**3GPP TSG-RAN WG1 Meeting #105-e R1-210xxxx**

**e-Meeting, May 10th – 27th, 2021**

**Agenda Item: 5.2**

**Source: Moderator (ZTE)**

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

**Document for: Discussion**

# Introduction

[105-e-NR-R17-SDT-01] Email discussion on RAN1 Aspects for NR small data transmissions in INACTIVE state) – Li (ZTE)

* 1st check point: 5/21
* 2nd check point: 5/25
* Final check: 5/27

In RAN1#104-e and RAN1#104bis-e meeting, RAN1 has discussed the physical layer issues of small data transmission requested by RAN2 LS R1-2100025 and R1-2102286, and some agreement have been achieved for RA-SDT and CG-SDT respectively.

Two reply LSs containing the agreements on part of issues was sent to RAN2 (R1-2102125 and R1-2104012).

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

This document contains the summary of remaining issues related to the physical layer aspects of small data transmission in RAN1#105-e meeting.

# Identified issues

|  |  |  |
| --- | --- | --- |
| Issue # | Description | Related TDoc # |
| 1 | TA validation for CG-SDT | R1-2104227(Nokia)  [R1-2104282](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104282.zip)(Huawei)  [R1-2104408](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104408.zip)(Spreadtrum)  [R1-2104798](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104798.zip)(OPPO)  [R1-2104840](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104840.zip)(ZTE)  [R1-2105508](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105508.zip)(Ericsson) |
| 2 | SSB to PUSCH mapping for CG-SDT | R1-2104227(Nokia),  [R1-2104282](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104282.zip)(Huawei)  [R1-2104408](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104408.zip)(Spreadtrum)  [R1-2104469](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104469.zip)(CATT)  [R1-2104840](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104840.zip)(ZTE)  [R1-2105073](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105073.zip)(Apple)  R1-2104884(Intel)  [R1-2105283](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105283.zip)(Samsung)  [R1-2105415](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105415.zip)(LGE)  [R1-2105471](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105471.zip)(InterDigital)  [R1-2105508](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105508.zip)(Ericsson) |
| 3 | Others:   1. CORESET/SS for RA-SDT 2. Beam correspondence in RRC\_INACTIVE 3. BWP related issues | [R1-2104408](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104408.zip)(Spreadtrum)  [R1-2104469](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2104469.zip)(CATT)  [R1-2105073](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105073.zip)(Apple)  [R1-2105415](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105415.zip)(LGE)  R1-2104227(Nokia)  [R1-2105073](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_105\Docs\R1-2105073.zip)(Apple) |

# TA validation for CG-SDT

**Reply LS on TA validation (R1-2104012)**

RAN1 discussed TA validation based on RSRP change criterion, and confirms that the change of RSRP could be taken as an optional criterion for determining the validity of the UL TA for CG-SDT considering the multi-beam operation. The criterion is valid only when the gNB configures RSRP change thresholds. RAN1 sees a few potential options on how the RSRP change thresholds are configured, e.g., cell level configured, or per set of SSBs configured, or configured per CG PUSCH configuration, etc. RAN1 understands this shall be studied in RAN2.

The RSRP in the criterion is a linear averaged RSRP of a subset of SSBs.The suitable mechanism for determining this subset of SSBs is still to be discussed further in RAN1. Candidates under study include e.g., determination based on an absolute RSRP threshold, or based on the SSB subset in configuration, etc. RAN1 will inform RAN2 if further progress is achieved in future.

Please note besides the RSRP change criterion and the TAT criterion (as agreed in RAN2), other criterions are under discussion in RAN1 to handle e.g., the potential issue of accuracy of TA validation from absolute RSRP. RAN1 does not reach consensus if the issue exists, and it is RAN1 understanding that this potential issue of accuracy of TA validation from absolute RSRP belongs to RAN4 expertise.

## Mechanism for determining the subset of SSBs

The following options to determine the subset of SSBs can be found in companies’ contributions.

***Discussion point 3.1:***

Down-select among the following options for the determination of the SSB subset for RSRP based TA validation.

* Option 1: Determination based on a configured absolute RSRP threshold [10][11][18]
* Option 2: The highest N beam measurement quantity values among the whole SSBs, where N shall not exceed *nrofSS-BlocksToAverage*. [7]
* Option 3: Explicitly indicated in RRC configuration [6][8]

Let us first collect more companies’ views on the pros and cons of each option, and then try to converge during the second round discussions.

### First round comments

Any comments on the above options?

|  |  |
| --- | --- |
| Company | Comment |
| CATT | We prefer to Option 1 because it is simple way to determine for RSRP based TA validation. |
| Samsung | Option 1 seems suitable. |
| Nokia | Option 3. We don’t see option 1 as sufficient. It would be important for the gNB to have control over which SSBs are considered in validation in order to be able to have different TAT configurations for different sets of SSBs. |
| Huawei, HiSi | Option 2, similar to legacy (and even simplfied).  Since the main effective tool to ensure the TA validation is performed at UE side on the RSRP change, it can be left to UE measurement and selection of the beams with highest quantity values. |
| Intel | We prefer Option 1. |
| Spreadtrum | Option 3. For CG-SDT, RSRP for TA validation should be based on the Rx beam at gNB, and the Rx beam is controlled by gNB. So, the subset of SSBs corresponding to the Rx beam should be controlled by gNB, i.e. explicitly configured by gNB. |
| Ericsson | Option 1. In our understanding, subset of SSBs with good SS-RSRP is varying at different time instances, meaning that it’s not feasible to use explicit signaling to indicate the subset of SSBs which should be determined dynamically based on the RSRP measurement and an absolute RSRP threshold. |
| vivo | We prefer Option 2, which is similar to the legacy behavior in IDLE/INACTIVE states. |
| Apple | Option 1 is preferred. |
| Qualcomm | We prefer Option 3 + Option 1.  gNB needs to configure a subset of SSB beams associated with the CG PUSCH, and the TA validation should be based on the SS-RSRP change of the configured subset. A RSRP threshold can be configured for the subset of SSB beams.  A potential issue with Option 1 only solution is that gNB may not use all RX beams available to receive CG PUSCH. In some cases, the SSB beams determined by the absolute RSRP threshold may not be the ones corresponding to the RX beams of CG PUSCH. |
| LG | We prefer Option 1. |

### Second round comments

Status of companies’ views:

Option 1 is supported by 6 companies (out of 11);

Option 2 is supported by 2 companies (out of 11);

Option 3 is supported by 2 companies (out of 11);

And one company support option 1+option3.

Based on the above, there could be two possible ways to move forward:

* One way is to follow the majority view, i.e. support option 1 that the subset of SSB is determined based on a configured absolute RSRP threshold.
* The other way is to support all the options (as all the options seems workable), and it is up to gNB’s configuration which option(s) is/are used.

***Proposal 3.1:***

* The SSB subset for RSRP based TA validation is determined based on a configured absolute RSRP threshold.

***Proposal 3.1A:***

* The SSB subset for RSRP based TA validation is determined based on one or multiple of the following approaches. Ask RAN2 to confirm.
  + Determined based on a configured absolute RSRP threshold
  + The highest N beam measurement quantity values among the whole SSBs is selected, where N shall not exceed *nrofSS-BlocksToAverage*
  + Explicitly indicated in RRC configuration

Any comments on the above proposals?

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| --- | --- |
| Company | Comment |
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## Other mechanisms for TA validation

Some other mechanisms are mentioned in [6][18], such as TDOA based criteria, time based schemes, multi-cell based RSRP measurements, multi-beam based RSRP measurements, in order to supplement the case when the RSRP based TA validation is not suitable.

Also one company [8] said it should be firstly studied in RAN4.

Since we have already included RAN4 in the reply LS, probably we can simply wait for RAN4 input or RAN2 requirement at this stage.

### First round comments

Any comments to the other potential mechanisms?

|  |  |
| --- | --- |
| Company | Comment |
| CATT | We are fine with FL suggestion on waiting for RAN4 input or RAN2 requirement at this stage |
| Nokia | We are interested in considering additional mechanisms for TA validation and don’t really see the point in awaiting other WGs work when TA validation of this level would be something for RAN1 to study. The LS sent out in RAN1#104bis did not include any questions or requests that would be relevant for this discussion to continue in RAN1. |
| Huawei, HiSi | Focusing on Discussion Point 3.1 first, and also fine to leave it to RAN4, if they consider needed. |
| Intel | We are fine with FL suggestion. |
| Spreadtrum | If as mentioned by Nokia the LS may not be discussed in RAN4 in time, RAN1 can discuss this issue for purpose of progress. |
| Ericsson | Agree with Nokia that it would be good to at least list a couple of detailed questions from RAN1 and send them to RAN4 directly in this meeting so that RAN4 can start studying this from August meeting. |
| vivo | Agree with FL’s suggestion and focus on the discussion point in 3.1 first. |
| Apple | Agree with FL’s suggestion. |
| Qualcomm | OK with the suggestion of FL. |
| LG | We are fine with FL’s suggestion. |
| Moderator (ZTE) | Still only two companies are interested to discuss the other mechanisms. I am afraid we have to put this with a lower priority, probably to be revisited later after the discussion point in 3.1 is concluded. |

# SSB to PUSCH mapping for CG-SDT

Agreement from the last meeting:

Agreement:

* It is RAN1’s common understanding that the CG configuration mechanism in licensed band can be reused for CG-SDT in principle.
* CG resources per CG configuration are associated with a set of SSB(s) configured by explicit signaling.
* FFS how to define an SSB-to-PUSCH resource mapping within the CG configuration.
* FFS specific changes to the CG configuration to support the additional SSB-to-PUSCH mapping, if any.

## SSB-to-PUSCH resource mapping within the CG configuration

For the first FFS, based on the contributions submitted to this meeting, three ways could be found to define the SSB-to-PUSCH mapping within the CG configuration.

***Discussion point #4.1:***

* Consider the following options for the SSB-to-PUSCH resource mapping within the CG configuration
  + Opt. 1: The mapping is explicitly included in the CG configuration. The indexing of the CG resources is captured in RAN2 spec. [11][12][13][17]
  + Opt. 2: The mapping is implicitly derived. The ordering of the SSB and CG resources are captured in RAN1 spec. [8][9][11][16][18][14]
    - Mapping ratio and association period could be explicitly signaled or implicitly derived
  + Opt. 3: SSB-to-PUSCH resource mapping is in relation to a RO associated with the SSB (e.g. based on a time and frequency offset in relation to the RO). [6]

Please first discuss the pros and cons of the above options. And a reply LS to RAN2 including the identified feasible solution(s) is expected to be prepared during the second round discussion.

### First round comments

Any comments on the mapping design?

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| --- | --- |
| Company | Comment |
| CATT | We are fine with Opt.2 because Opt.2 can save the signaling overhead compared with Opt.1. Regarding Opt.3, the benefit of SSB-to-PUSCH resource indirect mapping isn’t clear to us. |
| Samsung | We are supportive to option 2 as well (added our name in the summary).  Besides, we raised up two other related questions, but they seems not included in FL’s summary.  One is the using what SSB(s) to do the association if the explicit signaling is not provided. We think then all SSBs signaled in SIB1should be used. This is also a way for gNB to save signaling overhead;  Another is what will UE do if the selected SSB when triggers the CG-SDT is out of the indicated SSB sets? Which means it cannot have corresponding CG-PUSCH resource to use. We think it’s reasonable to allow it to switch to RA-SDT (even though it might be qualified from TA validation perspective). |
| Nokia | The motivation for option 3 is that in a hybrid BF cell the gNB doing Rx beam sweeping for RO would also need to do Rx beam sweeping for CG-SDT-PUSCH, so it would be important to be able to frequency mux RO and CG-SDT-PUSH transmission occasion. This property could be achieved with option 1 as well as with option 2, but it is a critical setup for the system to be able to achieve. In our view option 3 is a concrete solution of “option 2” on how to implicitly determine the time location. |
| Huawei, HiSi | It would be preferable to provide some more details for each option, or even some discussion/down-selection within RAN1, since RAN2 needs to know the impact of each option on signaling design.  Adding our support of Option 2 as well.  For Option 1, as commented by CATT signaling overhead could be significant especially when the number of associated SSBs is large. For Option 3, seems all SSBs are mapped as in SSB-to-RO mapping thus the mapping rule is in RAN1 spec while lack of flexibility and may cause larger delay for SDT transmission for a certain UE.  Option 2 provides a good tradeoff but still able to support the effect of both Option 1 and Option 3 with proper configurations. RAN1 spec work can be similar to what has been specified, as the examples shown in [7], wherein the CG resources including DMRS and CG periods can be ordered by the specification just like the PRU ordering or RO ordering, and the associated SSBs can be ordered by SSB index. The RAN2 impact is minimized – only one of the mapping ratio or association period need to be introduced and configured. With the consideration of Samsung, further signaling overhead reduction is possible when such single new parameter is absent. |
| Intel | We support Option 1.  As commented previously, as gNB already knows the SSB index used for the transmission of RRC release message for a UE, it can make prediction on a set of SSBs for association of CG-PUSCH resources for the UE. Given that UE with CG-SDT operation may be in stationary conditions or moving at a low speed, a limited number of SSBs around the last SSB index used for transmission of RRC release massage may be sufficient to allow UE to maintain the link and transmit the CG-PUSCH. In this case, signalling overhead in our view is not large for Option 1.  One question for clarification: the intention of the proposals is to agree all options and ask RAN2 to decide which option to be considered? |
| Spreadtrum | We prefer Option 2.  One question: does the CG resources in Option mean PUSCH resource unit? It is PUSCH resource unit, we suggest using the common terminology to avoid the confusion in future.  Regarding Samsung’s question on UE behavior if the selected SSB when triggers the CG-SDT is out of the indicated SSB sets, we are not sure whether it will happen. If UE want to trigger a CG-SDT, UE should select a SSB with RSRP above the threshold and select the associated PRU, according RAN2 agreement. So, the selected SSB should be explicitly indicated in CG configurations. |
| Ericsson | Opt2. To minimize the work load and reduce the unnecessary signaling overhead, we should try to reuse legacy mapping rules already specified for SSB to map to other channels for the mapping between SSBs and CG PUSCH, and there’s no need to introduce new explicit signaling for the mapping itself though the set of SSBs can be configured in RRC release as we agreed in last meeting. |
| vivo | We support Option 2.  We share the same view as Spreadtrum that the definition of CG PUSCH resource needs to be further clarified for all the options, e.g. a CG PUSCH resource is defined as a transmission occasion and a DMRS resource used for PUSCH transmission.  For option 1, as commented by CATT and Huawei, if multiple CG configurations are configured, the signaling overhead for configuring the SSB-to-CG resource mapping will be significant.  For option 2, the implicit mapping rule can be based on the RO-to MsgA PUSCH mapping, which has minimized RAN2 impact. For example, the detailed mapping for SSB-to-CG PUSCH can be defined by the ordering of CG PUSCH resources and SSB index. 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 |
| Apple | We support Option 1.  For the singalling overhead of Option, we don’t think the signaling overhead is the concern. First, many parameters are the same for different PUSCH resources, so these parameters can be optional configured. Second, The SSB number is limited. Third, the association is configured in UE specific manner via UE dedicated signaling, there is no overhead issue.  For option 2, it’s not so clear how to perform the implicit mapping between SSB and the PUSCH resource. According to the CG configuration, one PUSCH resource could be determined by the following parameters {*periodicity, timeDomainOffset, TimeDomainAllocation, frequencyDomainAllocation, antennaPort, dmrs-SeqInitialization* }. The combinations of these parameters are huge If there are no restrictions for parameter combinations, the PUSCH resource indices are almost infeasible. This is different from SSB-to-RO or to- MsgA association, as the RO periodicity is pre-defined in the spec, the MsgA PRB number is configured. Thus the MsgA PRU indices are limited. |
| LG | We support option 1. We also wonder if signaling overhead is significant considering that only SSB subsets can be mapped to CG configuration. We assume that the subset of SSBs for CG configuration can be provided in RRC Release message.  However, if signaling overhead is really problematic, the ordering of the SSB and CG resources could be studied in RAN1 for low signaling overhead. |

### Second round comments

Status of companies’ views:

Option 1 is supported by 3 (out of 10) companies, the concern is about the signaling overhead when the number of configured SSB is large (CATT, Huawei, vivo), while the proponents said this can be solved by limiting the number of configured SSB (Intel, Apple, LGE).

Option 2 is supported by 6 (out of 10) companies, the concern is about the complexity as the combinations of the parameters for PUSCH resource could be too large (Apple)

Option 3 is supported by 1 (out of 10) company, seems companies may need more analysis to understand the benefit of this option. (CATT, Huawei)

For the sake of progress, let us try to see if the majority view (option 2) could be a way forward, and maybe to add more details and some FFS to solve the concern? Otherwise, we have to report both options to RAN2 and ask them to take one based on their preference. The risk is that if RAN2 pick option 2 eventually, the remaining RAN1 work (those mapping details) would be further delayed by one or two meetings.

It is also noticed that the CG resource needs to be clarified as PUSCH occasion and DMRS;

To Samsung’s proposal on the switching to RA-SDT, it is the moderator’s understanding that it can be studied in RAN2.

***Proposal 4.1:***

* + 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
    - Mapping ratio and association period could be either explicitly signaled or implicitly derived
      * FFS details
    - FFS any limitation on the combination of the parameters for CG resources

Any comments on the above proposal?

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| --- | --- |
| Company | Comment |
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## Specific changes to the CG configuration

The following specific changes to the CG configuration are mentioned in the submitted contributions.

1. Support of multiple DMRS resources [7][11][12][16]
2. Interpretation of the repetition [11][14]
3. Candidate values of CG periodicity [11][18]

***Discussion point 4.2***:

Consider the following changes to the CG configuration

* Support multiple DMRS resources per CG configurations, and each DMRS resource could be mapped to the same or different SSB(s).
* For the interpretation of repetition, down-select between:
  + Alt. 1: Re-interpret the configured repetition as the number of TDMed transmission occasions within a CG period. Each transmission occasion could be mapped to the same or different SSB(s).
  + Alt. 2: The repetitions are considered as a bundle of transmission occasions that are mapped to the same SSB(s).
* Ask RAN2 if value set of the CG periodicity should be limited (for implicit mapping in section 4.1)

### First round comments

Any comments?

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| --- | --- |
| Company | Comment |
| CATT | For multiple DMRS resources per CG configurations, it isn’t necessary because SSB-to-PUSCH resource mapping (1:1 and 1: N) within the CG configuration can be guaranteed and the case that SSB-to-PUSCH resource mapping N:1 doesn’t appear based on gNB configuration.  For PUSCH repetition, for Alt.1, because gNB can’t identify which SSB is selected by the UE if Each transmission occasion of PUSCH repetition could be mapped to different SSB(s), gNB can’t know to use which SSB for PUSCH retransmission.  So we prefer to Alt.2.  We are fine with Asking RAN2 if value set of the CG periodicity should be limited. |
| Samsung | Multiple DMRS resources per CG configurations could be allowed.  For second bullet, alt.1 should be supported, it just acts like number of PO configured in one CG-PUSCH periodicity. Then the association to one SSB will be derived accordingly. In the case of multiple SSB for one PO, we think here DMRS resources should be used to differentiate SSBs, otherwise, it’s a gNB mis-configuration.  For third bullet, is the motivation to shorten the value set to save signaling bit size? Otherwise, isn’t it the gNB scheduling issue to choose which value? |
| Nokia | Multiple DMRS resources per CG-PUSCH config doesn’t seem to be necessary.  Repetitions should be considered as a bundle  We don’t quite see the necessity to request RAN2 input, RAN1 should be able to determine the needs and design accordingly. |
| Huawei, HiSi | For the listed 3 changes:   1. Fine with us. 2. Alt.2 is preferred with similar reason as CATT. 3. Similar to Samsung comments, we do not see obvious motivation to change the value set. |
| Intel | We fine with 1st bullet.  For the 2nd bullet, it is not clear to us why each repetition needs to be treated separately. In our view, Alt. 2 would be natural outcome for CG-PUSCH resource and no spec changed is needed.  For the 3rd bullet, we suggest to wait for discussion in 4.1 first. |
| Spreadtrum | 1. We are fine for it. 2. Alt. 2 is preferred. 3. Need further study. |
| Ericsson | For multiple CG resource allocation, we’re open to discuss:   * Multiple PO generation (time frequency)   + Try to reuse TDRA of type 1 configured grant PUSCH in RRC connected mode for the first PO configuration, multiple POs can be configured on top of that first PO.   + Which TDRA tables can be used should be discussed in RAN1 since UE is in RRC inactive state. * Multiple DMRS sequences   For repetition of CG PUSCH for SDT, follow the legacy interpretation, i.e. alt 2.  For CG periodicity for SDT, agree that it should be clarified by RAN2 since the SSB (minimum 5ms period) to CG PUSCH (can be quite small in legacy) association period is related to this.  On top of items listed above, the CG PUSCH validation should be addressed in RAN1 as well since it’s related to the SSB to CG PUSCH mapping, e.g. whether we support CG SDT on flexible symbols. |
| vivo | 1. multiple DMRS resources can be configured. 2. The two alternatives in the 2nd bullet seem talking two different issues. Alt. 1 is to provide a method to increase the transmission occasion within a CG periodicity, while Alt. 2 is to define the mapping rule for the repetition bundle with a CG periodicity.   In fact, we think if multiple TDMed transmission occasions with a CG periodicity can be configured, it would be beneficial because it can reduce the latency of CG-SDT transmission. We are open to further discuss whether and how to configure multiple TDMed transmission occasions.  For Alt.2, we think it needs to be supported once repetitions are configured for CG-SDT.   1. For the 3rd bullet, it is not clear why the periodicity needs to be limited. |
| Apple | First bullet, We are OK with the proposal.  Second bullet, Alt.2 is aligned the definition of repetition.  Third bullet, it’s up to the conclusion of section 4.1, then decide whether to ask RAN2. According to the comments, it seems the option 2 in section 4.1 is not clear enough. |
| Qualcomm | We are open to discuss the following items in RAN1:   1. multiple DMRS resources per CG configurations 2. CG PUSCH validation 3. repetitions of CG PUSCH are considered as a bundle of transmission occasions that are mapped to the same SSB(s). |
| LG | 1) We are fine with multiple DMRS resources  2) We are fine with Alt 1 and Alt 2 in the list.  For Alt 1, mapping between SSBs and PUSCH transmission occasions should be known to gNB, so that gNB can identify which SSBs are selected by the UE. UE may select one or more SSBs to avoid unnecessary retransmission with a different SSB. Mapping between SSBs and PUSCH transmission occasions could be determined within a CG periodicity or across CG periodicities.  For Alt 2, in our view the PUSCH repetitions in a bundle are configured within a CG periodicity.  3) We could not understand need of this LS. |

### Second round comments

For the multiple DMRS resources, 9 (out of 11) companies are either fine with it or open to discuss the details. Let us see if the majority view can be acceptable.

For the repetition, 10 (out of 11) companies prefers alt.2. Let us see if the majority view can be acceptable.

For the value set of CG periodicity, the majority view is that the LS to RAN2 is not needed, may be revisited later after the mapping design is concluded.

***Proposal 4.2:***

* Support multiple DMRS resources per CG configurations, and each DMRS resource could be mapped to the same or different SSB(s).
* If repetition is configured for CG-SDT, the repetitions are considered as a bundle of transmission occasions that are mapped to the same SSB(s).

Any comments on the above proposal?

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

# Others

There are some discussion points that are resubmitted

1. Beam correspondence in RRC\_INACTIVE [6]
2. CORESET/SS for RA-SDT [8][13][15]
3. BWP related issues [13]

Based on the comments in the last meeting, the majority view was that we should wait for RAN2 inputs before discussing those issues in RAN1.

Any further comments?

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| --- | --- |
| Company | Comment |
| CATT | We are fine with FL suggestion on wait for RAN2 inputs on above issues. |
| Nokia | Asking RAN4 to extend the beam correspondence requirement to apply to RRC\_Inactive has nothing to do with RAN2 ongoing work, but is a fundamental requirement for the SDT to work in FR2. On other two bullets we agree |
| Huawei, HiSi | Fine to wait for RAN2’s inputs on this issues. |
| Intel | 2) and 3) are under the discussion in RAN2. We suggest to wait for RAN2 inputs on this. For 1), it seems that it needs to be discussed in RAN4. |
| vivo | For 1), 2) and 3), we are fine for waiting RAN2’s input.  We think there is another issue that needs to be discussed in RAN1 after triggered by RAN2, i.e. mapping of RA-SDT resources and SSBs.  RAN2 has continued the discussion on the resource configuration aspects for RA-SDT in [POST113bis-e][507][SDT], including some aspects that may be related to RAN1. E.g. how to determine the 4-step/2-step RACH preambles per SSB for RA-SDT when ROs are shared between SDT and non-SDT, whether/how to determine the 4-step/2-step RACH preambles per SSB and the number of SSBs per RO for RA-SDT when ROs for SDT and non-SDT are separate, whether/how to determine the RO(s) for 4-step RA-SDT and 2-step RA-SDT.  Regardless whether shared or separate ROs between RA-SDT and non-SDT are used, it is still open on how to define the mapping between SDT ROs/preambles and SSBs. The mapping between 4-step RACH/2-step RACH RO/preambles and SSBs in Rel-16 can be used as starting point. RAN1 can further discuss the mapping of RA-SDT resources and SSBs once RAN2 triggers the discussion. |
| Ericsson | For 1.), agree with Nokia and Intel that beam correspondence test for CG SDT in RRC inactive state may be needed similar to PRACH test with SSB selection. As this is up to RAN4, we’re fine to send LS to RAN4 to trigger their discussions on this.  For 2.), 3.), it should be up to RAN2 discussion, no actions in RAN1 is needed at this stage. |
| LG | For the second issue, what we actually address in [15] is CORESET/SS used for dynamic retransmission in CG-SDT, not RA-SDT. RAN2 previously agreed to support retransmission by dynamic grant for CG-SDT. Thus, we think that RAN1 could discuss CORESET/SS used for dynamic retransmission in CG-SDT. |
| Moderator (ZTE) | It seems more companies show the interests on the beam correspondence issue. So may I ask the original proponent (Nokia) to help prepare a draft LS to RAN4 and share it to the draft folder, so that we can continue the discussion after the quiet period?  To vivo, I was also aware of that email discussion in RAN2, and I believe they will send another LS to us during this meeting, with some concrete issue to be solved by RAN1.  To LGE, thanks to point out the difference. Yes we can also discuss that once the reply LS on CORESET/SS is received from RAN2. |

***Proposal 5:***

* Send an LS to RAN4 asking to extend the beam correspondence requirement to apply to RRC\_Inactive

Any comments on the above proposal?

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

The final proposals and LSs will be updated later.

# References

1. RP-210870 Work Item on NR smalldata transmissions in INACTIVE state ZTE
2. R1-2100025 LS on physical layer aspects of small data transmission RAN2, ZTE
3. R1-2102125 Reply LS on physical layer aspects of small data transmission RAN1, ZTE
4. R1-2102286 LS on uplink timing alignment for small data transmissions RAN2, Lenovo
5. R1-2104012 Reply LS on uplink timing alignment for small data transmissions RAN1, Lenovo
6. R1-2104227 On physical layer aspects of small data transmission Nokia, Nokia Shanghai Bell
7. R1-2104282 Physical layer aspects of CG-SDT Huawei, HiSilicon
8. R1-2104408 Discussion on physical layer aspects of small data transmission Spreadtrum Communications
9. R1-2104469 Remaining issues on small data transmission CATT
10. R1-2104798 Discussion on NR small data transmissions in INACTIVE state OPPO
11. R1-2104840 Discussion on the remaining physical layer issues of small data transmission ZTE, Sanechips
12. R1-2104884 Discussion on physical layer aspects of small data transmission Intel Corporation
13. R1-2105073 Discussion on physical layer aspects of small data transmission Apple
14. R1-2105283 Discussion on physical layer aspects for NR small data transmissions in INACTIVE state Samsung
15. R1-2105415 Discussion on physical layer aspects of small data transmission LG Electronics
16. R1-2105453 Discussion on RAN1 impacts for small data transmisison vivo
17. R1-2105471 Physical layer aspects of small data transmission InterDigital, Inc.
18. R1-2105508 Discussion on RAN1 aspects for NR small data transmissions in INACTIVE state L.M. Ericsson Limited

# Appendix

List of proposals in the submitted contributions.

|  |  |
| --- | --- |
| TDoc | Proposals |
| R1-2104227  Nokia | **On CG resource association with SSB**  **Proposal 1:** The specific changes to the CG configuration to support the additional SSB-to-PUSCH mapping should be left to RAN2 to discuss, after the SSB-to-PUSCH mapping rule has been defined in RAN1.  **Proposal 2:** SSB-to-PUSCH resource mapping is in relation to a RO associated with the SSB (e.g. based on a time and frequency offset in relation to the RO).  **On TA validity within and across SSBs**  **Observation 1:** Cell-level RSRP is not suitable for RSRP based TA validation in multi-beam cells, because the observed RSRP variation does not necessarily increase as the UE moves closer to the cell centre nor necessarily decreases when the UE moves away from the cell centre.  **Proposal 3:** RAN1 to agree that Cell-level RSRP is not suitable for RSRP based TA validation in a multi-beam cell deployment.  **Proposal 4:** RAN1 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.  **Observation 2:** The determination at UE of the subset of SSBs to be used for TA validation based on absolute RSRP threshold does not guarantee that the set of selected SSBs avoids the behaviour where the averaged RSRP does not necessarily increase as the UE moves closer to the cell centre nor necessarily decreases when the UE moves away from the cell centre.  **Proposal 5:** RAN1 to agree that absolute RSRP threshold based determination of the subset of SSBs is not suitable for RSRP based TA validation in a multi-beam cell deployment.  **Observation 3:** The network should select the subset of SSBs for RSRP based TA validation based on the set of SSBs covering the location of the UE when the UE acquires a valid TA.  **Proposal 6:** RAN1 to agree that the RSRP for the TA validation should be based on the linear average of a set of configured SSBs and these can be provided as part of the CG-SDT configuration.  Error! No sequence specified.**Proposal 7:** The configuration of the RSRP change thresholds for RSRP based TA validation per subset of SSBs should be supported.  **Observation 4:** The RSRP change thresholds should be such that these are above the RSRP measurement error.  **Proposal 8:** Study additional TA validation methods in order to supplement the case when the RSRP based TA validation is not suitable.  **On PUSCH repetition with SDT-CG-PUSCH**  **Observation 5**: When SDT-CG-PUSCH configuration is associated to an SSB, there is no additional SSB mapping complication when repetitions are allowed.  **Proposal 9:** Allow using PUSCH repetition with SDT-CG-PUSCH. No spec changes needed.  **On beam correspondence in RRC\_Inactive**  **Observation 6:** The UE in RRC\_INACTIVE needs to support beam correspondence for the SDT-CG-PUSCH resource to SSB relation to be useful.  **Proposal 10:** Send an LS to RAN4 requesting the beam correspondence requirements to be applied to RRC\_INACTIVE |
| R1-2104282  Huawei | ***Proposal 1:*** *Multiple DMRSs per CG configuration is supported for CG-SDT.*  ***Proposal 2:*** *Confirm 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 in Rel-17.*  ***Proposal 3:*** *For the SSBs mapped to multiple DMRSs and CG periods within one CG configuration, reuse the preamble-to-PRU mapping rule in 2-step RACH MsgA.* *Either the association period or the number of SSBs per DMRS and CG period is explicitly configured per CG configuration.*  ***Proposal 4:*** *The RSRP is derived as the linear power scale average of the subset of SSBs with the highest N beam measurement quantity values among the whole SSBs, where N shall not exceed nrofSS-BlocksToAverage.* |
| R1-2104408  Spreadtrum | ***Proposal 1: The RSRP in the criterion for TA validation is a linear averaged RSRP of a subset of SSBs, where the subset of SSBs contains SSBs configured by gNB with explicit signalling.***  ***Proposal 2: The CORESET associated to the search space set for monitoring the PDCCH addressed to the C-RNTI after successful completion of the RACH procedure during RA-SDT is a common CORESET.***  ***Proposal 3: SSB-to-PUSCH resource units mapping within the CG configuration can be one-to-one mapping or many-to-one mapping.*** |
| R1-2104469  CATT | **Proposal 1: UE-specific CORESET or common CORESET for RA-SDT can be determined based on RAN2’s decision on the type of separate search space.**  **Proposal 2: Define the SSB-to-PUSCH resource mapping within the CG configuration based on the SSB-to-RO mapping rule.**  **Proposal 3: 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 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.** |
| R1-2104798  OPPO | ***Proposal 1: RSRP can be used as the criterion for determining the validity of the uplink timing alignment for CG-SDT.***  ***Proposal 2: Cell level RSRP shall be used for uplink timing alignment validation.*** |
| R1-2104840  ZTE | ***Proposal 1:***   * ***Either explicit mapping or implicit mapping can be considered for the SSB-to-PUSCH resource mapping within the CG configuration.***   + ***FFS if multiple DMRS needs to be configured***   + ***FFS if the repetition needs to be reinterpreted as the number of TDMed occasions per CG period***   + ***FFS if the value set of CG periodicity needs to be limited***   ***Proposal 2:***   * ***For TA validation based on RSRP change criterion, the absolute RSRP threshold used for deriving the serving cell RSRP which is used for cell reselection should be reused.*** |
| R1-2104884  InterDigital | **Proposal 1**   * *Association between SSBs and CG-PUSCH resources is configured by explicit signalling for CG-SDT.*    + *Multiple DMRS resources can be configured within a CG-PUSCH occasion.*   + *A DMRS resource is associated with an SSB from the configured set of SSBs.*   **Proposal 2**   * *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.* |
| R1-2105073  Apple | **Proposal 1: Explicit indication of association between SSB and CG-SDT PUSCH resource is supported.**  **Proposal 2: Time domain repetition can be supported for CG-SDT.**  **Proposal 3: For RA-SDT, the initial BWP is applied for UL and DL data transmission, where initial BWP is configured by SIB1. USS set is configured for SDT transmission.** |
| R1-2105283  Samsung | ***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 2: 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 3: 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.***  ***Proposal 4: 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.***  ***Proposal 5: if the selected SSB by UE is not within the indicated/determined SSB set, UE switch to RA-SDT.*** |
| R1-2105415  LGE | ***Proposal 1: A UE can be configured with multiple CG configuration indexes for CG-SDT. One or more SSBs are associated to a CG configuration index.***  ***Proposal 2: For a CG configuration index, a PUSCH resource in a CG periodicity can be associated to a set of SSB(s) for CG-SDT. UE selects one associated SSB to transmit on the PUSCH resource.***  ***Proposal 3: For PUSCH repetitions of a TB within a CG periodicity, if configured by gNB, UE can transmit multiple PUSCH resources associated to a same SSB or different SSBs of the set.***  ***Proposal 4: For a CG configuration index, different PUSCH transmissions in different CG periodicities of CG-SDT can be configured to be associated to the same set of SSB(s) or different SSB subsets of the set.***  ***Proposal 5: If one or multiple SSBs are associated with a CG PUSCH resource for CG-SDT and a measured quality of at least one SSB is above a threshold configured by gNB, UE can use the CG PUSCH resource for CG-SDT.***   * ***Even if the best SSB of a cell is not associated to any other CG PUSCH resource but if at least one SSB of which quality is above threshold is associated with a CG PUSCH resource for CG-SDT, UE can use the CG PUSCH resource for CG-SDT.***   ***Proposal 6: If measured quality of any SSB configured for CG-SDT is not above threshold for CG-SDT, UE triggers RACH e.g. for RA-SDT or for reconfiguring CG-SDT.***  ***Proposal 7: A separate SearchSpace that is different from the existing common SearchSpace should be supported for monitoring the PDCCH addressed to CS-RNTI for retransmission of CG-SDT.***  ***Proposal 8: CS-RNTI can be reused for retransmission of CG-SDT.***  ***Proposal 9: For detection of retransmission DCI in response to a CG PUSCH transmission, 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.*** |
| R1-2105453  vivo | **Proposal 1: 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**   **Proposal 2: 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 3: 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**   **Proposal 4: If CG-SDT PUSCH repetitions are supported, only PUSCH repetition type A can be configured for CG-SDT.**   * **All PUSCH repetitions are associated with the same SSB(s).** * **A fixed RV sequence for CG-SDT PUSCH repetitions is defined, e.g. RV= {0, 2, 3, 1}.**   **Proposal 5: Further discuss the mapping of mapping of RA-SDT resources and SSBs in RAN1.** |
| R1-2105471  InterDigital | **Proposal 1:** *An SSB associated to a CG-SDT configuration maps to all PUSCH resources of the CG-SDT configuration.*  **Proposal 2:** *No additional SSB-to-PUSCH mapping is introduced within a CG-SDT configuration (no change required to CG configuration).*  **Proposal 3:** *The UE selects RACH-based SDT when there is no valid CG for selection, including when the measured SSB-rsrp is not met for any SDT CG resource.*  **Proposal 4**: *Support reception of HARQ-ACK information for PUSCH transmissions for SDT operation.* |
| R1-2105508  Ericsson | Proposal 1 The set of SSBs is configured in CG PUSCH configuration in RRC release message for the mapping between SSBs to CG PUSCH resources configured by this CG PUSCH configuration.  Proposal 2 RAN1 should further discuss the TDRA for CG PUSCH resource in RRC inactive state.  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.  Proposal 4 Ask RAN2 about the CG period candidate values for SDT.  Proposal 5 The mapping rules used for SSB to RO mapping can be reused by SSB to CG PUSCH mapping.  Proposal 6 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.  Proposal 7 The subset of SSBs used for RSRP calculation is determined by an absolute RSRP threshold  Proposal 8 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.  Proposal 9 Different RSRP variation thresholds and TAT configuations can be configured for different sets of SSBs configured in different CG PUSCH configuations.  Proposal 10 On top of the TA validation based on RSRP change, support TDOA based crieterial for TA validation in CG based SDT. |
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