**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 : 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 SSBsProposal 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 |
| Huawei, HiSilicon | Q1: We would like to clarify again that TA validation is only related to the distance between gNB and UE, and should not be bundled with any or all CG configurations as well as the SSBs mapped to them. Some companies concern that the SSBs that not mapped to any CG configuration should not be counted for RSRP calculation because even though the TA is valid, no related CG resources can be used. That is not reasonable. For example, UE is covered by SSB2 and SSB2 is mapped to one CG configuration, while SSB1 does **not** mapped to one CG configuration. This UE can still use SSB1 to calculate the RSRP, e.g. averaging the RSRP of SSB1~SSB3, which helps to achieve better RSRP accuracy. When TA is still valid by this RSRP calculation, the UE can use the CG resources mapped to SSB2 to send CG-SDT. So it is not reasonable that the SSBs for TA validation must be within the SSBs mapped to CG configurations.Q2: There is no motivation to do TA validation per CG configuration with the same reason above. Anyway, this should be discussed in RAN2.Q3: Perhaps want to clarify that how does the “within a set of all SSBs” determined by UE? |
| CATT | Q1: Because TA validation is applicable for all CG configurations per UE, it is reasonable to select the SSB subset among a set of SSBs configured for all CG configurations per UE to calculate RSRP based TA validation. Moreover, if the RSRP change based on the SSBs mapped to CG transmission doesn’t exceed threshold and TA is valid, the SSBs mapped to CG transmission can be used for gNB receiving UL transmission and scheduling retransmission.Q2: For the TA validation per configuration, because TA validation based on the absolute RSRP threshold configured by the network is applicable for all CG configurations per UE, it isn’t necessary to determine the SSB subset and calculate RSRP based TA validation per CG configuration.Q3: for highest N SSBs, it is hard to determine N value. |
| Ericsson2 | Option 1. For Q1: Since the SSBs set per CG configuration is flexibly configured by the network, the network can make sure the SSBs configured for the UE when using such CG resource are within the beams covered by the SSBs. E.g. for high mobility UEs, gNB may configure more SSBs, otherwise, gNB can configure less SSBs, which is why we introduce such SSB set per CG configuration in our understanding. This could help to avoid too many SSB measurement in some cases especially when the UE is static.For Q2: Signals transmitted in different beams (or beam groups) will have different path, and thus TA is related to the possible SSB beams considered for the actual CG PUSCH transmission, since SSB beams actually used is configured per CG PUSCH configuration, the TA should be performed per CG configuration as well.For Q3: The issue is when you already know a subset of SSBs already includes the best SSB, why does the UE need to waste energy to measure all SSBs instead of only measuring the subset of SSBs configured by network to get the best SSB?The intention of configuring the SSB set per CG configuration is to avoid unnecessary measurement on SSBs never used. When UE is moving in a wide area, the gNB can configure all SSBs anyway. Option 1 is more flexible than other options and covers all other options. |
| Qualcomm | **Q1:** Yes. Strictly speaking, TA calculation/tracking is based on PRACH (and other UL signals) transmitted from UE, which is not directly related to the absolute measurement of L1-RSRP. In CG-SDT, SS-RSRP measurements can be used by UE for TA validation, because the UE is assumed to be stationary or low mobility. For stationary or low mobility UEs, the SSB set mapped to a CG-SDT configuration are expected to be sufficiently strong DL beams (based on CSI measurements/reports of UE in RRC connected state) , so that UE can transmit PUSCH using the associated UL beams to meet a given BLER target. Therefore, RSRP variation of the configured SSB is an indirect indication of UE’s mobility or changes of environment, assuming gNB’s location is fixed and the beam correspondence does not change on UE side for UL transmission. **Q2:** It is possible, and can be ensured by NW. Validation of PUSCH occasion for CG-SDT depends on UE capabilities and NW configurations, which is not relevant to the TA variation. TA validation and PUSCH occasion validation need to be jointly performed by UE before each CG-SDT occasion. If either validation fails, whether UE should skip a CG-SDT occasion temporarily and continue the validation at the following CG-SDT occasion, or cancel all CG-SDT occasions permanently can be determined by pre-configured rules/counter/timer. The rules/procedures of LTE PUR can be considered as a reference.**Q3:** Without UE-specific beam correspondence between SSB and PUSCH occasion, the highest *N* SSBs cannot not reflect UE’s mobility or TA variation. Instead, the time-varying order of the highest *N* SSBs can be linked to beam failure/mobility, which could be a consequence of TA variation. |
| ZTE, Sanechips | Q1:We don’t think the SSBs used for TA validation should be within the SSBs mapped to CG transmission. We cannot guarantee that the SSBs in a CG configuration can always contain the best beams, assuming that a UE moves around the gNB, the TA is always valid but the best beams may change, then the SSB subset from one CG configuration is used for TA validation, it might be derived that TA is not valid which is not the truth. To derive relatively accurate TA, the SSBs that are measured are better to be wide enough irrespective of CG configuration. Q2: The TA validation should be done per UE rather than per CG configuration. We do not think the UE could maintain multiple TAs. May need to ask RAN2 to confirm the possibility.Q3: Similar to the determination of cell-level RSRP, N could be configurable. If N is not configured then all the actually transmitted SSB will be used to determine the subset.  |
| Spreadtrum | Q1: Yes. The SSBs used for TA validation should be within the SSBs mapped to CG transmission. The SSBs not mapped CG transmission is not relevant for beam correspondence.Q2: Yes. It is possible to do the TA validation per configuration. If some of the CG configuration are valid while some others are not valid, UE can autonomously decide to transmit PUSCH in the valid CG configuration.Q2: Possible.  |
| InterDigital | Q1: Yes, the SSBs used for TA validation should be within the SSBs mapped to CG transmission. This seems the safest option to prevent UE from transmitting with invalid TA. Other SSBs may not have same RSRP vs distance relationship, so it is better to allow network to control this. It also avoids needless measurements as already mentioned by Ericsson and others.Q2: Yes, TA validation can be for each CG.Q3: Agree with Qualcomm’s comment. |
| Intel | Q1: Yes, we think SSBs used for TA validation should be within the SSBs mapped to CG transmission. We think the CG-SDT operation should be relatively short and in this case, it can be assumed that UE is in a relatively stationary or low mobility conditions as mentioned by QC, where TA validation can be performed within the selected SSB set from the network. Given that a suitable set of SSBs for CG-PUSCH association can be flexibly controlled by the gNB, we do not think we need separate SSB set for TA validation and CG-PUSCH association.Q2. TA validation can be done per CG or all CG configurations. Our understanding is that the network can configure a suitable set of SSBs for TA validation for one CG or all CG configurations.Q3. Given that a subset of SSBs is configured by the network, it is not clear why we need to additionally define a subset (highest N) of subset of SSBs for RSRP measurement.  |
| vivo | Q1: No. A valid TA should be applicable to all CG configurations. The TA validation is not dependent on the SSBs configured for a particular CG configuration. Q2: No. It is not necessary for TA validation per CG configuration.Q3: It is up to gNB configuration. |
| Samsung  | Q1, Q2,Q3: all NO. Both TA validation and SSB selection are the outcome of when UE measures the SSBs. But these two aspects should not limiting each other.We support option 3. |
| Moderator | Seems the views on the questions are quite diverse. Please continue to discuss and see if the concerns from either side can be addressed and whether a compromised middle ground can be found. If it is still hard to make down-selection among the options, the only way is to summarize the situation in the reply LS to RAN2 asking if they can make the decision. |
| CATT | We support sending reply LS to RAN2 for asking whether RAN2 can make the decision. |
| Huawei, HiSilicon | For Q1 and Q2, we insist the TA validation is not related to CG configurations and the SSBs mapped to them. For Q3, our intention of highest N SSBs is to reuse the existing cell measurement method that UE derives cell measurement quantity based on the highest beam measurement quantity values above *absThreshSS-BlocksConsolidation* where the total number of averaged beams shall not exceed *nrofSS-BlocksToAverage*. And if *nrofSS-BlocksToAverage* is not configured, UE derives cell measurement quantity based on the highest beam measurement quantity value (38.331, Section 5.5.3). We wonder if these methods are not reused, shall UEs use **all the SSBs** actually transmitted as indicated in SIB1 for calculating RSRP? That is not in line with the existing cell measurement method, which will bring unnecessary specific impact.  |
| Ericsson3 | Given this will impact RRC configuration discussions in September, it would be good to make a decision to move forward in RAN1 in our understanding.Our comments in last round still apply. Per CG configuration covers all other options as we pointed out earlier, how many SSBs are configured should be up to gNB scheduling considering whether UE is moving or not whether moving fast or not etc., which is the intention of introducing such SSB configuration per CG configuration. |
| ZTE, Sanechips | We still don’t think TA validation is related to CG configuration, whether TA is valid or not should apply to all CG configurations. If TA validation is per CG configuration, it is possible that multiple TAs will be derived based on different CG configurations, how to proceed with the multiple TAs is unclear. If no consensus can be achieved, we are fine to send an LS to RAN2 about the situation. |
| Qualcomm | Obviously there is no consensus in RAN1 on SSB subset selection for TA validation of CG-SDT. However, we are not sure if RAN2 can make the decision since this question is relevant to beam correspondence, which is RAN1 centric.Our views are still the same as the last round, and TA validation should be based on the subset of SSBs configured per CG-SDT configuration. |
| Intel | As this has been discussed multiple times with no consensus in RAN1, we are fine to move forward by sending LS to RAN2.  |
| Nokia, NSB (23.8) | **Q1: NO.** Valid TA is a valid TA, it is not related to whether or not a particular (set of ) SSB(s) is applicable for SDT-CG. What does matter is that the set of SSBs used to validate the last-known-good-TA remains the same.**Q2: No.** As above, there is no relation between TA and whether a particular SSB is linked to a CG-configuration.**Q3: Yes.** Possibility for multiple SSBs can add diversity and even out shadow fading related dips in the SSB RSRP |
| vivo | We are not convinced that the TA validation needs to be associated with CG configuration. Since there is no consensus in RAN1, we are fine to send an LS to RAN2 to inform the situation. |
| Samsung | We are fine to send a LS to ask RAN2 for more clarification. In addition to this specific issues, we also need to align the understanding of the use scenario for CG-SDT, e.g., when UE initiates the CG-SDT, does gNB knows which sets of SSB the UE will preferred? |

### 2.1.3 Final round discussion

Still companies’ views are not changed. As it is hard to find a middle-ground, it is suggest to provide the options to RAN2 and ask them to make the final decision.

**Proposed Conclusion 2.1**:

RAN1 cannot reach consensus on the following options for the SSB subset for RSRP based TA validation. Ask RAN2 if they can do the down-selection.

* 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~~4: Highest N SSBs of all SSBs actually transmitted as indicated in SIB1

|  |  |
| --- | --- |
| Company | Comment |
| CATT | We are fine with FL proposal. |
| Huawei, HiSilicon | Fine to make progress.  |
|  |  |

## 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* $N\_{SSB}$ *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* $DMRS\_{id}$ *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* $N\_{SSB}=ceil\left({T\_{SSB}}/{T\_{PUSCH}}\right)$*,* $T\_{SSB}$ *is a total number of SSBs mapped to this CG configuration provided by configuredGrantConfig, and* $T\_{PUSCH}$ *is a total number of valid CG periods per association period* $N\_{period}$ *multiplied by the number of DMRS resource indexes* $N\_{DMRS}$ *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 : 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 $N$ <1, each SSB index is mapped to 1/N consecutive valid CG PUSCH resources. If $N\geq 1$, 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 $DMRS\_{id}$ 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 $N$ <1, each SSB index is mapped to 1/N consecutive valid CG PUSCH resources. If $N\geq 1$, 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?

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | Fine with Proposal 3.1 |
| CATT | We are fine with FL proposal. |
| Ericsson2 | Considering:* valid CG PUSCH resources can be mapped to SSB,
* Mapping steps may also depends whether we also configure multiple CG PUSCH occasions FDMed or TDMed in one CG period,
* The association pattern period is formed automatically when association period is determined, same as SSB to RO mapping,

some updates are proposed from our side:**Proposal 3.1:*** Each N of consecutive SSB indexes associated to one CG configuration are mapped to valid CG PUSCH resources
	+ first, in increasing order of DMRS resource indexes, where a DMRS resource index $DMRS\_{id}$ 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 $N$ <1, each SSB index is mapped to 1/N consecutive valid CG PUSCH resources. If $N\geq 1$, 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~~ To determine the association pattern period, reuse SSB to RO association pattern period determination mechanism. ~~needs to be defined~~

The mapping ordering and steps may be revisited if multiple CG PUSCH occasions in one CG period is supported |
| Qualcomm | Agree with FL proposal in principle |
| ZTE, Sanechips | We are fine with the proposal. |
| Spreadtrum | Fine for us |
| Intel | Although we slightly prefer to explicitly configure the association period, we are fine to support the FL proposal in principle for progress. We have several questions as follows:* We share similar view as Ericsson that we need to add “valid” in the first main bullet.
* We may also need to agree first whether multiple CG-PUSCH occasions are supported for SSB-to-CG association per CG configurations, which will impact the mapping order.
* “Each N of consecutive SSB indexes” means that SSB index which is configured by the network, but not the actual SSB index?
* What is the motivation of supporting one to many mapping? In our view, N>=1 would be sufficient.
 |
| vivo | We are fine with the proposal in principle.We share similar view as Ericsson and Intel. If multiple CG-PUSCH occasions per CG period are supported, the mapping rule may need some changes. |
| Apple | We support the proposal. just one minor comments, if my understanding is correcte, the following bullet can be updated.* + - If $N$ <1, each SSB index is mapped to ~~1/N~~ N consecutive valid CG PUSCH resources. If $N\geq 1$, each valid CG PUSCH resource is associated with all the N SSB index.
 |
| Moderator | @ Ericsson, thanks for the comments I think adding “valid” in the main bullet is reasonable, and it seems fine to add the note at the end. For the association pattern period, maybe it is better to make it more clear by reusing the wording in 38.213, let us here more views on it. (see the discussion point 3.1 plus).@ Intel, N SSB indexes are the configured one because the mapping is done per CG configurations; and for the value set of N here is a just example, we can discuss it further.@ Apple, I think the original text was correct, because N<1, 1/N would be an integer number.The proposal is revised as follow.**Updated Proposal 3.1:*** Each N of consecutive SSB indexes associated to one CG configuration are mapped to valid CG PUSCH resources
	+ first, in increasing order of DMRS resource indexes, where a DMRS resource index $DMRS\_{id}$ 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 $N$ <1, each SSB index is mapped to 1/N consecutive valid CG PUSCH resources. If $N\geq 1$, 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
* Note: The mapping ordering and steps may be revisited if multiple CG PUSCH occasions in one CG period is supported

For the remaining issue, continue the discussion as follows.**Discussion point 3.1-plus (please indicate your support or concern below)*** An association pattern period includes one or more association periods and is determined so that a pattern between CG PUSCH occasions and SS/PBCH block indexes repeats at most every 160 msec.
	+ Supported by:
	+ Not supported by:
* Support multiple CG PUSCH occasions (FDM/TDM) in one CG period?
	+ Supported by:
	+ Not supported by:
 |
| CATT |  For the association pattern period, we want to clarify how to support SDT traffic related to long CG period such as (320ms, 640ms) or some special periods such as ( 64ms, 128ms) if association pattern period is defined for at most 160msec.In addition, we support multiple CG PUSCH occasions in TDM in one CG period which is similar with CG scheme in connection mode for NR. |
| Huawei, HiSilicon | Agree Updated Proposal 3.1For the two bullets of 3.1-plus, * Maybe the moderator want to say “An association pattern period includes one or more CG periods”?
* Only one CG PUSCH occasions with multiple DMRS in one CG period is supported, assuming the repetitions within one CG period are bundled as one PUSCH occasion. The TDMed or FDMed CG PUSCH occasions in one CG period brings much specification impact.
 |
| Ericsson3 | We’re fine with FL’s update on proposal 3.1.For proposal 3.1-plus:Agree with CATT that the SS/PBCH block to CG PUSCH resource association period should be up to 640ms according to the maximum supported CG period in current specification for Type 1 CG configuration.And considering the minimum SSB period is 5ms, the SSB to CG PUSCH resource association period should be larger than 5ms as well.So the association period should be between 5ms and 640ms in our understanding.Note that association pattern period is up to when a pattern be formed after a number of association periods, it doesn’t have to be explicitly defined, similar to SSB to RO pattern period definition. Copy some text from 38.213 on SSB to RO mapping:

|  |
| --- |
| An association period, starting from frame 0, for mapping SS/PBCH block indexes to PRACH occasions is the smallest value in the set determined by the PRACH configuration period according Table 8.1-1 such that  SS/PBCH block indexes are mapped at least once to the PRACH occasions within the association period, where a UE obtains  from the value of *ssb-PositionsInBurst* in *SIB1* or in *ServingCellConfigCommon*. If after an integer number of SS/PBCH block indexes to PRACH occasions mapping cycles within the association period there is a set of PRACH occasions or PRACH preambles that are not mapped to  SS/PBCH block indexes, no SS/PBCH block indexes are mapped to the set of PRACH occasions or PRACH preambles. An association pattern period includes one or more association periods and is determined so that a pattern between PRACH occasions and SS/PBCH block indexes repeats at most every 160 msec. PRACH occasions not associated with SS/PBCH block indexes after an integer number of association periods, if any, are not used for PRACH transmissions. |

We’re open to discuss whether/how multiple CG PUSCH occasions can be configured in each CG period together with multiple DMRS configurations. |
| ZTE, Sanechips | We are fine with the updated Proposal 3.1.For the 1st bullet of Proposal 3.1-plus, we agree with Ericsson that the association pattern period may not need to be explicitly defined.For the 2nd bullet of Proposal 3.1-plus, we may not need to define multiple TDMed or FDMed CG occasions in one CG period, because the duration of CG period could be quite short so that a larger number of CG periods could be configured within an association period instead.  |
| Qualcomm | For proposal 3.1-plus:Agree with CATT’s comments, since UL traffic for CG-SDT expects to be more sparse than Type-1 CG in connected mode. Therefore, SSB to CG PUSCH resource association period should be up to 640ms.We are open to discuss the support for multiple CG PUSCH occasions (FDM/TDM) in one CG period (e.g. up to 2). |
| Intel | We are fine with the updated proposal 3.1 in principle. We suggest to update the following. We can further discuss whether some values are needed. * 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~~ $N$ ~~<1, each SSB index is mapped to 1/N consecutive valid CG PUSCH resources. If~~ $N\geq 1$~~, each valid CG PUSCH resource is associated with all the N SSB index.~~

For Discussion point 3.1-plus, we are fine to support multiple CG PUSCH occasions  |
| vivo | We are fine with the updated proposal 3.1.For the proposal 3.1-plus:For the first bullet of 3.1-plus, we are generally fine.For the second bullet of 3.1-plus, we are fine to support multiple TDMed CG PUSCH occasions. It could be beneficial to reduce the latency of CG-SDT transmission. |
| CATT2 | We support updated proposal 3.1 and For the 2nd bullet of Proposal 3.1-plus, if the CG repetitions within one CG period are made as one bundle for one PUSCH occasion, we needn’t support multiple CG PUSCH occasions (FDM/TDM) in one CG period |
| Samsung  | Generally fine for updated proposal 3.1; just for the first bullet, “Each N of consecutive SSB indexes”, I think this is the logically consecutive SSB index as provided by ssb-PositionsInBurst in SIB1 or in ServingCellConfigCommon. It would be better to add a note to clarify this.For 3.1plus, first is fine; I think it’s align with the current spec for SSB-RO association. Just we may take care the up bound of the time period.Second one, we originally think it’s needed and we thought it’s straight-forward to reuse the repetition as the number of configured occasions. We don’t think additional new parameter should be introduced.  |
| Apple | We are fine with the updated proposal 3.1For Proposal 3.1-plus, our understanding of defining an association pattern period is trying to reuse the mechanism of SSB to RO mapping. However association period is still open. As commented by HW and to save the standard workload, maybe the association period could be replaced by CG periodicity. As for the association pattern period is 160ms or 640ms, this is depending on whether all the CG periodicities are applied to CG-SDT, or just select some sparse periodicities to be used. For FDM/TDM CG PUSCH occasion, we don’t support additional multiplexed PUSCH occasion. firs, it would introduce additional standard work, e.g., *ConfiguredGrantConfig* modification; second, the CG periodicities listed in *ConfiguredGrantConfig* provide more than enough choices for SSB to CG PUSCH association. |

### 3.1.3 Final round discussion

Seems the updated proposal 3.1 (with the example values removed as suggested by Intel) and the first bullet of proposal 3.1-plus (change 160ms to 640ms as suggested by CATT, Ericsson and QC) is acceptable by the majority. And for the second bullet of proposal 3.1-plus, companies have different views but are open to discuss further. So the proposal is updated as follows.

For Samsung’s comment on the consecutive SSB, it is the SSBs explicitly configured in CG configuration, since the mapping is done for each configuration.

**Updated Proposal 3.1:**

* Each N of consecutive SSB indexes associated to one CG configuration are mapped to valid CG PUSCH resources
	+ first, in increasing order of DMRS resource indexes, where a DMRS resource index $DMRS\_{id}$ 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~~ $N$ ~~<1, each SSB index is mapped to 1/N consecutive valid CG PUSCH resources. If~~ $N\geq 1$~~, 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.
	+ An association pattern period includes one or more association periods and is determined so that a pattern between CG PUSCH occasions and SS/PBCH block indexes repeats at most every ~~160~~ 640 msec.
		- ~~FFS if the association pattern period needs to be defined~~
* Note: The mapping ordering and steps may be revisited if multiple CG PUSCH occasions in one CG period is supported

|  |  |
| --- | --- |
| Company | Comment |
| CATT | We are fine with updated proposal 3.1 |
| Huawei, HiSilicon | Agree |
|  |  |

## 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 : 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 |
| Huawei, HiSilicon | Fine with Proposal 3.2 |
| CATT | We are fine with FL proposal. |
| Ericsson2 | As this may also depend on whether multiple CG PUSCH occasions will be supported or not, we propose following updates:**Proposal 3.2:*** Support multiple DMRS resources per CG configuration when single layer PUSCH transmission is assumed and when single PUSCH occasion is defined per CG period, 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

FFS if multiple CG PUSCH occasions are defined per CG period |
| Qualcomm | Agree with FL proposal in principle |
| ZTE, Sanechips | We are fine with the proposal.  |
| Spreadtrum | Fine for us |
| Intel | We are fine with the proposal.  |
| vivo | We are fine with the proposal.  |
| Apple | We are fine with the proposal.  |
| Moderator | The proposal is updated as follow based on the discussion in the email (acceptable by Ericsson).**Updated 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
	+ FFS any limitation on the DMRS configuration if multiple CG PUSCH occasions per CG period is supported

Continue the discussion on the support of multi-layer PUSCH transmission.**Discussion 3.2plus:*** Do you think it is useful to support multi-layer PUSCH transmission for CG-SDT? And is there any spec impact to support it?
 |
| CATT | We are fine with updated proposal 3-2.For the support of multi-layer PUSCH transmission, the motivation is that if we can support multiple layer transmission, it can potentially save time/frequency resource of PHY layer. In addition, the data payload size isn’t so small and actually the largest packet size of some instant messaging service is about 300 bytes. So we would like to keep multilayer PUSCH transmission for further study. |
| Huawei, HiSilicon | Support Updated Proposal 3.2For 3.2plus, we think for small data transmission, there is no strong need to use multi-layer PUSCH transmission.  |
| Ericsson3 | Fine with updated p3-2.For p3.2plus:It seems there’s no need to support multiple layers for a UE in small data in our understanding too. |
| ZTE, Sanechips | We support the updated Proposal 3.2.For 3.2plus, we don’t think there is a strong need to support multi-layer transmission for SDT. As for the spec impact, it potentially has impact on the mapping ratio, e.g., if Layer 3 transmission is supported, we need to consider to include values such as 1/3 in the candidate mapping ratio set. |
| Qualcomm | Since the main motivation of SDT is UE power saving, we think there is no strong motivation to support multiple UL layers for PUSCH in RRC inactive state.  |
| Intel | We are fine with the updated Proposal 3.2. We do not see the need to support multi-layer PUSCH transmission for CG-SDT. CG-SDT is mainly targeted for data transmission with small packet size (that is why this is called small data transmission). Further, during CG-SDT, there could be multiple UL transmissions and UE can still have more chances to transmit more packets.  |
| Nokia, NSB (23.8) | We are OK with the updated 3.2We haven’t seen a practical use case for more than 1 layer transmissions for SDT-CG-PUSCH. |
| vivo | We are fine with the updated proposal 3.2.Considering the use case for small data transmission, we don’t see the need to adopt multi-layer transmission for CG-SDT.  |
| Samsung  | Generally fine for updated 3.2;For 3.2plus, we don’t think it’s needed to support multi-layer, consider it’s only SDT. |
| Apple | We are ok with the updated Proposal 3.2.SDT is targeting for small data transmission. We don’t see the strong motivation to support multi-layer PUSCH transmission. |

### 3.2.3 Final round discussion

Seems proposal 3.2 is acceptable to all companies. Regarding multi-layer PUSCH transmission, the majority view is it is not needed, while only one company prefer to keep the FFS. So the FL leave the proposal with the two FFS bullets unchanged unless there is any strong concern.

**Updated 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
	+ FFS any limitation on the DMRS configuration if multiple CG PUSCH occasions per CG period is supported

|  |  |
| --- | --- |
| Company | Comment |
| CATT | We are fine with updated proposal 3.2 |
| Huawei, HiSilicon | Seems the multi-layer issue lasted from last meeting has no further consensus, the first sub-bullet can be moved for progress.  |
|  |  |

## 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. |

### 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 |
| Huawei, HiSilicon | Fine with Proposal 3.3 |
| CATT | We are fine with FL proposal. |
| Ericsson2 | Fine. |
| Qualcomm | Agree |
| ZTE, Sanechips | We are fine with the proposal.  |
| Spreadtrum  | Fine for us |
| Intel | We are fine with the proposal. |
| vivo | We are fine with the proposal.  |
| Samsung  | The concerns and the issues are exactly caused by 3.4 with the validation, the fairness issue is essential through all the designs of the msg1, msgA (RACH and PUSCH), why suddenly it becomes not a problem. We cannot agree this if there is no answer for our question.Alternatively, in addition to these options, there is a third option, which is: Option 3: the repetition factor configuration is disabled for CG-SDT. |
| Apple | We are fine with the proposal. |
| Moderator | The proposal is revised as follow according to the recent discussions in the email. The added subbullet is to address Samsung’s concern on the unfairness issue.**Updated proposal 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~~.
	+ If repetition K>1 is configured, ~~it is up to gNB implementation to guarantee~~UE expects a consistent number of valid repetitions across different CG periods for each associated SSB.
 |
| CATT | We are fine with FL proposal. |
| Huawei, HiSilicon | Almost agree the main bullet, and add the words below to make it clear. For the subbullet, if the repetitions means the configured K value, that’s fine; however we presume the intention is to restrict the final effective repetition number to be the same, after applying e.g. collision handling, then our concern is that it would be very difficult for the gNB to guarantee. As most companies support the existing repetition mechanism as moderator said, we think more time/discussion might be needed for the sub-bullet.* The repetitions within one CG period are considered as a bundle of transmission occasions that are mapped to the same SSB(s).
	+ FFS: If repetition K>1 is configured, whether and how to let UE use a consistent number of valid repetitions across different CG periods for each associated SSB.
 |
| Ericsson3 | Original main bullet is enough. * The repetitions are considered as a bundle of transmission occasions that are mapped to the same SSB(s), no additional specification rule is needed.

Regarding the sub bullet, it is already specified in 38.214 for CG PUSCH repetition period limitation and there’s no need to change this for SDT in our view.

|  |
| --- |
| **Type A:***The UE is not expected to be configured with the time duration for the transmission of K repetitions larger than the time duration derived by the periodicity P. If the UE determines that, for a transmission occasion, the number of symbols available for the PUSCH transmission in a slot is smaller than transmission duration L, the UE does not transmit the PUSCH in the transmission occasion.***Type B:***For any RV sequence, the repetitions shall be terminated after transmitting K nominal repetitions, or at the last transmission occasion among the K nominal repetitions within the period P, or from the starting symbol of a repetition that overlaps with a PUSCH with the same HARQ process scheduled by DCI format 0\_0, 0\_1 or 0\_2, whichever is reached first. The UE is not expected to be configured with the time duration for the transmission of K nominal repetitions larger than the time duration derived by the periodicity P.* |

 |
| Intel | We support the main bullet only. The sub-bullet is not needed.  |
| Nokia, NSB (23.8) | OK with the main bullet of the moderator’s updated proposal 3.3 and agree with Ericsson and Intel that that the main bullet is enough and sub-bullet is not needed. |
| vivo | We are fine with the main bullet.We don’t think the sub-bullet is needed. |
| Samsung  | We are ONLY ok with this updated proposals with the sub-bullet. Thx HW for the update of the sub-bullet, but leave it as FFS did not solve our concerns on how it will end.Thx E/// for the paste of the spec, but it did not solve our question and it’s not even targeting our problem. The quoted text only says the repetitions cannot be over the period, which is totally fine. And it’s perfectly fit the purpose that we want to repurpose the repetition as the number for CG PUSCH occasion is one period, which seems supported by many in above 3.1.2.To the proponent of not needing the sub-bullet, it may be reasonable at least to give some valid answers to the question. Pasted our concern below:Just one example, CG period is 1 slot and K =4, assuming 4 repetitions in every slot. since the current proposal is to regard the 4 repetitions as one occasion to be associated with SSB. However, the 4 repetitions (on physical resource) will be through the collision check with DL, or SSBs etc. then each slot may not have same number of repetitions, e.g., let's say 2 repetitions left for one slot and 4 left for another; then the 2 repetitions will be still associated with one SSB and the 4 repetitions will be associated with another SSB. that's called " the actual PUSCH coverage may be different". Note here I am concerning on the resource to be associated with SSB, rather than the actual resources to be used by UE at a given transmission (which can be temporarily cancelled by some operation). The same logic to that we will do SSB-RACH association on valid RACH resource, but a certain RACH transmission can be still cancelled. So it’s natural to consider this in PUSCH occasion as well. |
| Apple | We share the view with others, the original proposal is enough. |

### 3.3.3 Final round discussion

Still there is one company not ok with the proposal if the condition (same valid repetition across CG periods) is not mentioned. So to make progress, the FL would suggest to first agree on the case when the condition is met, and leave the other controversial case for further study.

**Updated proposal 3.3:**

* Repetition K>1 is supported at least when a consistent number of valid repetitions across different CG periods can be guaranteed for each associated SSB.
	+ The repetitions are considered as a bundle of transmission occasions that are mapped to the same SSB(s)~~, no additional specification rule is needed~~.
* FFS if repetition can be supported or not when the number of valid repetitions across different CG periods for each associated SSB is not consistent.

|  |  |
| --- | --- |
| Company | Comment |
| CATT | We are fine with updated proposal 3.3 |
| Huawei, HiSilicon | A minor: The repetitions within one CG period are considered as a bundle of transmission occasions that are mapped to the same SSB(s). |
|  |  |

## 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 $T\_{proc,2}$ 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 $T\_{proc,2}$ 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 $T\_{proc,2} $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;- $T\_{proc,2}$ is the PUSCH preparation time for the corresponding UE processing capability [6, TS 38.214] assuming $d\_{2,1}=1$ and $μ$ 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 $μ\_{r}$, where $μ\_{r}$ corresponds to the SCS configuration of the PRACH if it is 15kHz or higher; otherwise $μ\_{r}=0$;- 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?

|  |  |
| --- | --- |
| Company | Comment |
| Huawei, HiSilicon | The RO validation rule can be taken as reference for CG-SDT resource validation rule in RRC\_INACTIVE. For FDD bands, all the CG-SDT PUSCH configuration can be considered valid.For TDD bands, the cell-level configured *tdd-UL-DL-ConfigurationCommon* can be assumed as baseline, whether the *tdd-UL-DL-ConfigurationDedicated* and/or DCI-based SFI are supported is not clear. We can focus on *tdd-UL-DL-ConfigurationCommon* first*.*- if a UE is not provided *tdd-UL-DL-ConfigurationCommon*, a CG-SDT PUSCH is valid if it does not precede a SS/PBCH block and starts at least $N\_{gap}$ symbols after a last SS/PBCH block reception symbol, where $N\_{gap}$ is provided in Table 8.1-2- the candidate SS/PBCH block index of the SS/PBCH block corresponds to the SS/PBCH block index provided by *ssb-PositionsInBurst* in *SIB1* or in *ServingCellConfigCommon* , as described in Clause 4.1- If a UE is provided *tdd-UL-DL-ConfigurationCommon*, a CG-SDT PUSCH is valid if - it is within UL symbols, or - it does not precede a SS/PBCH block and starts at least $N\_{gap}$ symbols after a last downlink symbol and at least $N\_{gap}$ symbols after a last SS/PBCH block symbol, where $N\_{gap}$ is provided in Table 8.1-2- the candidate SS/PBCH block index of the SS/PBCH block corresponds to the SS/PBCH block index provided by *ssb-PositionsInBurst* in *SIB1* or in *ServingCellConfigCommon*, as described in Clause 4.1.  |
| CATT | We are fine with FL proposal |
| Ericsson2 | If we want to reuse both validation rules similar to MsgA PUSCH and those for CG Type 1, we need to at least cover all aspects in following text for MsgA PUSCH validation in our understanding:

|  |
| --- |
| A PUSCH occasion is valid if it does not overlap in time and frequency with any valid PRACH occasion associated with either a Type-1 random access procedure or a Type-2 random access procedure. Additionally, for unpaired spectrum and for SS/PBCH blocks with indexes provided by *ssb-PositionsInBurst* in *SIB1* or by *ServingCellConfigCommon* - if a UE is not provided *tdd-UL-DL-ConfigurationCommon*, a PUSCH occasion is valid if the PUSCH occasion- does not precede a SS/PBCH block in the PUSCH slot, and - starts at least $N\_{gap}$ symbols after a last SS/PBCH block symbol, where $N\_{gap}$ is provided in Table 8.1-2 and, if *channelAccessMode* = *semistatic* is provided, does not overlap with a set of consecutive symbols before the start of a next channel occupancy time where the UE does not transmit [15, TS 37.213].- if a UE is provided *tdd-UL-DL-ConfigurationCommon*, a PUSCH occasion is valid if the PUSCH occasion- is within UL symbols, or - does not precede a SS/PBCH block in the PUSCH slot, and - starts at least $N\_{gap}$ symbols after a last downlink symbol and at least $N\_{gap}$ symbols after a last SS/PBCH block symbol, where $N\_{gap}$ is provided in Table 8.1-2 and, if *channelAccessMode* = *semistatic* is provided, does not overlap with a set of consecutive symbols before the start of a next channel occupancy time where the UE does not transmit [15, TS 37.213]. |

So, we propose:**Proposal 3.4:*** The following PUSCH occasion validation rule is applied for CG-SDT
	+ for unpaired spectrum and for SS/PBCH blocks with indexes provided by *ssb-PositionsInBurst* in *SIB1* or by *ServingCellConfigCommon*
		- if a UE is provided *tdd-UL-DL-ConfigurationCommon*, 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
		- if a UE is not provided *tdd-UL-DL-ConfigurationCommon*, the valid PO does not precede a SS/PBCH block in the PUSCH slot, starts at least $N\_{gap}$ symbols after a last SS/PBCH block symbol,
		- $N\_{gap}$ is provided in Table 8.1-2
	+ A PUSCH occasion is valid if it does not overlap in time and frequency with any valid PRACH occasion associated with either a Type-1 random access procedure or a Type-2 random access procedure.
* FFS if ~~additional~~ any validation rule following the CG-PUSCH in RRC connected state is applicable, and which signals to be provided in RRC release message
 |
| Qualcomm | Please clarify the duplex modes and the corresponding validation rules.  |
| ZTE, Sanechips | We are fine with the proposal.  |
| Intel | We are fine with the first bullet. For the FFS, we suggest to add FFS for the validation rule between CG-PUSCH and MsgA PUSCH. We are not sure we need “which signals to be provided in RRC release message”.* 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,~~ overlapping between CG-PUSCH occasions for CG-SDT and MsgA PUSCH occasions for 2-step RACH
 |
| vivo | We are fine with the proposal.  |
| Samsung  | Fine. |
| Apple | We are fine with the proposal.  |
| Moderator | Please find the updated version by merging the comments from Huawei/Ericsson/Qualcomm/Intel.**Updated Proposal 3.4:*** The following PUSCH occasion validation rule is applied for CG-SDT
	+ for unpaired spectrum and for SS/PBCH blocks with indexes provided by *ssb-PositionsInBurst* in *SIB1* or by *ServingCellConfigCommon*
		- if a UE is provided *tdd-UL-DL-ConfigurationCommon*, 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
		- if a UE is not provided *tdd-UL-DL-ConfigurationCommon*, the valid PO does not precede a SS/PBCH block in the PUSCH slot, starts at least $N\_{gap}$ symbols after a last SS/PBCH block symbol,
		- $N\_{gap}$ is provided in Table 8.1-2
	+ A PUSCH occasion is valid if it does not overlap in time and frequency with any valid PRACH occasion associated with either a Type-1 random access procedure or a Type-2 random access procedure.
	+ FFS if ~~additional~~ any validation rule following the CG-PUSCH in RRC connected state is applicable, ~~and which signals to be provided in RRC release message,~~ overlapping between CG-PUSCH occasions for CG-SDT and MsgA PUSCH occasions for 2-step RACH.
 |
| CATT | We are fine with FL proposal. |
| Huawei, HiSilicon | The validation rule for TDD/FDD bands should be discussed separately as the existing RO/PO validation rules.We do not understand why the validation of CG-SDT PUSCH resources has the relationship with PRACH occasions and MsgA PUSCH occasions. For TDD bands, we agree the first sub-bullet and do not agree the second and third sub-bullet as mentioned above.For FDD bands, we propose to consider all the CG-SDT PUSCH occasions are valid, which is same as RO validation rule. |
| Ericsson3 | Fine with the updated proposal. At least PRACH occasions should be considered similar to MsgA PUSCH validation as PRACH should be prioritized. But for MsgA PUSCH validation, not sure whether it’s necessary and whether msgA PUSCH or CG PUSCH for SDT should be prioritized. Maybe it’s fine to let gNB implementation or we prioritize CG SDT PUSCH since MsgA preamble part can be transmitted anyway without MsgA PUSCH transmission. We’re open to discuss. |
| ZTE, Sanechips | For the 2nd sub-bullet regarding validation with PRACH occasions, it mentions the validation rule with 2-step ROs and 4-step ROs, it’s not clear whether it includes both non-SDT ROs and SDT ROs. The TA validation rule related to RA-SDT may also depend on the RO configuration in RAN2. |
| Intel | We are fine with the proposal. |
| vivo | We are fine with the proposal. |
| Samsung  | Fine with the updated proposals. |
| Qualcomm | Thanks FL for the update. In addition to TDD and FD-FDD, R17 introduces Type-A HD-FDD for RedCap UE. Currently, the DL/UL collision handling procedures are under discussion in AI 8.6.1.3. Could we add a FSS bullet for UEs supporting Type-A HD-FDD and SDT ? |
| Apple | We are fine with the proposal. |

### 3.4.3 Final round discussion

With the clarification that the condition is for TDD, the first bullet seems ok to the majority. And there are some concern on the second bullets regarding the overlapping between CG-SDT and PRACH, so it is updated as follows by moving it to FFS. Another FFS regarding the HD-FDD is added as suggested by QC.

**Updated Proposal 3.4:**

* The following PUSCH occasion validation rule is applied for CG-SDT
	+ for unpaired spectrum and for SS/PBCH blocks with indexes provided by *ssb-PositionsInBurst* in *SIB1* or by *ServingCellConfigCommon*
		- if a UE is provided *tdd-UL-DL-ConfigurationCommon*, 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
		- if a UE is not provided *tdd-UL-DL-ConfigurationCommon*, the valid PO does not precede a SS/PBCH block in the PUSCH slot, starts at least $N\_{gap}$ symbols after a last SS/PBCH block symbol,
		- $N\_{gap}$ is provided in Table 8.1-2
	+ ~~A PUSCH occasion is valid if it does not overlap in time and frequency with any valid PRACH occasion associated with either a Type-1 random access procedure or a Type-2 random access procedure.~~
	+ FFS if any validation rule following the CG-PUSCH in RRC connected state is applicable, and whether and how to handle the overlapping between CG-PUSCH occasions for CG-SDT and any valid PRACH occasion or MsgA PUSCH occasion.
	+ FFS for UEs supporting Type-A HD-FDD and SDT

|  |  |
| --- | --- |
| Company | Comment |
| CATT | We are fine with updated proposal 3.4 |
| Huawei, HiSilicon | The rules for FDD band should also be discussed in RAN1. Due to the limited time, we suggest to add the FFS for the rules for FDD bands.* + FFS the rule for paired spectrum and for UEs supporting Type-A HD-FDD and SDT
 |
|  |  |

# Other physical layer issues

|  |  |
| --- | --- |
| 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?

|  |  |
| --- | --- |
| 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%3A%5CUsers%5CDocs%5CR1-2106405.zip) (Reply LS to RAN1 on physical layer aspects of small data transmission, RAN2) by August 20 – Xiaohang (vivo)

Any other comments?

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

# Summary

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

Proposals by the 2nd check point:

**Proposed Conclusion 2.1**:

RAN1 cannot reach consensus on the following options for the SSB subset for RSRP based TA validation. Ask RAN2 if they can do the down-selection.

* 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~~4: Highest N SSBs of all SSBs actually transmitted as indicated in SIB1

**Updated Proposal 3.1:**

* Each N of consecutive SSB indexes associated to one CG configuration are mapped to valid CG PUSCH resources
	+ first, in increasing order of DMRS resource indexes, where a DMRS resource index $DMRS\_{id}$ 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~~ $N$ ~~<1, each SSB index is mapped to 1/N consecutive valid CG PUSCH resources. If~~ $N\geq 1$~~, 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.
	+ An association pattern period includes one or more association periods and is determined so that a pattern between CG PUSCH occasions and SS/PBCH block indexes repeats at most every ~~160~~ 640 msec.
		- ~~FFS if the association pattern period needs to be defined~~
* Note: The mapping ordering and steps may be revisited if multiple CG PUSCH occasions in one CG period is supported

**Updated 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
	+ FFS any limitation on the DMRS configuration if multiple CG PUSCH occasions per CG period is supported

**Updated proposal 3.3:**

* Repetition K>1 is supported at least when a consistent number of valid repetitions across different CG periods can be guaranteed for each associated SSB.
	+ The repetitions are considered as a bundle of transmission occasions that are mapped to the same SSB(s)~~, no additional specification rule is needed~~.
* FFS if repetition can be supported or not when the number of valid repetitions across different CG periods for each associated SSB is not consistent.

**Updated Proposal 3.4:**

* The following PUSCH occasion validation rule is applied for CG-SDT
	+ for unpaired spectrum and for SS/PBCH blocks with indexes provided by *ssb-PositionsInBurst* in *SIB1* or by *ServingCellConfigCommon*
		- if a UE is provided *tdd-UL-DL-ConfigurationCommon*, 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
		- if a UE is not provided *tdd-UL-DL-ConfigurationCommon*, the valid PO does not precede a SS/PBCH block in the PUSCH slot, starts at least $N\_{gap}$ symbols after a last SS/PBCH block symbol,
		- $N\_{gap}$ is provided in Table 8.1-2
	+ ~~A PUSCH occasion is valid if it does not overlap in time and frequency with any valid PRACH occasion associated with either a Type-1 random access procedure or a Type-2 random access procedure.~~
	+ FFS if any validation rule following the CG-PUSCH in RRC connected state is applicable, and whether and how to handle the overlapping between CG-PUSCH occasions for CG-SDT and any valid PRACH occasion or MsgA PUSCH occasion.
	+ FFS for UEs supporting Type-A HD-FDD and SDT

# References

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2. [R1-2106683](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2106683.zip) Discussion on physical layer aspects of small data transmission Spreadtrum Communications
3. [R1-2106765](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2106765.zip) Physical layer aspects for NR small data transmissions in INACTIVE state Ericsson
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7. [R1-2107007](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107007.zip) Discussion on the remaining physical layer issues of small data transmission ZTE, Sanechips
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10. [R1-2107309](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107309.zip) Draft Reply to RAN2 LS on Physical Layer Aspects of SDT Qualcomm Incorporated
11. [R1-2107433](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107433.zip) Discussion on physical layer aspects of small data transmission LG Electronics
12. [R1-2107566](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107566.zip) Discussion on physical layer aspects of small data transmission Intel Corporation
13. [R1-2107707](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107707.zip) Discussion on physical layer aspects of small data transmission Apple
14. [R1-2107971](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107971.zip) Discussion on RAN1 impacts for small data transmisison vivo
15. [R1-2107972](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2107972.zip) Draft reply LS on physical layer aspects of small data transmission vivo
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17. [R1-2106924](file:///D%3A%5CDocuments%5C3GPP%20documents%5CRAN1%5CTSGR1_106-e%5CDocs%5CR1-2106924.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