3GPP TSG RAN WG1 #106-e R1-2108253

e-Meeting, August 16th – August 27th, 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**

# 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 #106-e [3]-[28].

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

Previous Rel-17 agreements are listed in Appendix B, for reference.

# 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). A systematic categorization will be used in this document to summarize the content of all contributions. This is done according to both the number of submitted proposals on the different aspects and on the relevance the latter have for designing the feature, from FL’s perspective. Concerning the second criterion, its rationale 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:

* **High priority aspects**
  + TOT definition
  + Single TBoMS structure
  + Rate matching (including how RVs are refreshed, if applicable)
  + Whether and how to use the S slots
* **Mid priority aspects**
  + How to count slots for transmitting TBoMS: available vs. consecutive
  + How to indicate the number of allocated slots for TBoMS
  + UCI multiplexing and collision handling
  + TBS determination: calculation
  + TBoMS repetitions
* **Other aspects**
  + *Further design aspects of TBoMS*
    - Relationship between TBoMS and PUSCH repetitions
    - FDRA
    - DM-RS
    - Transmission power determination
    - Special TBS values for TBoMS
    - Rank of TBoMS transmission
    - Link adaptation
    - Frequency hopping
    - CB segmentation
    - Retransmissions
    - Interleaved TBoMS transmissions
    - Application of DM-RS bundling to TBoMS
  + *Signaling and interaction with other signals/channels*
    - Additional indicators and configuration options
    - Application of TBoMS for Msg3 transmission

The categorization above will determine the initial priority order for the discussions to be held for AI 8.8.1.2. In this context, sections 2.1 and 2.2 will focus on discussions which will (2.1) and may (2.2) be discussed during RAN1 #106-e. Section 2.3 will collect all other aspects.

Tags [OPEN], [CLOSED] and [PAUSED] will be used to identify the status of the discussion at any moment of the meeting. New sections for specific aspects will be open during the meeting, should discussions for the higher priority aspects progress fast.

## High priority aspects

Six high priority aspects are identified at the beginning of the meeting:

1. TOT definition
2. Single TBoMS structure
3. Rate matching (including how RVs are refreshed, if applicable)
4. Whether and how to use the S slots

Most companies have discussed at large about such aspects in the submitted contributions. Summary, discussion, and proposals on these aspects are provided in the following different sub-sections. Sub-section numbers follow the list above, for simplicity.

### [PAUSED] TOT definition

Most contributions acknowledged the fundamental nature of this aspect and discussed it in detail. High-level summary of companies’ preferences and opinions based on the contributions follows.

**Working assumption**

Six companies commented on aspects related to the existing working assumption on TOT (RAN1 #105-e), as follows:

* **Option 1**: WA should be confirmed, i.e., a TOT is constituted of at least one slot or multiple consecutive physical slots for UL transmission [2 companies]: ZTE [5], Lenovo Motorola [27]
* **Option 2**: WA should be modified by limiting the definition of TOT to one slot [2 companies]: Nokia/NSB [21], Qualcomm [17]
* **Option 3**:WA should be modified by expanding the definition of TOT to include also sets of multiple consecutive slots [2 companies]: Fujitsu [10], CMCC [12]

**Role of TOT in the signal generation**

Three companies commented on the role that TOT should have in the signal generation of TBoMS, as follows

* **Option 1**: The concept of TOT should be used to specify fundamental aspects of signal generation [2 companies]: vivo [6], Lenovo Motorola [27]
* **Option 2**: The concept of TOT should not be used to specify fundamental aspects of signal generation [1 company]: ZTE [5]

**Use of TOT in specification**

Three companies commented on whether the concept of TOT should be specified, as follows

* **Option 1**: The concept of TOT should be specified [2 companies]: vivo [6], Lenovo Motorola [27]
* **Option 2**: The concept of TOT should not be specified [1 company]: ZTE [5]

FL’s comments on August 16th

Views and proposals related to TOT are rather heterogeneous. The number of companies who expressed an explicit view on this aspect is not very large. However, from FL’s perspective, the implications of taking different directions related to the definition of TOT are large. More precisely, if the notion of TOT is different from the notion of slot, then it would be rather straightforward to expect TOT to be considered as a unit for important aspects of TBoMS such as rate matching, UCI multiplexing, power control, collision handling and so on. However, decisions on such aspects should be taken based on technical elements and not on the fact that an arbitrary unit of time has been taken as a reference. In a way this goes against common sense and logic. Indeed, we have that:

* The concept of TOT has been introduced to simplify the discussion related to the single TBoMS structure. In all generality, considering different units of time helped describing several Options (i.e., 4) for the TBoMS structure. On the other hand, its introduction was never meant to justify the adoption of a TOT-based logic to define other aspects of TBoMS, but for its structure.
* It is reasonable to assume that the goal of RAN1 in this AI is to specify the TBoMS feature according to technically solid rationales, which may or may not need the concept of TOT to be valid. In practice, RAN1 should not decide on aspects such as rate matching, UCI multiplexing, power control, collision handling and so on, depending on the definition of TOT, but rather the converse. Stated differently, decisions on aspects such as rate matching, UCI multiplexing, power control, collision handling and so on should bring RAN1 to decide whether specifying the notion of TOT is necessary or not, and not the converse.

Of course, discussions in RAN1 could lead to deciding to define and specify TOT in a specific way, however it is reasonable to assume that this should be the result of what is decided on all fundamental aspects of TBoMS, more than the starting point of the discussion.

In this context, the following question is formulated:

**2.1.1-Q1:** *Do you agree that RAN1 should first decide on aspects such as rate matching, UCI multiplexing, power control, collision handling and so on, and then decide whether or not the concept of TOT is needed (and revised and specified, if applicable)?*

#### First round of discussions

FL’s recommendation is to have a first round of discussion among companies about **2.1.1-Q1**. The goal is to identify the preferred direction RAN1 should pursue for handling the design of next aspects. Feel free to elaborate on your answer in the suitable box, if applicable. It is very much appreciated if discussion is kept at technical level, for the sake of an efficient use of the limited time RAN1 has.

|  |  |  |
| --- | --- | --- |
| Company | Answer (Yes/No) | Additional comments, if any. |
| Samsung | yes |  |
| Apple | Yes | ToT can be discussed later after the rate matching scheme is determined. |
| Lenovo, Motorola Mobility | Yes |  |
| NTT DOCOMO | Yes |  |
| Sharp | Yes | Rate-matching and UCI multiplexing is more critical since it affects the UE implementation of encoding aspect. |
| LG | Yes |  |
| Intel | yes | TOT concept and need of TOT in the specification should be a clear outcome from the decision on the rate matching scheme. |
| Panasonic | Yes |  |
| Qualcomm | Sure. | Thanks to progress made in the last meeting, we think it suffices to consider single slot TOTs. |
| vivo | Yes |  |
| ZTE | Yes |  |
| CATT | Yes |  |
| InterDigital | Yes |  |
| CMCC | Yes | TOT could be discussed according to the conclusion of rate-matching and UCI multiplexing. |
| TCL | Yes |  |
| OPPO | Yes |  |
| Ericsson | Yes |  |
| Nokia/NSB | Yes | This approach seems to be a natural way-forward. After other aspects have been worked out (especially rate-matching), decision on whether or not the concept of TOT is needed can be made accordingly. For example, if rate-matching is done per slot, then the concept of TOT is not needed. |
| Huawei, Hisilicon | Yes |  |
| WILUS | Yes |  |
| Fujitsu | Yes |  |
| MediaTek | Yes |  |

FL’s comments on August 17th

All companies agree that RAN1 should first decide on aspects such as rate matching, UCI multiplexing, power control, collision handling and so on, and then decide whether or not the concept of TOT is needed (and revised and specified, if applicable). The discussion is paused for the time being.

### [OPEN] Single TBoMS structure

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

|  |  |
| --- | --- |
| Option 3  [19 companies] | Option 4  [10 companies] |
| Huawei/HiSi [3] | Panasonic [18] |
| ZTE [5] | LGE [28] |
| ~~vivo [6]~~ | CMCC [12] |
| CATT [8] | Qualcomm\* [17] |
| Ericsson [28] | Apple [16] |
| OPPO [9] | NEC [25] |
| China Telecom [11] | Samsung [19] |
| Interdigital [14] | MediaTek [20] |
| Intel [15] | Sharp\* [24] |
| Fujitsu [10] | vivo [6] |
| NTT Docomo [26] |  |
| Lenovo/Motorola [27] |  |
| WILUS [29] |  |
| Sierra Wireless [23] |  |
| Nokia/NSB [21] |  |
| Qualcomm\* [17] |  |
| Sharp\* [24] |  |
| Xiaomi [13] |  |
| WILUS [7] |  |

FL’s comments on August 16th

Option 3, based on the use of single RV is preferred by 17 companies, whereas Option 4, which is based on RV cycling, is preferred by 10 companies (“starred” companies expressed views which seem to accommodate both Options, depending on further choices in terms of rate-matching).

Several arguments are used by companies to substantiate their preference. In summary:

* Companies supporting Option 3 state that it provides larger robustness against systematic bit loss, yielding better performance overall, regardless of the TBS value. It should be noted that this problem can never occur in PUSCH repetition Type A, where TBS is calculated using the resources of one slot. Additionally, Options 3 also allows to puncture a lower number of parity bits as well, if any, in turn yielding a lower effective coding rate for the TBoMS. These advantages are observable regardless of the chosen rate-matching time unit (per slot/TOT/TBoMS).
* Companies supporting Option 4 state that it arguably allows to support efficient UCI multiplexing and collision handling approaches, given how different RVs can be decoded by gNB (0 and 3 assumed to be self-decodable as in case of PUSCH Type A repetitions). Solutions to avoid puncturing of systematic bits are proposed, to ensure that coded bits are continuously selected from the circular buffer during the rate matching. Such solutions should yield same result as single RV utilization.

From FL’s perspective, several technical observations can be made from companies’ Tdocs:

* Considerations made for Option 3 are valid independently of the assumptions on the code rate the number of allocated slots for TBoMS [28].
* Option 3 does not ensure self-decodability per slot of a sub-set of slots. Self-decodability of the first slot may depend on the actual code rate.
* Option 4 may not offer self-decodability per slot of a sub-set of slots for the following three reasons:
  + When the equivalent coding rate of the TBoMS transmission is larger than one (i.e., R×M>1, where R denotes ideal coding rate, M denotes the number of available slots allocated for a single TBoMS transmission, and R×M is the equivalent coding rate) self-decodability per slot of a sub-set of slots is not guaranteed [3].
  + PUSCH repetitions type A offer self-decodability of RV0 and RV3 since TBS is calculated using the resources of one slot. This guarantees that a sufficiently large number of systematic bits is present in RV0 and RV3, together with an adequate number of parity bits, for the decoding to be effectively possible. Conversely, TBS is calculated using the resources of more than one slot in TBoMS. In this case, the number of systematic bits per slot may or may not be sufficient to guarantee self-decodability of RV0 and RV3, depending on the scaling factor *K* used to calculate , which cannot be arbitrarily larger than the number of RVs used to transmit the TB [22].
  + In case coded bits were continuously selected from the circular buffer, as per proposed solutions to address the systematic bit puncturing issue, self-decodability per slot of a sub-set of slots would not be guaranteed. In this case, in fact, self-decodability per slot would be the same as for Option 3.
* Both Option 3 and Option 4 are compatible with “on the fly” determination of the coded bits to be transmitted on a given slot and with predetermined approach to identify the starting bit location for each slot be prior to the start of the TBoMS transmission [17]. In this sense, RAN1 would have complete flexibility to pick one approach or the other, for the determination of the coded bits to be transmitted on a given slot, regardless of which option is retained for the single TBoMS structure. It is worth reminding that coded bit selection is one of the two components of rate-matching, the other being the interleaver. Further discussion on this aspect are carried out in Section 2.1.3.
* By definition, all rate-matching options are compatible with Option 3, whereas Option 4 is compatible only with rate-matching per slot and per TOT.

Given all the considerations above, the following 5 questions are formulated.

**2.1.2-Q1**: *Option 3 and Option 4 differ only as to which coded bits are to be transmitted on a given slot, i.e., how starting bit location for each slot is determined. Do you agree with this statement?*

**2.1.2-Q2**: *The coded bits transmitted on any given a slot in Option 3 and Option 4 are exactly the same if a suitable offset is applied to the coded bit selection in Option 4, such that the first bit selected from the circular buffer for any given slot is right after the last bit selected from the circular buffer for the previous slot. Do you agree with this statement?*

**2.1.2-Q3**: *Do you agree with the following statements?*

* *Option 3 is compatible with all considered rate-matching options for TBoMS (per slot/TOT/TBoMS).*
* *Option 4 is compatible only with rate-matching per slot and per TOT.*

**2.1.2-Q4**: *Following limitation is necessary to ensure both self-decodability per slot of a sub-set of slots and decodability of the whole TB at gNB, if Option 4 is retained:*

* *A limit in terms of target maximum code rate supported by Option 4 for any given number of slots allocated for TBoMS.*
* *The scaling factor used to calculate TBS cannot be arbitrarily larger than the number of RVs used to transmit the TB.*

*Is this acceptable or should RAN1 rather aim at guaranteeing that the same link adaptation and scheduling flexibility exist for PUSCH type A repetition and TBoMS configuration?*

**2.1.2-Q5**: *If self-decodability per slot of a sub-set of slots cannot be guaranteed by either Option 3 or Options 4, then advantage of one option over the other for what concerns UCI multiplexing and collision handling may depend on how MCS, FDRA and TDRA are configured. Do you agree with statement?*

#### First round of discussions

FL’s recommendation is to have a first round of discussion among companies about **2.1.2-Q1**, **2.1.2-Q2**, **2.1.2-Q3**, **2.1.2-Q4** and **2.1.2-Q5**. The goal is to identify the preferred directions RAN1 should pursue for handling the designof the single TBoMS structure. Feel free to elaborate on your answer in the suitable box, if applicable. It is very much appreciated if discussion is kept at technical level, for the sake of an efficient use of the limited time RAN1 has.

**2.1.2-Q1**

|  |  |  |
| --- | --- | --- |
| Company | Answer (Yes/No) | Additional comments, if any. |
| Samsung | Yes |  |
| Apple | Yes | The whole TB is transmitted in all ToTs for Option 3. But for Option 4, the whole TB is transmitted in a ToT, and the TB is repeated with different RV in following ToTs.  FL’s reply: I do not think what you wrote is accurate, given existing agreements. According to them, in Option 4 “The TB is transmitted on the multiple TOTs using different RVs”. In this sense, Option 4 does not provide any deterministic guarantee that the whole TB is transmitted in one TOT and then repeated on other TOTs. In fact, the group has never agreed that TBoMS operate as a Type A repetition where a TOT replaces a slot. Furthermore, some examples were already given by some companies, e.g., [22], in which you could see that the whole TB may never be transmitted completely according to Option 4, not even once, that is BLER=1.  I am sorry to insist on this, but it is very important for all to be on the same page to avoid fundamental misunderstandings and be able to progress. |
| Lenovo, Motorola Mobility | Yes |  |
| NTT DOCOMO | Yes |  |
| Sharp | Yes |  |
| LG | Yes |  |
| Intel | Yes |  |
| Panasonic | Yes |  |
| Qualcomm | Yes |  |
| vivo | Yes | BTW: vivo’s 1st preference is option 3 not option 4, and we made the correction in the table above, and the table in section 2.1.3.  FL’s reply: sorry for the mistake. Thank you for fixing it. |
| ZTE | Yes | Is it a correct understanding that this is based on the assumption that the TBS is calculated on all resources in all slots allocated for the TBoMS for both Option 3 and Option 4?  FL’s reply: This is based on the assumption that TBS is calculated using the same scaling factor K for both Option 3 and Option 4. As far as I am concerned, the intuition related to which bits are selected from the circular buffer in the two cases holds not matter which value is chosen for K, provided that K is the same for both Option 3 and Options 4. |
| CATT | Yes |  |
| InterDigital | Yes |  |
| TCL | Yes |  |
| OPPO | Yes |  |
| Ericsson | Yes, if not considering the possibly different time unit of interleaving | Both options should consider all slots of TBoMS for TBS determination. |
| Nokia/NSB | Yes | This is the only difference regarding the design of the two options. However, the pros and cons of the two options caused by this design difference is non-negligible. |
| Huawei, Hisilicon | Yes | If the interleaving is discussed regardless what coded bits are transmitted on each time unit.  FL’s reply: I agree. |
| WILUS | Yes |  |
| Fujitsu | Yes |  |
| MediaTek | Yes |  |

**2.1.2-Q2**

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | Agree |
| Apple | We agree the first bit selected form circular buffer is right after the last bit from the previous slot. But we are not sure why the coded bits transmitted on a slot are the exactly same for option 3 and option 4, our understanding is more coded bits are transmitted in a slot for Option 4, due to the coded bits for the TB need to be transmitted in A ToT.  FL’s reply: Assume the same TB, the same MCS index, the same number of PRBs and the same TDRA are configured for both Option 3 and Option 4. This is the only way to have a fair comparison and understand what’s going on. In this case, the encoded bits written in the circular buffer are exactly the same for both Option 3 and Option 4. The difference comes in how bits are extracted in Option 3 and Option 4:   * + - * Option 3: the first bit selected from the circular buffer for any given slot is right after the last bit selected from the circular buffer for the previous slot. In other words, all the systematic bits are selected and as many coded bits as possible are also selected, until all the allocated REs are used.       * Option 4: the first bit selected from the circular buffer for any given slot is at a certain gap (which depends on the RV id) from the last bit selected from the circular buffer for the previous slot. In other words, a certain number of systematic bits are selected (some of them could be punctured) and a certain number of coded bits are selected (come of them are certainly punctured).   Given the above, the point is not about how many coded bits are transmitted in slots for Option 3 or 4, but if the ratio between transmitted systematic and transmitted parity bits is favourable or not. According to several results presented by different companies, this ratio is always favourable for Option 3, and may not be favourable for Option 4 (if RxK>1). However, the ratio could be always favourable for Option 4 as well, if suitable offset is applied to the coded bit selection in Option 4, such that the first bit selected from the circular buffer for any given slot is right after the last bit selected from the circular buffer for the previous slot. If this is the case, coded bits transmitted by Option 3 and 4 would be exactly the same. |
| Lenovo, Motorola Mobility | Agree |
| NTT DOCOMO | Yes |
| Sharp | Agree |
| LG | In our understanding, Option 3 performs rate-matching by applying the same first bit (based on the same RV value) for each rate-matching unit. It means transmitting the same coded bits for each rate-matching. Therefore, for each unit of rate-matching, the transmitted bits are the same in Option 3, whereas the transmitted bits are different in Option 4. So I cannot agree with 2.1.2-Q2.  FL’s reply: your understanding contradicts the agreement we had during RAN1 #105-e, that is:  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.   In Option 3, applying a different first bit for each rate-matching unit (i.e., the first bit selected from the circular buffer for any given slot is right after the last bit selected from the circular buffer for the previous slot) requires specification enhancement. When comparing Option 3 with this enhancement and Option 4, in Option 4, there are up to 4 first positions according to 4 RV values, so it seems difficult to say that it is the same as Option 3 even if a suitable offset is applied.  FL’s reply: this not entirely accurate, since for Option 3 it all depends on how the parameter “E” is defined in 38.212. If rate-matching is performed per TBoMS the specification impact is zero for the bit selection part, and very minor for the interleaver part. Conversely, if rate matching is per slot or TOT, then specification impact is expected also for the bit-selection part, yes. Regardless of which approach is retained, the coded bits would always be selected from the circular buffer continuously, i.e,, the first bit selected from the circular buffer for any given slot is right after the last bit selected from the circular buffer for the previous slot.  Now, moving to your last sentence. It does not matter how many RVs we consider for Option 4. According to specification, the first bit selected from the circular buffer for any given slot would **not be** right after the last bit selected from the circular buffer for the previous slot. In order to ensure that this can happen, and performance degradation never occurs, an offset should be applied to each bit selection to ensure that the first bit selected from the circular buffer for any given slot is right after the last bit selected from the circular buffer for the previous slot. This would also increase specification impact of Option 4, regardless of which unit of time is used for the interleaver.  Please remember that TBoMS is not a PUSCH repetition, where TBS is calculated using the resources of one slot. In that case, the gap between the first bit selected from the circular buffer for any given slot and the last bit selected from the circular buffer for the previous slot is **never** a problem, due to the slot-based approach. However, once the TBS is calculated using the resources of multiple slots, simply applying the legacy RV cycling scheme exposes to performance degradation whenever RxK>1. |
| Intel | Agree |
| Panasonic | We agree the FL statement. It can be interpreted that in Option 4, starting point (bit position in circular buffer) in the first slot in a TOT is determined based on RV in current specification. |
| Qualcomm | Agree |
| ZTE | Yes |
| CATT | Agree. And we think that new RV definition (or bit section breakpoint) may be needed for Option 4 to achieve the same signal generation.  FL’s reply: I agree. |
| InterDigital | Yes |
| TCL | Yes |
| OPPO | Yes |
| Ericsson | Agree. Continuous bit selection across all slots of TBoMS has the least standard impact in terms of bit selection and interleaving and shown the best performance among three rate matching options when used together with Option 3. This observation also applies to Option 4, which can be considered with an offset of starting point for each RV if compared with the RV used for Option 3.  FL’s reply: I agree on the specification impact of the bit selection part. It would be lower in case of Option 3, if we want to fix performance of Option 4. Isolating specification impact of Option 3, aside from bit selection part, is on the other hand harder. However, the same applies to Option 4. I think it is important we all keep in mind that we either analyse the impact properly (as I suggest in other sections) or we’ll keep circling around the problem without finding a solution. |
| Nokia/NSB | Yes. Option 3 aims to have the encoded bits continuously mapped across the allocated resource for TBoMS, starting from the first bit in the circular buffer. If we simply read Option 4 as what is written in the agreement (i.e., “The TB is transmitted on the multiple TOTs using different RVs”) without having any implication on whether the “different RVs” follow the Rel-15/16 RV cycling concept or not, then the two options can be the same. RAN1 then only needs to work out on the starting (and length) of the encoded bits in the circular buffer to be mapped on each time-unit (slot/TOT). This may be done by defining RV index per time unit (or continuous mapping if no implementation issue identified). |
| Huawei, Hisilicon | Basically, to facilitate the implementation, option 3 may be optimized on selecting the first bit for each TOT or slot. And the key is how to calculate the first bit of each slot.  FL’s reply: I guess this would also apply to Option 4, if we want to fix its performance issues when RxK>1. A different implementation solution would be needed, but impact is expected in that case as well. |
| WILUS | Yes |
| Fujitsu | Yes |
| MediaTek | Yes |

**2.1.2-Q3**

|  |  |  |
| --- | --- | --- |
| Company | Answer (Yes/No) | Additional comments, if any. |
| Samsung | No need this comparison | Both option could apply to per slot, tot or all resources, the option 4 for per all resource is simply there is no “second” time unit to apply a different RV, but it should not mean option 4 was not compatible with “per all resources”.  FL’s reply: Given that more than one RV is used in Option 4, it seems natural to exclude the interleaver across all the slots from the possible options. Performing bit selection “per slot/TOT” but interleaver across all the slots would make me wonder if this is still Option4…Then again, I think our understanding is aligned and it may be just a matter of calling the same thing differently. It may also be worth observing that according to existing agreements, the three options on the table have the same time unit for both bit selection and bit interleaving (please see Appendix B). |
| Apple | Yes |  |
| Lenovo, Motorola Mobility | Yes |  |
| NTT DOCOMO | Yes |  |
| Sharp | Yes |  |
| LG | Yes |  |
| Intel | Yes |  |
| Panasonic | Yes |  |
| Qualcomm | Agree |  |
| ZTE | Yes |  |
| CATT | Yes |  |
| InterDigital | Yes |  |
| TCL | Yes |  |
| OPPO | Yes |  |
| Ericsson | Yes. | When option 3 is used, the agreement “The single RV is not constrained to have only the same coded bits in each slot or in each TOT ” should be conformed with.  FL’s reply: Agreed. |
| Nokia/NSB | Yes | Agree with Ericsson. |
| Huawei, Hisilicon | Yes |  |
| WILUS | Yes |  |
| Fujitsu | Yes |  |
| MediaTek |  | Share the similar view as Samsung. Actually, Option 3 can be considered as a special case of Option 4. In that sense, Option 4 can be applied for more cases than Option 3  FL’s reply: I guess that formally speaking Option 3 is Option 4 with “bit offset” applied to each RV. However, I am not sure this is so relevant after all, if not to understand that the same behaviour could be obtained in both options if suitable offsets are applied to bit selection in Option 4. The question is: would it be even relevant to differentiate between the two Options anymore, if we start playing with offsets? I guess this is the fundamental issue at hand. Please see my comments/proposals below for further clarification about this. |

**2.1.2-Q4**

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | The *self-decodability* could be achieved by also gNB properly schedule instead of specifying the limitation on the configuration. The option 4 will have larger opportunity to be self-decodable than that of option 3.  FL’s reply: I agree that this would be the case. However, properly schedule a transmission subject to design constraints is more cumbersome for the gNB than scheduling a transmission with no design constraint. According to my understanding this would not only impact TBoMS but other UL transmissions as well, given that gNB would have to configure other UL transmissions in such a way that TBoMS can be scheduled, given the constraints of the “proper scheduling” due to the not-so-robust design of Option 4, unless suitable bit offset is applied during the bit selection. Furthermore, we may observe a situation in which the performance gain against PUSCH repetition type A vanishes as mentioned by Ericsson below. |
| Apple | For Option 4, self-decodability per ToT is enough, not sure why it is required self-decodable per slot?  FL’s reply: self-decodability per TOT has never been discussed, nor analyzed. In fact, it depends on the rate-matching of TBoMS, which has not been agreed on yet. Hence, I am not sure how self-decodability per ToT can be guaranteed at this stage. The reference to the self-decodability per slot is due to the fact that this is the case for PUSCH repetition type A and several companies supporting Option 4 mentioned that such Option offers self-decodability per slot thanks to the RV cycling.  The coding rate is not the issue for coverage limited UEs, we don’t expect the higher coding rate is configured for this type of UE.  FL’s reply: I think this I reasonable, however the max number of configurable slots for TBoMS according to Option 4 would still depend on the configured coding rate, unless the bit offset is applied, regardless of the whether rate matching is performed per slot/TOT/TBoMS. If we think that R16 supports up to 16 slots for PUSCH repetitions type A, then we can clearly see how such limitation may result in the performance enhancement brought by TBoMS over PUSCH repetition Type A can vanish if we need to respect certain limitations imposed by Option 4 (as commented by Ericsson).  Not sure the scaling factor is the same meaning as in PDSCH TBS determination? Current assumption for TBS determination is based on the number of slots assigned for TBoMS, is this right understanding?  FL’s reply: scaling factor K is what UE uses to calculate TBS, where K is used to scale the resources available in one slot. The value(s) of K is (are) still to be agreed on. |
| Lenovo, Motorola Mobility | It is not necessary to introduce the proposed limitations for the self-decodability with option 4. Network should be able to handle that.  FL’s reply: agreed. But is this the most suitable approach. Please see my reply to Samsung. |
| NTT DOCOMO | In our views, a scaling factor can be larger than the number of RVs, as long as TBoMS can be decoded in the end. Instead, scaling factor might not be larger than the number of slots allocated for one RV and TBoMS to achieve the self-decodability of a TOT and whole TB, respectively. This is because decodability of the whole TB is lost if the actual code rate over all slots (ideal coding rate in FL’s word) is more than 1. In this way, the scaling factor should not be arbitrary number in order to achieve decodability of the whole TB. One potential constraint is to limit the scaling factor up to the number of available slots allocated for one RV. |
| Sharp | In our view, the effective code rate Reff = TBS/NTBOMS will be restricted to ensure mapping of all systematic bits for Option 4 where NTBOMS is the number of available bits for a TBoMS.  FL’s reply: we have not agreed on this yet, and many companies seem to object this approach. |
| LG | We are not sure specifying some limitations is necessary. |
| Intel | As noted by FL, the TBS is calculated on the whole resources allocated for the TBoMS, so the self-decodability is proven only for the whole TBoMS with continuous rate-matching of single RV.  The self-decodability for any time unit less than TBoMS can be ensured only for low enough coding rates. Agree with Apple, as PUSCH repetition type A like resource allocation is agreed to TBoMS, so TBS should be determined based on the number of slots assigned for TBoMS.  At the same time, the need of the self-decodability for time unit less than TBoMS should be discussed from the coverage enhancement perspective, considering the fact that it can decrease the decodability of the whole TB.  FL’s reply: I agree. In fact, as explained above, with current MCS tables, if no modification is introduced to Option 4, only a very limited slots may be allocated for TBoMS without incurring performance degradation due to the RV cycling, or very small TBS can be supported. |
| Panasonic | These are managed by the gNB scheduler and it is not required to have the specification limitation. When TBoMS is used for the retransmission after NACK reception at gNB, self-decodability is not essential.  FL’s reply: please see my reply to Samsung. |
| Qualcomm | Not too sure of the intent here. For TBoMS, due to TBS scaling, we’ll necessarily have to consider self-decodability at the granularity of a subset of slots. For poor choices of MCS and TBS scaling, it may not be possible to ensure self-decodability.  This is an issue that affects both Option 3 and 4 depending on which subset of slots we choose to focus on. Its one of the reasons why an RV refresh every few slots may be useful to consider.  FL’s reply: according to my understanding the problem of self-decodability as such is ill posed. Neither of the two Options can guarantee self-decodability per slot or per TOT, all the times. It’s a case-by-case situation. What we can say though is that Option 4 can result in performance degradation if more than a certain number of slots are allocated to TBoMS (for instance, if R16 numbers for PUSCH repetition type A are reused). This is what we should probably agree on first. Please see my comments/proposal below. |
| Vivo | It can be up to NW to ensure the decodability. For option-4, only decodability of a whole TBoMS, which is composed of multiple TOTs, are needed. Ensuring decodability for a TOT in a TBoMS is not necessary. |
| ZTE | Basically, we are aligned with Intel. |
| CATT | We have understanding that the coding rate or scaling factor need to be restricted, or new RV definition (or rules) is needed, if we have to make sure the TBoMS is self-decodable. Otherwise, as long as that the TBS of TBoMS is calculated based on K slot and RV0 is transmitted in K2 slot (K2 < K), self-decodability may have problem. |
| OPPO | Self-decodable per TBoMS may be needed. However, it is not necessary for the slot/TOT level.  We accept the option 4 may have this consideration and the criteria should not be based on that. |
| Ericsson | Our simulation result shows for option 4 TBS determined by all slots of the TBoMS outperforms those when TBS is determined by one or some of all slots. But it risks TB decoding failure, if the number of slots for TBS determination is multiple times, e.g. 8, of the time unit of rate matching because too many systematic bits are not transmitted. However, it is not necessary to keep self-decodability for option 4 by limiting the scaling factor for TBS determination, otherwise the performance gain against PUSCH repetition type A vanishes.  FL’s reply: I agree. |
| Nokia/NSB | Any limitation on the scheduling flexibility should be avoided for TBoMS, at least on the TBS and the number of allocated slots, which are the two main motivations for specifying TBoMS, i.e., transmitting a larger TBS on a larger resource and extending resource in time-domain to compensate for the reduction of resource in frequency-domain for improving coverage by increasing the energy per RE. We have strong concerns related to this scheduling flexibility limitation, and if Option 4 is retained eventually, a solution to avoid such limitations should be specified (for instance what is suggested by Ericsson above in 2.1.2-Q2). In this context, self-decodability per slot does not seem a relevant aspect to consider for TBoMS, since it is not a PUSCH repetition, and we must ensure that the advantage of TBoMS over what can already be achieved in R16 is still observable (again agree with Ericsson on this) |
| Huawei, Hisilicon | Limiting the target maximum code or scaling factor for TBS determination is not a good choice. And it is not clear what is the meaning of “the number of RVs”. |
| WILUS | Specifying limitation is not a preferable choice to ensure self-decodability. |
| Fujitsu | In our view, self-decodability per slot for TBoMS does not contribute to coverage enhancement. Therefore, no need to make such comparison here. |
| MediaTek | Share the similar view as Samsung, option 4 will have larger opportunity to be self-decodable than that of option 3. Specially, Option 4 may enable the earlier decoding than Option 3 in case of large number of code blocks.  FL’s reply: I am not sure multiple code blocks is a very likely use case for coverage limited communications. Even if this were the case, we already know that this would likely break the RxK<=1 limitation and Option 4 (with no modifications) would incur performance degradation. Earlier decoding may then be attempted, but according to my understanding it is hard to speculate about BLER in this case, without simulating. |

**2.1.2-Q5**

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | The impact to UCI multiplexing will reply on two aspects: one is the timeline determination; the other is the number of UCI bits to be multiplexed. The later one will be related to the MCS and RE number (TDRA and FDRA), but also with the calculation methods for the UCI bit numbers; the first one will be related to if we want to change the timeline determination or not. E.g, if we follow current method, then obviously the per slot handling will be friendly. |
| Apple | If self-decodabilityis not available for Option 3. The re-transmission for Option 3 will use all the assigned slots for TBoMS, Option 4 re-transmission could just use the slots in one ToT.  FL’s reply: we have not agreed on whether and how re-transmission of TBoMS is supported. |
| Lenovo, Motorola Mobility | Yes, we agree with the statement |
| Panasonic | We are not clear on the meaning of the statement. The amount of the UCI resource usage may depend on how MCS, FDRA and TDRA are operated. On the other hand, UCI multiplexing and collision handling "procedure" would not depend on option 3 or option 4.  FL’s reply: I agree. The question was meant to highlight this aspect exactly, given that some companies stated that Option 3 (or 4) were more suitable for UCI multiplexing and collision handling for several reasons. |
| Qualcomm | Impact on aspects such a UCI multiplexing may be determined more by what we do with rate matching and less so on Option 3 or Option 4. With rate matching per slot, we are able to preserve all existing behavior with little to no cost.  FL’s reply: I agree. The question was meant to highlight this aspect exactly, given that some companies stated that Option 3 (or 4) were more suitable for UCI multiplexing and collision handling for several reasons. I am not sure that rate-matching per slot allows preserving all existing behaviour. However, it should indeed be the case for most, according to my understanding. |
| Vivo | Regarding UCI multiplexing and collision handling, option 4 may lead to finer time domain granularities for UCI multiplexing and relaxed timeline if timeline is check per slot/TOT.  For number of symbols for UCI multiplexing, it is not only related to TDRA, FDRA, MCS, but also beta-offset, alpha(scaling), and whether the number of REs for UCI is calculated in a finer time domain unit when option 3 or option 4 is considered. |
| ZTE | We think this is under the assumption that a suitable offset is applied to the coded bit selection in Option 4.  FL’s reply: yes. |
| CATT | Not sure. We think spec impact still need to be taken into consideration. If Option 4 requires to specify a lot of rules just for being close to Option 3 (e.g. offset for coded bit selection, or new RV definition), then Option 3 would be preferred. |
| InterDigital | We are not sure about “*UCI multiplexing and collision handling may depend on how MCS, FDRA and TDRA”.* Would it be possible to elaborate?  FL’s reply: The amount of the UCI resource usage may depend on how MCS, FDRA and TDRA are operated, as commented by Panasonic. How rate-matching is performed also impacts how straightforward UCI multiplexing and collision handling can be. |
| CMCC | The option 3 and 4 could be determined based on the discussion on self-decodability and repetition. And the multiplexing with UCI could based on the basic unit of option 3 or 4 as a starting point.  FL’s reply: most companies seem to disagree with this and I share similar view. The self-decodability per slot/TOT cannot be guaranteed in any of the two Options. Additionally, we have not agreed on whether and how repetitions of TBoMS are supported, hence I do not see how we could use this aspect to determine which Option should be retained. |
| OPPO | Hard to justify each option by that criteria. |
| Ericsson | Not exactly. In out simulation, we keep the same TBS and spectrum efficiency between the two options. More specifically, the same TDRA, FDRA and MCS are used if option 4 uses all slots for TBS determination. Otherwise, higher MCS index is used for option 4 is TBS is determined by smaller number, e.g. TOT size. |
| Nokia/NSB | Yes. In addition, it is worth noting that if Rel-15/16 RV cycling is applied across slots/TOTs for Option 4, then a single TBoMS can only be conveyed by maximum 4 slots/TOTs corresponding to the maximum 4 RV indices. The remaining slots/TOTs are just repetitions of the single TBoMS (without RV cycling in TBoMS level, since exactly the same encoded bits are repeated). Hence, it can be observed that:   * Limiting a single TBoMS to only maximum 4 slots/TOTs may not only lead to several technical issues as pointed out by many companies, but also go against the motivation for specifying TBoMS, as mentioned in our answer for Q4. * Integrating TBoMS repetition into the structure of a single TBoMS reduces the flexibility of designing both single TBoMS transmission (scheduling flexibility limitation) and TBoMS repetition (RV cycling per TBoMS cannot be applied). In contrast, proper solutions can be found if these two aspects are designed independently. |
| Huawei, Hisilicon | It is not clear what the intention of the question is. From our side, the UCI multiplexing depends on how the UCI will be multiplexed for TBoMS which is not clear for the time being, it is hard to judge whether there is advantage of one over the other.  FL’s reply: I agree. The question was meant to highlight this aspect exactly, given that some companies stated that Option 3 (or 4) were more suitable for UCI multiplexing and collision handling for several reasons. I am not sure that rate-matching per slot allows preserving all existing behaviour. However, it should indeed be the case for most, according to my understanding. |
| WILUS | We share the similar view with Qualcomm. UCI multiplexing is more related with rate matching.  FL’s reply: I agree. The question was meant to highlight this aspect exactly, given that some companies stated that Option 3 (or 4) were more suitable for UCI multiplexing and collision handling for several reasons. I am not sure that rate-matching per slot allows preserving all existing behaviour. However, it should indeed be the case for most, according to my understanding. |
| MediaTek | Considering UCI multiplexing, rate matching per slot is more preferred. |

FL’s comments on August 17th

Thanks for all your comments. This was a useful exercise and I added my reply to specific companies’ comments whenever needed, in the form of “FL’s reply” to company’s comments. I thus addressed all the questions asked to me and also provided further clarification in case I did not agree with what was stated. I invite all companies to have a quick look at the 5 table above to ensure you do not miss those comments. Some of decisions I will take in the following also depend on them. Thank you. More precisely, answers where given to these companies:

* 2.1.2-Q1
  + Apple
  + Vivo
  + ZTE
  + Huawei/HiSi
* 2.1.2-Q2
  + Apple
  + LGE
  + CATT
  + Ericsson
  + Huawei/HiSi
* 2.1.2-Q3
  + Samsung
  + Ericsson
  + MediaTek
* 2.1.2-Q4
  + Samsung
  + Apple
  + Lenovo/Motorola
  + Sharp
  + Intel
  + Panasonic
  + Qualcomm
  + Ericsson
  + MediaTek
* 2.1.2-Q5
  + Apple
  + Panasonic
  + Qualcomm
  + ZTE
  + InterDigital
  + CMCC
  + Huawei/HiSi
  + WILUS

From my perspective, we should avoid getting stuck on Option 3 and Option 4 and similar to what I proposed for the rate matching, we should focus on isolated pieces of the TBoMS and build the structure step by step. At this stage, I think that before progressing we should decide if **possible performance degradation experienced by the single TBoMS** is important or not (regardless of its interactions with other channels or signals, which will impact our decisions on rate-matching, UCI multiplexing and collision handling).

It has been shown by several companies, and acknowledged by many others that one of the most quantitative differences between using a single RV or multiple RVs to transmit a single TBoMS is a performance degradation observed in case multiple RVs are used and , where R is the nominal code rate and K is the multiplicative factor used to calculate the TBS (which scales the number of resources available in one slot allocated to TBoMS). As I said above, this would imply that a limit in terms of maximum number of configurable slots for Option 4 exists, for any given configurable code rate, if performance degradation is to be avoided. This limit would not exist if a suitable offset was applied to each RV id>0 during the bit-selection phase to ensure that the first bit selected from the circular buffer for any given slot is right after the last bit selected from the circular buffer for the previous slot. This limitation does not exist for Option 3.

Therefore, I think it would be good to agree on this aspect before continuing the discussion on the Options. In this context, it is worth highlighting once again that the source the performance degradation problem in Option 4, when this occurs, is how coded bits are selected from the circular buffer, i.e., the first step of the rate-matching. If too many systematic and/or parity bits are punctured (or alternatively, not selected for the bit-to-RE mapping after the interleaver), then performance can degrade. Scheduling limitations would then be imposed on gNB to ensure that no degradation occurs, in turn potentially affecting how gNB allocates resources for other UL channels/signals, depending on the limitations for TBoMS.

The following question is then asked.

**2.1.2-Q6**: *Performance degradation occurs for the single TBoMS, if Option 4 is used and , regardless of how interleaving is performed.* *Three alternative ways exist to address this problem:*

1. *Option 4 is adopted as described so far and gNB is subject to the limitation of never configuring a TBoMS such that , with all the corresponding scheduling limitations and impact on other UL transmissions.*
2. *Option 4 is modified with suitable bit offsets applied to each RV id>0 to ensure that the first bit selected from the circular buffer for any given slot is right after the last bit selected from the circular buffer for the previous slot. Option 4 is adopted.*
3. *Option 3 is adopted.*

Companies are invited to express their preference in the table below. A FL’s proposal will be formulated after this round of questions. I warmly invite all companies to consider the possibility of adding your name to the “Can live with” column, if applicable. We need to converge on this as soon as possible and constructive attitude of all will be fundamental to achieve this target.

A second table is also added to input further comments if any (for instance on the specification/implementation impact of each alternative, if applicable).

**Preference for 2.1.2-Q4**

|  |  |  |
| --- | --- | --- |
|  | First preference | Can live with |
| **Alt. 1** | Samsung (with more general statement) |  |
| **Alt. 2** |  |  |
| **Alt. 3** |  |  |

**Additional comments**

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | I think the statement in alt.1 is bit too strong and restrictive.   1. *Option 4 is adopted as described so far and gNB is subject to make proper configuration and scheduling ~~the limitation of never configuring a TBoMS such that , with all the corresponding scheduling limitations and impact on other UL transmissions.~~* |
|  |  |

### [OPEN] Rate matching (including how coded bits are selected)

Most contributions acknowledged the fundamental nature of this aspect and discussed it in detail. A high-level summary of companies’ preferences and views based on the contributions is as follows.

|  |  |  |
| --- | --- | --- |
| Per slot  [11 companies] | Per TOT  [7 companies] | Across all allocated slots for TBoMS [7 companies] |
| Panasonic [18] | Huawei/HiSi [3] | ~~vivo [6]~~ |
| Qualcomm\* [17] | LGE [28] | Ericsson [28] |
| NEC [25] | CMCC [12] | ZTE [5] |
| Samsung [19] | Apple [16] | China Telecom [11] |
| MediaTek [20] | Sharp\* [24] | Intel [15] |
| Sharp\* [24] | Fujitsu [10] | CATT [8] |
| Nokia/NSB [21] | WILUS [7] | Xiaomi [13] |
| Interdigital [14] | vivo [6] |  |
| NTT Docomo [26] |  |  |
| Lenovo/Motorola [27] |  |  |
| NEC [25] |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

Additionally, the following comments on how coded bits are selected have been made:

* Starting points of bit selections other than the first bit selection are right after encoded bits taken from circular buffer in the previous bit selection [4 companies]: NTT DOCOMO [26], Ericsson [28], Lenovo/Motorola [27], Panasonic [18].
  + In this context, one company (NTT DOCOMO) proposed that the starting point of bit selections should be calculated based on available slots for PUSCH transmission
* An offset factor for bit selection may be introduced [2 companies]: OPPO [9], Huawei/HiSilicon [3]

Finally, one company proposed that the index of the starting coded bit for each transmission occasion is predetermined prior to the start of the TBoMS transmission (Qualcomm [17]).

FL’s comments on August 16th

A majority exists in favor of one option (i.e., rate-matching per slot) but support for other options is non-negligible. On the other hand, almost all companies commenting on rate-matching aspects highlighted that selecting coded bits such starting points of bit selections other than the first bit selection are right after encoded bits taken from circular buffer in the previous bit selection should be supported. At times, this seems to contradict the preference some companies expressed for Option 4 in Section 2.1.2.

This brings me to say that differences may exist on how different companies model and think of rate-matching. This may cause confusion and possible misunderstandings. Like what I have done for Section 2.1.1 and 2.1.2, I would then formulate some questions to clarify these aspects, aiming at simplifying any further discussion.

According to TS 38.212, the rate matching for LDPC code is defined per coded block and consists of selecting and interleaving a sequence of bits selected from the circular buffer, where the N-sized bit sequence after encoding, i.e., , is stored. This is done in two steps, i.e., bit selection and bit interleaving. In this context:

* The result of **Bit selection** is impacted by decisions taken in Section 2.1.2, i.e., whether TBoMS transmission makes use of single or multiple RVs. Depending on that decision, discussions on possible optimized bit selections could take place.
* The result of the **Interleaver** does not depend on decisions taken in Section 2.1.2, but rather on decisions which impact the value of , that are the decisions on the time unit to be used for the rate matching. Of course, other parameters will also impact the value of , but those would be related to code rate, modulation order, FDRA and so on, i.e., aspects who impact which bits are rate matched but not the time unit over which they will be rate matched.

Therefore, it seems more appropriate to decouple the two steps of the rate matching to ensure we focus on what will actually impact the size of the output sequence of the rate matching function, i.e., , and not its content (which will depend on the bit selection, in turn depending on decisions related to the single TBoMS structure).

Given the above, the focus of the discussion is switched to the *interleaver* part of the rate matching for the time being.

#### First round of discussions

FL’s recommendation is to have a first round of discussion among companies about pros and cons of different interleaver options for TBoMS.

Four tables are added to this end. Companies are invited to list pros and cons of each solution, according to their understanding, in the first three tables below, the last column of each table is added for each company to provide analysis of implementation and specification impact. The fourth table is added for company to express an initial preference on one of the options and also indicate an alternative solution which could be acceptable, although not preferred, if applicable. Please do not hesitate to add your company’s name in the fourth table as well. Constructive attitude in this regard is greatly appreciated.

**Interleaver per slot**

( is calculated using the resources of one slot)

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Pros | Cons | Analysis of implementation and specification impact |
| Samsung | Less implementation impact  No complexity increase  No performance loss  The operation per slot will not impact the benefits of TBoMS in case whichever single/different RV are selected |  |  |
| Lenovo, Motorola Mobility | Similar views as Samsung |  |  |
| NTT DOCOMO | Small UE implementation problem | Performance is susceptible to which slots drop. If the slot where systematic bits are allocated drops, the performance gets worse than other units of interleaving. |  |
| Sharp | Less specification impacts. If the interleaver is per slot, UCI multiplexing and collision handling can reuse legacy behaviour. |  | No specification and implementation impact to the interleaver. |
| Intel |  | Performance loss is expected compared to rate-matching/interleaving per TBoMS due to time diversity, especially when considering TBoMS based on available slot. | It highly depends on how UE implements the rate-matching/interleaving. Implementation impact may be similar for both approaches:  For interleaving per slot, UE may still needs to store the encoded bits, and perform rate-matching per slot.  For interleaving per TBoMS, UE performs rate-matching per TBoMS and stores the interleaved bits, and transmits the stored encoded bits per slot. |
| Panasonic | This simplifies the TB generation/channel coding processing.  Simple design is possible for the handling of UCI multiplexing, the interaction of higher priority transmission, the reservation for SRS/PUCCH symbol in a slot. | Systematic bits may not obtain frequency diversity in case inter-frequency hopping is enabled. |  |
| Qualcomm | Same views as Samsung. |  |  |
| ZTE |  | Performance loss due to less time diversity;  Different UE implementation compared to legacy, where UE performs TBS determination, bit selection and interleaving for the same time unit, i.e., per slot. | For interleaving per slot, the UE needs to first generate the encoded bits based on all slots for TBoMS, while perform interleaving per slot.  For interleaving per TBoMS, the TBS determination, bit selection and interleaving are all based on all slots for TBoMS. |
| CATT |  | The interleaving depth is shallow and thus no as robust as the case of per TOT and per TBoMS. | Whether this is implementation friendly to a UE still depends on the TBoMS structure. The UE may still have to store the break point of the encoded bits when single RV is used.  Even if per slot RV is applied, UCI may not be handled in a unit of slot.  On the re-transmission, it is unclear since we may have to make CRC per slot in this case. |
| InterDigital | Robust performance against dynamic TDD, suitable for UCI-multiplexing or partial retransmission |  |  |
| Ericsson |  | When a slot of a TBoMS is dropped due to collision, interleaving per slot loses ~2 dB relative to interleaving per TBoMS as can be seen in figure 8 of R1-2107560. |  |
| Nokia/NSB | * The interleaver sizes are the same across slots as in Rel-15. * Rel-15/16 rules can be exploited as much as possible for aspects related to collision handling and power control. * RAN1 does not need to specify the concept of TOT. |  | The impact on implementation and specification is very low. |
| Huawei, Hisilicon |  | Larger number of systematic bits are placed in the first slot, and this will result in lower systematic bits time domain diversity. |  |

**Interleaver per TOT**

( is calculated using the resources of all allocated slots in a TOT)

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Pros | Cons | Analysis of implementation and specification impact |
| Samsung |  | Pls see the comments on below, similar concerns. |  |
| Apple | For option 4, it’s natural interleave is performed per ToT. |  |  |
| Sharp | We can see this solution as a compromised one. Time domain diversity can be increased. | Specification impacts are expected regarding UCI multiplexing and collision handling. | No specification impact to the interleaver. Memory consumption may increase when the unit of the interleaver is long in time domain. |
| Panasonic |  | Processing delay to generate whole PUSCH transmissions for TBoMS.  Complex design is required for how to handle UCI multiplexing and, the interaction with UL CI and higher priority transmission. |  |
| Qualcomm |  | Huge increase to UE complexity. | How to buffer interleaved bits across non-consecutive slots? How to handle UCI-multiplexing? What to do about unused bits in case of cancellations/UCI-multiplexing? Timelines get impacted. We need to revise many legacy rules on dropping/prioritization, etc. |
| CATT | A compromise between per slot and per TBoMS. |  | May need to define TOT, and subsequent handling of bit selection has specification impact. |
| CMCC | The complexity could be less than over TBoMS | Each TOT(multiple slots) could be self-decodable |  |
| Ericsson |  | When a slot of a TBoMS is dropped due to collision, interleaving per TOT loses ~1 dB relative to interleaving per TBoMS as can be seen in figure 8 of R1-2107560. |  |
| Nokia/NSB | Better time diversity property than interleaver per slot, if a TOT consists of more than 1 slot. | * Different interleaver sizes are needed if the number of slots per TOT is different across TOTs (this can happen). * Aspects related to collision handling and power control should be reconsidered. * RAN1 should specify the concept of TOT, which requires non-trivial efforts. | The impact on implementation and specification is high. The potential presence of different interleaver sizes is particularly problematic to handle.  Timeline and prioritization rules would also need to be rediscussed. Agreeing on how to perform UCI multiplexing would also require longer discussions. Simulations in this sense have not been made by many companies, hence decision would be taken based on “opinions and preferences”. This could take a long time and lead to ineffective results. |
| Huawei, Hisilicon | appropriate systematic bits interleaving depth and appropriate implementation complexity |  |  |
| WILUS | Compromise option that can address concerns of both per slot and across all allocated slots for TBoMS. |  |  |

**Interleaver over all allocated slots for TBoMS**

( is calculated using the resources in all allocated slots for TBoMS)

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Pros | Cons | Analysis of implementation and specification impact |
| Samsung |  | Need to carry/store all the input bits for the interleaving for all slots, might need to consume larger storage cost for hardware.  The processing procedure might need to figure out all the situation for all slots, in case of UCI multiplexing and cancellation. | Per slot:    Per TOT (2slots for a TOT)    Per all slots in a TBoMS (total 4 slots)    Apparently, the operation per all slots in a TBoMS or per TOT (when there are multiple slots per TOT) requires bigger changes to implementation in both hardware and software, without clear benefits. |
| Apple |  | decoding delay is longer comparing with other options |  |
| Sharp | Time domain diversity can be increased. | Specification impacts are expected regarding UCI multiplexing and collision handling. | Memory consumption may increase when the unit of the interleaver is long in time domain. |
| Intel | Best performance is expected compared to rate-matching/interleaving per slot/TOT, due to time diversity as mentioned above. | UCI multiplexing rule needs to be defined. |  |
| Panasonic |  | Processing delay to generate whole PUSCH transmissions for TBoMS.  Complex design is required for how to handle UCI multiplexing and, the interaction with UL CI and higher priority transmission. |  |
| Qualcomm |  | Huge increase to UE complexity. | How to buffer interleaved bits across non-consecutive slots? How to handle UCI-multiplexing? What to do about unused bits in case of cancellations/UCI-multiplexing? Timelines get impacted. We need to revise many legacy rules on dropping/prioritization, etc. |
| ZTE | Better performance due to more time diversity.  The similar signal generation procedure as legacy as commented above. | May impact the timeline for UCI multiplexing |  |
| CATT | Best performance theoretically, due to the possibility to have deepest interleaving. |  | UCI multiplexing may or may not be handled in the unit of slot. |
| Ericsson |  |  | Regarding complexity, it was said interleaving per slot has no complexity increase. This is by considering UCI multiplexing on TBoMS is done by rate matching PUSCH around UCI. Rate matching in one slot of a larger time unit than a slot may have impact on the transmission in other slots in the time unit, therefore we propose UCI multiplexing by puncturing, which is simpler than rate matching and doesn’t rely on time unit of rate matching.  No option guarantees self-decodability, therefore it is unjustified to say whether it has larger decoding delay. |
| Nokia/NSB | * Concern on different interleaver sizes does not exist. * RAN1 does not need to specify the concept of TOT. * Best performance in terms of time diversity. | Aspects related to collision handling and power control should be reconsidered. | Impact on implementation may be low (subject to further discussion).  Impact on specification may be high due to the fact that current spec operates according to a per slot logic. Additionally, timeline and prioritization rules would also need to be rediscussed. Agreeing on how to perform UCI multiplexing would also require longer discussions. Simulations in this sense have not been made by many companies, hence decision would be taken based on “opinions and preferences”. This could take a long time and lead to ineffective results. |
| Huawei, Hisilicon |  | 1. Largest decoding delay. |  |

**Time unit for the interleaver**

( is calculated using the resources in the time unit)

|  |  |  |
| --- | --- | --- |
|  | First preference | Can live with |
| **Per slot** | Samsung (also, strong concern on other two methods due to implementation impact), Lenovo, Motorola Mobility, DCM, Sharp, Panasonic, QC (very serious concerns on other two options), Nokia/NSB, MediaTek | Apple, vivo |
| **Per TOT** | Apple, LG (if Option 4 (multiple RVs) is applied), vivo, CMCC, Huawei, HiSilicon, WILUS, Fujitsu | DCM, Sharp, |
| **Over all allocated slots for TBoMS** | LG (if Option 3 (single RV) is applied), Intel, ZTE, CATT (with single RV), Ericsson, Fujitsu | DCM, WILUS |

FL’s comments on August 17th

Thank you all for the comments.

In terms of preferences, applying the interleaver per slot is supported by a relative majority of companies, with two of them expressing very serious concerns on the other two options). Interleaver per TOT and over all allocated slots for TBoMS have non-negligible support.

Situation is very heterogenous. At the same time, we can rely on what companies commented about the pros and the cons of each solution. I aggregated such views into two tables, one summarizing the PROS and one summarizing the CONS. Please find the result of this exercise below, where:

* point number 2 of the “per slot” part of the CONS table is highlighted in yellow, due to the fact that I am not sure I fully understand it. Given that no decision had been taken yet on many aspects mentioned in that bullet, I am not sure those implications can be made. Company who made that remark may want to clarify it.
* Point number 4 of the “per TOT” part of the PROS table is highlighted in yellows, due to the fact that I am not sure I understand what “appropriate” means in this context. I am not sure the notion of “appropriateness” is the same for all companies, given that it depends on the specific implementation that is considered to assess that such “appropriateness” is there.

**SUMMARY OF PROS**

|  |  |
| --- | --- |
|  | Summary of companies’ views on pros aspects for each rate-matching approach |
| **Per slot** | 1. Less implementation impacts 2. Less specification impacts 3. No additional complexity 4. No performance loss 5. The operation per slot will not impact the benefits of TBoMS regardless of whether single or different RV are selected 6. UCI multiplexing and collision handling can reuse legacy behaviour 7. This simplifies the TB generation/channel coding processing. 8. Simple design is possible for the handling of the interaction of higher priority transmission, the reservation for SRS/PUCCH symbol in a slot. 9. Robust performance against dynamic TDD, suitable for UCI-multiplexing or partial retransmission 10. The interleaver sizes are the same across slots as in Rel-15. 11. RAN1 does not need to specify the concept of TOT. |
| **Per TOT** | 1. Time domain diversity can be increased. 2. A compromise between per slot and per TBoMS. 3. The complexity could be less than over TBoMS 4. Appropriate systematic bits interleaving depth and appropriate implementation complexity |
| **Over all allocated slots for TBoMS** | 1. Time domain diversity can be increased. 2. Best performance is expected due to time diversity and deepest interleaving. 3. The similar signal generation procedure as legacy. 4. Concern on different interleaver sizes does not exist. 5. RAN1 does not need to specify the concept of TOT. |

**SUMMARY OF CONS**

|  |  |
| --- | --- |
|  | Summary of companies’ views on cons aspects for each rate-matching approach |
| **Per slot** | 1. Performance loss is expected due to lower time/frequency diversity (especially on the systematic bits). 2. Different UE implementation compared to legacy, where UE performs TBS determination, bit selection and interleaving for the same time unit, i.e., per slot. 3. The interleaving depth is shallow and thus not as robust as the case of per TOT and per TBoMS. 4. When a slot of a TBoMS is dropped due to collision, interleaving per slot loses ~2 dB relative to interleaving per TBoMS as can be seen in figure 8 of R1-2107560. |
| **Per TOT** | 1. Need to carry/store all the input bits for the interleaving for all slots, might need to consume larger storage cost for hardware. 2. Specification impacts are expected regarding UCI multiplexing, collision handling and power control. 3. Processing delay to generate and decode whole PUSCH transmission per TOT. 4. Huge increase to UE complexity. 5. When a slot of a TBoMS is dropped due to collision, interleaving per TOT loses ~1 dB relative to interleaving per TBoMS as can be seen in figure 8 of R1-2107560. 6. Different interleaver sizes are needed if the number of slots per TOT is different across TOTs (this can happen). 7. RAN1 should specify the concept of TOT, which requires non-trivial efforts. |
| **Over all allocated slots for TBoMS** | 1. Need to carry/store all the input bits for the interleaving for all slots, might need to consume larger storage cost for hardware. 2. Specification impacts are expected regarding UCI multiplexing, collision handling and power control. 3. Processing delay to generate and decode the whole PUSCH transmissions for TBoMS. 4. Huge increase to UE complexity. |

From where I stand and parsing the comments above situation seems rather clear to me.

* **Interleaver per slot** enables the reuse of most of the existing logics and implementations. It offers simpler TB processing (very similar to legacy), robustness to be used with dynamic TDD, quite intuitive and likely very close (if not identical) handling of collisions and UCI multiplexing. It is compatible with both Option 3 and Option 4 in Section 2.1.2 with no specific optimization and does not require the concept of TOT to be specified. I think it is safe to say that according to companies, this seems to be the solution with the lowest specification and implementation impact, while still meeting the target for TBoMS. Price to pay for this is the limit in terms of maximum time diversity that can be harnessed by this approach (performance loss has been reported to be a round 2 dBs).
* The practically relevant advantages brought by **interleaver per TOT** and **across all allocated slots** for TBoMS are the following:
* Interleaver per TOT and across all allocated slots for TBoMS mainly offer advantages in terms of performance, due to the larger time diversity they can exploit thanks to the longer interleaver period.
* Interleaver over all allocated slots for TBoMS can also provide similar signal generation as for legacy approach (I assume in case Option 3 in section 2.1.2 is used, which is yet to be agreed on).
* Interleaver per TOT could have lower complexity than interleaver over all allocated slots for TBoMS.

Disadvantages brought by these two approaches seem to be much larger than the disadvantages brought by the interleaver per slot, according to companies’ comments, especially for what concerns the interleaver per TOT.

Given the above, I think it is fair to say that the trade-off between pros and cons is favourable to interleaver per slot. Arguments in favour in the other two approaches may be less relevant in the context of TBoMS, where the arguable performance loss of interleaver per slot due to time/frequency diversity reduction can be mitigated by configuring a suitable TBS and MCS. I think it is also fair to say that, differently from the decodability problem we are discussing in 2.1.2, herein the possible performance reduction would not be due to a structural issue of the solution, but rather to a less advanced approach to one aspect of it (i.e., the interleaver).

In this sense, my FL’s recommendation would be to agree on **interleaver per slot**. At the same time, I understand that some companies may want to still discuss about a different time unit for the interleaver before taking a final decision. While not ideal, it would be affordable for the time being, provided that we down-select one of the two other approaches, to then agree that only one approach will be selected before RAN1 #106-e ends. My choice in this sense would be the **interleaver across all allocated slots for TBoMS** for the following reasons:

* It is the one which offers the best time-frequency domain diversity harnessing potential (which is highlighted as a CON for the “per slot” approach).
* Similar to the “per slot” approach, it does not require the definition of the TOT.
* Specification impact seems lower than the “per TOT” approach and does not suffer from issues due to possible different TOT sizes.
* Implementation impact may not be much larger than the “per TOT” approach, given that in both cases the existing “per slot” logic would have to be changed.

The following proposal is then formulated.

**FL’s proposal 6**

**For the rate-matching of TBoMS, RAN1 to downselect during RAN1 #106-e only one of these two options:**

* **Bit interleaving is performed per slot.**
* **Bit interleaving is performed over all the allocated slots for TBoMS.**

**FFS: further details.**

Companies are invited to input their views in the table below. understand that some company may not be happy with this proposal, but we need to advance on this. As usual, constructive attitude is highly appreciated, and additional comments can be added in the second table, if any.

|  |  |
| --- | --- |
|  | Company name |
| **Support FL’s Proposal 6** | Samsung (for the sake of progress step by step) |
| **Does not support FL’s Proposal 6** |  |

**Additional comments**

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | When read the cons that per slot operation could have 2dB loss comparing the over-all-slots. We are actually not surprised after we looked at the figure 8 in proponent contribution. Because that simulation is very carefully selected (e.g., single RV and the first UL slot to be dropped, and also the bit size to be dropped) to show the so called “benefit”, we appreciate the effort from proponents for figure 8, but that result is easy to predict, we can also find in another situation, the gain will be in per slot operation.  When single RV and first UL slot among the 4 UL slots is dropped, the systematic bits will be mainly in the first slot. Then in this “first slot to be dropped” situation, of course the over-all-slot operation will be better since some of the systematic bits are transferred to other slots. But this is just one single situation among many possible situations. What will be the performance comparison of 2 last slots to be dropped? It can be expected, some systematic bits dropped due to the same reason, while per-slot operation can avoid such situation. And considering the odds that the first slot will be actually less possibly to be dropped due to the cancellation timeline processing. |
|  |  |

### [OPEN] Whether and how to use the S slot

Observations on how S slots should be handled in the context of TBoMS are provided in different forms in several contributions. A high-level summary of companies’ preferences and views based on the contributions is as follows.

* Three companies (MediaTek [20], China Telecom [11], CMCC [12]) proposed that UL symbols in the special slots should be used for TBoMS and the indication of these symbols should be supported.
* One company (ZTE [5]) proposed that no optimization specific for the use of special slot in TDD is pursued.
* One company (Panasonic [18]) proposed that if the special slot, where one of the symbols indicated by TDRA for a PUSCH in the slot overlaps with the semi-static symbol not intended for PUSCH transmission, needs to be supported, simple modification of PUSCH repetition Type A framework should be supported. Following options should be considered.
  + Option 1: SLIV for special slot is additionally configured for TDRA entry. In normal slot, current SLIV is used and in special slot, SLIV for special slot is used.
  + Option 2: Current SLIV is used even in special slot, while PUSCH resource for special slot is obtained from the symbols indicated by TDRA but not collided with non-UL symbols in the slot.
* One company (Ericsson [22]) proposed that the net gains and use cases of TBoMS support for special slot with different number of UL symbols than that in UL slot for the TB should be carefully studied prior to specifying it.
  + Such study should address how SRS and PUCCH can be transmitted as well as the performance of interference suppression when DMRS in a special or normal uplink slot is used for interference suppression in the other type of slot.
  + If specified, and performance gains are targeted for this case, a TB over consecutive UL symbols in special slot and the following UL slot can be based on PUSCH repetition type-B like TDRA.

FL’s comments on August 16th

From FL’s perspective, and as argued during RAN1 #104-b-e and RAN1 #105-e, the use of S slot for TBoMS is not precluded by current agreements.

No company has argued against this understanding. At the same time, there is no clear consensus on whether the use of S slots can bring non-negligible performance gains, and whether use cases for it are relevant. Indeed, some additional resources for TBoMS could be found in the S slot. From FL’s perspective, no company claims the opposite in the submitted contributions. However, the extent of the actual performance gain one could expect from the S slots, if optimizations targeting its use are considered, seems to depend on the slots structure, on how many slots one can use for TBoMS and which starting slot is used, as evident from the plots in [3]. In some cases, and as argued in [22], using the S slot could lead to a loss of resources, e.g., if DDDSU slot structure is used and 3 slots are allocated to TBoMS one S slot and one U slot (DDD**SU**DDSU) could be used instead of 2 U slot (DDDS**U**DDDS**U**). Further observations found in [3] and [22], and other contributions, highlight that optimizations targeting the use of the S slot would impact aspects such as DMRS mapping type, DMRS positioning, rate matching, TBS determination, UCI multiplexing, power control, coexistence with other channels/signals and so on. This would bring additional and likely non-negligible specification and implementation impact which many companies find unjustified by the arguable, but not deterministic, coverage gain brought by using S slots together with the U slots.

From FL’s perspective, this issue has been open and discussed for way too long. This is unfortunate, since it is clearly not a fundamental issue which can determine the success of TBoMS as a feature or not. It is an optimization over which consensus cannot be reached. Furthermore, and as discussed in other sections, this issue is blocking several other discussions for which progress would be much faster if we closed it. Given the very limited time left before the end of the WI, it must then be resolved during this meeting, to allow the group to move forward with more fundamental aspects of the design.

#### First round of discussions

Given the above analysis of what companies have provided so far, I would ask companies to focus on the technical aspects of the matter and provide technical comments in these regards. Specific focus should be put on the following three items (guidelines explaining how to discuss about them are given):

* **Performance increase/reduction**. Please note that any statement without supporting evidence cannot be expected to be retained by FL. At this stage of the WI, it is expected that companies against or in favor of this optimization can provide such evidence, e.g., simulation results, constructive examples, or counterexamples, and so on.
* **Specification impact**. The list above stems from observations companies made in the submitted contributions. Other aspects can be added, if needed. Similar to the performance increase, supporting evidence should be given as well. This may not come in the form of precise reference to specification, but to how the impact can be isolated and characterized.
* **Implementation impact**. Any relevant observation related to implementation impacts expected at both UE and gNB, given how current operations are performed, can be added. Example of description of implementation impact have been provided in the previous meeting, e.g., how the device handles slot boundary event. This is considered sufficient by FL for the observation to be retained.

All companies are invited to respond and comment on what is stated by other companies in the three tables below (one per analyzed item). Direct questions can be asked. If your company receives a question, please ensure you provide an answer. This would help the group converging faster. The goal is to have a technical discussion such that the most reasonable and sensible direction to solve this use can be identified.

Constructive attitude in this regard is greatly appreciated.

**Performance increase/reduction brought by supporting optimizations targeting the use of S slots for TBoMS**

|  |  |
| --- | --- |
| Company | Analysis of performance increase/reduction |
| InterDigital | Utilizing extra uplink resources in the special slot, modulation and coding can be optimized as shown in R1- 2009583, Figure 10. |
| CMCC | Additional resources could be used for the TBoMS compared with the case without the special slot. Both data rate and available time domain resources for TBoMS could be increased. |
| Ericsson | As we show in R1-2107561 figure 10, while jointly estimated DMRS in special slot can theoretically improve channel estimation performance slightly, in a fair comparison, where the total amount of system resources used by the UE is kept unchanged and 14% of the UL is needed for A/N or SRS, we found no net gains from having DMRS in special slot. |
| Huawei, HiSilicon | An example is given in our contribution and shown above as well. In this example, there are 14% increases of available time domain resources for uplink transmission.  In addition, the performance of using special slots analysed under the same available slots in [22] is not fair. It should be analysed under the same delay (or physical slots), as shown above. |

**Specification impact of supporting optimizations targeting the use of S slots for TBoMS**

|  |  |
| --- | --- |
| Company | Analysis of specification impact (if any) |
| Apple | If the S slot is used for TBoMS, it could be semi-stacit indicated. At the same time, SRS is configured in the special slot. In this case, the additional calculation on available symbols in the special slot would be required, for example skipping the symbols for SRS transmission or dropping/ignore the SRS transmission, in either way, the gain of transmission on S slot is lower than the expectation. |
| Qualcomm | We’ll need separate TDRA configurations to support S slots. Depending on what the proponents have in mind, we’ll need to consider L>14 in the SLIV. DMRS in S slot needs to be resolved. Determining availability of slots for TBoMS needs to scoped out. |
| ZTE | It needs to specify how to indicate the number of symbols used in S slots, the impact on TBS determination (i.e., scaling factor K), impact on UCI multiplexing (e.g., whether orphan symbol is valid for multiplexing), potential new DMRS design..., and so on. |
| CATT | Need to specify new TDRA method for allocating different symbols in ‘S’ slot and ‘U’ slot. Need to specify special DMRS handling in this case. Need to consider how to precisely calculate TBS based on the different assumption (whether ‘S’ slot is the first slot of the TBoMS or not) |
| InterDigital | A new entry in TDRA configuration to indicate TBoMS. DMRS position in the special slot is another possible specification impact. |
| CMCC | The special slot could be combined with the following normal uplink slot(s) and determined as an TOT. The detailed design could be further discussed. |
| OPPO | The gain would also be the same in Type A repetition enhancement. We would like consider them together, but the agenda 8.8.1.1 have no conclusion. |
| Ericsson | Concerns mentioned above in the FL summary of the use of the S slot such as impacts on DMRS, rate matching, TBS determination, UCI multiplexing, coexistence with other channels/signals etc. could be relevant depending on the optimizations.  More specifically, optimization of S slots indicating a different number of UL symbols in S slot in TDRA could be allowed. As to the particular number, a separate TDRA may be needed. Whether the special slot is counted in the number of slots, for TBS determination also needs consideration. |
| Nokia/NSB | Agree with all the aspects listed by the FL.  It is also worth noting that RAN1 has been making a good progress by adopting the PUSCH repetition-type-A-like option for time-domain resource allocation (TDRA) of TBoMS. The whole motivation of that agreement is to simplify the discussion on TDRA and avoid specification efforts on indicating different symbols per slot (and the related issues, e.g., DM-RS allocation, collision handling, rate-matching, etc.). At this stage, supporting further optimization on the use of S slots would go against the previous agreement and remove all good progress that the whole group had so far on TDRA for TBoMS. We do not see any substantial and irrefutable gain that can justify such effort. |
| Huawei, HiSilicon | 1. An additional SLIV can be introduced to indicate time domain resource allocation for special slots for TBoMS. 2. The PUSCH mapping type for special slots can be PUSCH mapping type B. In other words, DMRS positions can be determined using legacy mechanism. 3. The definition of scaling factor K should just further consider the symbols of special slots and uplink slots. 4. In our understating, there is possibly no impacts on rate matching, UCI multiplexing, power control, if special slots are used for TBoMS. |

**Implementation impact of supporting optimizations targeting the use of S slots for TBoMS**

|  |  |
| --- | --- |
| Company | Analysis of implementation impact (if any) |
| Qualcomm | Not specific to S slots, but rate matching across slots leads to significant implementation impact. |
| Huawei, HiSilicon | In our understating, there is possibly no impacts on rate matching, UCI multiplexing, power control, if special slots are used for TBoMS. The procedure can reuse the procedure in discussion, e.g. rate matching. |
|  |  |

FL’s comments on August 17th

Thank you for your comments. I have aggregated all comments in three tables, to simplify further elaboration. Please find them here. Other FL’s comments are added below them.

**SUMMARY OF PERFORMANCE INCREASE/REDUCTION**

|  |  |
| --- | --- |
|  | Summary of companies’ views on performance increase/reduction when supporting optimizations targeting the use of S slots for TBoMS |
| **Gain** | 1. Modulation and coding can be optimized as shown in R1- 2009583, Figure 10. 2. Both data rate and available time domain resources for TBoMS could be increased thanks to the additional resource. 3. There are 14% increases of available time domain resources for uplink transmission. |
| **No gain** | 1. The total amount of system resources used by the UE is kept unchanged and 14% of the UL is needed for A/N or SRS, we found no net gains from having DMRS in special slot as shown in R1-2107561, Figure 10. 2. The gain of transmission on S slot is lower than the expectation due to the presence of SRS in the S slots. |

**SUMMARY OF SPECIFICATION IMPACTS**

|  |  |
| --- | --- |
|  | Summary of companies’ views on specification impacts of supporting optimizations targeting the use of S slots for TBoMS |
| **No impact/positive impacts** | 1. Possibly no impacts on rate matching, UCI multiplexing, power control, if special slots are used for TBoMS. 2. DMRS positions can be determined using legacy mechanism. 3. The S slot could be combined with the following normal U slot(s) and determined as a TOT. |
| **Negative impacts** | 1. The additional calculation on available symbols in the special slot would be required due to the presence of SRS or other channels in the S slots. 2. Separate TDRA configurations are needed to support S slots. 3. L>14 in SLIV may need to be considered. 4. Aspects related to DMRS allocation in S slot need to be resolved. 5. Aspects related to the determination of available slots should also consider S slots. 6. Aspects related to rate-matching need to be resolved. 7. Impact on TBS determination (complication on defining the scaling factor K, complication when the first slot is “S” slot). 8. Impact on UCI multiplexing (whether orphan symbol is valid for multiplexing). 9. further optimization on the use of S slots would go against the previous agreement and remove all good progress that the whole group had so far on TDRA for TBoMS, which aimed to simplify the discussion/specification impact on TDRA. |

**SUMMARY OF IMPLEMENTATION IMPACTS**

|  |  |
| --- | --- |
|  | Summary of companies’ views on implementation impacts of supporting optimizations targeting the use of S slots for TBoMS |
| **No impact** | Possibly no impacts on rate matching, UCI multiplexing, power control, if special slots are used for TBoMS. The procedure can reuse the procedure in discussion, e.g. rate matching. |
| **Negative impacts** | Rate matching across slots leads to significant implementation impact (comment is not specific to S slots). |

Unfortunately, not all comments are based on quantitative evidence or explanatory examples. Most of them are intuitive and self-explanatory, but some of them are not. It is rather difficult for me to retain them. It would not be very fair, given that we are trying to tackle down this problem seriously.

For instance, it is in my opinion to be expected that using the S slot could impact at least:

* UCI multiplexing (this depends on how bits are mapped between S and adjacent U slots, especially if SLIV>14 is considered).
* Power control (if same ofdm symbol is used for transmitting both SRS and TBoMS, for instance, then power per RE of TBoMS in the S slot could be different from the power of each RE in the U slot).
* Rate-matching (if SLIV>14 is used can per slot rate-matching be used with no modifications? This is not trivial and current operations are performed per slot, hence a change to accommodate other logics would be needed).
* DMRS allocation in S slot (this would depend on how the resources in the S slot are determined. If PUSCH mapping type B is used, this requires two SLIVs to be conveyed to the UE and the available resources in the S slot may be reduced [which are already reduced by A/N and SRS as shown in R1-2107561]).

Are the above fundamentally unsolvable problems? Not at all. I think RAN1 has sufficient tools to solve then if a strong justification exists and time allows it. The strong justification does not seem to be there, according to companies’ comments. Simulation results have been provided to show that the actual resource increase may not occur if concurrent signals in the S slot are considered. Even assuming that this problem does not occur every time, the amount of the additional resources that could be found in the best case does not seem sufficient to most companies to justify the work that RAN1 would need to do to achieve this result. This brings me to the time constraint we have, given by the very few meetings left in this WI, and considering all other long-standing issues that we are still working out. Had we progressed differently in those issues, my recommendation would be different, but at this stage my recommendation can only be to go with majority view (which is clear). I understand this is sub-optimal for few companies. On the other hand, opinions of all other companies have not changed since last time and there is no reasonable middle ground to be found here, given that the decision is binary.

For all the above reasons I propose to modify the WA of RAN1 #105-e as follows and turn it into an agreement.

**FL’s proposal 7**

**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.**

Companies are invited to input their preference in the table below. This counter will be then be communicated to Mr. Chairman when this proposal will be brought online, together with the analysis the group performed during the first round. Constructive attitude is highly appreciated.

|  |  |
| --- | --- |
|  | Company name |
| **Support FL’s Proposal 7** |  |
| **Does not support FL’s Proposal 7** |  |

## Mid priority aspects

Five mid priority aspects are identified at the beginning of the meeting:

1. How to count slots for transmitting TBoMS: available vs. consecutive
2. How to indicate the number of allocated slots for TBoMS
3. UCI multiplexing & collision handling
4. TBS determination: calculation
5. TBoMS repetitions

Significant attention has been given by several companies to such aspects in the submitted contributions. Although arguably less paramount at this stage of the discussion, they have been included here and will be discussed when need arises, regardless of how many high priority aspects are still being discussed. Summary, discussion, and FL’s comments/proposals on these aspects are provided in the following different sub-sections, whose numbers are given in the list above.

### [OPEN] How to count slots for transmitting TBoMS: available vs. consecutive

Most contributions acknowledged the fundamental nature of this aspect and proposed that available slots should be used for counting the number of slots allocated for TBoMS. A high-level summary of companies’ preferences based on the contributions, is as follows:

* The number of slots allocated for TBoMS is counted based on the available UL slots [7 companies]:
  + Nokia/NSB [21], Panasonic [18], Ericsson [22] (if TBoMS with more than 2 slots is to be supported), Intel [15], Apple [16], Sharp [24], NTT DOCOMO [26]

FL’s comments on August 16th

Situation seems rather clear from FL’s perspective. The following proposal is then formulated.

**FL’s proposal 1**

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

**FFS: details of available slot determination**

#### First round of discussions

FL’s recommendation is to have a first round of discussion about **FL’s proposal 1**. Companies are invited to input their views in the corresponding table below. Constructive attitude in this regard is greatly appreciated. In this sense, if you cannot support the proposal, please propose an alternative formulation which takes into account the current spirit.

**Views on FL’s proposal 1**

|  |  |
| --- | --- |
| Company | Views |
| Samsung | The FFS point actually opens a big window for this issue: whether this available slots to be like that discussed in sub-agenda 8.8.1.1 or in sub-agenda 8.8.3, or a new one? |
| Apple | We support Proposal 1. |
| Lenovo, Motorola Mobility | We support FL’s proposal 1 |
| NTT DOCOMO | Support the proposal. |
| Sharp | Support for unpaired spectrum. |
| LG | We are ok with the proposal. |
| Intel | We support Proposal 1 in principle.  Our view is that we should reuse the mechanism for PUSCH repetition type A based on the available slots. So it would be good to add the following as sub-bullet  “reusing the mechanism as defined for PUSCH repetition type A based on available slots”. |
| Panasonic | We support the FL’s proposal. |
| Qualcomm | Okay with Proposal 1 but would prefer to tighten it to reuse AI 8.8.1.1’s framework. |
| Vivo | Support. |
| ZTE | Fine with the proposal, and support the suggestion from Intel. |
| CATT | Support FL’s proposal. We think the definition of available slot can follow the one in AI 8.8.1.1. |
| InterDigital | We support the FL’s proposal and ok with the Intel’s modification. |
| CMCC | Support the proposal |
| TCL | Support the proposal. |
| OPPO | Support. |
| Ericsson | Support |
| Nokia/NSB | Support. |
| Huawei, HiSilicon | Support the proposal. |
| WILUS | We support the proposal. |
| Fujitsu | Support |

FL’s comments on August 17th

Thank you for your comments. Situation looks reasonably stable already. I will modify the proposal according to the proposed modifications.

**FL’s proposal 1-v2**

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

* + **The mechanism for PUSCH repetition type A based on available slots, as defined in AI 8.8.1.1, is reused.**

Companies are invited to input further comments on **FL’s proposal 1-v2** in the table below **only if strong concerns exist**. In case no strong concern is expressed this proposal will be brought online during the GTW on Thursday,19th for approval.

**Additional comments on FL’s proposal 1-v2**

|  |  |
| --- | --- |
| Company | Comments |
| Samsung | The outcome in AI8.8.1.1 is not finizaed yet, we would like to wait a little while to see how it goes. |
|  |  |

### [PAUSED] How to indicate the number of allocated slots for TBoMS

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

* **Indication of the number of allocated slots for TBoMS:**
  + A new column is configured in TDRA table [7 companies]:
    - Huawei/HiSi [3], ZTE [5], Samsung [19], CATT [8], Sharp [24]
    - Vivo [6] (to indicate only the number of slots per TOT, the number of TOTs is separately configured)
    - LGE (indication could be for number of slots or TOTs)
  + Reuse the number of repetitions indicated by TDRA for PUSCH repetition type A [4 companies]:
    - Lenovo/Motorola [27] (if PUSCH repetition is not allowed when TBoMS feature is enabled), OPPO [9], Qualcomm [17], LGE [28] (If repetition is not applied for TBoMS)
  + Configure a separate TDRA table for TBoMS:
    - TCL communications [4]
* **Candidate values for the number of allocated slots for TBoMS:**
  + Nokia/NSB [21]: {[1], 2, 3, 4, 7}
  + ZTE [5]: {1, 2, 3, 4, 7, 8, 12, 16}
  + Apple [16]: maximum number is 8

The following was also additionally proposed:

* One company (CATT [8]) proposed further studying the configurable set of values for the number of slots.
* Three companies (Fujitsu [10], Qualcomm [17], Sharp [24]) proposed supporting TBoMS for both DG and CG.

FL’s comments on August 16th

Views on this aspect are rather heterogenous. From FL’s perspective, this discussion seems to depend on the decisions which will be taken on at least four other aspects:

* Whether and how to use the S slot.
* Single TBoMS structure (concerning the maximum number of configurable slots).
* How to count slots for transmitting TBoMS.
* Whether TBoMS repetitions are supported,

Where decision on whether TBoMS repetitions are supported depends on the four structural aspects of TBoMS above. This shows that deciding on such structural aspects during #106-e is paramount. We cannot afford leaving the four aspects open after this meeting. Several other aspects are blocked by them. Conversely, decision on how to count slots for transmitting TBoMS seems less controversial at this stage (please see Section 2.2.1).

Having said this, using one TDRA table column to indicate the number of allocated slots for TBoMS is already agreed on. For this reason, the following two proposals are formulated, as first further step to progress on this topic, one based on some conditions related to TBoMS repetitions. Further steps can be taken when decisions on the other discussions are finalized (hopefully during RAN1 #106-e).

|  |
| --- |
| **FL’s proposal 2**  **Indication of the number of allocated slots for TBoMS is performed based on the existing TDRA table configured via *PUSCH-TimeDomainAllocationList-r16* as follows:**   * **If TBoMS repetitions are not supported: reuse the existing column for configuring the number of repetitions in the TDRA for PUSCH repetition type A, i.e., *numberOfRepetitions-r16*.** * **If TBoMS repetitions are supported: a new column is configured in TDRA table**   **FFS: which and how many values for the number of allocated also for TBoMS can be configured**  **FFS: whether TBoMS are supported.** |

|  |
| --- |
| **FL’s proposal 3**  **TBoMS is supported for both configured grant and dynamic grant.**  **Note: Indication of the number of allocated slots for TBoMS is performed based on the existing TDRA table configured via *PUSCH-TimeDomainAllocationList-r16*.** |

#### First round of discussions

FL’s recommendation is to have a first round of discussion about **FL’s proposal 2** and **FL’s proposal 3**. Companies are invited to input their views in the corresponding tables below. Please remember that the goal is to advance as much as we can, given current agreements in other discussions, without hindering possible further refinements, e.g., range of configurable values for the number of allocated slots and so on. Therefore, constructive attitude in this regard is greatly appreciated. In this sense, if you cannot support the proposal, please propose an alternative formulation which takes into account the current spirit.

**Views on FL’s proposal 2**

|  |  |
| --- | --- |
| Company | Views |
| Apple | For the first bullet in Proposal 2, the field of *numberOfRepetitions-r16* is reused by TBoMS, does that mean TBoMS re-transmission is only by TBoMS, not by repetition, or not by single DCI scheduling without repetition? |
| Lenovo, Motorola Mobility | Does the note preclude the possibility of TBoMS with repetition, where the number of repetitions can be dynamically indicated? |
| NTT DOCOMO | Since multiple RV for single TBoMS can be viewed as TBoMS repetitions where single TBoMS consists of single RV. we prefer to replace “TBoMS repetitions” with “TBoMS repetitions or multiple RVs for single TBoMS” in proposal. |
| Sharp | We are OK with FL proposal. I guess that the last FFS should be “whether TBoMS ***repetitions*** are supported”. |
| Intel | We are fine with the proposal 2 in principle. We are fine with the main bullet, but suggest to put the sub-bullet as FFS given that repetition for TBoMS is still not decided. Also it is not clear the last sub-bullet “whether TBoMS are supported” means here.  **Indication of the number of allocated slots for TBoMS is performed based on the existing TDRA table configured via *PUSCH-TimeDomainAllocationList-r16* ~~as follows~~:**   * **FFS details** * **~~If TBoMS repetitions are not supported: reuse the existing column for configuring the number of repetitions in the TDRA for PUSCH repetition type A, i.e.,~~ *~~numberOfRepetitions-r16~~*~~.~~** * **~~If TBoMS repetitions are supported: a new column is configured in TDRA table~~**   **FFS: which and how many values for the number of allocated also for TBoMS can be configured**  **~~FFS: whether TBoMS are supported.~~**  One clarification question: if UE supports both TBoMS and PUSCH repetition type A, how does UE know whether TBoMS or PUSCH repetition type A is used? |
| Panasonic | We are fine with the FL’s proposal. |
| Qualcomm | We prefer to not have a dedicated table for TBoMS. A table that can accommodate entries for PUSCH or TBoMS with a simple reinterpretation of the fields/columns would be preferred. |
| vivo | Not sure whether number of slots of a TOT should be indicated in the TDRA table, if concept of TOT would be specified. Or concept of TOT would not be reflected in time domain resource determination, even if it is specified? |
| ZTE | If TBoMS with repetition is not supported, it means gNB only configures either TBoMS or repetition at a given time. Then, we wonder why gNB configures *PUSCH-TimeDomainAllocationList-r16* and then do some re-interpretation? Instead, gNB can directly configure a dedicated TDRA table for TBoMS.  In addition, there are lots of things are not clear to us:   1. Does this proposal mean the candidate number of slots for TBoMS is the same as *numberOfRepetitions-r16*? 2. What’s about the number of entries of the TDRA, the same as Rel-16? 3. Is the table is per DCI format configuration for non-fallback DCI as legacy? If so, it seems *PUSCH-TimeDomainAllocationList-r16* should be replaced by *PUSCH-TimeDomainResourceAllocationList-r16*   pusch-TimeDomainAllocationListDCI-0-2-r16 SetupRelease { PUSCH-TimeDomainResourceAllocationList-r16 }    pusch-TimeDomainAllocationListDCI-0-1-r16 SetupRelease { PUSCH-TimeDomainResourceAllocationList-r16 } |
| CATT | Support in principle. But ‘FFS: whether TBoMS are supported’ is unclear to us. Does it mean ‘FFS: whether TBoMS repetitions are supported’? |
| CMCC | Fine with the proposal. |
| TCL | Prefer to have a dedicated table for TBoMS. |
| OPPO | We also prefer to not have a dedicated table for TBoMS. The further detail of adding column should be FFS either. |
| Ericsson | Support the FL’s proposal, with CATT’s understanding that “repetitions” was omitted in “FFS: whether TBoMS repetitions are supported”. |
| Nokia/NSB | Support. We think there is a typo, i.e., a missing “repetitions” in the second FFS. |
| Huawei, HiSilicon | We think that the number of the slots for the TBoMS should be discussed together with the symbols allocation for each slots. And then we share the same view as Intel, that the existing TDRA table can be a starting point to indicate the number of the slots and the details can be FFS according to the first priority questions discussion. |
| Fujitsu | Fine with the proposal. |

**Views on FL’s proposal 3**

|  |  |
| --- | --- |
| Company | Views |
| Apple | We support Proposal 3. |
| NTT DOCOMO | Support the proposal. |
| Sharp | We are OK with FL proposal. |
| LG | We are ok with the proposal. |
| Intel | We support Proposal 3. |
| Panasonic | We are fine with the FL’s proposal. |
| Qualcomm | Support |
| vivo | Support. |
| ZTE | Support the main bullet while not for the note.  If I understand correctly, CG type 1 PUSCH, CG type 2 PUSCH activated by DCI 0\_0, and DG PUSCH scheduled by DCI 0\_0 all use Rel-15 TDRA table in Rel-16, instead of *PUSCH-TimeDomainAllocationList-r16*, which has 64 entries at maximum. This seems impossible to support such table at least for PUSCH activated or scheduled by DCI 0\_0.  Regarding the TDRA table selection, we think the Rel-15/16 rules can be reused as much as possible, summarized below per our understanding.  •Step 1: Determine the TDRA table.  •CG PUSCH type 1: Rel-15 TDRA table.  •DG PUSCH or CG PUSCH type 2: Per DCI format TDRA configuration  •DCI format 0\_0: Rel-15 TDRA table  •DCI format 0\_1/2: pusch-TimeDomainAllocationListDCI-0-2-r16, pusch-TimeDomainAllocationListDCI-0-1-r16. If Rel-16 TDRA is not configured, reuse Rel-15 TDRA table.  •Step 2: Determine the # of slots  •Use *numberOfRepetitions* if in the TDRA table; Else if, pusch-AggregationFactor if configured; Otherwise, no repetition. |
| CATT | Support |
| CMCC | Fine with the proposal. |
| TCL | Support. |
| OPPO | Fine for the proposal. |
| Ericsson | Support |
| Nokia/NSB | Support. |
| Huawei, HiSilicon | Support the proposal. |
| Fujitsu | Support. |

FL’s comments on August 17th

Given the relevance of other more important aspects discussed in Section 2.1 and the fact some nontrivial further tuning is needed on these two proposals, the discussion is paused for the time being and will be resumed at a later time during RAN1 #106-e.

### [PAUSED] UCI multiplexing & collision handling

Details of collision handling for TBoMS were discussed in several contributions and can be summarized as follows.

* Twelve companies discussed about UCI multiplexing on TBoMS
  + One company (Huawei/HiSi [3]) proposed that in case of overlapped PUCCH and TBoMS transmissions, UCI multiplexing should be performed per TOT by rate matching. For latency-sensitive UCI, per-slot UCI multiplexing by puncturing should be allowed.
  + One company (vivo [6]) proposed that the number of modulated symbols in the TBoMS for UCI should be same/close to that multiplexed in a single slot PUSCH.
  + One company (Samsung [19]) proposed that parallel transmission of PUCCH and TBoMS PUSCH is not preferred due to power splitting during CE situation. UCI multiplexing on TBoMS is supported and the timeline requirement is applied for the actual overlapped slot in the TBoMS.
  + One company (OPPO [9]) proposed that UCI is equally multiplexed into all slots of TBoMS transmission.
  + One company (Qualcomm [17]) proposed reusing Rel-15/16 framework for UCI multiplexing.
  + One company (Ericsson [22]) proposed that, if UCI multiplexing in TBoMS is supported, HARQ-ACK can be multiplexed in any overlapping slot by puncturing, and CSI or HARQ-ACK can be repeated in all slots of a TBoMS.
  + One company (Interdigital [14]) proposed further studying whether UCI is repeated on the multiple slots of TBoMS.
  + One company (Sharp [24]) proposed that UCI is multiplexed in a slot or a TOT overlapping with a PUCCH for reporting the UCI.
  + Four companies (ZTE [5], CATT [8], Intel [15], WILUS [29]) proposed further discussing UCI multiplexing rules for TBoMS.
* Two companies discussed overlap between different UL transmission and TBoMS and, more in general, collision handling aspects for TBoMS:
  + One company (ZTE [5]) proposed reusing repetition-like behaviour for collision handling between TBoMS and PUCCH.
  + One company (Qualcomm [17]) proposed reusing Rel-15/16 framework for collision handling.

FL’s comments on August 16th

From FL’s perspective, albeit very relevant in general, discussions on this aspect for TBoMS may not be as paramount as discussions on the high priority aspects in Section 2.1 and strongly depend on other aspects e.g., rate-matching, usage of S slots. On the other hand, and like what has been done for sections 2.2.1 and 2.2.2, first steps forward can be taken both in terms of UCI multiplexing and collision handling, nonetheless. The idea would be to agree on basic concepts which can then be revised, or not, depending on the outcome of the discussions on other high priority aspects, e.g., rate matching, S slots and so on. The advantage of this approach is to ensure some basic agreement about these aspects exists, should further aspect prioritization be needed in the discussion (i.e., the more time we have for this in the future the better, however this depends on much time companies are willing to spend discussing on other more structural aspects).

The following two proposals are thus formulated.

|  |
| --- |
| **FL’s proposal 4**  **UCI multiplexing with PUSCH is supported in case TBoMS transmission is scheduled. Legacy R15/R16 framework for UCI multiplexing with PUSCH is reused as much as possible in case of TBoMS transmission. New rules can be defined if needed and agreed on, otherwise legacy framework applies as is.**  **FFS: details of the new rules, if any.** |

|  |
| --- |
| **FL’s proposal 5**  **For collision handling for TBoMS, at least legacy Rel-15/16 rules for PUSCH repetition type A could be reused by replacing a repetition to a slot of the multiple slots for TB processing.**  **FFS: Whether new collision handling rules are defined.** |

#### First round of discussions

FL’s recommendation is to have a first round of discussion about **FL’s proposal 4** and **FL’s proposal 5**. Companies are invited to input their views in the corresponding tables below. Please remember that the goal is to advance as much as we can, given current agreements in other discussions, without hindering possible further refinements, e.g., range of configurable values for the number of allocated slots and so on. Therefore, constructive attitude in this regard is greatly appreciated. In this sense, if you cannot support the proposal, please propose an alternative formulation which takes into account the current spirit.

**Views on FL’s proposal 4**

|  |  |
| --- | --- |
| Company | Views |
| Samsung | **FL’s proposal 4**  **UCI multiplexing with PUSCH is supported in case TBoMS transmission is scheduled. Legacy R15/R16 framework for UCI multiplexing with PUSCH is reused as much as possible in case of TBoMS transmission. ~~New rules can be defined if needed and agreed on, otherwise legacy framework applies as is~~.**  **FFS: ~~details of the~~ whether any additional ~~new~~ rules, if any.** |
| Apple | For multiplexing, is the UCI multiplexing on the first slot or all the configured slots for TBoMS? This is related to UCI feedback delay, especially for the HARQ-ACK feedback. |
| Lenovo, Motorola Mobility | We support the proposal and are also fine with Samsung’s updates. |
| Sharp | More direct statement for the proposal is preferred. In the FL proposal, we are not sure what is the legacy framework.  In our view, the legacy framework implies that UCI multiplexing is applied to a unit (i.e., repetition) for encoding procedure specified in TS38.212. Otherwise, more effort to build a specification for TBoMS is required. Therefore, our proposal is that UCI multiplexing is done per unit X, which is the unit for rate-matching. |
| LG | We are fine with the proposal |
| Intel | Given that the basic structure for TBoMS transmission is not decided, we suggest to defer the discussion until the design framework is clear. Also TBoMS may be based on configured grant, so it may not be scheduled.  We suggest the following update:  **UCI multiplexing with PUSCH is supported in case of TBoMS transmission ~~is scheduled. Legacy R15/R16 framework for UCI multiplexing with PUSCH is reused as much as possible in case of TBoMS transmission. New rules can be defined if needed and agreed on, otherwise legacy framework applies as is.~~**  **FFS: details ~~of the new rules, if any~~.** |
| Panasonic | We are fine with the FL’s proposal. “Not to support UCI multiplexing” has the big issue from the functionality perspective. “UCI is mapped over a TOT/TBoMS” increase the UE/gNB complexity and the delay on the transmission of UCI. |
| Qualcomm | Prefer to wait for clarity on rate matching. If we don’t agree to rate matching per slot, these proposals will not be worth much. We will have to go back to the drawing board and start over afresh.  If on the other hand, we converge to rate matching per slot, this would be the most obvious way to proceed. |
| vivo | Perhaps, if we can list the potential issues for UCI multiplexing on TBoMS, it may helpful to decide whether the existing mechanism can be reused. |
| ZTE | Agree in principle while prefer to discuss this later as Intel commented. |
| CATT | Generally fine with the FL’s proposal. To avoid excessive specification impact, we think it is important to reuse current mechanism as much as possible.  Agree that the issues in 2.1.2 and 2.1.3 should be tackled firstly. |
| InterDigital | This discussion may depend on the outcome of 2.1.2, i.e., whether Option 3 or Option 4 is supported. |
| CMCC | Support FL’s proposal. The basic unit of multiplexing could wait for the conclusion of other parts. |
| TCL | Support the proposal |
| OPPO | Support it. |
| Ericsson | To avoid the UE complexity of rate matching PUSCH around UCI in a time unit larger than a slot, the simple method of UCI multiplexing on TBoMS, e.g. puncturing, should be used as a starting point.  Further enhancement, e.g. repeating UCI in multiple slots of TBoMS can be considered, especially when there is no UL-SCH. |
| Nokia/NSB | Support. |
| Huawei, HiSilicon | Support the proposal. Given that less RBs allocated for TBoMS will degrade the performance of UCI feedback, the UCI should be multiplexed on a TOT. |
| WILUS | We support the FL’s proposal. Details can be further discussed according to conclusions in high priority issues. |

**Views on FL’s proposal 5**

|  |  |
| --- | --- |
| Company | Views |
| Lenovo, Motorola Mobility | We are fine with the proposal |
| Sharp | More direct statement for the proposal is preferred. In the FL proposal, we are not sure what is the legacy Rel-15/16 rule. In our view, the legacy Rel-15/16 rule implies that collision handling is applied to a unit (i.e., repetition) for encoding procedure specified in TS38.212. However, we are not supportive of the above proposal due to potential inefficiency. For example, if the unit (i.e., unit X) is defined as all resources in the TBoMS, does the above proposal mean all TBoMS transmission should be dropped if at least one OFDM symbol in all the TBoMS resource collides with downlink?  Our preference is collision handling per-slot basis irrespective of the definition of the unit X. |
| LG | Reusing the legacy rule for TBoMS by replacing a repetition to a slot seems not clear when the unit of rate-matching for TBoMS is larger than a slot.  If rate-matching is performed in the unit of TOT or over the entire TBoMS slots, and TBoMS transmission is omitted in a slot due to the collision, does it mean that TBoMS is it punctured in the overlapped slot? |
| Intel | Similar comment as above. We suggest to defer the discussion until the design framework is clear |
| Panasonic | We are fine with the FL’s proposal. |
| Qualcomm | See comment to Proposal 4. |
| ZTE | Agree in principle while prefer to discuss this later. |
| CATT | Agree with the proposal. |
| InterDigital | This discussion may depend on the outcome of 2.1.2, i.e., whether Option 3 or Option 4 is supported. |
| CMCC | Support FL’s proposal. |
| OPPO | We need more time for decision on this detail. As we comment earlier, the signalling should be reused mostly from repetition type A. |
| Ericsson | Support |
| Nokia/NSB | Support. |
| Huawei, HiSilicon | It may need to investigate the dropping rule per slot or per TOT, this needs more study. |

FL’s comments on August 17th

Given the relevance of other more important aspects discussed in Section 2.1 and the fact some nontrivial further tuning is needed on these two proposals, the discussion is paused for the time being and will be resumed at a later time during RAN1 #106-e.

### [PAUSED] TBS determination: calculation

Most contributions acknowledged the fundamental nature of this aspect and discussed it in detail. The discussions focused on the scaling factor K in the agreement made during RAN1#105-e for calculation. A high-level summary of companies’ preferences based on the contributions, is as follows:

* **Definition of the scaling factor K**:
  + K equals the number of slots allocated for TBoMS [8 companies]:
    - Wherein the number of slots allocated for TBoMS are available slots:
      * Nokia/NSB [21], CATT [8], Ericsson [22], Huawei/HiSi [3] (if the number of symbols in each slot allocated for TBoMS is the same)
    - ZTE [5], Samsung [19], NTT DOCOMO [26], WILUS [7]
  + K equals the number of slots in a TOT [3 companies]:
    - Fujitsu [10], LGE [28], vivo [6] (if rate-matching is performed per TOT)
  + K equals the number of slots in multiple TOTs which construct a TBoMS [1 company]:
    - Vivo [6] (if rate-matching is performed across TOTs)
  + K equals the ratio of the number of all the symbols allocated for TBoMS transmission excluding DMRS symbols and the one in an uplink slot allocated for TBoMS transmission excluding DMRS symbols [1 company]:
    - Huawei/HiSi [3] (if the number of symbols in an uplink slot allocated for TBoMS transmission and the one in a special slot allocated for TBoMS transmission are different).
  + K is indicated independently from the slots/symbols allocated for TBoMS (e.g., from a set of integer values) [3 companies]:
    - K {2, 4, 8} OPPO [9]
    - K {2, 4, 8, 16} Qualcomm [17]
    - LGE [28]
* **Indication of the scaling factor K**:
  + K is indicated via DCI [2 companies]:
    - Sharp [24], Panasonic [18] (separate field or TDRA)
  + Further study the signaling aspects for the indication of K [1 company]:
    - Qualcomm [17]

The following was also additionally proposed:

* One company (OPPO [9]) proposed that 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 number of slots for repetition.

FL’s comments on August 16th

This discussion seems to depend on the decisions which will be taken on at least two other aspects:

* Whether and how to use the S slot.
* How rate matching is going to be performed, i.e., the time unit of the interleaver.

This shows, once again, that deciding on the two aspects above during #106-e is paramount. We cannot afford leaving the two aspects open after this meeting. Several other aspects are blocked by them.

Having said this, most companies seem to agree on the fact that the case =total number of allocated slots for TBoMS should be configurable. Other values may still be subject to discussion, depending on the outcome of the discussions above. For this reason, the following proposal is formulated, as first further step to progress on this topic, until further steps can be taken (hopefully during RAN1 #106-e).

**FL’s proposal 5**

**At least the scaling factor value =total number of allocated slots for TBoMS should be configurable to calculate**   **for TBS determination.**

**FFS: details related to the indication of .**

**FFS: whether and how further values can be indicated.**

#### First round of discussions

FL’s recommendation is to have a first round of discussion about **FL’s proposal 5**. Companies are invited to input their views in the table below. Please remember that the goal is to advance as much as we can, given current agreements in other discussions, without hindering possible further refinements, i.e., indication of , further supported configurable values and so on. Therefore, constructive attitude in this regard is greatly appreciated. In this sense, if you cannot support the proposal, please propose an alternative formulation which takes into account the current spirit.

|  |  |
| --- | --- |
| Company | Views |
| Samsung | First to clarify, whether the allocated slots are the available slots? |
| Apple | Our understanding is that allocated slots are available slots. |
| Lenovo, Motorola Mobility | Support FL’s proposal 5 and our understanding is also that allocated slots are available slots |
| NTT DOCOMO | Support the proposal. |
| Sharp | We see two issues on FL proposal 5.  Issue#1: Potential mis-alignment of TBS between gNB/UE.  Even when the UE is configured with “counting based on the available slots” for TBoMS, the number of repetitions configured by RRC cannot be ensured due to potential collision with the other channels. Therefore, the behaviour in the FL proposal causes mis-alignment of TBS between gNB/UE when the UE mis-detects some of the scheduling DCI for other channels.  On top of that, clarification on the definition of “total number of allocated slots for TBoMS” are necessary. Is it a number of slots for transmission occasions for “counting based on available slots” or is it a number of slots for actual transmission?  Issue#2: TBS determination for retransmission  TBS for retransmission needs to be aligned with the one for the initial transmission. When the FL proposal is agreed, the scheduler needs to schedule the same number of slots for retransmission. One may argue that we can use a reserved MCS value for it. However, the reserved MCS value causes an issue when the UE failed to detect the DCI for initial transmission. Therefore, explicit signalling of K is preferred. |
| LG | The decision on the scaling factor K depends on the rate-matching discussion, and since the discussion is ongoing, we’d like to keep other options as follows.  **At least the scaling factor value ~~=total number of allocated slots~~ for TBoMS should be configurable to calculate**   **for TBS determination.**  **One option among following options is selected.**   * **Option 1: K equals the number of slots allocated for TBoMS** * **Option 2: K equals the number of slots on a TOT.** * **Option 3: K equals the number of slots in multiple TOTs which construct a TBoMS.**   **FFS: details related to the indication of .**  **FFS: whether and how further values can be indicated.** |
| Intel | We are fine with the proposal in principle. But it is not clear to us “configurable”. If this is based on the value via TDRA table and indicated in the DCI, it would be good to update this as  **At least the scaling factor value =total number of allocated slots for TBoMS should be ~~configurable~~ indicated to calculate**   **for TBS determination.**  **FFS: details related to the indication of .**  **FFS: whether and how further values can be indicated.** |
| Panasonic | We are fine with the FL proposal. |
| Qualcomm | Don’t support. Needs discussion.  I know we are in the minority here, but we have to take retransmissions into account. Retransmissions can be shorter in duration, but we still need to be able to compute the same TB size as the original grant. For this reason, we prefer to not couple K and number of slots allocated for TBoMS in the TDRA table.  Also, there is no reason to choose scale factor to be the same as number of slots. It leaves many valuable operating points (in terms of coding rate, TB size and modulation order) for a coverage limited UE off limits.  Since the primary goal of TBoMS is to avoid unnecessary payload segmentation, consider the following comparison between legacy PUSCH and TBoMS:  Legacy PUSCH config: Single 600 bit payload, segmented into two TBs (due to small RB allocation, say), and each TB transmitted using 2 repetitions each.  TBoMS: Single 600 bit payload, no segmentation, transmitted over 4 slots, using same MCS and RB allocation as legacy PUSCH but with TB scaled by a factor of 2.  This is a simple example where number of slots don’t match TBS scaling while offering an enhanced operating point compared to legacy PUSCH using the exact same time-freq resources. |
| vivo | Fine with revisions from LG. |
| ZTE | Agree in principle. Similar comments as Intel. |
| CATT | Generally fine with FL’s proposal. According to our understanding, when discussing TBS ‘calculation’, it is only for initial transmission.  Regarding to the retransmission case, we think the current rule should be followed, i.e. the TBS remains unchanged and need not to be re-calculated. This is the same with current mechanism.  So, only the indicated slot number K in the initial transmission is used to calculate the TBS. In retransmission, even if the value of indicated K is changed, the TBS is unchanged. Hence we propose:  **For initial transmission, at least the scaling factor value =total number of allocated slots for TBoMS should be configurable to calculate**   **for TBS determination.**   * **For retransmission, the TBS remains the same with the initial transmission, i.e. same mechanism as in Rel-15/16.** * **FFS: details related to the indication of .**   **FFS: whether and how further values can be indicated.** |
| CMCC | Support the proposal. |
| OPPO | The proposal is reasonable simple and should be the baseline. |
| Ericsson | Agree in principle & prefer Intel’s wording. |
| Nokia/NSB | Ok with the spirit but we wonder if this might lead to mismatch between the TBS calculated using K=allocated slots, and the actual resources UE finds in available slots. Please note that this problem does not occur for PUSCH type A repetition, since TBS is always calculated using the resources of only one slot. Conversely, this can potentially happen anytime TBS of TBoMS is calculated, if countermeasures are not taken. We strongly suggest agreeing on how to count the allocated slots first. The optimal solution should be that the allocated slots are counted based on available slots for TBoMS. This approach could help avoiding any confusion on the resource used for TBS determination. |
| Huawei, HiSilicon | We propose to add one sub-bullet “FFS how to define the scaling factor K if special slots are used for TBoMS.”  **At least the scaling factor value =total number of allocated slots for TBoMS should be configurable to calculate**   **for TBS determination.**  **FFS: details related to the indication of .**  **FFS: K value in case of special slot is used for TBoMS**  **FFS: whether and how further values can be indicated.** |
| WILUS | We support the FL’s proposal. |

FL’s comments on August 17th

Given the relevance of other more important aspects discussed in Section 2.1 and the fact some nontrivial further tuning is needed on these two proposals, the discussion is paused for the time being and will be resumed at a later time during RAN1 #106-e.

### [CLOSED] TBoMS repetitions

Observations on the support of the repetition of a single TBoMS are provided in different forms in several contributions. A high-level summary of companies’ preferences based on the contributions is as follows:

* **Option 1**. Support the repetition of a single TBoMS [5 companies]
  + - vivo [6], Samsung [19], Intel [15], Apple [16], Xiaomi [13]
* **Option 2**. Do not support the repetition of a single TBoMS [1 company]
  + - Sierra Wireless [23]
* **Option 3**. Further discuss on whether to support the repetition of a single TBoMS (e.g., based on the outcome of the definition of a single TBoMS) [2 companies]
  + - Lenovo/Motorola [27], Ericsson [22]

The following was also additionally proposed:

* One company (vivo [6]) proposed that the repetition factor is indicated in TDRA table.
* One company (China Telecom [11]) proposed down-selecting between two options: (i) the maximum number of aggregated slots for TBoMS is the same as the maximum number of repetition for PUSCH repetition type A in Rel-17 or (ii) repetition on top of TBoMS is supported.
* One company (Lenovo/Motorola [27]) proposed that if repetition of TBoMS is supported, then only PUSCH repetition type A should be considered and two methods can be considered to indicate the number of slots for TBoMS and repetition factor for TBoMS repetition: (i) introduce indication for number of slots for TBoMS in addition to repetition factor via TDRA row index or (ii) only support dynamic indication for number of slots for TBoMS via TDRA, but the repetition factor for TBoMS repetition is indicated only via RRC configuration.
* One company (Sharp [24]) proposed that TBoMS is viewed as repetition in unit of a slot or a TOT.

FL’s comments on August 16th

Most companies who commented on this aspect prefer supporting repetitions of TBoMS. One company prefer not supporting PUSCH repetitions for TBoMS. Two companies propose to further discuss this aspect when the definition of a single TBoMS is finalized.

Current situation seems rather in favour of supporting repetitions of TBoMS. On the other hand, it is acknowledged by FL that the technical need of repetitions of TBoMS may depend on agreements taken for the discussions in Section 2.1, where the structure of a single TBoMS is discussed. It is very likely that a decision on whether supporting repetitions of TBoMS or not will be an incremental effort once details related to single TBoMS transmission are worked out. Indeed, time-domain constraints, if any, and more precise characterization/estimation of the minimum effective coding rate achievable by TBoMS would be available by then.

For all these reasons, and also given that several companies would like to study this aspect further, FL’s suggestion is to focus on the most foundational aspects of TBoMS and to postpone discussion on repetitions of TBoMS to a later time (during #106-e or later).

## Others

As discussed at the beginning of Section 2, discussions on different aspects of TBoMS have been prioritized to ensure that constructive discussions and effective progress can be achieved during RAN1 #106-e. Priority has been given to the aspects and topics discussed in sections 2.1 and 2.2, which mostly focus on resource allocation for TBoMS and structure of single TBoMS in general. All other aspects are listed in this section, i.e, 2.3., where proposals made by companies in their contributions are reported and described in detail.

These aspects may not be handled during RAN1 #106-e unless technical need arises during the discussion on other aspects. For this reason, no specific FL’s proposal or recommendation is formulated at this stage. Should discussions for 2.1 and 2.2 progress fast and converge to agreements, sections for specific aspects, currently in 2.3, may be open for discussions and corresponding FL’s proposals and recommendations may be made.

### [CLOSED] FDRA

Three companies (ZTE [5], Xiaomi [13], and Samsung [19]) proposed that the maximum number of PRBs allocated for TBoMS should be limited.

From FL’s perspective, albeit very relevant in general, discussions on this aspect for TBoMS may not be as paramount as discussions on the higher priority aspects in Sections 2.1-2.2. FL suggests postponing discussions on this topic until need arises (during #106-e or later).

### [CLOSED] DM-RS

One company (Nokia/NSB [21]) proposed that DM-RS optimization for TBoMS is deprioritized in Rel-17.

One company (Ericsson [22]) proposed that DM-RS optimization is discussed after agreements of time unit for rate matching are reached.

### [CLOSED] Transmission power determination

The transmission power determination was discussed in several contributions and can be summarized as follows:

* One company (Huawei/HiSi [3]) proposed that the transmission power determination of TBoMS should be based on the TOT.
* One company (ZTE [5]) proposed that the transmission power determination should be based on the total number of Res within all slots for TBoMS, excluding the overhead of reference signals.
* One company (Ericsson [22]) proposed that the power control aspect is discussed after agreements of time unit for rate matching are agreed.
* One company (CATT [8]) proposed that the transmitted power of a TBoMS remains unchanged during the transmission.
* One company (WILUS [7]) proposed further discussing how to determine the number of REs for UCI multiplexing and UL transmission power in case of TBoMS.

### [CLOSED] Special TBS values for TBoMS

Special TBS values for TBoMS were discussed in several submitted contributions, including maximum supported TBS for TBoMS. Content of such discussions, and related proposals, can be summarized as follows.

* One company (ZTE [5]) proposed that the maximum TBS can be limited by the conditions of data rate limitations DataRate and DataRateCC.
* One company (CATT [8]) proposed that no restriction is specified except for the maximum TBS.
* One company (NEC [25]) proposed that the maximum supported TBS should not exceed legacy maximum supported TBS in Rel-15/16 for TBoMS.
* One company (Qualcomm [17]) proposed to restrict TBoMS transmissions to TB sizes that permit single codeblock transmission.
* One company (Qualcomm [17]) proposed that no new TBSs are introduced.

### [CLOSED] 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 [22]) proposed that the number of layers is discussed after agreements of time unit for rate matching are reached.
* Two companies (vivo [6], Qualcomm [17]) proposed that TBoMS should be limited to single-layer transmission.

### [CLOSED] Link adaptation

One company (Ericsson [22]) proposed RAN1 to discuss issues of MCS after agreements of time unit for rate matching are reached.

From FL’s perspective, discussions on this aspect for TBoMS may not be as paramount as discussions on the higher priority aspects in Sections 2.1-2.2. FL suggests postponing discussions on this topic until need arises (during #106-e or later).

### [CLOSED] Frequency hopping

Frequency hopping (FH) aspects were discussed in several contributions and can be summarized as follows:

* Two companies (China Telecom [11] and TCL Communications [4]) proposed that inter-slot FH should be supported for TBoMS.
* Two companies (China Telecom [11] and Intel [15]) proposed that inter-slot FH with inter-slot bundling should be supported for TBoMS.
* One company (TCL Communications [4]) proposed that intra-slot FH should be supported for TBoMS.
* One company (Intel [15]) proposed further studying the support of intra-slot FH for TBoMS.
* One company (Xiaomi [13]) proposed supporting intra-TB FH for TBoMS.

### [CLOSED] CB segmentation

One company (Ericsson [22]) proposed that CB segmentation is needed for TBoMS in order to reuse Rel-15/16 LDPC coding.

One company (Samsung [19]) proposed that RAN1 should confirm whether one or multiple CBs are supported for TBoMS.

### [CLOSED] Retransmissions

Details of retransmission of a TBoMS were discussed in several contributions and can be summarized as follows.

* Three companies (CMCC [12]), InterDigital [14], Lenovo/Motorola [27]) proposed supporting enhanced retransmission mechanisms to avoid the retransmission of the entire TBoMS.
* One company (Ericsson [22]) proposed that the unit of retransmission is discussed after agreements of time unit for rate matching are reached.
* One company (Lenovo/Motorola [27]) proposed that if retransmission for duration shorter than the overall duration of TBoMS is supported, then implicit/explicit configuration of the portion (duration) should be supported with portion indication in the retransmission DCI.

From FL’s perspective, discussions on this aspect for TBoMS may not be as paramount as discussions on the higher priority aspects in Sections 2.1-2.2 and may depend on other aspects e.g., rate-matching. FL suggests postponing discussions on this topic until need arises (during #106-e or later).

### [CLOSED] Interleaved TBoMS transmission

One company (Qualcomm [17]) proposed that interleaved TBoMS transmissions (carrying different TBs) are not permitted. A UE does not expect a TBoMS transmission in a component carrier to begin before the completion of an ongoing TBoMS transmission in the same component carrier.

### [CLOSED] Application of DM-RS bundling to TBoMS

One company (TCL Communications [4]) proposed that the inter-slot bundling with inter-slot frequency hopping should be supported for TBoMS.

### [CLOSED] Additional indicators and configuration options

Activation 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 are summarized as follows

* One company (Nokia/NSB) proposed to specify an indication method for enabling TBoMS per PUSCH scheduling/configuration.
* One company (Lenovo/Motorola [27]) proposed that semi-static and/or dynamic configuration of TBoMS feature for PUSCH should be supported, and independent from PUSCH repetition.
* One company (Interdigital [14]) proposed to support dynamic enabling/disabling of TBoMS transmission using TDRA list configuration.
* One company (Xiaomi [13]) proposed considering the configuration and indication signalling design when a single UE supports both repetition and TBoMS.

From FL’s perspective, albeit very relevant in general, discussions on this aspect for TBoMS may not be as paramount as discussions on the higher priority aspects in Sections 2.1-2.2. In addition, some of these indicators may depend on other aspects e.g., TDRA. FL suggests postponing discussions on this topic until need arises (during #106-e or later).

### [CLOSED] Application of TBoMS for Msg3 transmission

One company (TCL Communications [4]) proposed studying whether Msg3 transmission also supports TBoMS.

# 3 [CLOSED] Proposals for GTW

# 4 [CLOSED] Agreements during Ran1 #106-e

# 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. R1-2106496 Discussion on TB processing over multi-slot PUSCH, Huawei, HiSilicon
4. R1-2107198 Discussion on TBoMS, TCL Communication Ltd.
5. R1-2106740 Discussion on TB processing over multi-slot PUSCH, ZTE
6. R1-2106612 Discussion on PUSCH TB processing over multiple slots, vivo
7. R1-2108158 Discussion on TB processing over multi-slot PUSCH, WILUS Inc.
8. R1-2106989 Discussion on TB processing over multi-slot PUSCH, CATT
9. R1-2107257 Issues for TB over multi-slot PUSCH, OPPO
10. R1-2107035 Views on TB processing over multi-slot PUSCH, Fujitsu
11. R1-2107124 Discussion on TB processing over multi-slot PUSCH, China Telecom
12. R1-2107418 Discussion on TB processing over multi-slot PUSCH, CMCC
13. R1-2107936 TB processing over multi-slot PUSCH, Xiaomi
14. R1-2107651 TB processing over multi-slot PUSCH, InterDigital, Inc.
15. R1-2107603 Discussion on TB processing over multi-slot PUSCH, Intel Corporation
16. R1-2107754 Discussion on TB processing over multi-slot PUSCH, Apple
17. R1-2107360 TB processing over multi-slot PUSCH, Qualcomm Incorporated
18. R1-2107117 Discussion on TB processing over multi-slot PUSCH, Panasonic Corporation
19. R1-2106903 TB processing over multi-slot PUSCH, Samsung
20. R1-2107523 Discussion on TB Processing over multi-slot PUSCH, MediaTek Inc.
21. R1-2106656 Transport block processing for PUSCH coverage enhancements, Nokia, NSB
22. R1-2107560 TB Processing over Multi-Slot PUSCH, Ericsson
23. R1-2107635 Design Considerations for TB Processing over Multi-Slot PUSCH, Sierra Wireless
24. R1-2107800 TB processing over multi-slot PUSCH, Sharp
25. R1-2107141 Discussion on TB processing over multi-slot PUSCH, NEC
26. R1-2107873 TB processing over multi-slot PUSCH, NTT DOCOMO, INC.
27. R1-2107191 Enhancements for TB processing over multi-slot PUSCH, Lenovo, Motorola Mobility
28. R1-2107549 Discussions on TB processing over multi-slot PUSCH, LG Electronics

# Appendix A: Proposals from contributions aggregated by topic

## A.1 TDRA [S slots, number of allocated slots, how allocated slots are counted]

**The use of the S slot**

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| **R1-2106496 Huawei/Hisi**  ***Proposal 1****: Support different time domain resource allocations between special slots and uplink slots for TBoMS to fully use the available uplink symbols in special slots.*  ***Proposal 2****: Introduce an additional SLIV field in RRC configured TDRA table to indicate time domain resource allocation for special slots for TBoMS.*  **R1-2106656 Nokia/NSB**  Proposal 4. Optimizations on time domain resource determination for allocating resource in the S slots is deprioritized.   * DMRS optimization for TBoMS is deprioritized in Rel-17.   **R1-2106740 ZTE**  ***Proposal 1:*** *Confirming the working assumption of* allocating resources for TBoMS in the special slot in TDD is possible according to the agreed time domain resource determination for TBoMS.   * *No optimization specific for the use of special slot in TDD is pursued.*   **R1-2106903 Samsung**  ***Proposal 1****: the usage of UL symbols (unequal to L in SLIV) in special slot should be supported.*  **R1-2107117 Panasonic**  **Proposal 1**: Time domain resource determination for TBoMS can be performed only via PUSCH repetition Type A like TDRA without optimization for allocating resource in the S slots.  **R1-2107124 China Telecom**  **Proposal 1:** Time domain resource determination for TBoMS can be performed via separate PUSCH repetition Type A like TDRA for UL slots and special slots.  **R1-2107198 TCL Communications**  **Proposal 3:** The special slot in TDD should be a conditional available slot for TBoMS.  **R1-2107560 Ericsson**  **Proposals:**   1. The net gains and use cases of TBoMS supporting special slot with different number of UL symbols than that in UL slot for the TB should be carefully studied prior to specifying it.    1. Such study should address how SRS and PUCCH can be transmitted as well as the performance of interference suppression when DMRS in a special or normal uplink slot is used for interference suppression in the other type of slot.    2. If specified, and performance gains are targeted for this case, a TB over consecutive UL symbols in special slot and the following UL slot can be based on PUSCH repetition type-B like TDRA. 2. UL symbols in special slot in TDD are not included for time domain resource determination for TBoMS according to the agreed Type A like time domain resource determination for TBoMS.   **R1-2107651 InterDigital**  **Proposal 7:** For PUSCH repetition Type A like TDRA, support the number of symbols in PUSCH larger than 14 when uplink symbols are allocated in the a special slot, prior to an uplink slot.  **R1-2107754 Apple**  **Proposal 3:** Confirm the following working assumption:   * Allocating resources for TBoMS in the special slot in TDD is possible according to the agreed time domain resource determination for TBoMS.   **R1-2107936 Xiaomi**  **Proposal 3**: Support optimizing time domain resource allocation for making use of S slots in unpaired spectrum   * The reference point of the start symbol can be the first available symbol in special slot * The actual symbol length for TBoMS transmission in special slot can be less than the allocated symbol length |

**The use of non-consecutive slots**

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| **R1-2107560 Ericsson**  **Proposals:**   1. Non-consecutive physical slots can be supported for TBoMS for paired spectrum. |

**Indication of the number of slots allocated for TBoMS**

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| **R1-2106496 Huawei/Hisi**  **Proposal 3**: If repetition of TBoMS is supported, existing repetition number field in RRC configured TDRA table should indicate the repetition number of TBoMS, and a new field should be introduced in RRC configured TDRA table to indicate the number of available slots allocated for one TBoMS transmission.  **R1-2106612 vivo**  **Proposal 3:** Number of slots in a TOT is associated with entries in the TDRA table, and a single value for number of TOTs for a TBoMS is separately configured.    **R1-2106656 Nokia/NSB**  Proposal 6. RAN 1 to consider the following candidate values of the number of slots allocated for TBoMS as a starting point:   * [1], 2, 3, 4, or 7 slots   Note: value 1 may or may not be introduced depending on how TBoMS is enabled/disabled.  **R1-2106740 ZTE**  ***Proposal 2:*** *For TBoMS, add an new column in TDRA table to indicate the number of slots.*   * *Support {1, 2, 3, 4, 7, 8, 12, 16} as the candidate values.*   **R1-2106903 Samsung**  ***Proposal 2****: Indicating number of slot for one TB with an extra parameter in a TDRA row.*  **R1-2106989 CATT**  **Proposal 1**: For time domain resource allocation of TBoMS, a new IE is introduced in the TDRA entry to indicate the number of allocated slots for TBoMS.   * FFS the configurable set of values for the number of slots.   **R1-2107035 Fujitsu**  **Proposal 4**: The row index of a TDRA list for determining the number of slots allocated for TBoMS is indicated either by the configured grant configuration or by TDRA field in a DCI.  **R1-2107191 Lenovo/Motorola**  **Proposal 11:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, if PUSCH repetition is not allowed when TBoMS feature is enabled, then the repetition factor indicated by TDRA can utilized to indicate the number of slots for TBoMS PUSCH transmission.  **R1-2107198 TCL Communications**  **Proposal 1:** Configure a separate TDRA table for TBoMS PUSCH.  **R1-2107257 OPPO**  **Proposal 2**: The existing PUSCH repetition type A TRRA and its configuration can be the reused for the TBoMS.  **R1-2107360 Qualcomm**  **Proposal 2:**  Reuse TDRA for Type A PUSCH repetition for TBoMS.  **Proposal 13:** Support TBoMS for both dynamic grants and configured grants.  **R1-2107549 LGE**  **Proposal 4**: Discuss following options for slot number determination of TBoMS.   * Option 1. The number of slots for TBoMS is indicated by TDRA field. * Option 2. The number of TOTs for TBoMS is indicated by TDRA field.   **Proposal 5**: If repetition is not applied to TBoMS, repetition number in TDRA field can be used to indicate the number of slots or TOTs for TBoMS.  **R1-2107754 Apple**  **Proposal 1**: Considering the maximum number of usable slots for TB transmission is 8.  **R1-2107800 Sharp**  **Proposal 6:** The number of slots can be indicated through a TDRA field in the DCI format for dynamic scheduling of a TBoMS.  **Proposal 7:** The number of slots can be indicated through a value provided by RRC for configured scheduling of a TBoMS.  **Proposal 8:** The number of slots can be indicated through a TDRA field in the DCI format for retransmission of the TBoMS. |

**How slots allocated for TBoMS are counted**

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| R1-2106656 Nokia/NSB  Proposal 5. The number of slots allocated for TBoMS is counted based on the available slots.  **R1-2107117 Panasonic**  **Proposal 2:** For the time domain resource determination for TBoMS, unified solution of determination of available slot is supported.  **R1-2107560 Ericsson**  **Proposals:**   1. If TBoMS with more than 2 slots is to be supported, TBoMS configuration uses the number of available slots, otherwise physical slots are used.   **R1-2107603 Intel**  **Proposal 3**   * *TBoMS can be transmitted on the basis of available UL slots.*   **R1-2107754 Apple**  **Proposal 2**: The number of slots for TBoMS transmission is counted based on available slot.  **R1-2107800 Sharp**  **Proposal 1:** Repetition type A-like TDRA employs counting on the basis of available slots.  **R1-2107873 NTT DOCOMO**  **Proposal 5**: The number of slots allocated for TBoMS should be counted on the basis of available slots. |

**Others**

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| **R1-2107257 OPPO**  **Proposal 1**: In TBoMS, TB size determination over multiple slots is configured with PUSCH repetition operation.  The TB can be transmitted in the multi-slot configured in the PUSCH repetition.  The enhanced Type A PUSCH repetition is included.  **R1-2107360 Qualcomm**  **Proposal 1:** Prioritize a modular approach to TBoMS transmission, i.e., when resources for TBoMS span across multiple contiguous/noncontiguous slots, view resources in each slot as one self-contained segment of a longer transmission. |

## A.2 TOT definition

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| **R1-2106612 vivo**  **Proposal 5:** Concept of TOT should be specified at least for the following purposes   * RV refreshing; * UCI multiplexing; * TB size determination.   **R1-2106656 Nokia/NSB**  Proposal 1. The following definition of transmission occasion for TBoMS (TOT) and approach for rate-matching for TBoMS is supported:   * *A TOT is one slot and rate-matching is performed per slot.*     **R1-2106740 ZTE**  ***Proposal 7****: Confirming the WA of a transmission occasion for TBoMS (TOT) is constituted of at least one slot or multiple consecutive physical slots for UL transmission.*   * *No need to specify the concept of TOT.* * *The concept of TOT will be not used for designing aspects related to signal generation.*   **R1-2107418 CMCC**  **Proposal 1:** The un-consecutive slots, such as multiple sets of consecutive slots, carrying a single TB should be discussed.  **R1-2107035 Fujitsu**  **Proposal 1**: Both consecutive slots and non-consecutive slots can be contained in a TOT.  **R1-2107191 Lenovo/Motorola**  **Proposal 1:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, the concept of a transmission occasion for TBoMS (TOT) should be specified, where a TOT constitutes of at least on slot or multiple consecutive physical slots for UL transmission.  **Proposal 2:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, if TOT is specified, then it could be used for further design aspect including redundancy version, rate-matching, power control, partial retransmissions of TBoMS and others (if any).  **R1-2107360 Qualcomm**  **Proposal 3:** A transmission occasion for TBoMS (TOT) constitutes one slot of transmission.  **R1-2107549 LGE**  **Proposal 1**: Define the maximum number of slots constituting a TOT. |

## A.3 Single TBoMS structure

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| R1-2106496 Huawei/HiSi  ***Proposal 6****: The TB is transmitted on the multiple TOTs using a single RV.*  **R1-2106612 vivo**  **Proposal 2:** TBoMS definition Option-3 is supported together with rate-matching method Option-c, and TBoMS definition Option-4 is supported together with rate-matching method Option-c.  R1-2106656 Nokia/NSB  Proposal 2. For definition of a single TBoMS, Option 3 should be adopted, i.e., the TB is transmitted using a single RV.  **R1-2106740 ZTE**  ***Proposal 5:*** *Option 3 should be supported for TBoMS.*  **R1-2106903 Samsung**  ***Proposal 7****: Option 4(different RV) is slightly preferred for the definition of a single TBoMS.*  **R1-2106989 CATT**  **Proposal 3**: For the structure of TBoMS, at least Option 3 with single RV and continuous rate-matching across all the allocated slots/TOTs for TBoMS is supported.   * FFS whether/how to additionally support Option 4 with multiple RVs and continuous rate-matching across all the allocated slot(s) per TOT.   **R1-2107117 Panasonic**  **Proposal 3:** TB is transmitted on the multiple TOTs using different RVs. The (maximum) length of TOT is 4 slots.  **R1-2107124 China Telecom**  **Proposal 2:** Option 3 is supported. Multiple TOTs are determined for a TBoMS. The TB is transmitted on the multiple TOTs using a single RV.  **R1-2107141 NEC**  **Proposal 1:** Select Option 4, i.e. if a design based on different RVs is adopted.  **Proposal 2:** If a design based on different RVs is adopted and resource in TBoMS is not transmitted due to collision with other resources, the RV should be counted.  **R1-2107191 Lenovo/Motorola**  **Proposal 3:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, option 3 is adopted where a single RV is applied across entire TBoMS.  **R1-2107257 OPPO**  **Proposal 3**: TBoMS support multiple TOTs to enable non-consecutive/consecutive physical slots for UL transmission.  **Proposal 6**: Single RV scheme can be used across all the TOTs in one TBoMS transmission over multi-slot.  Reducing the complexity of TB and RE processing in each slot, e.g., restricting TB size.  Consider an offset factor for bit selection.  **R1-2107360 Qualcomm**  **Proposal 5:** For TBoMS, refresh RV indices once every S transmission occasions.   * FFS: Value of S.   **R1-2107418 CMCC**  **Proposal 2:** The option 4, a design based on different RVs is preferred.  **R1-2107523 MediaTek**  **Proposal 1**: Option-4 to be down selected because it allows each PUSCH transmission (or one slot) to be independent with different RV.  **R1-2107549 LGE**  **Proposal 3**: RV values applied for TBoMS are cycled for each TOT.  **R1-2107560 Ericsson**  **Proposals:**   1. TBoMS is transmitted using a single RV.   **R1-2107603 Intel**  **Proposal 1**   * *For the definition of a single TBoMS, Option 3 is supported.* * *For the rate-matching of TBoMS, Option C is supported.*   **R1-2107635 Sierra Wireless**  **Proposal 1:** TBoMS encoding follows option 3:  Option 3: Multiple TOTs are determined for a TBoMS. The TB is transmitted on the multiple TOTs using a single RV.  Repetition is not supported with TBoMS.  FFS: Maximum number of slots  FFS: If and how to support early termination  **R1-2107651 InterDigital**  **Proposal 2:** Single RV is supported for TBoMS transmission.  **Proposal 3:** For the structure of TBoMS, Option 3 is supported.  **R1-2107754 Apple**  **Proposal 5:** A transmission block for TBoMBS is transmitted on multiple TOTs using different RVs, and the rate matching is performed across all slots per TOT.  **R1-2107873 NTT DOCOMO**  **Proposal 2**: A single RV should be transmitted over one TOT for consecutive slots or multiple TOTs for non-consecutive slots in a single TBoMS, where starting points of bit selections other than the first bit selection are right after encoded bits taken from circular buffer in the previous bit selection (Opt.3-2).  **R1-2107936 Xiaomi**  **Proposal 1**: Support transmitting a single RV on multiple slots for TBoMS.  **R1-2108158 WILUS**  **Proposal 1**: For TBoMS, the TB is transmitted on multiple TOTs using a single RV (Option-3), and the single RV is continuously rate-matched across all the allocated slot(s) per TOT (Option-b).   * + FFS: Handling for issues on rate-matching, such as UCI multiplexing. |

**Relationship between TBoMS and PUSCH repetitions**

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| **R1-2106656 Nokia/NSB**  Proposal 3. RAN1 should specify TBoMS as an independent feature according to WID. It should not be considered as an enhancement of PUSCH repetition type A, regardless of how time domain resource determination is indicated.  **R1-2107560 Ericsson**  **Proposals:**  From an interleaving and RV perspective, TBoMS is designed as a new feature, rather than a Type A PUSCH repetitions enhancement.  **R1-2107873 NTT DOCOMO**  **Proposal 1**: Performance gain of TBoMS compared to PUSCH repetition type A should be taken into consideration, when designing TBoMS. |

## A.4 Rate-matching

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| **R1-2106496 Huawei/HiSi**  ***Proposal 7****: RM is performed per TOT, where the start position of bit selection in the circular buffer on TOT is defined as*  *where denotes the end position of bit selection in the circular buffer on TOT , , denotes the length of coded bits in the circular buffer, is the LDPC lifting size, and denotes the TOT number,*  **R1-2106612 vivo**  **Proposal 1:**Both rate-matching per TOT (Option-b) and rate matching across TOTs (Option-c) can be supported based on UE capability reporting.   * Rate matching per TOT (Option-b) can be considered as baseline capability for TBoMS.   **Proposal 2:** TBoMS definition Option-3 is supported together with rate-matching method Option-c, and TBoMS definition Option-4 is supported together with rate-matching method Option-c.    **R1-2106656 Nokia/NSB**  Proposal 1. The following definition of transmission occasion for TBoMS (TOT) and approach for rate-matching for TBoMS is supported:   * *A TOT is one slot and rate-matching is performed per slot.*   **R1-2106740 ZTE**  ***Proposal 6:*** *Rate matching is performed continuously across all the allocated slots/TOTs for TBoMS.*  **R1-2106903 Samsung**  ***Proposal 8****: option a (*Rate-matching is performed per slot*) shall be supported for TBoMS.*  **R1-2106989 CATT**  **Proposal 2**: For rate-matching for TBoMS, at least Option c is supported, i.e. rate matching is performed continuously across all the allocated slots/TOTs for TBoMS.   * FFS whether/how to additionally support Option b, i.e. rate matching is performed continuously across all the allocated slot(s) per TOT.   **R1-2107035 Fujitsu**  **Proposal 2:** Option b for rate-matching for TBoMS is supported. In other words, rate matching is performed continuously across all the allocated slot(s) per TOT.  **R1-2107117 Panasonic**  **Proposal 4:** Rate matching is performed per slot. Starting point (bit position in circular buffer) for rate matching in the subsequent slots in a TOT is based on the number of REs determined in the first L symbols over which the TBoMS transmission is allocated.   * + For example, the start position of rate matching in the circular buffer on TOT i can be given by , where is the reference number of bits based on the number of REs determined in the first L symbols over which the TBoMS transmission is allocated.   **R1-2107124 China Telecom**  **Proposal 3:** Rate matching is performed continuously across all the allocated slots/TOTs for TBoMS.  **R1-2107141 NEC**  ***Proposal 3:*** *For rate-matching for TBoMS, support option a, i.e. Rate-matching is performed per slot.*  **R1-2107191 Lenovo/Motorola**  **Proposal 5:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, option a should be adopted for rate-matching i.e., the rate-matching is performed per slot basis.  **R1-2107360 Qualcomm**  **Proposal 4:** Adopt per-slot rate matching for TBoMS.  **R1-2107418 CMCC**  **Proposal 3:** For the rate matching for TBoMS, the option b with all the allocated slot(s) per TOT is preferred.  **Proposal 4:** An updated version of option b should be considered for the further discussion.   * Option b’: Rate matching is performed continuously across all the allocated slots over X TOTs;   **R1-2107523 MediaTek**  **Proposal 2**: Rate-matching has to be done for every PUSCH transmission (i.e per slot approach). Option-a is preferred as it allows UE to transmit each PUSCH as a fresh transmission.  **R1-2107549 LGE**  **Proposal 2**: Select one option among TOT based rate-matching and slot based rate-matching for TBoMS.  **R1-2107560 Ericsson**  **Proposals:**   1. Rate matching is performed continuously across all the allocated slots/TOTs for TBoMS, if CB segmentation doesn't happen. Otherwise every CB is rate matched once   **R1-2107603 Intel**  **Proposal 1**   * *For the definition of a single TBoMS, Option 3 is supported.* * *For the rate-matching of TBoMS, Option C is supported.*   **R1-2107651 InterDigital**  **Proposal 4:** Rate matching is performed per slot (Option a).  **R1-2107754 Apple**  **Proposal 5:** A transmission block for TBoMBS is transmitted on multiple TOTs using different RVs, and the rate matching is performed across all slots per TOT.  **R1-2107800 Sharp**  **Proposal 3:** Bit-selection should be defined as a slot or a TOT. The size G should be defined by REs available for transmission of UL-SCH in a slot or a TOT.  **Proposal 4:** RE mapping should be performed per a slot or a TOT.  **R1-2107873 NTT DOCOMO**  **Proposal 3**: Support rate matching per slot for TBoMS, unless the CovEnh performance gap is large between rate matching per slot and rate matching per TOT.  **R1-2107936 Xiaomi**  **Proposal 2**: Support continuous rate-matching for TBoMS transmission.  **R1-2108158 WILUS**  **Proposal 1**: For TBoMS, the TB is transmitted on multiple TOTs using a single RV (Option-3), and the single RV is continuously rate-matched across all the allocated slot(s) per TOT (Option-b).   * + FFS: Handling for issues on rate-matching, such as UCI multiplexing. |

**How coded bits are selected**

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| **R1-2106496 Huawei/HiSi**  ***Proposal 7****: RM is performed per TOT, where the start position of bit selection in the circular buffer on TOT is defined as*  *where denotes the end position of bit selection in the circular buffer on TOT , , denotes the length of coded bits in the circular buffer, is the LDPC lifting size, and denotes the TOT number,*  ***Proposal 8****: The start position of bit selection in the circular buffer on the first TOT for each repetition is denoted by RV index and the RV index is cycled for each repetition in a configured sequence.*  **R1-2107191 Lenovo/Motorola**  **Proposal 4:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, if option 3 with single RV is adopted, then different starting points (to apply coded bits) from a single RV should be considered for different slots or TOTs.  **R1-2107257 OPPO**  **Proposal 6**: Single RV scheme can be used across all the TOTs in one TBoMS transmission over multi-slot.  Reducing the complexity of TB and RE processing in each slot, e.g., restricting TB size.  Consider an offset factor for bit selection.  **R1-2107360 Qualcomm**  **Proposal 6:** Defining a transmission occasion of TBoMS to span a single slot, the index of the starting coded bit for each transmission occasion is predetermined prior to the start of the TBoMS transmission.  **R1-2107560 Ericsson**  **Proposals:**   1. For TBoMS based on single RV and Option a, b and c, continuous coded bits are selected for all slots/TOTs of TBoMS.   **R1-2107873 NTT DOCOMO**  **Proposal 2**: A single RV should be transmitted over one TOT for consecutive slots or multiple TOTs for non-consecutive slots in a single TBoMS, where starting points of bit selections other than the first bit selection are right after encoded bits taken from circular buffer in the previous bit selection (Opt.3-2).  **Proposal 6**: The starting point of bit selections should be calculated based on available slots for PUSCH transmission |

## A.5 TBS determination

***N*Info calculation**

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| **R1-2106496 Huawei/Hisi**  **Proposal 4**: If the number of symbols in each slot allocated for TBoMS transmission is the same, K should be defined as the number of available slots allocated for TBoMS transmission.  **Proposal 5**: If the number of symbols in an uplink slot allocated for TBoMS transmission and the one in a special slot allocated for TBoMS transmission are different, K can be defined as the ratio of the number of all the symbols allocated for TBoMS transmission excluding DMRS symbols and the one in an uplink slot allocated for TBoMS transmission excluding DMRS symbols.  **R1-2106612 vivo**  **Proposal 6:** For definition of scaling factor K, it can be   * Number of slots in a TOT, if rate matching is performed per TOT; * Number of slots of multiple TOTs which construct a TBoMS, if rate-matching is performed across the multiple TOTs.   **R1-2106656 Nokia/NSB**  Proposal 7. For Ninfo calculation, NRE is scaled by K, where K equals the number of slots allocated for TBoMS counted based on the available UL slots.  **R1-2106740 ZTE**  **Proposal 8:** The number of slots for TBoMS could be reused as scaling factor K for NInfo calculation.  **R1-2106903 Samsung**  **Proposal 5**: K is the number of slots these are allocated to UE for one TBoMS transmission.  **R1-2106989 CATT**  **Proposal 4**: TBS of TBoMS is calculated by the following steps:   * + Step 1: A UE first determines the number of REs allocated for TBoMS within a PRB () by .   + Step 2: A UE determines the total number of REs allocated for TBoMS () by .   + Step 3: Obtain unquantized intermediate variable () by .   Where *K* is the total number of the allocated available slots for TBoMS, and is the maximum bandwidth of the active UL BWP.  **R1-2107035 Fujitsu**  **Proposal 3**: Scaling factor K is equal to the number of slots per TOT assuming that a TOT can be configured to contain one or more consecutive and/or non-consecutive physical slots for UL transmission.  **R1-2107117 Panasonic**  **Proposal 5**: For TBS determination, scaling factor K is indicated via DCI (separate field or TDRA).  **R1-2107257 OPPO**  **Proposal 4**: 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 5**: 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 number of slots for repetition.  **R1-2107360 Qualcomm**  **Proposal 7:** When determining for TBoMS, is the number of resource elements available in one slot of a TBoMS transmission as indicated by the SLIV in the TDRA and the FDRA. Further, is computed as , where denotes the code rate, denotes the modulation order and denotes the number of layers.  **Proposal 8:** The scale factor used to determine the TBS of TBoMS is determined independently of the number of slots over which TBoMS transmission is scheduled. The scale factor may take at least the following values: 2, 4, 8, 16.  FFS: signaling aspects of the scale factor.  **R1-2107549 LGE**  **Proposal 6**: Discuss following alternatives for the scaling factor K for TB size determination.   * Alternative 1: K is the number of slots consisting a TOT. * Alternative 2: K is indicated independently of the number of slots consisting the TOT/TBoMS.   **R1-2107560 Ericsson**  **Proposals:**   1. NInfo for TBoMS should be based on the number of REs across all slots of the TBoMS, no matter if the TBoMS is based on single RV or multiple RVs. Namely, K= the number of slots for the TBoMS. 2. When the number of symbols in each slot is the same for TBoMS,  * If the number of physical slots is configured, use TDD UL/DL configuration for TBS determination * If the number of available slots is configured, TBS determination is according to the number of available slots.   **R1-2107800 Sharp**  **Proposal 5:** K is dynamically adapted or signalled by the scheduling DCI for TBoMS.  **R1-2107873 NTT DOCOMO**  **Proposal 4**: Scaling factor *K* for the number of REs in TBS determination should be the number of slots allocated for one TB, considering the overhead and the issue of code rate in PUSCH repetition type A**.**  **R1-2108158 WILUS**  **Proposal 2**: The definition of K in Approach 2 is the number of slots allocated for TBoMS determined by using a row index of a TDRA list, configured via RRC.  **Proposal 3**: Ninfo is calculated based on the symbols over which TBoMS transmission is allocated. |

**Specific TBS values for TBoMS [To be included to ask companies if they envision new TBS values to be introduced, without touching max TBS value – Mid priority]**

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| **R1-2106740 ZTE**  ***Proposal 9:*** *The maximum TBS can be limited by the conditions of date rate limitations DataRate and DataRateCC.*  **R1-2106989 CATT**  **Proposal 6**: For TBoMS, no restriction is specified except for the maximum TBS.  **R1-2107141 NEC**  **Proposal 4**: Limit Ninfo upper bound to make sure that the maximum supported TBS not exceeds legacy maximum supported TBS in Rel-15/16 for TBoMS.  **R1-2107360 Qualcomm**  **Proposal 9:** For TBoMS, no new TB sizes are introduced.  **Proposal 10:** Restrict TBoMS transmissions to TB sizes that permit single codeblock transmissions (i.e., entire TB can be encoded as a single codeblock). Furthermore, restrict TBoMS transmission to single layer transmissions. |

## A.6 FDRA

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| **R1-2106740 ZTE**  ***Proposal 4:*** *The maximum number of PRBs can be limited when TBoMS is enabled.*   * *FFS how to determine the maximum number of PRBs.*   **R1-2106903 Samsung**  **Proposal 4**: The maximal number of PRB allocated in time domain is reduced for TB over multi-slot.  **R1-2107936 Xiaomi**  **Proposal 5**: Limit the number of RBs allocated for TB processing over multi-slot PUSCH by gNB scheduling. |

## A.7 TBoMS repetitions [mid priority – comment on the fact that this depends on the TBoMS structure decisions and several companies would like to study this further]

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| **R1-2106612 vivo**  **Proposal 4:** Repetition on top of TBoMS is supported, and the repetition number *M* is indicated in TDRA table.   * Where *M* is the repetition times of *X* TOTs which composes the TBoMS.     **R1-2106903 Samsung**  **Proposal 3**: Repetition is supported for TB over multi-slot.  **R1-2107124 China Telecom**  **Proposal 4:** Down selection on the following options for TBoMS:   * Option 1: The maximum number of aggregated slots for TBoMS is the same as the maximum number of repetition for PUSCH repetition type A in Rel-17. * Option 2: Repetition on top of TBoMS is supported.   **R1-2107191 Lenovo/Motorola**  **Proposal 8:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, repetitions of TBoMS should be further discussed.  **Proposal 9:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, if repetition of TBoMS is supported, then only PUSCH repetition type A should be considered  **Proposal 12:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, if PUSCH repetition is allowed when TBoMS feature is enabled, then following two methods can be considered to indicate the number of slots for TBoMS and repetition factor for TBoMS repetition:   * Introduce indication for number of slots for TBoMS in addition to repetition factor via TDRA row index * Only support dynamic indication for number of slots for TBoMS via TDRA, but the repetition factor for TBoMS repetition is indicated only via RRC configuration   **R1-2107560 Ericsson**  **Proposals:**  The need for repetition of TBoMS is further considered.  **R1-2107603 Intel**  **Proposal 2**   * Repetition is supported for the transmission of TBoMS.   **R1-2107635 Sierra Wireless**  **Proposal 1:** TBoMS encoding follows option 3:  Option 3: Multiple TOTs are determined for a TBoMS. The TB is transmitted on the multiple TOTs using a single RV.  Repetition is not supported with TBoMS.  FFS: Maximum number of slots  FFS: If and how to support early termination  **R1-2107754 Apple**  **Proposal 4:** For TB transmission over consecutive UL slots, repetition can be supported on top of TBoMS.  **R1-2107800 Sharp**  **Proposal 10:** TBoMS is viewed as repetition in unit of a slot or a TOT.  **R1-2107936 Xiaomi**  **Proposal 8**: TB processing over multi-slot can be transmitted in conjunction with repetitions. |

## A.8 DM-RS

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| **R1-2106656 Nokia/NSB**  Proposal 4. Optimizations on time domain resource determination for allocating resource in the S slots is deprioritized.   * DMRS optimization for TBoMS is deprioritized in Rel-17.   **R1-2107560 Ericsson**  **Proposals:**   1. RAN1 is to discuss issues of DMRS, MCS, number of layers, unit of retransmission and power control after agreements of time unit for rate matching are reached. |

## A.9 Transmission power determination

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| **R1-2106496 Huawei/HiSi**  ***Proposal 9***: *The transmission power determination of TBoMS should be based on the TOT.*  **R1-2106740 ZTE**  ***Proposal 11:*** *For TBoMS, the transmission power determination should be based on the total number of REs within all slots for TB processing with excluding the overhead of reference signals.*  **R1-2106989 CATT**  **Proposal 7**: The transmitted power of a TBoMS remains unchanged during the transmission.  **R1-2107560 Ericsson**  **Proposals:**   1. RAN1 is to discuss issues of DMRS, MCS, number of layers, unit of retransmission and power control after agreements of time unit for rate matching are reached.   **R1-2108158 WILUS**  **Proposal 4**: It should be further discussed how to determine the number of REs for UCI multiplexing and UL transmission power in case of TBoMS. |

## A.10 Rank of TBoMS transmission

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| **R1-2106612 vivo**  **Proposal 9**: PUSCH with TB processing over multiple slots should be limited to single transmission layer.  **R1-2107360 Qualcomm**  **Proposal 10:** Restrict TBoMS transmissions to TB sizes that permit single codeblock transmissions (i.e., entire TB can be encoded as a single codeblock). Furthermore, restrict TBoMS transmission to single layer transmissions.  **R1-2107560 Ericsson**  **Proposals:**   1. RAN1 is to discuss issues of DMRS, MCS, number of layers, unit of retransmission and power control after agreements of time unit for rate matching are reached. |

## A.11 Link adaptation

***MCS index***

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| **R1-2107560 Ericsson**  **Proposals:**   1. RAN1 is to discuss issues of DMRS, MCS, number of layers, unit of retransmission and power control after agreements of time unit for rate matching are reached. |

## A.12 Frequency hopping

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| **R1-2107124 China Telecom**  **Proposal 5:** Both inter-slot frequency hopping and inter-slot frequency hopping with inter-slot bundling should be supported for TBoMS.  **R1-2107198 TCL Communications**  **Proposal 4:** Intra-slot and inter-slot frequency hopping should be supported for TBoMS.  **R1-2107603 Intel**  **Proposal 4**   * *Inter-slot frequency hopping and inter-slot frequency hopping with inter-slot bundling are supported for TBoMS.*   + *FFS: intra-slot frequency hopping for TBoMS*   **R1-2107936 Xiaomi**  **Proposal 6**: Support intra-TB frequency hopping for TB processing over multi-slot PUSCH. |

## A.13 CB segmentation

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| **R1-2107560 Ericsson**  **Proposals:**  CB segmentation is needed for TBoMS in order to reuse Rel-15/16 LDPC coding.  **R1-2106903 Samsung**  ***Proposal 6****: RAN1 to confirm whether one or multiple CBs are supported for TBoMS.* |

## A.14 Retransmissions

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| **R1-2107191 Lenovo/Motorola**  **Proposal 6:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, retransmission procedure and signaling should be enhanced to support retransmission of only partial slots from the TBoMS.  **Proposal 7:** For PUSCH coverage enhancements in NR Rel-18 with TBoMS, if retransmission for duration shorter than the overall duration of TBoMS is supported, then implicit/explicit configuration of the portion (duration) should be supported with portion indication in the retransmission DCI. Exact duration of the portion can be as follows:   * Explicitly configured to the UE * Implicitly determined by UE depending on the duration of TBoMS, number of TOTs, duration of TOTs   **R1-2107418 CMCC**  **Proposal 5**: Per slot/TOTs retransmission could be considered for the retransmission of TBoMS.  **R1-2107560 Ericsson**  **Proposals:**   1. RAN1 is to discuss issues of DMRS, MCS, number of layers, unit of retransmission and power control after agreements of time unit for rate matching are reached.   **R1-2107651 InterDigital**  **Proposal 6:** Support enhanced retransmission mechanisms to avoid the retransmission of the entire TBoMS. |

## A.15 UCI multiplexing, SRS/DL collisions/cancellations [mid-priority – this is well discussed in contributions but strongly depends on how rate matching is performed, and S slot discussion. It should stay close at the beginning of the meeting]

**UCI multiplexing**

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| **R1-2106496 Huawei/HiSi**  ***Proposal 10****: In case of overlapped PUCCH and TBoMS transmissions, perform UCI multiplexing per TOT.*  ***Proposal 11****: For latency-sensitive UCI, allow performing per-slot UCI puncturing.*  **R1-2106612 vivo**  **Proposal 7**: For UCI multiplexing on PUSCH with TB processing over multiple slots, the starting symbol for TBoMS used for determining S0 is the starting symbol of a TOT or a TBoMS.  **Proposal 8**: For UCI multiplexing on TBoMS, the number of modulated symbols in the TBoMS for UCI should be same/close to that multiplexed in a single slot PUSCH, following options can be considered   * Opt-1: Re-define the parameter as number of symbols per slot allocated for TBoMS; * Opt-2: BetaOffset and scaling () is scaled by 1/K, where K is the number of slots for a TOT or TBoMS.     **R1-2106740 ZTE**  **Proposal 10:** Further discuss UCI multiplexing rules for TBoMS with aiming for reusing existing UCI multiplexing rules for PUSCH repetition type A as much as possible.  **R1-2106903 Samsung**  **Proposal 9:** Parallel transmission of PUCCH and TBoMS PUSCH is not preferred due to power splitting during CE situation.  **Proposal 10:** UCI multiplexing in TBoMS PUSCH is supported in Rel-17 CE,  **Proposal 11:** The timeline requirement is applied for the actual overlapped slot in the TBoMS*.*  **R1-2106989 CATT**  **Proposal 5:** Consider the following options for UCI handling in TBoMS.   * Option 1: UCI multiplexing is not supported by TBoMS. * Option 2: Reuse the UCI multiplexing of PUSCH repetition type A in TBoMS, i.e. the UCI is multiplexed into each overlapped slot of the TBoMS. * Option 3: UCI multiplexing is supported in a unit of TOT. * Option 4: UCI multiplexing is supported in a unit of TBoMS. * FFS details, e.g. determination of the number of REs for UCI multiplexing.   **R1-2107257 OPPO**  **Proposal 7**: UCI is equally multiplexed into all slots of TBoMS transmission.  **R1-2107360 Qualcomm**  **Proposal 11:** Defining a transmission occasion of TBoMS to span a single slot and restricting rate matching to occur on a per-slot basis, reuse R15/R16 framework for UCI multiplexing on PUSCH for TBoMS as well.  **R1-2107560 Ericsson**  **Proposals:**   1. If UCI multiplexing in TBoMS is supported, HARQ-ACK can be multiplexed in any overlapping slot by puncturing, and CSI or HARQ-ACK can be repeated in all slots of a TBoMS.   **R1-2107603 Intel**  **Proposal 5**   * *FFS how to handle overlaps between TBoMS and other uplink transmission.*   **R1-2107651 InterDigital**  **Proposal 5:** Support UCI multiplexing with TBoMS. FFS whether UCI is repeated on the multiple slots of TBoMS.  **R1-2107800 Sharp**  **Proposal 2:** UCI is multiplexed in a slot or a TOT overlapping with a PUCCH for reporting the UCI.  **R1-2108158 WILUS**  **Proposal 4**: It should be further discussed how to determine the number of REs for UCI multiplexing and UL transmission power in case of TBoMS. |

**Collision handling**

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| **R1-2106740 ZTE**  **Proposal 3:** For collision handling of TBoMS, legacy Rel-15/16 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.  **R1-2107360 Qualcomm**  **Proposal 12:** Defining a transmission occasion of TBoMS to span a single slot and restricting rate matching to occur on a per-slot basis, reuse R15/R16 framework for collision handling between PUSCH and other channels/signals for collision handling between TBoMS and other channels/signals. |

## A.16 Additional indicators and configuration options

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| **R1-2106656 Nokia/NSB**  Proposal 8. RAN1 to specify an indication method for enabling TBoMS transmission per PUSCH scheduling/configuration.   * *FFS: Details of the indication method.*   **R1-2107191 Lenovo/Motorola**  **Proposal 10:** For PUSCH coverage enhancements in NR Rel-17 with TBoMS, semi-static and/or dynamic configuration of TBoMS feature for PUSCH should be supported, and independent from PUSCH repetition,  **R1-2107651 InterDigital**  **Proposal 1:** Support dynamic enabling/disabling of TBoMS transmission using TDRA list configuration.  **R1-2107936 Xiaomi**  **Proposal 7**: Consider the configuration and indication signalling design when a single UE supports both repetition and TBoMS. |

## A.17 Interleaved TBoMS transmissions

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| **R1-2107360 Qualcomm**  **Proposal 14:** Interleaved TBoMS transmissions (carrying different TBs) are not permitted. A UE does not expect a TBoMS transmission in a component carrier to begin before the completion of an ongoing TBoMS transmission in the same component carrier. |

## A.18 Application of TBoMS to Msg3 transmission

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| **R1-2107198 TCL Communications**  **Proposal 2:** Study whether MSG3 support TBoMS. |

## A.19 Application of DM-RS bundling to TBoMS

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| **R1-2107198 TCL Communications**  **Proposal 5:** The inter-slot bundling with inter-slot frequency hopping should be supported for TBoMS. |

# Appendix B: Previous agreements on TB processing over multi-slot PUSCH

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.

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.

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 are different.

Agreement:

* 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.

Agreement:

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

Agreement:

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.

Agreement:

One or two of the following approaches will be considered as a starting point to decide how NInfo 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.

Agreement:

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