilicon**  Proposal 2: The repetition type B like TDRA for TB over multi-slot PUSCH should be supported where a number of consecutive symbols after the start symbol S is allocated.  **R1-2100916**  **Discussion on TB processing over multi-slot PUSCH, China Telecom**  Proposal 2: Both consecutive slots and non-consecutive slots can be aggregated for TB processing over multi-slot PUSCH.  Proposal 3: The number of aggregated slots for TB processing over multi-slot PUSCH can be semi-statically configured by RRC or dynamically indicated by DCI.  Proposal 4: For both consecutive slot aggregation and non-consecutive slot aggregation for TB processing, network indicates the symbol allocation 1st slot, and the same symbol allocation is applied over multiple slots except for the special slots. For the special slots, the available UL symbols can be used for PUSCH transmission.  **R1-2101521**  **TB Processing over Multi-Slot PUSCH, Ericsson**  Proposals:   * Reuse resource determination and signaling of Rel-15/16 PUSCH repetition as much as possible to avoid specifying duplicate functionality. * Type A multi-slot TB can be prioritized, which occupies the same symbols in all the multiple slots of a TB. Type A with different number of symbols in different slots and Type B multi-slot TB can be further studied. * RAN1 to decide if non-contiguous slots can be used for a TB.   R1-2101328 Design Considerations for TB processing over multi-slot PUSCH, Sierra Wireless  Proposal 1: Specify support for multi-slot encoding with gaps.  FFS: sizes of gaps  Proposal 2: Multi-slot encoding should be specified with a maximum of 2 slots of encoding.  R1-2101711 Transport block processing for PUSCH coverage enhancements, Nokia/NSB  Proposal 1: For multi-slot TB transmission, RAN1 to down-select the following time-domain resource indication/determination options:   * Option 1: Define a time-domain window wherein all valid PUSCH symbols are used for multi-slot TB transmission.   + FFS details of window indication. * Option 2: Define a new PUSCH mapping type that allows L and S+L > 14; L valid symbols starting from the symbol with index S in the slot indicated by K2 are used for multi-slot TB transmission. * Option 3: Reuse the time-domain allocation from PUSCH repetition type B.   R1-2101642 TB processing over multi-slot PUSCH, NTT DOCOMO  Proposal 1: S+U slots in TDD configuration should be considered for TB processing over multi-slot PUSCH  R1-2101396 Discussion on TB processing over multi-slot PUSCH, Apple  Proposal 1: Considering the maximum number of slots for TB transmission is 8.  Proposal 2: The number of slots for TB processing is dynamic indicated via DCI.  Proposal 3: The same PUSCH mapping type and SLIV are applied to slots for TB transmission.  R1-2100173 Supporting TB over multi-slot PUSCH, OPPO  Proposal 2: A TB size over multi-slot should be configurable in case of enhanced PUSCH repetition Type A is configured  R1-2100458 Discussion on PUSCH TB processing over multiple slots, vivo  Proposal 2: For PUSCH with TB processing over multiples slots, the multiple slots does not need to be consecutive slots.  Proposal 3: Following options can be considered to indicate transmission occasions for PUSCH with TB processing over multiple slots  - Option 1: PUSCH repetition Type-A/B like time domain resource allocation;  - Option 2: Multi-PUSCH scheduling like resource allocation;  - Option 3: Support time domain length L>14 for resource allocation.  R1-2100096 Discussion on TB Processing Over Multi-Slot PUSCH, ZTE  Proposal 1: For time domain resource determination of TB processing over multiple slots, legacy rules specified for PUSCH repetition type A could be a starting point.  Proposal 2: For TB processing over multiple slots, the number of slots is jointly coded with the TDRA table***.*** |

## A.2 FDRA

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| **R1-2101222** **TB processing over multi-slot PUSCH, Samsung**  Proposal 4: The maximal number of PRB allocated in time domain is reduced for TB over multi-slot.  **R1-2100713**  **Discussions on TB Processing Over Multi-Slot PUSCH, LGE**  Proposal 3: It is considerable to apply TB processing over multi-slot PUSCH when a PUSCH has a small number of PRBs  **R1-2100732**  **TB processing over multi-slot PUSCH, InterDigital**  Proposal 2: Support multi-slot TB transmission if the number of PRBs is under a limit.  Proposal 3: At least 1 PRB is supported for the possible number of resource blocks for multi-slot TB transmission  **R1-2101521**  **TB Processing over Multi-Slot PUSCH, Ericsson**  Proposal:   * The same DMRS configuration, MCS index, number of layers, and PRB allocation can be used for multiple slots of multi-slot PUSCH. |

## A.3 TBS determination

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| **R1-2101222**  **TB processing over multi-slot PUSCH, Samsung**  Proposal 5: TBS determination is based on all REs in all slots for the TB. Further study on how to count the higher layer configured overhead.  **R1-2100743**  **Views on TB processing over multi-slot PUSCH, Fujitsu**  Proposal 2: Unquantized intermediate variable (Ninfo) is obtained by the following:  **R1-2100943**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, NEC**  Proposal 1: TBS is determined based on number of RE over multiple slots or number of RE in one slot scaling by number of slots of multiple slots transmission.  **R1-2101056**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, CMCC**  Proposal 1: The procedure of transport block size determinations should be updated considering the multiple slot PUSCH transmission. 3 alternatives have been proposed for the updates of the 1st step of determining the number of REs.   * Alternative 1: counting the RE number within a slot on an average value then multiplied by the slot number. * Alternative 2: counting the RE number slot by slot * Alternative 3: counting the RE number in total   **R1-2100398**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, CATT**  Proposal 1: For TB processing over multi-slot PUSCH, the TBS should be determined by the allocated REs in the multi-slots.  Proposal 2: For TB processing over multi-slot PUSCH, the upper bound of TBS should be adjusted other than 156\* nPRB.  **R1-2100713**  **DISCUSSIONS ON TB PROCESSING OVER MULTI-SLOT PUSCH, LGE**  Proposal 6: To determine TBS based on multiple slots, scaling of NRE or Ninfo can be considered.  **R1-2100732**  **TB processing over multi-slot PUSCH, InterDigital**  Proposal 4: For multi-slot TB transmission, assume same value of for all slots.  **R1-2100666**  **Discussion on TB processing over multi-slot PUSCH, Intel Corporation**  Proposal 3:   * Number of slots is included for TBS determination of mPUSCH spanning multiple slots.   **R1-2101680**  **Discussion on TB processing over multi-slot PUSCH, WILUS**  Proposal 1: RE calculation can be extended to multiple slots by redesigning total number of REs calculation, .  **R1-2101018**  **Discussion on TB processing over multi-slot PUSCH, Panasonic**  Proposal 1: The multiple slots for TBS determination are not required to be the same value as multiple slots for PUSCH transmissions.  Proposal 3: For the TBS determination for TB processing over multi-slot PUSCH, there could be the following steps:   * TBS is determined based on the number of REs over multiple slots.   + UE first determines the number of REs within a PRB over multiple slots for TB processing,   + Then, UE determines the TBS based on the equation in the current specification in TS38.214.   **R1-2100232**  **Discussion on TB processing over multi-slot PUSCH, Huawei, HiSilicon**  Proposal 1: The TBS calculation of multi-slot PUSCH is based on the resources of multiple slots with following options:  Option1: Count all REs over the multiple slots which carry UL-SCH data in TBS calculation.  Option2: Multiply the number of available REs of the first slot with the number of slots for multi-slot TB.  **R1-2100916**  **Discussion on TB processing over multi-slot PUSCH, China Telecom**  Proposal 1: For TB processing over multi-slot PUSCH, TBS is determined based on multiple slots and different segment is transmitted in each slot.  Proposal 5: For TB processing over multi-slot PUSCH, the computation of TBS is defined based on the total number of REs allocated for PUSCH.  **R1-2101406**  **ON TB PROCESSING OVER MULTIPLE SLOTS FOR PUSCH, IITH, CeWiT, IITM, Reliance Jio, Tejas Networks**  Proposal: The gNB signals a TBS\_scaleK factor to the UE which indicates the number of slots over which the UE must calculate the effective transport block size using the frequency domain resources indicated via the DCI. The frequency domain allocation is assumed to be the same across TBS\_scaleK slots. The number of slots to aggregate can vary between 1,2,4, and 8. If not indicated, the UE only assumes 1 slot processing.  **R1-2101546**  **TB processing over multi-slot PUSCH, Sharp**  Proposal 1: A TBS scaling factor is indicated through a DCI format for scheduling the PUSCH or RRC signaling.  Proposal 2: The TBS scaling factor is applied to calculate Ninfo.  **R1-2101711**  **Transport block processing for PUSCH coverage enhancements, Nokia/NSB**  Proposal 2: For multi-slot TBS determination, the UE determines the overhead for N\_RE^' calculation depending on both xOverhead and the resources allocated for multi-slot TB transmission, expressed in number of actual PUSCH symbols/slots.   * FFS: if the overhead is calculated by scaling the single slot xOverhead w.r.t. the resources allocated for multi-slot TB transmission or by configuring different values of xOverhead for different number of actual PUSCH symbols/slots.   Proposal 3: For multi-slot TBS determination, the UE determines the reference number for N\_RE calculation depending on both xOverhead and the resources allocated for multi-slot TB transmission, expressed in number of actual PUSCH symbols/slots.   * FFS: how different multi-slot parameters and configurations are used to determine the reference number for N\_RE calculation in case of multi-slot TB transmission.   **R1-2100173**  **Supporting TB over multi-slot PUSCH, OPPO**  Proposal 1: For coverage enhancement, TB size of PUSCH can be derived by a larger than 1 factor in case when PUSCH repetition is configured.   * Ninfo can be multiplied by factor of 2, 4, 8 for determining TBS.   Proposal 3: A multi-slot TB size factor is introduced for TB size determination in case when PUSCH repetition is configured.   * The multi-slot TB size factor is not larger than configured aggregation factor.   **R1-2101478**  **TB processing over multi-slot PUSCH, Qualcomm**  Proposal 1: Support multi-slot TB transmission using TB scaling with repetitions and RV cycling. Introduce a new scale factor that can be used to increase the TB size when determining TB size for PUSCH transmission.   * FFS: permitted values for the scale factor. * FFS: Signaling aspects of the scale factor.   Proposal 2: Identify constraints or conditions under which TBS scaling can be used. Constraints may include limits on RB allocation, MCS, number of layers, TB size, number of code blocks, etc. |

## A.4 Relationship between TBoMS and PUSCH repetitions

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| **R1-2101222**  **TB processing over multi-slot PUSCH, Samsung**  Proposal 2: Repetition is supported for TB over multi-slot.  **R1-2100096**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, ZTE**  Proposal 4: Discuss whether to support PUSCH repetition together with TB processing over multiple slots.  **R1-2100458**  **Discussion on PUSCH TB processing over multiple slots, vivo**  Proposal 8: For PUSCH with TB processing over multiple slots, PUSCH repetition is not supported. |

## A.5 DM-RS

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| **R1-2101222**  **TB processing over multi-slot PUSCH, Samsung**  Proposal 3: Further study the following method for time domain location of DMRS considering the joint channel estimation over multi-slot and transmissions:   * DMRS time domain location is determined per PUSCH transmission * DMRS time domain location is determined per slot   **R1-2100743**  **Views on TB processing over multi-slot PUSCH, Fujitsu**  Proposal 3: Existing DM-RS specifications should be reused  **R1-2100232**  **Discussion on TB processing over multi-slot PUSCH, Huawei, HiSilicon**  Proposal 4: For TB over multi-slot PUSCH, DMRS position can be determined per slot or the DMRS determination mechanism of PUSCH repetition type B can be reused.  Proposal 5: If joint channel estimation is enabled for TB over multi-slot PUSCH, DMRS positions can be determined per L symbols where L is configurable.  **R1-2101521**  **TB Processing over Multi-Slot PUSCH, Ericsson**  Proposal:   * The same DMRS configuration, MCS index, number of layers, and PRB allocation can be used for multiple slots of multi-slot PUSCH.   **R1-2101642**  **TB processing over multi-slot PUSCH, NTT DOCOMO**  Proposal 2: DM-RS configuration should be extended so that one PUSCH can have more than 14 OFDM symbols with uniform DM-RS symbol distribution.  Proposal 3: It is better to support more than 3 additional DM-RS positions in case that one PUSCH has more than 14 OFDM symbols. |

## A.6 CB segmentation, redundancy version, rate-matching and interleaving

***CB segmentation***

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| **R1-2101521**  **TB Processing over Multi-Slot PUSCH, Ericsson**  Proposals:   * CB segmentation is deprioritized for TB over multiple slots. * RAN1 to decide a maximum TBS of TB over multiple slots to avoid CB segmentation.   **R1-2101396**  **Discussion on TB processing over multi-slot PUSCH, Apple**  Proposal 4: Both TB segmentation and CBG based TB processing can be considered.  **R1-2101222**  **TB processing over multi-slot PUSCH, Samsung**  Proposal 6: The supported Max TBS remains unchanged.  **R1-2100096 DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, ZTE**  Proposal 5: For TB processing over multiple slots, the maximum supporting TBS per HARQ process should not exceed legacy TBS in Rel-15/16.   * FFS detailed method for TBS determination. |

***Redundancy version***

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| **R1-2100713**  **DISCUSSIONS ON TB PROCESSING OVER MULTI-SLOT PUSCH, LGE**  Proposal 5: The value of rvid applied to n-th transmission occasion of the TB is determined based on the value ‘n mod 4’.  **R1-2100173**  **Supporting TB over multi-slot PUSCH, OPPO**  Proposal 4: Single RV scheme can be used across all the repetition slots in case of TB size over multi-slot and PUSCH repetition is configured.  **R1-2100666**  **Discussion on TB processing over multi-slot PUSCH, Intel Corporation**  Proposal 4: Existing RV cycling pattern for PUSCH with repetition is reused for mPUSCH with repetition. |

***Rate-matching and Interleaving***

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| **R1-2101222**  **TB processing over multi-slot PUSCH, Samsung**  Proposal 7: Further study the operation of interleaving and rate-matching output for TB over multi-slot. |

## A.7 Link adaptation

***MCS index***

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| **R1-2101521 TB Processing over Multi-Slot PUSCH, Ericsson**  Proposal:   * The same DMRS configuration, MCS index, number of layers, and PRB allocation can be used for multiple slots of multi-slot PUSCH. |

## A.8 Frequency hopping

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| **R1-2101002**  **Enhancements for TB processing over multi-slot PUSCH, Lenovo/Motorola**  Proposal 2: For one TB processing over multi-slot PUSCH in NR coverage enhancements in Rel-17, support multi-slot frequency hopping and multi-slot DM-RS bundling for joint channel estimation for entire hop  • Association between frequency hop duration and DM-RS bundle duration should be considered  **R1-2100666**  **Discussion on TB processing over multi-slot PUSCH, Intel Corporation**  Proposal 2:   * For mPUSCH without repetition, inter-slot frequency hopping with inter-slot bundling is supported. * For mPUSCH with repetition, inter-slot and inter-repetition frequency hopping are supported. |

## A.9 Transmission power determination

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| **R1-2100096**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, ZTE**  Proposal 7: For TB processing over multiple slots, the transmission power determination should be based on the multiple slots for TB processing |

## A.10 Rank of TBoMS transmission

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| **R1-2101521**  **TB Processing over Multi-Slot PUSCH, Ericsson**  Proposal:  The same DMRS configuration, MCS index, number of layers, and PRB allocation can be used for multiple slots of multi-slot PUSCH.  **R1-2100458**  **Discussion on PUSCH TB processing over multiple slots, vivo**  Proposal 9: PUSCH with TB processing over multiple slots should be limited to single transmission layer. |

## A.11 Channel estimation

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| **R1-2100732**  **TB processing over multi-slot PUSCH, InterDigital**  Proposal 5: Support joint channel estimation for the multi-slot PUSCH transmission  **R1-2100458**  **Discussion on PUSCH TB processing over multiple slots, vivo**  Proposal 1: It is up to UE capability to ensure phase continuity for PUSCH with TB processing over multiple slots. |

## A.12 Retransmissions

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| **R1-2101056**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, CMCC**  Proposal 4: Per slot retransmission should be considered for the retransmission of multiple slot PUSCH transmission.  **R1-2100732**  **TB processing over multi-slot PUSCH, InterDigital**  Proposal 6: Support enhanced retransmission mechanisms to avoid the retransmission of the entire multi-slot PUSCH. |

## A.13 UCI multiplexing, SRS/DL collusions/cancellations

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| **R1-2100943**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, NEC**  Proposal 3: UCI could multiplex with PUSCH when PUCCH transmission overlapping with PUSCH transmission of TB processing over multi-slot in one or more slots.  **R1-2101056**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, CMCC**  Proposal 2: The solution or the behavior on how to deal with the collision issue between multiple slot PUSCH and PUCCH/SRS should be discussed.  **R1-2100666**  **Discussion on TB processing over multi-slot PUSCH, Intel Corporation**  Proposal 1: mPUSCH is transmitted on the basis of available UL slots.  Proposal 5: When mPUSCH overlaps with PUCCH in time, if the timeline requirement is satisfied, the whole mPUSCH transmission is cancelled and the PUCCH is transmitted in the overlapped slots  **R1-2101680**  **Discussion on TB processing over multi-slot PUSCH, WILUS**  Proposal 3: It should be further discussed how to determine the number REs for UCI multiplexing in case of TB processing over multi-slot PUSCH.  **R1-2101018**  **Discussion on TB processing over multi-slot PUSCH, Panasonic**  Proposal 4: To specify how to handle the interactions of TB processing over multi-slot PUSCH with DL / UL direction and cancellation.  **R1-2100232**  **Discussion on TB processing over multi-slot PUSCH, Huawei, HiSilicon**  Proposal 3: The resolution mechanism of collisions between signals (e.g. PUCCH) with PUSCH in current specification should be further improved before it’s applied to TB over multi-slot PUSCH.  **R1-2100096**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, ZTE**  Proposal 3: For collision handling of TB processing over multiple slots, legacy collision handling rules for PUSCH repetition type A could be reused by replacing a repetition to a slot of the multiple slots for TB processing.  Proposal 6: Discuss the UCI multiplexing rules in case PUCCH overlaps with PUSCH in one or more slots of the multiple slots for TB processing.  **R1-2100458**  **Discussion on PUSCH TB processing over multiple slots, vivo**  Proposal 4: For UCI multiplexing on PUSCH with TB processing over multiple slots, the number of modulated symbols in the PUSCH for UCI multiplexing is determined based on  - the number of symbols for PUSCH in a slot, which is overlapping with the PUCCH, or  - a configured PUSCH length, which is less than or equal to 14 symbols.  Proposal 5: For PUSCH with TB processing over multiple slots, UCI multiplexing behavior should be performed per PUSCH transmission occasion within a slot, and UCIs can be multiplexed more than once to different PUSCH occasions.  Proposal 6: The amount of resources for UCI multiplexing can be optimized to limit the resource allocated for UCI multiplexed in a later PUSCH occasion, if there are already UCI(s) multiplexed on previous PUSCH occasions  Proposal 7: HARQ-Ack multiplexing on PUSCH with TB processing over multiple slots can be allowed if HARQ-Ack for the scheduling DCI comes after the UL grant for the PUSCH   * The HARQ-Ack can be mapped to the PUSCH resource by puncturing some symbols in the PUSCH occasion. |

## A.14 Multi-slot/Single-slot switch/indication

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| **R1-2100943**  **DISCUSSION ON TB PROCESSING OVER MULTI-SLOT PUSCH, NEC**  Proposal 2: Dynamic switching between TB processing over multi-slot and single-slot is adopted. Switching is based on implicit indication by conditions of RB/MCS.  **R1-2100732**  **TB processing over multi-slot PUSCH, InterDigital**  Proposal 1: Dynamic enabling/disabling of multi-slot PUSCH transmission is supported.  **R1-2101711**  **Transport block processing for PUSCH coverage enhancements, Nokia/NSB**  Proposal 4: RAN1 to specify an indication method for enabling multi-slot TB transmission per PUSCH scheduling/configuration.   * FFS: Details of the indication method, including introducing a new field or reusing the available field in the scheduling DCI (or RRC parameter in case of configured grant configuration), e.g. some rows in the TDRA table are used to configure for multi-slot TB transmission. |

## A.15 Service-like prioritization of TBoMS

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| **R1-2100666**  **Discussion on TB processing over multi-slot PUSCH, Intel Corporation**  Proposal 6:   * mPUSCH is treated as low priority uplink transmission. |

## A.16 Simulation assumptions

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| **R1-2101521**  **TB Processing over Multi-Slot PUSCH, Ericsson**  Proposals:   * Evaluate low data rate services, such as VoIP or 30 kbps data for simulations. * To keep comparable PDCCH overhead, Rel-15/16 PUSCH repetition (including RV cycling) can be used as baseline for performance evaluation. |

# Appendix B: Previous agreements on TB processing over multi-slot PUSCH [placeholder during RAN1 #104-e]