**3GPP TSG-RAN WG1 Meeting #106-e R1-210xxxx**

**e-Meeting, August 16th – 27th, 2021**

**Agenda Item: 5.2**

**Source: Moderator (ZTE)**

**Title: Summary on the physical layer aspects of small data transmission**

**Document for: Discussion**

# Introduction

In this meeting, it is necessary to continue the discussion on the remaining physical layer issues, i.e. mainly on the mapping details of SSB-to-PUSCH resource and TA validation for CG-SDT.

This document contains the summary of remaining issues related to the physical layer aspects of small data transmission in RAN1#106-e meeting.

[106-e-NR-R17-SDT-01] Email discussions on remaining issues on NR SDT in INACTIVE state – Li (ZTE)

* 1st check point: August 19
* 2nd check point: August 25
* 3rd check point: August 27

# TA validation for CG-SDT

Agreement from the last meeting:

Agreement in 105-e:

* The SSB subset for RSRP based TA validation is determined at least based on a configured absolute RSRP threshold.
* FFS the SSB subset which could be
* within a set of SSBs configured per CG configuration
* or within a set of SSBs configured for all CG configurations
* or within a set of all SSBs actually transmitted as indicated in SIB1.
* or highest N SSBs that are measured to derive the subset for a UE across all CG configurations

## SSB subset determination

Companies’ views from the submitted contributions are collected in the following table:

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2106458 Huawei [1] | *Observation 1: The TA validation is highly correlated to the distance between UE and gNB, and is decoupled to the CG configuration. The SSBs in the subset should indicate this distance and do not relate to the CG configurations.*  *Proposal 4: The SSB subset for RSRP based TA validation* *should be included in the SSBs actually transmitted as indicated in SIB1, and is the highest N SSBs that are measured by a UE to derive the subset.* |
| R1-2106683 Spreadtrum [2] | *Proposal 1: The SSB subset for RSRP based TA validation is determined at least based on a configured absolute RSRP threshold, where the subset of SSBs is a set of SSBs configured per CG configuration.* |
| R1-2106765 Ericsson [3] | [Proposal 10 SSB subset for the average RSRP calculation is within a set of SSBs per CG PUSCH configuration.](#_Toc79227320)  [Proposal 11 RSRP change is the difference between RSRP calculated at the time when the UE receives the latest TAC from the network and the RSRP calculated at the time when UE determines TA validation for a CG PUSCH SDT.](#_Toc79227321)  [Proposal 12 Different RSRP variation thresholds and TAT configuations can be configured for different sets of SSBs configured within a set of SSBs configured per CG configuration](#_Toc79227322) |
| R1-2106855 Samsung [5] | *Proposal 2: SSB subset is determined from all SSBs actually transmitted as indicated in SIB1.* |
| R1-2106926 CATT [6] | Proposal 5: the SSB subset which is within a set of SSBs configured for all CG configurations is used for RSRP based TA validation. |
| R1-2107007 ZTE [7] | *Proposal 4: For TA validation based on RSRP change criterion of the SSB set, the subset of SSBs could be determined within a set of all SSBs actually transmitted as indicated in SIB1.* |
| R1-2107075 InterDigital [8] | *Proposal 1: SSB subset for RSRP-based TA validation is within a set of SSBs configured per CG configuration.* |
| R1-2107971 vivo [14] | Proposal 1: For CG-SDT, the SSB subset for RSRP based TA validation could be up to gNB configuration with the following:   * + a set of SSBs configured for all CG configurations   + or a set of all SSBs actually transmitted as indicated in SIB1.   + or highest N SSBs that are measured to derive the subset for a UE across all CG configurations |
| R1-2108089 Nokia [16] | Observation 3: A single absolute RSRP threshold might lead to no SSB being eligible to be part of the TA validation subset.  Proposal 4: The RSRP threshold is based on strongest SSBs  Proposal 5: RAN 1 to agree that the same subset of SSBs should be used for TA validation for obtaining the reference RSRP and the subsequent RSRP measurements to monitor the RSRP variation. |

### 2.1.1 First round discussion

Companies’ views are quite split, and there are more options than those listed in the FFS bullet from the last meeting. So the moderator would like to suggest companies to provide views on these options, especially on which option(s) is preferred and which one(s) is not acceptable.

***Discussion point 2.1***:

The following options are summarized from the companies’ contributions:

* Option 1: Within a set of SSBs configured per CG configuration[2][3][8]
* Option 2: Within a set of SSBs configured for all CG configurations[6][14]
* Option 3: Within a set of all SSBs actually transmitted as indicated in SIB1[5][7][14]
* Option 4: Highest N SSBs that are measured to derive the subset for a UE across all CG configurations[14]
* Option 5: The same SSB subset as for obtaining reference RSRP[16]
* Option 6: Highest N SSBs of all SSBs actually transmitted as indicated in SIB1[1]

Any comments on the above options?

|  |  |  |  |
| --- | --- | --- | --- |
| Company | Option(s) preferred | Option(s) cannot accept | Comment |
| Huawei, HiSilicon | Option 6 | Option 1,2,4 | As we proposed in [1], the TA validation is highly correlated to the distance between UE and gNB, and is decoupled to the CG configuration. So Option 1, 2 and 4 are not feasible. Towards Option 5, more details should be provided to prove the motivation of using same SSB subset as for obtaining reference RSRP. |
| CATT | Option 2 |  | For Option4 and Option 6, we wonder whether some SSBs which don’t belong to any of the CG configurations are used for RSRP calculation for TA validation. We hope proponent to clarify this. |
| Qualcomm | 1, 2, 5 | 3, 6 | • Due to channel fading or other impairments, the ordering of the highest N SSBs could change over time among all SSBs actually transmitted.  • A CG-SDT occasion configured for a UE is not necessarily mapped to all SSB indexes actually transmitted in the cell. |
| Samsung | Option 3 | Option 1, 2, 4,5  [want to further clarify on option 6] | Same reason as HW to not ok with option 1, 2 ,4;  Option 3 did not require the CG to map to all the SSBs.  For option 5, there will be always cases that some UE in some situation that its measurement may not meet the threshold; we should not design some additional method to pretend it wont happen. Lower than threshold means the UE’s channel is not good enough for CG-SDT. This situation is not purely like the SSB selection for RACH, which UE has already decoded the MIB for further operation.  For option 6, we did not understand why it needs this N strongest limitation. Note that this subset is just what UE will select (from the ones above the threshold). As when UE actually initiates the CG-SDT, which SSB might be possible is unknown. It’s natural to allow all the SSB indicated in SIB1 to be the candidates as long as the UE measure it is above threshold. |
| ZTE, Sanechips | Option 3, 6 | Option 1 | We share similar view with Huawei that whether TA is valid or not does not rely on any of the CG configuration, it only depends on the distance between UE and gNB. The SSB subset that used for TA validation doesn’t need to associate with that of the CG configuration. Besides, the SSB subset discussed here is aimed for TA validation, not for SSB to PUSCH mapping.  Regarding Option 6, from our understanding, it requires a configurable parameter N compared with Option 3, so that SSB subset in Option 6 can be a subset of Option 3, this option is also aligned with the existing cell level RSRP derivation procedure and it is also acceptable. |
| Ericsson | Option 1 | Other options. | Since the SSBs not associated with the CG PUSCH resources configured by the CG PUSCH configuration are not expected to be checked, option 1 should be used instead of checking other SSBs not associated with the CG PUSCH resources configured by the CG PUSCH configuration.  It can be up to network to configure how many SSBs will be supported per CG PUSCH configuration, which is flexible enough. gNB can configure all SSBs for the CG PUSCH configuration if necessary, which is not precluded when we adopt option 1. |
| Intel | Option 1 or 2 |  | It is not clear to us why additional set of SSBs are needed for average RSRP calculation. It is up to gNB implementation to configure a suitable set of SSBs for CG-PUSCH association and RSRP measurement. |
| Spreadtrum | Option 1 | Other options | We don’t understand if an SSB is not configured in a CG configuration (not associated to or QCLed to any PUSCH), why the “irrelevant’ SSB can be still used for TA validation? TA to transmit the PUSCH in the CG configuration cannot rely on the irrelevant SSB (beam). |
| vivo | Option 3 | Option 1 | Similar view as Huawei. In the existing spec, when TA is valid, it is applicable to all CG configurations. If TA validation is dependent on a set of SSBs configured for a particular CG configuration, TA needs to be configured per CG configuration, which is different from current TA configuration. |
| LG | Option 1 |  | CG configuration configured for a UE can be mapped to a set of SSBs. How to map can be up to gNB. We think that this mapping can be used for TA validation. |

### 2.1.2 Second round discussion

Companies’ stands are summarized as follows

* Option 1: Within a set of SSBs configured per CG configuration
  + Supported by: Qualcomm, Ericsson, Intel, Spreadtrum, LG
* Option 2: Within a set of SSBs configured for all CG configurations
  + Supported by: CATT, Qualcomm, Intel
* Option 3: Within a set of all SSBs actually transmitted as indicated in SIB1
  + Supported by: Samsung, ZTE, vivo
* Option 4: Highest N SSBs that are measured to derive the subset for a UE across all CG configurations
  + Supported by:
* Option 5: The same SSB subset as for obtaining reference RSRP
  + Supported by: Qualcomm
* Option 6: Highest N SSBs of all SSBs actually transmitted as indicated in SIB1
  + Supported by: Huawei, ZTE

Based on the comments in the first round, one main controversial part is whether there should be a relationship between the SSBs used for TA validation and the SSB for CG configuration. This is the main difference between option 1/2/4 and options 3/6. And the main difference between option 1 and 2 is that option 1 may need to perform the TA validation per configuration, and each configuration will have a TA validation result.

Seems no companies support option 4 so I would suggest to exclude option 4 in the following discussion. For option 5, as we already agreed that the reference RSRP is explicitly configured, I am not sure whether it is suitable to introduce an additional SSB subset to derive the reference RSRP.

**Proposal 2.1:**

Further down-select among the following options for the SSB subset for RSRP based TA validation

* Option 1: Within a set of SSBs configured per CG configuration
* Option 2: Within a set of SSBs configured for all CG configurations
* Option 3: Within a set of all SSBs actually transmitted as indicated in SIB1
* Option 6: Highest N SSBs of all SSBs actually transmitted as indicated in SIB1

To help on the analysis of pros and cons among the options, please also try to provide your views on the following questions. It would be appreciated if there is more suggestions on how to make further down-selection.

Q1: do you think the SSBs used for TA validation should be within the SSBs mapped to CG transmission, and would this achieve better accuracy for the RSRP change?

Q2: do you think it is possible to do the TA validation per configuration, and how to decide the overall result for TA validation if some of the CG configuration are valid while some others are not valid?

Q3: do you think selecting highest N SSBs would result in better accuracy for the RSRP change?

Any comments on the above options?

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

## Other issues related to TA

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2106765 Ericsson [3] | [Proposal 12 Different RSRP variation thresholds and TAT configuations can be configured for different sets of SSBs configured within a set of SSBs configured per CG configuration](#_Toc79227322)  [Proposal 13 On top of the TA validation based on RSRP change, support TDOA based crieterial for TA validation in CG based SDT.](#_Toc79227323)  [Proposal 14 TA based on latest UL transmissions before RRC release message should be provided in the RRC release message as initial TA to be used by CG SDT in RRC inactive.](#_Toc79227324)  [Proposal 15 The TA for CG SDT should be relative to the subcarrier spacing of initial UL BWP or the separately configured for CG SDT.](#_Toc79227325)  [Proposal 16 TA offset is optionally configured in RRC release message for CG SDT and the default TA offset is used when absent.](#_Toc79227326) |
| R1-2106683 [2] | In RAN1 view, other criterion for TA validation is still under discussion of RAN1. Some companies in RAN1 concern about the accuracy of TA validation based on absolute RSRP. It should be firstly studied in RAN4 in RAN1’s understanding. |

### 2.2.1 First round discussion

It is the moderator’s suggestion to focus on SSB subset determination, and the issues related to TA configuration can be discussed later if justified sufficiently. For any other TA validation mechanism, let us wait for RAN4’s response for now.

Any comments?

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | Fine with moderator’s suggestions. |
| CATT | We are fine with FL’s suggestion. |
| Qualcomm | SSB subset determination should be prioritized |
| Samsung | Fine. |
| ZTE, Sanechips | We are fine with FL’s suggestion. |
| Ericsson | Agree that we should prioritize things to move forward.  However, it would also be good that RAN1 could give guidance on which RRC parameters list should be signalled in which configuration to make such TA validation/SSB determination can work, given we have only 3 meetings left for Rel-17 in RAN1. |
| Intel | We are fine with FL’s suggestion. |
| Spreadtrum | Fine. |
| vivo | We are fine with FL’s suggestion. |

# SSB to PUSCH mapping details for CG-SDT

Agreement from the last meeting is copied as below. Still some details regarding the implicit mapping between SSB and PUSCH resource for CG-SDT need to be finalized.

Agreement in 105-e:

* The SSB-to-PUSCH resource mapping within the CG configuration is implicitly defined.
* The ordering of the SSB and CG PUSCH resources are to be captured in RAN1 spec.
* A PUSCH resource refers to a transmission occasion and a DMRS resource used for PUSCH transmission
* The ordering of the SSB can reuse from the SSB-to-RO mapping
* The ordering of CG PUSCH resources can reuse from that of MsgA PUSCH as much as possible
* FFS determination of mapping ratio and association period, e.g., explicitly signaled or implicitly derived
* FFS any limitation on the combination of the parameters for CG resources

## Mapping ratio and association period

Companies’ views from the submitted contributions are collected in the following table:

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2106458 Huawei [1] | *Proposal 3:* *Each of consecutive SSB indexes associated to one CG configuration*  *- in increasing order of SSB indexes*  *are mapped to PUSCH occasion in CG period and the associated DMRS resource*  *- first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index*  *- second, in increasing order of CG period indexes*  *where , is a total number of SSBs mapped to this CG configuration provided by configuredGrantConfig, and is a total number of valid CG periods per association period multiplied by the number of DMRS resource indexes provided by cg-DMRS-Config.* |
| R1-2106683 Spreadtrum [2] | *Proposal 3: The mapping ratio of SSB-to-RO mapping is determined by the legacy parameters in SIB1.* |
| R1-2106765 Ericsson [3] | [Proposal 4 Number of SSBs per CG PUSCH resource can be explicitly configured by network.](#_Toc79227314)  [Proposal 5 SSB to CG PUSCH association (pattern) period is implicitly derived based on the SSB period and the CG period. Ask RAN2 about the CG period candidate values for SDT.](#_Toc79227315)  [Proposal 6 When multiple CG PUSCH configurations are configured, RAN1 to discuss how a common SSB to CG PUSCH association period should be derived.](#_Toc79227316) |
| R1-2106855 Samsung [5] | *Proposal 5: the SSB-PUSCH mapping ratio is signalled to UE and if it’s absent, UE will calculate it based on the SSB number and PUSCH resource number in one CG-PUSCH resource.* |
| R1-2106926 CATT [6] | Proposal 2: For CG-SDT, mapping ratio between SS/PBCH blocks and TOs of one Type1 CG configuration can be configured by RRC signaling within the association period. The association period is integer number of CG period starting from SFN0 and is configured by high layer signaling.  Proposal 3: For CG-SDT, if mapping ratio between SS/PBCH blocks and TOs of one Type1 CG configuration is > 1, DMRS resource including DMRS port and DMRS sequence in one TO is used to further distinguish SSBs. |
| R1-2107007 ZTE [7] | *Proposal 1: By default support 1-to-1 mapping between SSBs and CG PUSCH resources.*  *Proposal 2: The association period could be either implicitly derived or explicitly signaled*   * *If implicit determination is selected, the value set of CG period should be limited to reduce complexity, e.g. {1,2,4,8,16} frames.* * *If explicit indication is selected, the association period could be set as the same value as CG period, or a different value from a set such as {10ms, 20ms, 40ms, 80ms, 160ms}.* |
| R1-2107566 Intel [12] | Proposal 3   * *For the association between SSBs and CG-PUSCH resources*   + *Multiple DMRS resources can be configured within a CG-PUSCH occasion.*   + *Mapping ratio and association period are explicitly configured*   + *Many-to-one and one-to-one mapping between SSB and CG-PUSCH occasion are supported.* |
| R1-2107707 Apple [13] | Proposal 1: SSB-to-PUSCH association period is configured by the network explicitly. The SSB-to-PUSCH mapping ratio is derived implicitly. |
| R1-2107971 vivo [14] | Proposal 3: Support many-to-one or one-to-one mapping between SSBs and PUSCH resource units within a CG configuration.   * + Mapping ratio between SSBs and PUSCH resource units per CG configuration can be configured by higher layer, e.g. *N* SSB(s) is associated with a PUSCH resource unit.   Proposal 4: Each consecutive number of 𝑁 SSB indexes provided for a CG configurationare mapped to the CG PUSCH occasions within the CG configuration in the following order.   * + first, in increasing order of DMRS resource indexes within a PUSCH occasion, where a DMRS resource index is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index   + second, in increasing order of time resource indexes for time multiplexed PUSCH occasions within a CG periodicity   + third, in increasing order of indexes for PUSCH occasions across CG periodicities |
| R1-2108089 Nokia [16] | Proposal 1: Adopt the following rule for mapping the SDT-CG-PUSCH resources to SS/PBCH blocks:   * UE is provided with *K* SDT-CG-PUSCH resources, that map to the *N* SS/PBCH blocks 0,…,*N*-1 provided in the cell, where *n*=*N*/*K* * The first SDT-CG-PUSCH is mapped to SS/PBCH blocks {0,…floor (*n*-1)}, * The second SDT-CG-PUSCH is mapped to SS/PBCH blocks {floor (*n*),…,floor (2*n*-1)}, * The third SDT-CG-PUSCH is mapped to SS/PBCH blocks {floor (2*n*),…, floor (3*n*-1)}, * And so on until all the *K* SSBs are mapped to one SDT-CG-PUSCH resource each. |

### 3.1.1 First round discussion

For the mapping ratio and association period, at least one of them should be determined (pre-defined or explicitly indicated), and the other one can be implicitly derived; or both values are explicitly indicated.

***Discussion point #3.1:***

Down-selection among the following options for the indication of mapping ratio and association period:

* Option 1: Mapping ratio and association period are both explicitly signalled[6][7][12]
  + The association period is an integer number of CG period
  + FFS candidate value sets of mapping ratio and association period
* Option 2: Mapping ratio is explicitly signalled and association period is implicitly derived (similar to SSB-to-RO mapping) [1][3][5][7][14][16]
  + FFS candidate value set of mapping ratio, e.g. {1/8,1/4,1/2,1,2,4,8,16}
    - If <1, each SSB index is mapped to 1/N consecutive valid CG PUSCH resources. If , each valid CG PUSCH resource is associated with all the N SSB index.
  + The SSB to CG PUSCH association period is the duration of multiple of CG periods depending the smallest time duration required to map all SSBs at least once to CG PUSCH resources.
    - FFS if the association pattern period needs to be defined
* Option 3: Association period is explicitly signalled and mapping ratio is implicitly derived[13]
  + FFS candidate value set of association period

Regarding the details for the ordering of CG PUSCH resources, since it is highly related to the issues listed in section 3.2 (multiple DMRS) and 3.3 (repetition), let us come back later once we have consensus on those issues.

Preference and comments on the above options?

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | Almost fine with moderator’s suggestion. |
| CATT | First of all, we are supportive of mapping ratio configuration which is similar to SSB-to-RO mapping.  Secondly, for association period, we are fine with one of ways on explicitly signaling or implicitly derivation (similar to SSB-to-RO mapping) for association period. |
| Qualcomm | Option 1 is preferred. It is fine to re-visit these options at a later time. |
| Samsung | Discuss later. |
| ZTE, Sanechips | Option 2 is preferred since it reuses the mechanism of SSB-to-RO mapping, and Option 1 is also acceptable, gNB could handle the possible resource waste. As for the ordering, we agree with FL that it can be discussed after other issues are fixed. |
| Ericsson | Option 2 is enough so that we can try to reuse SSB-RO mapping rules. Number of SSBs per PO (PUSCH occasion) can be explicitly defined similar to number of SSBs per RO configuration so that the mapping ratio will be derived based on the number of DMRS resources if multiple DMRS resources per PO are to be supported. |
| Intel | We prefer Option 1, i.e., explicitly configure mapping ratio and association period.  We are also fine to discuss this later. |
| vivo | Option 2 is preferred.  We are fine to discuss later. |
| Nokia | OK to discuss later |
| LG | We also prefer to discuss this later. |
| Apple | OK to discuss later |

### 3.1.2 Second round discussion

Seems I need to first clarify that the previous FL comment to discuss “this” later only refers to the mapping order, while the mapping ratio and association period can be discussed independently with the DMRS and repetition issues.

Anyway, assuming we can eventually converge on proposal 3.2 and 3.3, the mapping order of DMRS-first-Time-second seems to be sufficient. And for the mapping ratio and association period, let us see if the similar principle as SSB-to-RO mapping (i.e. option 2 with slight majority view) can be acceptable.

**Proposal 3.1:**

* Each N of consecutive SSB indexes associated to one CG configuration are mapped to CG PUSCH resource
  + first, in increasing order of DMRS resource indexes, where a DMRS resource index is determined first in an ascending order of a DMRS port index and second in an ascending order of a DMRS sequence index
  + second, in increasing order of CG period indexes in the association period
* The mapping ratio N is explicitly signalled and the association period is implicitly derived
  + FFS candidate value set of mapping ratio, e.g. {1/8,1/4,1/2,1,2,4,8,16}
    - If <1, each SSB index is mapped to 1/N consecutive valid CG PUSCH resources. If , each valid CG PUSCH resource is associated with all the N SSB index.
  + The SSB to CG PUSCH association period is the duration of multiple of CG periods depending the smallest time duration required to map all SSBs at least once to CG PUSCH resources.
    - FFS if the association pattern period needs to be defined

Any comments?

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| --- | --- |
| Company | Comment |
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Any comments?

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| --- | --- |
| Company | Comment |
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## Multiple DMRS per CG configuration

Companies’ views from the submitted contributions are collected in the following table:

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2106458 Huawei [1] | *Proposal 1: The multiple DMRSs per CG configuration is supported for CG-SDT.* |
| R1-2106926 CATT [6] | Proposal 3: For CG-SDT, if mapping ratio between SS/PBCH blocks and TOs of one Type1 CG configuration is > 1, DMRS resource including DMRS port and DMRS sequence in one TO is used to further distinguish SSBs. |
| R1-2107971 vivo [14] | Proposal 2: For CG-SDT, one or multiple DMRS resources per CG configuration are supported.   * + The number of DMRS ports and/or DMRS sequences per CG configuration can be configured by gNB |
| R1-2108089 Nokia [16] | Observation 2: The DMRS resource based SSB identification can be achieved by configuring the same CG-PUSCH resources for the SSBs with different *DMRS-UplinkConfig.* No additional specification rules for SSB-to-DMRS mapping is needed to achieve this.  Proposal 3: Do not specify redundant mechanism for mapping different *DMRS-UplinkConfig* on one CG-PUSCH configuration e.g. for SSB identification purposes |
| R1-2107566 Intel [12] | Proposal 3   * *For the association between SSBs and CG-PUSCH resources*   + *Multiple DMRS resources can be configured within a CG-PUSCH occasion.*   + *Mapping ratio and association period are explicitly configured*   + *Many-to-one and one-to-one mapping between SSB and CG-PUSCH occasion are supported.* |

### 3.2.1 First round discussion

5 companies mentioned the issue of multiple DMRS per CG configuration, 4 companies support multiple DMRS per CG configuration when single layer PUSCH transmission is assumed, and whether each DMRS resource is mapped to the same or different SSB(s) depends on the mapping ratio between SSBs and CG PUSCH resource, one company believe the DMRS resource based SSB identification can be achieved by configuring the same CG-PUSCH resources for the SSBs with different *DMRS-UplinkConfig* and there is no need to specify other mechanisms.

The other relevant issue mentioned during the discussion in the last meeting is whether multi-layer PUSCH transmission is supported for CG-SDT. Companies are also encouraged to provide views on it.

***Discussion point 3.2***:

Down-select from the following options:

* Option 1: Support multiple DMRS resources per CG configuration when single layer PUSCH transmission is assumed, and each DMRS resource could be mapped to the same or different SSB(s) [1][6][12][14]
  + FFS if multi-layer PUSCH transmission is supported for CG-SDT
* Option 2: Multiple DMRS resources per CG configuration for single layer PUSCH transmission is not supported for CG-SDT. No spec change is needed. [16]

Preference and comments?

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | Option 1 |
| CATT | We are fine with Option 1. |
| Qualcomm | Option 1 |
| Samsung | Option 1 |
| ZTE, Sanechips | We are fine with Option 1. |
| Ericsson | Multiple DMRS is something similar to MsgA PUSCH resource definition, and this should be discussed together with the open issue on whether we should configure multiple PUSCH occasions per CG period.  If multiple CG PUSCH occasions are supported per CG period, maybe multiple DMRS can be not supported, while if only single PO is configured per CG period, multiple DMRS may be supported. |
| Intel | We support Option 1. |
| Spreadtrum | Option 1 |
| vivo | Option 1 |
| Nokia | We have not seen the point in changing how a CG-PUSCH resource is configured in Rel-15, that would lead to the need of defining a new rule for DMRS resource selection otherwise not necessary. Thus we prefer “option 2”, i.e. do nothing, as it is obviously much simpler than the additional feature that does not seem to do anything that couldn’t be done without it. |
| Apple | Option 1 |

### 3.2.2 Second round discussion

The situation is clear, 10 out of 11 companies support option 1, and 1 company prefer to keep the Rel-15 CG configuration as it is. Since it has been discussed over multiple meetings and all the other companies believe it is nice to have multiple resources per CG period, I think it is reasonable to go for the majority view.

**Proposal 3.2:**

* Support multiple DMRS resources per CG configuration when single layer PUSCH transmission is assumed, and each DMRS resource could be mapped to the same or different SSB(s)
  + FFS if multi-layer PUSCH transmission is supported for CG-SDT

Any comments on the proposal, and any views on the sub-bullet?

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

## Repetitions

Companies’ views from the submitted contributions are collected in the following table:

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2106458 Huawei [1] | *Proposal 2: The repetition mechanism in CG configuration in licensed band is reused for CG-SDT. Do not support different repetitions within one CG period mapped to different SSBs.* |
| R1-2106855 Samsung [5] | *Proposal 3: Configure the number of PUSCH transmission occasion (PO) in one CG-PUSCH period by new parameter or re-interpret the number of repetitions configured.* |
| R1-2106926 CATT [6] | Proposal 4: PUSCH repetition should be supported for CG-SDT. When PUSCH repetition is applied for Type1 CG configuration during CG-SDT, SS/PBCH blocks should be associated with one TO bundle including K TOs corresponding to the K repetitions. |
| R1-2107007 ZTE [7] | *Proposal 3: For CG repetition, the repetitions are considered as a bundle of transmission occasions that are mapped to the same SSB(s).* |
| R1-2107707 Apple [13] | Proposal 2: Time domain repetition can be supported for CG-SDT. |
| R1-2108089 Nokia [16] | Observation 1: When SDT-CG-PUSCH configuration is associated to an SSB, there is no additional SSB mapping complication when repetitions are allowed.  Proposal 2: Allow using PUSCH repetition with SDT-CG-PUSCH. No spec changes needed. |

### 3.3.1 First round discussion

6 companies mentioned repetitions, 5 companies among them support to consider the repetitions as a bundle of transmission occasions that are mapped to the same SSB(s), while one company support to re-interpret the configured repetitions as TDMed transmission occasions within a CG period.

***Discussion point 3.3***:

Down-select between the following two options for the interpretation of PUSCH repetation:

* Option 1: Re-interpret the configured repetitions as TDMed transmission occasions within a CG period.[5]
* Option 2: The repetitions are considered as a bundle of transmission occasions that are mapped to the same SSB(s), no additional specification rule is needed. [1][6][7][13][16]

The situation is unchanged from the previous meetings. So the moderator would suggest to go with the majority view, i.e. option 2.

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | Fine with the moderator’s suggestion. |
| CATT | We are fine with Option 2 |
| Qualcomm | Option 2 is supported |
| Samsung | One general question is: why CG-SDT should support repetition? We already agree the CG-SDT will be selected based on a threshold, certainly a UE with certain good channel condition is able to use CG-SDT, rather than these in poor channel condition who needs repetition.  Another concern was that, the configured repetitions (equal to the transmission occasions) will be through the validation check, or availability check; so it will end up with different number of occasions from time to time, but the option 2 will count each group with different of transmission occasions as the same level unit for SSB association, it is an unfair design principle. |
| ZTE, Sanechips | We are fine with Option 2. |
| Ericsson | Agree that there’s no need to introduce new repetition occasions, and same SSB is mapped to all repetitions. |
| Intel | We are fine with Option 2. |
| Spreadtrum | Option 2 |
| vivo | Option 2.  Regarding multiple TDMed transmission occasions within a CG period, it can be a separate discussion. |
| Nokia | Prefer option 2. |
| LG | We are fine with both options. UE could be configured with none or one of the options. |
| Apple | Option 2. |

### 3.3.2 Second round discussion

The situation is clear, option 2 is supported by 11 out of 12 companies, and objected by 1 company. Since it has been discussed over multiple meetings and all the other companies believe it is better to keep the configuration of repetition as it is, I think it is reasonable to go for the majority view. I think Samsung’s concern on the unfairness is valid but I am not sure how serious the issue would be, probably we can discuss it further in section 3.4 w.r.t. the validation of CG PUSCH occasion.

**Proposed Conclusion 3.3:**

* The repetitions are considered as a bundle of transmission occasions that are mapped to the same SSB(s), no additional specification rule is needed.

Any comments?

|  |  |
| --- | --- |
| Company | Comment |
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## Validation of PUSCH occasion

Companies’ views from the submitted contributions are collected in the following table.

|  |  |
| --- | --- |
| Tdocs | Proposals |
| R1-2106765 Ericsson [3] | [Proposal 7 Further discuss in RAN1 on whether and how CG SDT can be allowed on flexible symbols when UE is in RRC inactive state. Similar UE behavior for CG PUSCH transmissions in RRC connected state can be followed by UE doing CG based SDT.](#_Toc79227317) |
| R1-2106855 Samsung [5] | *Proposal 4: the valid PO is the PO in UL part in a slot, or at least Ngap symbols after the end of the DL part in a slot or after the end of the SSB in a slot.* |
| R1-2107566 Intel [12] | Proposal 4   * *CG-PUSCH occasion validation rule for CG-SDT follows that was defined for MsgA PUSCH occasion for 2-step RACH.*    + *FFS: potential overlapping between CG-PUSCH occasions for CG-SDT and MsgA PUSCH occasions for 2-step RACH.* |

### 3.4.1 First round discussion

The PUSCH validation has been discussed in previous meeting with low priority. Let us check if more companies are positive to discuss it at this stage.

***Discussion point 3.4***:

* The following PUSCH occasion validation rule is applied for CG-SDT
  + the valid PO is the PO in UL part in a slot, or at least *Ngap* symbols after the end of the DL part in a slot or after the end of the SSB in a slot
    - FFS: potential overlapping between CG-PUSCH occasions for CG-SDT and MsgA PUSCH occasions for 2-step RACH

Any comment?

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | This issue may need to be revisited later, after more progress is available from the discussion points of 3.1~3.3 related to SSB-to-CG mapping. |
| CATT | We are fine with FL proposal. |
| Qualcomm | We are fine with the main bullet.  FFS part does not seem relevant. Check with RAN2 to see if Type-2 RACH procedure can be triggered during CG-SDT. |
| Samsung | Support FL proposal. |
| ZTE, Sanechips | We are fine with the proposal. |
| Ericsson | Instead of following rules of MsgA PUSCH which is cell specific, for such UE specific CG PUSCH occasion validation, it may be better to follow similar rules as CG Type 1 PUSCH in RRC connected state in our understanding.  We try to copy existing related text from 38.213 below, which may be helpful for us to understand and define rules of collision handling and validation of a CG PUSCH for SDT with minimum change to the specifications.  Probably some of the signalings not provided in RRC inactive can be provided in RRC release message and dynamic SFI can be assumed to be not supported compared to legacy CG Type 1 PUSCH transmission.  For a set of symbols of a slot that are indicated to a UE as downlink by *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated*, the UE does not transmit PUSCH, PUCCH, PRACH, or SRS when the PUSCH, PUCCH, PRACH, or SRS overlaps, even partially, with the set of symbols of the slot.  For a set of symbols of a slot that are indicated to a UE as flexible by *tdd-UL-DL-ConfigurationCommon*, and *tdd-UL-DL-ConfigurationDedicated* if provided, the UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception by the UE in the set of symbols of the slot.  For operation on a single carrier in unpaired spectrum, for a set of symbols of a slot indicated to a UE by *ssb-PositionsInBurst* in *SIB1* or *ssb-PositionsInBurst* in *ServingCellConfigCommon*, for reception of SS/PBCH blocks, the UE does not transmit PUSCH, PUCCH, PRACH in the slot if a transmission would overlap with any symbol from the set of symbols and the UE does not transmit SRS in the set of symbols of the slot. The UE does not expect the set of symbols of the slot to be indicated as uplink by *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated*, when provided to the UE.  …  For a set of symbols of a slot indicated to a UE as flexible by *tdd-UL-DL-ConfigurationCommon* and *tdd-UL-DL-ConfigurationDedicated* if provided, or when *tdd-UL-DL-ConfigurationCommon* and *tdd-UL-DL-ConfigurationDedicated* are not provided to the UE, and if the UE detects a DCI format 2\_0 providing a format for the slot using a slot format value other than 255  -…  - if the UE is configured by higher layers to transmit PUCCH, or PUSCH, or PRACH in the set of symbols of the slot, the UE transmits the PUCCH, or the PUSCH, or the PRACH in the slot only if an SFI-index field value in DCI format 2\_0 indicates the set of symbols of the slot as uplink  -…  - a UE does not expect to detect an SFI-index field value in DCI format 2\_0 indicating the set of symbols of the slot as downlink or flexible if the set of symbols of the slot includes symbols corresponding to any repetition of a PUSCH transmission activated by an UL Type 2 grant PDCCH as described in clause 10.2  ….  For a set of symbols of a slot that are indicated as flexible by *tdd-UL-DL-ConfigurationCommon*, and *tdd-UL-DL-ConfigurationDedicated* if provided, or when *tdd-UL-DL-ConfigurationCommon*, and *tdd-UL-DL-ConfigurationDedicated* are not provided to the UE, and if the UE does not detect a DCI format 2\_0 providing a slot format for the slot  -…  - if the UE is configured by higher layers to transmit SRS, or PUCCH, or PUSCH, or PRACH in the set of symbols of the slot and the UE is not provided *enableConfiguredUL*, then  - if the UE does not indicate the capability of [partialCancellation], the UE does not expect to cancel the transmission of the PUCCH, or the PUSCH, or an actual repetition of the PUSCH [6, TS 38.214], as determined in clauses 9 and 9.2.5 or in clause 6.1 of [6. TS 38.214], or the PRACH in the slot if the first symbol of the PUCCH or the PUSCH or actual repetition of the PUSCH or the PRACH in the slot occurs within relative to a last symbol of a CORESET where the UE is configured to monitor PDCCH for DCI format 2\_0; otherwise, the UE cancels the PUCCH, or the PUSCH, or an actual repetition of the PUSCH [6, TS 38.214], as determined in clauses 9 and 9.2.5 or in clause 6.1 of [6. TS 38.214], or the PRACH in the slot;  - if the UE indicates the capability of [partialCancellation], the UE does not expect to cancel the transmission of the PUCCH, or the PUSCH, or an actual repetition of the PUSCH [6, TS 38.214], as determined in clauses 9 and 9.2.5 or in clause 6.1 of [6. TS 38.214], or the PRACH in symbols from the set of symbols that occur within relative to a last symbol of a CORESET where the UE is configured to monitor PDCCH for DCI format 2\_0. The UE cancels the PUCCH, or the PUSCH, or an actual repetition of the PUSCH [6, TS 38.214], as determined in clauses 9 and 9.2.5 or in clause 6.1 of [6. TS 38.214], or the PRACH transmission in remaining symbols from the set of symbols;  - the UE does not expect to cancel the transmission of SRS in symbols from the set of symbols that occur within relative to a last symbol of a CORESET where the UE is configured to monitor PDCCH for DCI format 2\_0. The UE cancels the SRS transmission in remaining symbols from the set of symbols;  - is the PUSCH preparation time for the corresponding UE processing capability [6, TS 38.214] assuming and corresponds to the smallest SCS configuration between the SCS configuration of the PDCCH carrying the DCI format 2\_0 and the SCS configuration of the SRS, PUCCH, PUSCH or , where corresponds to the SCS configuration of the PRACH if it is 15kHz or higher; otherwise ;  - if the UE is configured by higher layers to transmit SRS, or PUCCH, or PUSCH, or PRACH in the set of symbols of the slot and the UE is provided *enableConfiguredUL*, the UE can transmit the SRS, or PUCCH, or PUSCH, or PRACH, respectively. |
| Intel | We are fine with FL’s proposal. |
| vivo | We are fine with the proposal. |
| Nokia | Similar to Ericsson, we see the Rel-15 CG-PUSCH handling applicable to SDT-CG-PUSCH. |
| Apple | Similar view as Qualcomm. FFS bullet is not needed. |

### 3.4.2 Second round discussion

In the first round discussion, 7 companies support the original text (2 of them suggest to remove the sub-bullet), and 2 companies suggest to follow the Rel-15 CG-PUSCH handling of validation, 1 company prefers to discuss it later after more progress is achieved for the mapping design.

The proposal is revised as follows.

**Proposal 3.4:**

* The following PUSCH occasion validation rule is applied for CG-SDT
  + the valid PO is the PO in UL part in a slot, or at least *Ngap* symbols after the end of the DL part in a slot or after the end of the SSB in a slot
  + FFS if additional validation rule following the CG-PUSCH in RRC connected state is applicable, and which signals to be provided in RRC release message

Any comments?

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| Company | Comment |
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# Other physical layer issues

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| --- | --- |
| Tdocs | Proposals |
| R1-2106765 Ericsson [3] | Proposal 3 Further discuss in RAN1 on how to generate multiple CG PUSCH resources on top of the PO determined by TDRA per CG period. |
| R1-2106788 Sony [4] | Proposal 4: RAN1 to discuss whether BFD and BFR procedures are employed for SDT or just rely on the expire of the SDT failure detection timer.  Proposal 10: For CG-SDT, the UE shall monitor the SDT-RNTI (or SDT-CS-RNTI) for CG retransmissions. If adopted, RAN1 should send an LS to RAN2 about the agreement. |
| R1-2107443 LGE [11] | *Proposal 5: For CG-SDT, the UE can assume the PDCCH carrying the DCI has the same DM-RS antenna port quasi co-location properties as for a SSB associated to the CG PUSCH transmission e.g. for detection of retransmission DCI in response to a CG PUSCH transmission.* |
| R1-2106855 Samsung [5] | *Proposal 1: in case of the SSB set indication is absent, the UE determines the SSB(s) associated with the CG-PUSCH by one of the following*  *1.Associating to all the indicated SSB in the SIB1*  *2.Determine the SSB according to the sequential order of CG-PUSCH configuration lists*  *Proposal 3: Configure the number of PUSCH transmission occasion (PO) in one CG-PUSCH period by new parameter or re-interpret the number of repetitions configured.*  *Proposal 6: if the selected SSB by UE is not within the indicated/determined SSB set, UE switch to RA-SDT.* |
| R1-2107566 Intel [12] | Proposal 4   * *CG-PUSCH occasion validation rule for CG-SDT follows that was defined for MsgA PUSCH occasion for 2-step RACH.*    + *FFS: potential overlapping between CG-PUSCH occasions for CG-SDT and MsgA PUSCH occasions for 2-step RACH.* |
| R1-2107139 NEC [9] | *Proposal 4: UE should monitor PDCCH on USS using DMRS QCL (Quasi Co-located) with SSB and/or CSI which is used to transmitted CG PUSCH resource during RRC INACTIVE state.* |

According to the submitted contributions, the following issues may have RAN1 impact:

* 4.1 Multiple CG occasions per CG period based on TDRA configuration[3][5]
* 4.2 Default SSB subset if not indicated[5]
* 4.3 SDT type switching[5]
* 4.4 BFD and BFR procedure[4]
* 4.5 RNTI definition for SDT[4]
* 4.6 QCL relationship between PDCCH and SSB[11]

### 4.1.1 First round discussion

These issues are mostly proposed by single company. So the moderator suggests to first identify which issues are critical and need RAN1’s input, and for the low priority issues we can either treat them later or ask RAN2 to trigger the discussion if needed. Any comments?

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| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | For 4.1, the multiple CG occasions per CG period is being discussed in 3.3.  4.2, 4.4 and 4.6 need RAN1 input, but can be discussed after more critical issues such as 3.1~3.3 are agreed.  4.3 and 4.5 are being discussed in RAN2. We can wait for RAN2’s further input. |
| CATT | For 4.3 and 4.5, we need RAN2’s input.  For 4.1, 4.2, 4.4, 4.6, we can come back to these 4 issues after we have consensus on critical issues on 3.1-3.3. |
| Samsung | Fine to discuss later. |
| ZTE, Sanechips | We are fine to discuss later. |
| Ericsson | For 4.1, it’s important to determine whether a CG period includes one or more POs and whether multiple DMRS configurations are necessary, similar to MsgA PUSCH resource configuration. This will affect how to do the SSB to PUSCH mapping.  For 4.2, what is “Default SSB subset”, isn’t it all SSBs actually transmitted if not configured?  For 4.3, SDT type switching is in RAN2 discussions, maybe RAN1 can clarify what is the definition of the RSRP threshold if it’s not clear. Otherwise, it seems RAN2 discussion is enough.  For 4.4, RAN2 is discussing this. RAN2 input on whether support this is needed before RAN1 discussions in our view.  For 4.5, For RA-SDT, RNTI overlapping issue should be solved which is related to other features as well. Similar discussions are needed in RAN1 as we did in 2-step RACH work item when separate RO is introduced. But for CG SDT, we do not see the need of such new RNTI.  For 4.6, QCL relationship between PDCCH and SSB, it seems this can be up to gNB. |
| vivo | We are fine to discuss later and focus on the issues in section 2 and 3 first. |
| LG | We are fine to discuss them later. |
| Apple | Fine to discuss later. |

# Issued raised in the latest RAN2 reply LS (R1-2106405)

This one will be handled in a separate email discussion, by using the NWM tool with the document name [***RAN1-106-e-NWM-NR-R17-SDT-02***].

[106-e-NR-R17-SDT-02] Reply LS to [R1-2106405](file:///C:\Users\Docs\R1-2106405.zip) (Reply LS to RAN1 on physical layer aspects of small data transmission, RAN2) by August 20 – Xiaohang (vivo)

Any other comments?

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| --- | --- |
| Company | Comment |
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# Summary

Proposal by the 1st check point: To agree on Proposal 3.2 and 3.3, and continue the discussions for Proposal 2.1, 3.1 and 3.4

The final proposals will be added later.

# References

1. [R1-2106458](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106458.zip) Physical layer aspects of CG-SDT Huawei, HiSilicon
2. [R1-2106683](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106683.zip) Discussion on physical layer aspects of small data transmission Spreadtrum Communications
3. [R1-2106765](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106765.zip) Physical layer aspects for NR small data transmissions in INACTIVE state Ericsson
4. [R1-2106788](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106788.zip) Physical layer aspects of small data transmission Sony
5. [R1-2106855](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106855.zip) Discussion on physical layer aspects for NR small data transmissions in INACTIVE state Samsung
6. [R1-2106926](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106926.zip) Discussion on remaining issues on small data transmission CATT
7. [R1-2107007](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107007.zip) Discussion on the remaining physical layer issues of small data transmission ZTE, Sanechips
8. [R1-2107075](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107075.zip) Physical layer aspects of small data transmission InterDigital, Inc.
9. [R1-2107139](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107139.zip) Discussion on RAN1 Aspects for NR small data transmissions NEC
10. [R1-2107309](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107309.zip) Draft Reply to RAN2 LS on Physical Layer Aspects of SDT Qualcomm Incorporated
11. [R1-2107433](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107433.zip) Discussion on physical layer aspects of small data transmission LG Electronics
12. [R1-2107566](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107566.zip) Discussion on physical layer aspects of small data transmission Intel Corporation
13. [R1-2107707](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107707.zip) Discussion on physical layer aspects of small data transmission Apple
14. [R1-2107971](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107971.zip) Discussion on RAN1 impacts for small data transmisison vivo
15. [R1-2107972](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2107972.zip) Draft reply LS on physical layer aspects of small data transmission vivo
16. [R1-2108089](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2108089.zip) On physical layer aspects of small data transmission Nokia, Nokia Shanghai Bell
17. [R1-2106924](file:///D:\Documents\3GPP%20documents\RAN1\TSGR1_106-e\Docs\R1-2106924.zip) Draft Reply LS on on physical layer aspects of small data transmission CATT
18. R1-2106405 Reply LS to RAN1 on physical layer aspects of small data transmission vivo